U-space

# U-SPACE CONCEPT OF OPERATIONS (CONOPS)

## FOURTH EDITION

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# U-space ConOps and architecture (edition 4)

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### Authors of the document

| Beneficiary | Date |
|---|---|
| EUROCONTROL | 20-7-2023 |

### Reviewers internal to the project

| Beneficiary | Date |
|---|---|
| | |

### Reviewers external to the project

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A more detailed explanation of the evolution of the content of this document appears in section 1.2.



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# CORUS-XUAM

## CORUS-XUAM

This Concept of Operations is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 101017682 under European Union's Horizon 2020 research and innovation programme.

The SESAR3 Joint Undertaking was co-founded by EUROCONTROL who provide in kind contribution to its operations and projects. This project has benefited from that support.

### Abstract

U-space is Europe's traffic management system for Uncrewed Aerial Systems, also called *drones*. The CORUS project, 2017 to 2019, produced three editions of the U-space Concept of Operations or ConOps. The third edition [1] was produced in October 2019. The ConOps explains how U-space works from a user's point of view. A preliminary version of the fourth edition of the ConOps, labelled 3.10, was released in July 2022 for comment. This is now the consolidated fourth edition. It differs from the third edition for three reasons: Improved consideration of UAM needs; adjustments according to the regulatory evolution; incorporation of inputs stemming from other R&D projects.

Meeting the needs of UAM focuses on processes at the vertiport, airspace structure and flight rules, particularly as passenger carrying operations with electric vertical take-off and landing (EVTOL or eVTOL) aircraft are expected within U-space; initially with a pilot on board, later remotely piloted. The key feature of the eVTOL, currently, is short flight duration and U-space has to be able to provide safe operation with this constraint.

The European Union regulations, primarily 2021/664, 665 and 666 known as the U-space regulatory framework, sets the minimum requirements for the U-space in terms of seven services, six functional plus "common information." This ConOps includes these services.

Some research projects bring more precise descriptions of services or processes already mentioned, for example dynamic capacity balancing (DACUS), and some projects bring new services like altitude conversion services (ICARUS).

This fourth edition of the U-space ConOps aims to serve as a reference manual for U-space.



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# 1 Introduction

The opinions expressed herein reflect the authors' views only. Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein.

## 1.1 What is a ConOps

*A concept of operations (abbreviated CONOPS, or ConOps) is a document describing the characteristics of a proposed system from the viewpoint of an individual who will use that system. It is used to communicate the quantitative and qualitative system characteristics to all stakeholders*[1].

This ConOps tries to answer the basic question "how does U-space work" and in doing so provides a common basis for discussion of details. The ConOps provides terminology and a general model of the overall system of U-space. Ideally the ConOps expresses a set of ideas and assumptions that the reader absorbs, applies and is not conscious of. Until that is achieved this document aims to be a reference manual for, or an encyclopaedia of U-space.

## 1.2 U-space Concept of Operations edition 4 compared to ed 3

The CORUS project ran from September 2017 to November 2019 and produced three editions of the U-space ConOps in an iterative process involving collaboration with a large number of stakeholders including other research projects. (The CORUS project received funding from the SESAR Joint Undertaking under grant agreement No 763551 under European Union's Horizon 2020 research and innovation programme.) Edition 3 of the U-space ConOps [1] was published in October 2019 and since then has been downloaded more than 4000 times.

This document is the fourth edition of the U-space ConOps. Due to the rapid development of the U-space knowledge domain, the need for an updated version of the ConOps became evident. Specifically, this edition aims to address the following.

- The presentation should be concise and easy to read. The 3rd edition [1] is very long and contains a great deal of discussion. The original CORUS project put a lot of effort into explaining as the audience being addressed was generally new to the topic. The audience for edition 4 is better informed.
- Several European regulations have been published that diverge from the U-space ConOps in detail if not in spirit. They need to be fully embraced in the ConOps.
- The specific aim of CORUS-XUAM (The CORUS Extension for Urban Air Mobility), which is to study how the needs of Urban Air Mobility impact U-space.
- Many developments, research & demonstration projects have occurred, standards and legislation have been written that have moved the state of the art.

The latter three bullets are expanded below.

[1] Wikipedia, https://en.wikipedia.org/wiki/Concept_of_operations accessed January 2023

### 1.2.1 The scope and impact of EU regulations

One of the motivations for producing the fourth edition of the U-space ConOps was to reconcile the impact of the EU (European Union) regulations. The Edition 3 ConOps [1] was produced in 2019. Since then the U-space regulatory framework has been published: EU Implementing Regulation (IR) 2021/664 [8], 2021/665 [9] and 2021/666 [10] and the relevant Acceptable Means of Compliance and Guidance Material (AMC-GM) [11]. The scope of the U-space regulatory framework is a U-space airspace. The U-space regulatory framework addresses the competent authority, the common information service provider, the U-space service provider, the UAS operator and in 2021/666, other aviators.

These U-space regulatory framework does not address other airspaces, notably controlled airspace or UAS geographic zones which are not U-space airspaces. Y and Z airspaces are volumes in which U-space services are used, which include but might not be limited to the U-space airspaces of the regulations.

The U-space regulatory framework provides a minimal set of functions to enable low density beyond-visual-line-of-sight (BVLOS) flight. The scope is approximately U2 in terms of Figure 1.

The terms and scope of the U-space regulatory framework, [8] [9] [10], with [11] are reconciled in this version.

### 1.2.2 Impactful research projects

The SESAR Joint Undertaking has organised a forum called the ConOps Coordination Cell (CCC) which has promoted the U-space Conops edition 3 as a foundation of SESAR U-space projects and encouraged the feeding back of ideas into this, the U-space ConOps edition 4. Of the sixteen projects that took part in the CCC, several whose impacts are most visible are bulleted below. The others all contributed providing refinements of the ConOps and validating its contents in experiments, those listed below are examples whose impacts can be summarised briefly.

- ICARUS [28] examined the Common Altitude Reference System, proposing two new services and modifying two others.
- BUBBLES [54] studied the processes of separation and proposed a new service. The BUBBLES project refined the definition of the Tactical Conflict Detection and Tactical Conflict Resolution services.
- DACUS [55] provided a detailed method for demand capacity balancing in U-space and refined the definition of the dynamic capacity management service.
- The Gulf of Finland 2 project [46] (GOF2) developed and validated a set of data exchange models to enable U-space. The same models were validated in the AURA project [47]. GOF2 deliverable D4.2 detailing these models is an annex to this ConOps.
- AMU-LED [45] examined, among other things, a division of the airspace in function of risk & performance.

### 1.2.3 The key differences between edition 3 and edition 4

This comparison is between edition 3 of October 2019 [1] and this document. This comparison assumes a good knowledge of edition 3. The comparison in this section is not required reading to understand edition 4 and the reader may wish to skip to section 1.3.

### 1.2.3.1 Terminology

The term U-plan is used in edition 4 to mean a plan for a flight managed by U-space. Edition 3 used the term "operation plan." Throughout the period of the CORUS project and in subsequent interactions with stakeholders there was often confusion about what was being referred to be operation plan, which led to other terms being used like "drone flight plan" leading to more confusion, typically about whether an Uncrewed[2] Aerial System (UAS) could fly under a flight plan as described in ICAO document 4444 [57] . By putting the emphasis on U-space the term U-plan seeks to clarify. EU IR 2021/664 [8] uses the term "flight authorisation request," a term that can lead to confusion with the requirements in EU IR 2019/947 [4].

The names used for airspace volumes have been revised slightly in edition 4. In edition 3, the airspace volume Zu could be a region in which U-space gave tactical separation instructions or offered tactical conflict resolution advice. This ambiguity has prevented clear discussion. Now the two modes of operation are now given distinct names. In a Zu volume U-space will give tactical separation instructions. In a Zz volume U-space will offer tactical conflict resolution advice.

The definition of the Y volume has been revised allow it to be the U-space airspace of EU implementing regulation 2021/664 [8]. The mapping is not two way, all U-space airspace is Y, not all Y is U-space airspace. See 2.3.5.3.

### 1.2.3.2 How the services differ between editions 3 and 4

The list of services has been changed between editions 3 and 4.

Some service names have been changed in edition 4 to bring them in line with the EU IR 2021/664 [8]. This difference is explored in Table 7.

Some services have been split into parts. For both strategic and tactical conflicts, the detection and resolution functions have been separated. This is done to better match the likely implementations. ASTM standard F3548 [18] describes a strategic conflict detection mechanism. The standard mentions that conflict resolution would be by negotiation between the concerned service providers but does not describe the negotiation process in detail. EU IR 2021/664 [8] can be implemented with ASTM F3548 for strategic conflict detection, but in EU IR 2021/664 the process for resolution of strategic conflicts is not negotiation between U-space Service Providers (USSP).

Edition 3 described the "operation plan processing service" as doing many things. Edition 4 splits the activities between the Flight Authorisation service whose focus is pre-flight and the U-plan processing service which is concerned with active flights, following work in the Gulf of Finland 2 (GOF2) project [46].

The AURA project [47] explored the interactions between Air Traffic Control (ATC) and U-space. They proposed a finer grain of services than Edition 3. Following proposals of the AURA project, the Collaborative interface with ATC now includes the Tactical Operational Message Info Exchange and the Procedural interface with ATC now includes the Dynamic Airspace Reconfiguration (DAR) Service. See sections 3.18 and 3.17 respectively.

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[2] UAS may also be expanded as Unmanned Aerial Systems.

Some services have been removed. Edition 3 mentioned a "registration assistance" service. Interactions with stakeholders since the publication of Edition 3 show the service and its name causes confusion. The authors of edition 3 considered the "registration assistance" service to be an example of a value-added services which might be offered. The description of the service in edition 3 was vague. It is not mentioned in edition 4.

Some services have been added. CORUS-XUAM has added the Vertiport availability service in section 3.7. The ICARUS project [28] added two new services to edition 4 and refined the definitions of several others. The new services are the Vertical Conversion Service, section 3.19, and the Vertical Alert and Information Service in section 3.20. See Table 2 for the services revised by ICARUS.

A number of other services have revised definitions following the work of CORUS-XUAM as well as other research projects such as DACUS, ICARUS, BUBBLES, AURA and others.

Accommodating EU IR 2021/664 also extended the scope of the services of the ConOps between editions 3 and 4. EU IR 2021/664 describes a Common Information Service – see 2.5.1 – which among other things, lists which U-space Service Providers are certified to provide services in any U-space Airspace.

## 1.3 What is in the scope of this ConOps

### 1.3.1 U-space

U-space is based on a set of services, see the U-space Blueprint [2] and Commission Implementing Regulation (EU) 2021/664 [8]. These services are provided from the ground (generally) and concern safety, security and efficient flight. This ConOps describes these services, how they are used and the environment in which they are used.

There are many other closely related services that may be supplied to U-space stakeholders, for business or other reasons, which are not considered to be in the scope of this ConOps. They may be mentioned in passing.

### 1.3.2 Urban Air Mobility

Urban Air Mobility (UAM) in this document is defined as air operations which are:

- above urban areas, at least for part of the flight,
- in 'U-space airspace,' – see Section 2
- performed by a mix of traffic which includes aircraft:
    - incapable of flying Instrument Flight Rules (IFR) or Visual Flight Rules (VFR),
    - with very limited range,

UAM is expected to involve some situations in which the combined effect of a high level of traffic and uncertainties in the navigation necessitate tactical separation to ensure safe operations.

The operations include passenger carrying operations with highly automated remotely piloted electrically powered aircraft, as well as cargo and other flights with no human on board.



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The European Union Aviation Safety Agency, EASA, has announced that the steps to 1) passenger carrying operations with 2) remote pilot and a high degree of automation in 3) an electrically powered aircraft in 4) lower airspace with novel traffic management will be made separately. Hence initial operations may have pilot on board, but this should be viewed as a transition measure towards remote piloting. Urban Air Mobility includes any flights meeting the conditions above.

That the operations are above urban areas implies that there are limited opportunities for safe emergency landing which impacts the planning of operations.

The increased risk of Urban Air Mobility compared to other U-space operations, both in terms of ground risk and in the air risk, especially when passengers are being carried, will influence the performance requirements on the operations and procedures, but may not impact the procedures themselves.

### 1.3.3 In scope

- Management of remotely piloted aviation of any level of autonomy
- Management of Pilot-on-board aviation
- Use of U-space in flight scenarios by different stakeholders
- Ground infrastructure such as Vertiports
- Contingency scenarios
- Safety
- Security including cyber-security
- Risk assessment and mitigation
- Social acceptability
- Flight rules
- Traffic management
- Optimisation of flight or traffic or airspace use according to key performance areas

### 1.3.4 Not in scope

- Whether or not there should be UAS flight and UAS applications[3]
- Business viability of drone uses, or of U-space service provision
- The environmental impact of UAS flight.
- Aircraft design, aircraft performance, aircraft certification
- Avionics, on board systems, detect and avoid, remote piloting stations
- Batteries, recharging, fuel cells, hydrogen production and storage
- Specific technologies (as far as possible)
- Command and Control (C2) links, navigation systems, surveillance technologies
- Human performance, Human-Machine Interface (HMI) design
- Licencing and certification of U-space service providers or their suppliers
- Pre-flight processes to determine whether a flight is possible, such as executing a Specific operations risk assessment (SORA) when required to obtain an operational authorisation.

[3] This document should be read as "if there is to be UAS flight then it should be as described here."



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How both the mandatory and optional U-space services can be used as mitigation measures starting from the pre-defined residual airspace risk class (ARC) associated to each U-space airspace, is considered to be outside the scope of this ConOps.

## 1.4 Expected evolution of U-space

At the time of writing, the number of UAS flights on an average day in Europe is small. The need for what is described in this document may not be apparent. It is anticipated that the number of UAS flights will rise and that urban air mobility will become more common. To help simplify discussion of the problems this rise in traffic will cause and the solutions that U-space should bring, the CORUS-XUAM project groups the expected traffic evolution into five eras, considering the following assumptions.

### 1.4.1 Assumptions:

- While passenger carrying operations have higher risk than non-passenger carrying operations, the procedures they use will be the same. Hence the concept of operations for U-space can and should be extended to cover “Urban Air Mobility.” It may be that some service providers are certified to provide services to passenger carrying operations and others not, but the operational processes they are involved in will be the same for both.
- The services won’t all be available at the same time, and the most complicated will arrive last (e.g., tactical conflict resolution).
- Technologies improvements and evolutions will allow UAS to fly more and more autonomously.
- Required equipment costs will decrease with the time so that the cost for a crewed aircraft shall be increasingly acceptable. Hence it is not a question of whether there will be passenger operations, it is a question of when.
- As time progresses the proportion of operations that are uncrewed grows to exceed crewed operations.
- U-space airspace will become more common with the different volume types eventually being recognized as ICAO airspace classes.
- UAM infrastructure will be built incrementally to support operational needs.
- Airspace design will change to accommodate all operations.
- There is a balance between commercial secrecy and providing a common picture of operations. As this ConOps is written that balance is that small UAS operators would prefer that their operations are not generally known. The balance may shift.
- U-space service provision will be a competitive commercial activity. There will be multiple simultaneous service providers and they will have to cooperate. That said, this ConOps should be applicable to situations with one or more service providers.

The "U levels" or "U blocks" as defined in the U-space Blueprint [2] are assumed, as shown in Figure 1.

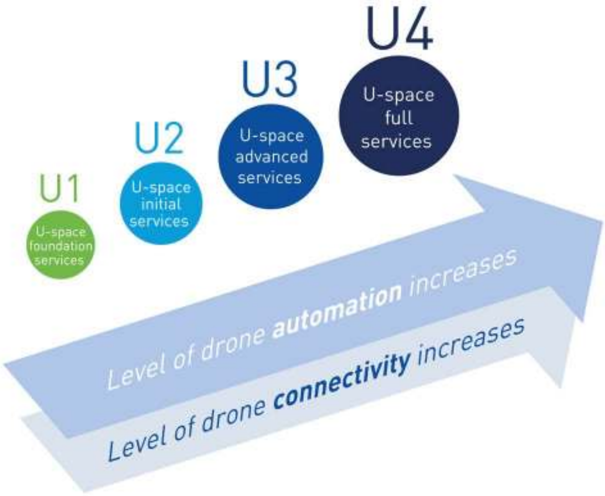


**Figure 1: U-space levels, from U-space Blueprint**

Airbus UTM Blueprint [20] proposes a timeframe of the automation level. CORUS XUAM would like to propose a vision with a kind of calendar for U-space implementation. The topics that need to be considered are the following.

- Availability of the U-space services
- Availability of the required technologies for Communication, Navigation and Surveillance, (CNS) and ground infrastructure for drone operations
- Availability of the "drones effective enough" to perform specific operations (e.g., carry heavy payload, long haul trip)
- Evolution of the airspace design and structure
- Interactions with crewed aviation in controlled and uncontrolled airspace
- Rules of the air

In the following five subsections, the different considered implementation phases are outlined.

### 1.4.2 Before 2023: the foundations of U-space

States are setting up registries and defining geographic areas in accordance with the UAS regulatory framework, EU IR 2019/947 [4] & EU DR 2019/945 [5] and subsequent amendments such as 2020/639, 2020/746, 2020/1058, 2021/1166, 2022/425, etc, together with the corresponding AMC-GM [6] & [7]. Drones fly without U-space services. Manual coordination with and authorizations from the involved authorities are usually required. ATC procedures make Visual Line of Sight (VLOS) flights possible, though sometimes requiring some effort. Beyond Visual Line of Sight (BVLOS) flights are limited, time consuming and expensive to set up.

### 1.4.3 Initial U-space implementation (2023-2030)

The U-space regulatory framework [8], [9], [10] and corresponding AMC-GM [11] came into force on the 26th of January 2023. In line with these, a limited number of services are available, providing a digital assistance to the authorities in charge of authorising the operations, and a digital assistance to the operators to plan and declare their operations. When required, airspace structures are defined, temporarily or permanently, to allow drone operations (e.g., corridors for point-to-point goods or passenger carriage).

- U-space airspaces are defined:
    - In controlled airspace, crewed aviation is not allowed to enter U-space airspace hence ensuring separation from all UAS operations. Using the concept of Dynamic Airspace Reconfiguration (DAR), Air Traffic Control can temporarily change the boundaries of U-space by deactivating parts of the U-space airspace to allow for exceptional passage of crewed aircraft. The U-space Service Providers (USSPs) are informed by ATC if and when DAR is being used so they can adapt their flight authorisations in order for the drone operators to no longer use these temporarily deactivated parts of the U-space airspace.
    - In uncontrolled airspace, crewed aviation is allowed to freely enter U-space airspace provided that it is electronically conspicuous.

- In U-space airspace conflict resolution is strategic, that is, the plans are free of conflicts.
- Within U-space airspace, BVLOS operations are significantly easier to organise than has been possible before.
- Traffic densities are expected to be relatively low. In the initial period flights are expected to be widely spaced.

U-space is made aware of the current position and motion of the aircraft (surveillance)[4] mostly by the UAS reporting the position of the aircraft through the Network Identification Service. Initial operations are expected to occur before the performance of U-space surveillance is well understood[5]. Plans will initially be subject to wide separations in time and/or distance to allow for this uncertainty about the performance of this surveillance.

The U-space regulatory framework [8], [9], [10] resolves strategic conflicts by prioritising "first to file." The authors of this ConOps expect when the U-space regulatory framework is revised, another resolution scheme will be adopted in the interest of fairness to flights that cannot be planned long in advance. This topic is explored in the paper *Market Design for Drone Traffic Management*, [27], but at the time of writing no mature proposal for a fairer resolution scheme exists.

As experience grows, U-space and UAS evolve rapidly. Standards and best practice will emerge in a number of fields. It is expected that during this period the level of performance achievable in

[4] A traffic management system being made aware of the positions and motions of the vehicles being managed is referred to as *surveillance.* When the observations of the traffic are made by an independent system, for example a radar, then this is *independent surveillance.* When traffic management relies on the vehicles to report their own positions, the surveillance is referred to as *dependent surveillance.* Network Id is (usually) dependent surveillance.

[5] U-space operations begin with the question of how precisely the positions and motions of UAS can be observed under all conditions. Once the performance is understood, requirements can be specified. These two phases can be inferred from EU IR 2021/664 having conformance monitoring optional. Conformance monitoring compares observed position and expected position and is valuable if the accuracy of the observed positions is known.



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communications, navigation and surveillance will improve. Confidence in the Communication, Navigation and Surveillance (CNS) performance will lead to the safe provision of U-space tactical services.

### 1.4.4 General U-space (2030-…)

In view of rising UAS traffic and as experience grows, many U-space airspace volumes have been defined, in what was previously controlled or uncontrolled airspace. In uncontrolled airspace, as most drone operations are performed in the VLL, U-space airspace is declared below 500 feet AGL. For some UAS operations which require to fly higher, such as inter-cities passengers or cargo transportation, corridors are in place and published in the AIP.

In more densely occupied U-space airspaces tactical conflict resolution is routinely offered. UAS traffic in ATC controlled areas is routinely controlled by ATC through U-space; that is using U-space means of CNS. In order to avoid exceeding the capabilities of the tactical conflict resolution service, a dynamic capacity management service will be needed to match the capacity and traffic demand.

Some U-space airspaces with tactical services will accommodate remotely piloted flight according to a new flight rule, UFR (see Section 4)

### 1.4.5 Advanced U-space

UAS operations are now very common, as are U-space volumes. U-space services and volumes are increasingly used by crewed aircraft. U-space volumes are commonly defined above 500 feet AGL, up to a few thousand feet as traffic necessitates. Tactical U-space services are in common use as is UFR.

### 1.4.6 Full U-space Integration

U4 is deployed. Most professional aerial operations are uncrewed. Uncrewed and crewed operations use U-space services and fly UFR. U-space airspace is defined widely. Uncrewed aircraft are capable to autonomously detect and avoid collision with any other aircraft.

The timing of Full U-space Integration is hard to gauge. While U-space may have followed the trajectory mentioned above, full integration requires that most aircraft used for professional purposes are uncrewed. If that requires new aircraft then the time taken may be a function of the useful life of the final generation of crewed aircraft. Currently aircraft are expected to have a working life of 25 to 30 years on average, see [41] and [42].

## 1.5 The structure of this ConOps and how to read it

Sections 2, 3 and 4 are a reference manual for the elements of U-space. There is no correct order to read them as understanding any section requires some knowledge of the others. Note that Sections 2, 3 and 4 are highly 'compartmentalised' and contain many levels of sub-heading to aid navigation.

Section 5 contains examples of how the elements in Sections 2, 3 and 4 are combined in operations. The needs of different users are addressed in different subsections. If you are new to U-space start with section 5 then refer to sections 2, 3 and 4

Sections 6, 7 and 8 provide the usage guides for what is presented in Sections 2, 3 and 4.



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Section 9 gives references, explains terms and expands acronyms and abbreviations.

Five documents are provided in annex to this ConOps.

- U-space ConOps Architecture Annex 1.0, "U-space ConOps - Architecture Annex_1.0.docx". This document describes the architecture of U-space in five major chapters:
  - **Drivers** addresses main inputs and architecture principles taken into consideration for developing the U-space architecture in CORUS-XUAM.
  - **Strategic Architecture** presents architecture elements and views to describe the U-space architecture from a strategic point of view. It provides the description of the U-space Capability Model.
  - **Business Architecture** presents architecture elements and views to describe the U-space architecture from a conceptual point of view. It provides the description of the business process diagrams.
  - **Service Architecture** presents architecture elements and views to describe the U-space architecture from a service-oriented point of view. It provides the list of the identified services and their links that present how the services realise the business and supports the strategy.
  - **System Architecture** presents architecture elements and views to describe the U-space from a system point of view. It provides the description of possible breakdown of the U-space in systems (in some cases with a further possible breakdown in functional blocks) and their relationships.
- U-space ConOps Regulatory and Legal Impact Study, "SESAR CORUS X UAM D4.4 edition 01.00.00.docx". The study aims to identify discrepancies between ConOps content and current European regulations, and at making suggestions to adapt or improve, if required, the regulatory framework.
- The Advanced U-space definition, "CORUS XUAM - D3.1 - Advanced U-space Definition2.1.docx". The section titles of this document are:
  - Definition of the Operational Framework
  - Operational Performance of UAM
  - Safety and Contingency in UAM Operations
  - Social Acceptance of Urban Air Mobility

  The reader's attention is particularly drawn to the Safety and Contingency section of the Advanced U-space Definition, as the topic is not covered in this ConOps. In addition, the Social Acceptance section is much more detailed than section 6 of this ConOps.
- The GOF2.0 project deliverable 2.4: GOF2.0 VLD Updated Service Specifications, "D2.4 GOF2.0 VLD Updated Service Specifications.docx". This Word document contains embedded Word documents. It proposes a number of data exchange models to support U-space. These models have been developed and validated in the GOF2.0 project.
- U-space ConOps: Interface U-space/ATM (AURA sol.2), "U-space ConOps - Interface U-space-ATM (AURA sol.2).docx". This document provides the AURA team's view of the architecture needed to support the services they add to the ConOps. The document has been developed by the AURA project in collaboration with CORUS-XUAM.


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# 2 Operating environment

This chapter aims to give the context(s) in which the U-space services are used. Highlighting a significant difference with the previous version of the ConOps, [1], Urban Air Mobility is explained. The section then explains the lifecycle of a flight, the nature of the airspace and the ground infrastructure of relevance to U-space.

## 2.1 Urban Air Mobility

"Urban Air Mobility" or UAM can be parsed thus:

- Mobility: someone or something is made able to move
- Air: above the ground
- Urban: over/near a town or city

Urban mobility refers to commonly used transport means such as train, bus, car/taxi, bicycle, walking or boat. "Air" in UAM distinguishes mobility involving aircraft. The aircraft may have a crew on board or might not. The following diagram shows this relationship.


Figure 2 Urban Air Mobility Venn diagram

As so much urban mobility involves people going to/from work, the OECD definition of "functional urban area" is used, see [22], "A functional urban area consists of a city and its commuting zone. Functional urban areas therefore consist of a densely inhabited city and a less densely populated commuting zone whose labour market is highly integrated with the city."

The European Commission (EC) Sustainable and Smart Mobility Strategy [58] lays out a vision for sustainable mobility that mentions drone and air transport as being part of multi-modal logistics and also smart mobility. The European Commission fully supports the deployment of drones and unmanned aircraft as part of this vision.

Urban air mobility flights by crewed aircraft are likely to involve current Air Traffic Control providing services via radio. The expectation is that U-Space services will increasingly be used.

## 2.2 The phases in the life of a flight

The plan for an operation in U-space is referred to as a U-plan. Table 1 lists the activities in the different phases of U-plan. Figure 3 shows the phases in a timeline. The sections that follow focus on the U-space services used in each phase.

| Phase | Typical activities |
|---|---|
| Strategic – long term | • Capacity planning: provision of services, airspace design<br>• Acquisition of aircraft, recruitment & training of crew<br>• Obtaining an operator's licence / certificate (if appropriate) |
| Strategic – pre-flight | • Developing a plan for a flight, selecting & configuring aircraft & crew<br>• Specific Operations Risk Assessment (SORA), Pre-defined Risk Assessment (PDRA), etc, if needed<br>• Seeking permission to enter airspace / overfly (if needed)<br>• Contingency planning. |
| Pre-tactical | • Demand capacity balancing<br>• Pre-flight de-confliction |
| Tactical | • Activation<br>• **Aviation** (contingencies)<br>• Termination |
| Post-flight | • Logging<br>• Reporting (as required),<br>• Maintenance,<br>• Performance assessment. |

**Table 1: Lifecycle of the U-plan**

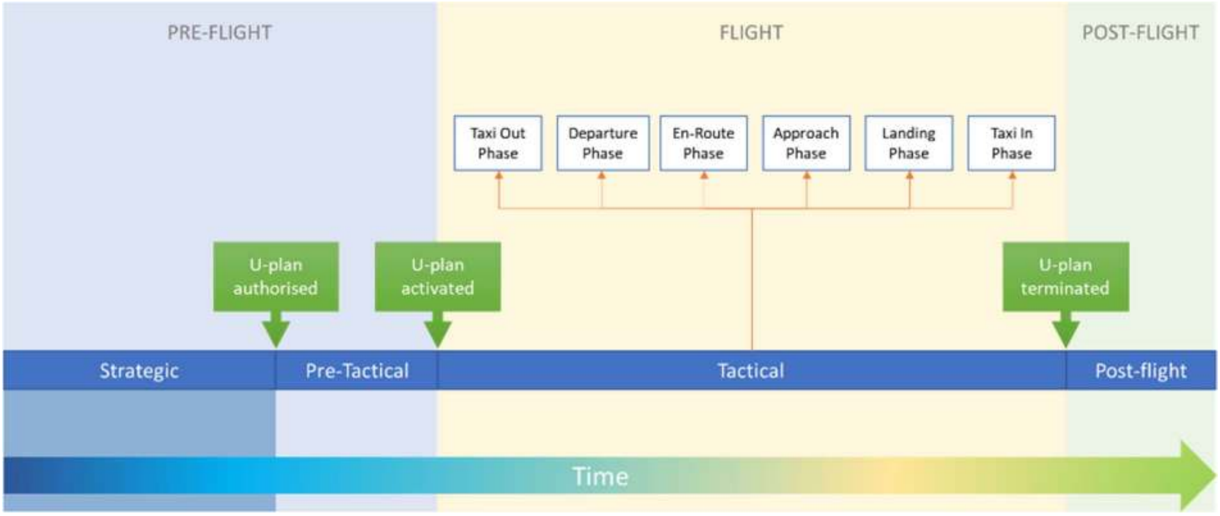


**Figure 3: Timeline schema of the lifecycle of a U-plan**



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### 2.2.1 Strategic – long term

Many activities must take place to prepare for flight. These relate to the operator of an aircraft, the aircraft and to the operating environment.

#### 2.2.1.1 Airspace design & redesign

The competent authority, see 7.3, establishes the airspace structure including U-space airspaces services and any technical constraints associated with them, in view of the expected risks, in line with EU regulation 2021/664, and the airspace risk assessment mentioned in article 3 – see [8][11]. These technical constraints will include factors that set the capacity of the airspace. The competent authority is also required to review these requirements periodically in function of the expected UAS traffic.

#### 2.2.1.2 UAS operator registration

The UAS operator shall be registered according to EU regulation 2019/947 – see [4][6]. In some situations the aircraft may also need to be registered.

#### 2.2.1.3 UAS type approval

Depending on the flight category or risk level a UAS may need a Type Certificate or a Design Verification Report (DVR).

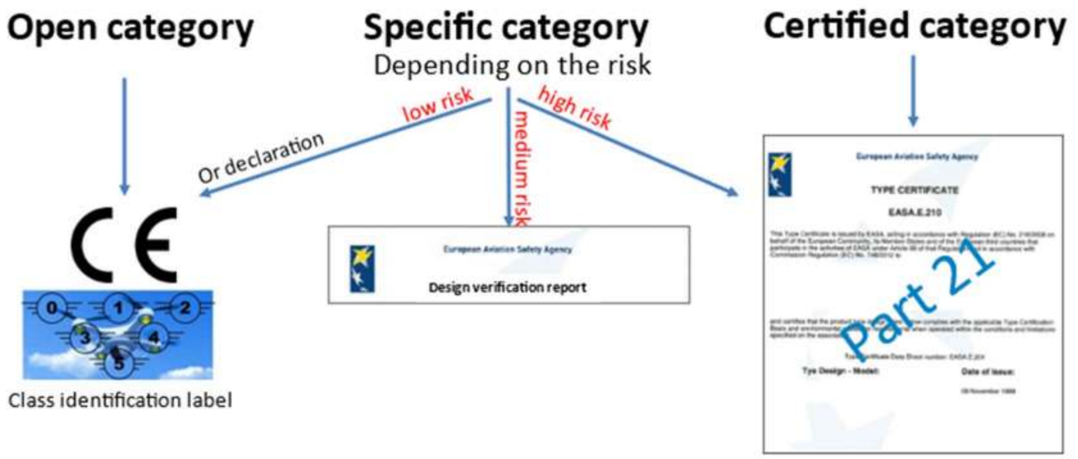


**Figure 4 Verification of the design of a UAS (diagram from EASA)**

Figure 4 is from https://www.easa.europa.eu/en/domains/civil-drones-rpas/specific-category-civil-drones/design-verification-report. The processes to obtain either a DVR or a type certificate are out of the scope of this document.

### 2.2.2 Strategic – pre-flight

During the strategic pre-flight phase, the flight goes from being an idea to a concrete plan for one or more specific instances of flight. The process is likely to be iterative and balance business needs (or the equivalent for a leisure flight) with risk, regulations and cost.

#### 2.2.2.1 Operational category

The operational category of the flight may lead to approval being needed. The regulations embody requirements of safety and public acceptability.

EU regulation 2019/947 – see [4] and [6] – describes different circumstances in which a flight may occur, summarised below. Operations are categorised according to risk by combining aspects of the aircraft such as mass with how, where & when it is flown.

- Open category operations must meet various criteria that all limit risk to people and property. A flight not compatible with Open might be possible as Specific or Certified.
- There are different ways a Specific category flight can be permitted; by following an approved specific operations risk assessment (SORA) or Pre-defined Risk Assessment (PDRA), by conforming to a Standard Scenario (STS), as result of the operator holding a Light UAS operator Certificate (LUC), or by following a process defined in an accepted alternate means of compliance.
- Flights that do not meet the Open or Specific category conditions may be possible as Certified category.

The determination of the operation category and then obtaining any necessary approval is a pre-flight process that has some support from U-space. During this process the UAS operator may refine the U-plan iteratively supported by U-space services, for example by routing the flight through areas of lower "ground risk" and so on. The relevant services are:

- Geo-awareness, see Section 3.4.2
- Risk Analysis Assistance, see Section 3.5.1.5

Specific operations risk assessment is described in the SORA package of documents published by JARUS [21]. The process aids the identification of risks associated with the flight and their mitigation, including by use of U-space services. SORA approval may be for one flight or for a set of flights that meet the same criteria. It is expected that U-space service providers will supply services and tools that help the UAS operator optimise U-plans, including with the aim of conducting and optimising SORA. Edition 3 of the ConOps mentioned the "U-plan preparation / optimisation" service, with a vague description. While such services are assumed to exist, they are not described in this edition of the ConOps.

#### 2.2.2.2 Flight priority

EU regulation 2021/664 [8] article 10, paragraph 8 defines two levels of priority for flights which we refer to as Normal and Priority. It states:

> *When processing UAS flight authorisation requests, the U-space service providers shall give priority to UAS conducting special operations as referred to in Article 4 of Implementing Regulation (EU) No 923/2012.*

EU regulation 2012/923 is SERA [12], the Standard European Rules of the Air. SERA Article 4 lists special operations that may be granted exemptions:

a) *police and customs missions;*
b) *traffic surveillance and pursuit missions;*
c) *environmental control missions conducted by, or on behalf of public authorities;*
d) *search and rescue;*


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e) *medical flights;*
f) *evacuations;*
g) *fire fighting;*
h) *exemptions required to ensure the security of flights by heads of State, Ministers and comparable State functionaries.*

How priority impacts U-plan processing is discussed in sections 2.2.2.4 and subsequent.

#### 2.2.2.3 Vertiport constraints

An U-plan for a flight may include taking off from or landing at a vertiport. That ground movement may be constrained by a number of factors that must be taken into account in the U-plan.

- The flight must have permission to use the vertiport. This has different aspects. The aircraft should be compatible with the vertiport, which could include flight characteristics, size, noise, charging or refuelling requirements, ground handling needs, etc. As there are likely to be fees for using the vertiport, the vertiport operator may require some contractual arrangements to be set up before the aircraft operator can plan operations. (Or not, a vertiport may be open to all.) The net result is that the flight planning may be limited to a subset of the total number of vertiports.
- A vertiport is likely to have a limited number of FATO (Final Approach and Take-Off areas.) The vertiport operator is likely to be optimising the use of the vertiport and may constrain the time slot available for take-off or landing for any flight. Hence the U-planning will have to fit into these time slots.

There are (at least) three possible approaches to including the vertiport in the strategic phase of U-planning.

1. The vertiport is "mostly available" and in terms of deconfliction it can be treated like airspace; it is a resource at which there may be a conflict between operations. The allocation of the vertiport as a resource can be achieved in the same way as flights are strategically deconflicted.
2. The vertiport is "busy" and has its own planning process which imposes time-slot constraints on the take-off and landing. These time slots balance the need for vertiport efficiency while allowing enough margin that strategic uncertainties can be accommodated. Strategic U-planning can usually respect these time slots, hence vertiport planning and U-planning are loosely coupled.
3. The vertiport is "extremely busy" and is the most constraining resource of the entire network. Hence time slots are as brief as operations allow and all aspects of U-planning are in function of these slots. U-planning cannot be decoupled from vertiport planning in case the needs of in-flight strategic deconfliction trigger a change to vertiport planning. This model can be dealt with in two ways: as a static construction or by dynamically updating the planning continuously.

The three approaches are touched on below.

#### 2.2.2.4 U-plan optimisation & approval

It is assumed that during the strategic phase the U-plan is created including any necessary permissions being obtained.



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The last activity of the strategic phase is when the U-plan is filed. EU IR 2021/664 [8] calls the U-plan the "flight authorisation request." Unfortunately, the term "authorisation" is used in both EU IR 2019/947 [4] and EU IR 2021/664 with different meanings. The authorisation of 2019/947 is part of the general permission to fly and may cover more than one instance of the flight, while the authorisation of 2021/664 refers to a single instance of flight at a specified date and time. The U-plan is the latter.

"Filing" or submitting the U-plan makes use of the Flight Authorisation service , see 3.5.2. The filed U-plan might be authorised or rejected. In case the U-plan is rejected, an explanation will be given as to why the U-plan has been rejected and there may be a suggestion for how to construct a valid U-plan which is similar to that which was rejected. Following rejection, the UAS operator might refile a modified U-plan which addresses the reason for rejection. Successive filings may form part of the iterative process of planning.

Many UAS operators are expected to use tools to prepare and file their U-plans. These tools will build the U-plan based on the business need of the operator. These tools will optimise the U-plan given the various preferences of the operator and the constraints coming from U-space, and should manage the process of successively modifying and re-filing to find a U-plan that is free of conflicts.

The strategic phase ends when the U-plan is authorised.

Authorisation logic depends on the era. In the Initial U-space implementation (2023-2030) era, the U-plan is only authorised if it is free of conflict with other U-plans of the same or higher priority. In the later eras, it is likely that strategic conflict resolution cannot be completed at the time of filing, hence authorisation might not indicate an absence of conflicts. Such conflicts would be resolved in the pre-tactical phase, as is explained below.

## 2.2.3 Pre-tactical

Once the U-plan has been authorised the pre-tactical phase begins. The pre-tactical phase ends with activation of the U-plan, which triggers the start of the tactical phase.

During the pre-tactical phase the U-plan may have its authorisation withdrawn or a warning may be issued, for any of three reasons:

1 Due to a conflict with another U-plan
2 Due to traffic demand exceeding airspace capacity
3 Due to a change in the airspace structure

Each is explained below. Each can occur at any moment. The logic depends on the operating environment and the prioritisation scheme in conflict resolution.

### 2.2.3.1 The pre-tactical phase during the Initial U-space implementation (2023-2030)

The U-space regulations [8], [9], [10], [11] refer to a flight authorisation request which is considered to be equivalent to a U-plan. The regulations require that a U-plan can only be authorised if it is free of conflicts and that U-plans are prioritised by filing time. Hence the filing of a new U-plan in conflict with an already approved U-plan of the same priority leads to that new U-plan being rejected and the already authorised U-plan not being impacted. However, if a new U-plan of higher priority is filed and is in conflict with any authorised U-plan(s), that/those U-plans have their authorisation withdrawn. As



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the U-space regulations do not describe a change process, the lower priority U-plan is in effect rejected.

The U-space regulations; 2021/664 [8], 2021/665 [9], 2021/666 [10] & Acceptable Means of Compliance and Guidance Material (AMCGM) [11], describe an environment without demand-capacity balancing, hence the second reason for pre-tactical permission removal, above, does not apply.

U-space regulation 2021/664 Annex iv [8] proposes a "flight authorisation request" format which lacks any means to indicate that a flight has permission to enter any airspace. The Acceptable Means of Compliance and Guidance material to Article 10(7) of 2021/664 [11] explains that in cases where permission is needed, processing on the basis of Annex iv will result in a warning. The USSP may be able to test technical compliance in some cases, or directly request permission, where possible.

### 2.2.3.2 Conflict resolution & dynamic capacity management

In eras after that described in 2.2.3.1, there is expected to be dynamic capacity management and the following model is expected to apply. The details are currently the subject of research [29] and may change.

#### 2.2.3.2.1 Reasonable Time To Act

It is assumed that U-plans will be filed at different times in advance of activation, depending on the business process of the UAS operator. Some UAS operators would like to file their U-plans very shortly before activation.

It is also expected that U-plans will be subject to revision to meet the needs of the UAS operator. These changes can also appear at any time before activation.

Hence any process that is going to impact plans in order to balance demand and capacity will only have a "complete" picture of the demand very close to activation. Whatever the balancing process is, the impact it has (for example changing the route or delaying activation, hence take-off) needs to be absorbed by the UAS operator. There may be operators whose businesses cannot accommodate impacts on their U-plans very shortly before activation.

Hence a compromise is reached. An agreed time is used as the moment to determine what is the demand and which if any U-plans are impacted if the demand exceeds the capacity. This agreed time is the "reasonable time to act," (RTTA.) It is an agreed amount of time before the activation.

RTTA might be 5 minutes, or perhaps 1 minute, or even more or less. It may be that in different airspaces different RTTA are used. The principle remains the same.

#### 2.2.3.2.2 Demand Capacity Balancing and RTTA

As explained above at RTTA there should be an acceptably complete picture of the traffic, hence the balance can be made between demand and capacity. The description that follows may be subject to refinement as it is tested experimentally.

The process of DCB with RTTA proceeds continuously but is best understood in terms of four cohorts of U-plans. Those which have passed RTTA, those at RTTA, those not yet at RTTA and "late filers", U-plans that are either filed or changed after RTTA.

U-plans that have passed RTTA are "frozen" and no longer subject to change. They form part of the demand picture but cannot be impacted in order to match that demand to the capacity.

U-plans that are "at RTTA", whatever that means, form part of the demand picture. They are fitted into the available capacity and impacted if necessary. In this process they "freeze" and the impacts are revealed to the operators. The DCB process acts on the "pool" of U-plans at RTTA and will optimise for some metric, for example fewest flights impacted, minimum total impact (minutes of delay) or whatever is agreed.

U-plans that are not yet at RTTA form part of the demand picture. They are tentatively fitted into the available capacity but may be subject to revised impacts later.

Late filers are added to the frozen set as well as can be achieved after the "at RTTA" cohort has been optimally served.

There may be sudden changes in capacity, for example the closure of an airspace or vertiport, that impact U-plans that are past RTTA. It is expected that this situation is infrequent.

#### 2.2.3.2.3 Applying RTTA to Strategic Conflict Resolution

In the absence of schemes like auctions, applying RTTA to strategic conflict resolution can avoid the systematic disadvantage imposed by "first to file" prioritisation on businesses that cannot file far in advance such as on-demand delivery or air-taxis. The scheme is similar to that for DCB

- Until the RTTA a U-plan is not deconflicted. It is counted as part of the expected traffic but not acted upon.
- During the period a flight is considered to be at RTTA, the flight is subject to a conflict resolution process and subject to measures to balance demand and capacity. These processes do not change flights which have passed RTTA, and for those flights at RTTA, seek to find an optimal deconfliction. It is at this time that the flight authorisation may be withdrawn and the operator may have to file a modified plan.
- After the required time to act, the flight is left alone unless:
    - It is in conflict with a higher priority flight
    - There are other circumstances that prevent flight, such as a closed vertiport

#### 2.2.3.2.4 On the management of uncertainty

In the execution of any plan there is some uncertainty of the outcome. The sources of the uncertainty may be considered at the level of an individual operation to be exceptional (the head-wind was strong and the flight took longer than planned) while at the macro level these may be normal events (a few days a year there are very strong winds). In a mature operating environment, uncertainty can be characterised by previous experience.

Control theory shows that precision can be improved by the application of negative feedback, for example by varying the speed of the flight to achieve a precise arrival time, but doing so sacrifices another optimisation, for example fly so as to maximise battery life. Negative feedback also sets the "normal" performance much worse than the "best" – the flight always takes as long to arrive as it would on the most windy day. (Analogous to the difference between open-loop and closed-loop gain.)

These uncertainties limit the precision of the plans and hence the optimisations of the system. There will need to be trade-offs in U-space between different optimisations, including at least three: the optimisation of each flight, optimisation of vertiport utilisation and optimisation of airspace capacity. This ConOps cannot quantify these imprecisions nor propose how to trade-off between these optimisations but highlights that planning precision should be considered and quantified at all phases of the operation. The RTTA value and precise process are likely to impact this trade-off.

#### 2.2.3.3 Pre-tactical overall, in the later eras

At the beginning of the pre-tactical phase, the flight is authorised.

During the pre-tactical phase this authorisation may be withdrawn at any time due to a change in the airspace structure, due to an unresolvable change in capacity (e.g. vertiport closure) or due to a conflict with a higher priority flight. The 2.2.3.3 authorisation might be withdrawn at RTTA due to an excess of demand or a conflict with one or more flights of the same priority.

Any withdrawal *might* be resolved by a change in the U-plan.

The pre-tactical phase ends when the flight is activated.

### 2.2.4 Aviation: the tactical phase

The tactical phase starts when the U-plan is successfully activated. The tactical phase continues until the aircraft operator, which could be the pilot, indicates that the U-plan has ended.

#### 2.2.4.1 Activation Request & Activation.

There is not a distinct activation service. Activation is a function of the U-plan processing service. The UAS operator, which could be the pilot, requests the activation of an existing authorised U-plan. The U-plan processing service makes a final check of the flight conditions and responds (promptly) either that the U-plan is activated or that the U-plan authorisation is withdrawn.

The activation request must be made during the period specified in the U-plan. Once the planned activation period is over, if the operation has not been activated its authorisation is withdrawn.

#### 2.2.4.2 Commencement of tactical U-space services

U-space tactical services only operate for an active U-plan. These could include:

- Network identification, hence Tracking and Surveillance Data Exchange
- Conformance Monitoring service
- Traffic Information service
- Tactical Conflict Prediction and Tactical Conflict Resolution, if relevant
- Emergency Management
- Other monitoring services

These services all require connections to U-space. The activation will include a “logging on” process that “creates an active flight session” which links the sources/sinks of the services (computer network) and data with a planned operation and the aircraft operator / pilot.

#### 2.2.4.3 Flight phases, conformance with the U-plan.

From the activation of the U-plan, the U-plan should be followed. Non-conformance with the U-plan can occur at any time. The flight phases depend on the operation type, for example an air taxi or a delivery with a small UAS and could include:

- Pre-flight operations that follow activation, for example confirmation that network identification is operating
- Taxi-out phase:
    - Pushback / towing if appropriate, involving ground handling processes and equipment.
    - Taxiing, if needed.
- Departure phase:
    - (probably) a check that everyone / everything is clear
    - Take-off.
    - Initial climb. The initial part of the flight may have the aim of "getting clear of the take-off site." There may be restrictions on the procedure due to obstacles, noise abatement or ground risk.
- En-route. Once the aircraft is clear of the departure region, it can achieve the purpose of the flight, for example go to the destination.
- Approach. Safety / noise / environmental concerns may dictate that there is a particular way this type of aircraft needs to descend into the landing site in the current weather conditions. The approach phase involves getting the aircraft into position to start such a descent and then descending as required.
- Landing including final descent, flaring, touch down. These are likely to follow a check that everyone / everything is clear.
- Taxi in, if needed, meaning ground movement under aircraft power, possibly followed by towing in, if needed, meaning ground movement by means of ground handling equipment. Then parking.

Other events may occur depending on the nature of the operation. The operation should follow its plan.

The en-route section of the flight may be planned in such a way as to optimise a number of factors such as cost, ground risk, noise abatement and/or airspace limits – for example the flight may be constrained to remain within some height band relative to the ground immediately below. As a result of these optimisations, the flight path of an urban air mobility may not resemble the "straight and level" flight familiar in stratospheric flight.

The tactical phase can be viewed as a continuous sequence of challenges that the aircraft must overcome in order to follow the plan, for example completing checks in the planned time, or correcting course deviations due to gusts of wind. The plan represents a best guess as to what the prevailing conditions will be and how well the aircraft can meet these challenges. The aircraft follows the plan within agreed limits, or in control-system terms, acceptable error.

As shown in Figure 10 and Figure 11, the U-plan is a series of volumes around which there may be deviation thresholds. If the flight does not follow the U-plan then it is initially "non-conforming" and is expected to make every effort to return to the U-plan. If the non-conformance persists beyond 5% of the time in the volume or exceeds the deviation thresholds then the aircraft is in a contingency situation and should invoke a/the previously filed contingency plan.

#### 2.2.4.4 Non-conformance with the U-plan

There are many reasons that an aircraft might not follow the U-plan.

- Failure:
    - The plan is unachievable. This aircraft just can't fly that fast, that far, that high, that precisely.
    - The conditions have changed. For example, the wind is stronger than was allowed for in the plan.
    - Something has happened to or gone wrong with the aircraft. For example, a rotor is out of balance.
    - Something has gone wrong with the communications, navigation or surveillance. The aircraft is unable to communicate its position, does not know its position, does not know where it is supposed to go, …
- 'External' event:
    - A manoeuvre associated with Tactical conflict resolution is unusually large and requires the aircraft to fly outside the planned volume(s), for example a crewed or other aircraft is in an emergency close to the aircraft and avoiding action must be taken.
    - The airspace has been "reconfigured dynamically." The aircraft has to evacuate the region where it is currently.

In each case a previously announced contingency plan should be followed. These plans may be preprogramed, for example fly directly to a predetermined location, or manually flown by the remote pilot.

#### 2.2.4.5 Contingencies

Contingencies are dealt with in more detail in the Annex "CORUS XUAM - D3.1 - Advanced U-space Definition", this is an overview.

The UAS operator should be cognisant of the contingency plans the aircraft will follow autonomously and their probable triggers. Possible triggers for contingency plans may include lost C2 link, low battery, loss of GNSS, mechanical or electrical failure. Many autonomous contingency plans are possible. Examples of contingency plans might include "fly straight back to take-off point," or "fly to and land at an alternative landing site," or "continue to follow the plan to the destination," or "switch off motors and deploy parachute" or many others.

The UAS operator should also prepare contingency plans for hazards that risk assessment indicates are worthy of anticipating. Examples might include planning alternate landings or fitting a parachute.

When an aircraft is following a contingency plan, it may no longer be "strategically deconflicted." In that case all conflicts must be dealt with tactically. An example of when this is likely to occur is dynamic airspace reconfiguration which requires the aircraft to exit an airspace.

Contingency plan activation in some cases lead to a state that can be deconflicted by updating the U-plan during the active phase.

#### 2.2.4.6 Updates to the U-plan during the active phase.

If the USSP's agreement with the UAS operator allows it, then the UAS operator may update the U-plan during flight. The following guidelines seem likely:



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- A flight which is following contingency plan, particularly in the case of a change, above, may be given priority over non-active flights in the strategic deconfliction, including those that have passed RTTA
- A flight which is active but not currently in contingency may not considered a priority, but rather a “late filer.” Rejection of the change would imply that the current U-plan remains authorised.

#### 2.2.4.7 Termination of the flight & Ending of tactical U-space services

There is not a distinct flight termination service. The aircraft operator, which could be the pilot, signals to the U-plan processing service that the operation has ended. This triggers the ending of tactical U-space services that are running.

### 2.2.5 Post flight

The U-plan and records of how it was flown should be archived by the “legal recording service” but remain available for authorised use for as long as necessary. Uses include:

- Accident and incident investigation
- Criminal investigation other than aviation accident/incident
- Assessment of performance by or for the competent authority of UAS, UAS operators, U-space design, U-space services, social impact and so on
- Research.

## 2.3 Airspace

This section describes different aspects of the airspace of interest to U-space.

### 2.3.1 Urban airspace

“Urban Airspace” is not currently much used by aviation for reasons of risk and nuisance, especially noise. The general expectation is that urban air mobility will make use of airspace which is currently mostly unused.

### 2.3.2 ICAO airspace classes

ICAO Annex 11 [14] Section 2.6 defines seven airspace classes, A to G, in terms of VFR and IFR flight rules, and the services offered. Only subsets of flight rules {VFR, Special VFR, IFR} are permitted in classes A to G. ICAO Annex 2 [13] defines Prohibited and Restricted areas as being something other than classes A to G. Restricted areas can enable air use which is neither IFR nor VFR.

### 2.3.3 Geographic Zones and U-space Airspace

EU regulation 2019/947 [4] Article 15 allows for the creation of Geographical Zones (Geo-Zones) for the management of UAS traffic. EU regulations 2021/664 [8] and 2021/665 [9] allow for a Geographic Zone to be designated as a U-space airspace. U-space airspaces are, in effect, Restricted Areas in ICAO terms. ICAO Annex 2 defines a *Restricted area* as “An airspace of defined dimensions, above the land areas or territorial waters of a State, within which the flight of aircraft is restricted in accordance with certain specified conditions.” For U-space airspaces the specified conditions are:


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- UAS operations must consume U-space services, following EU regulation 2021/664 [8]
- Crewed aircraft must be electronically conspicuous, as EU regulation 2021/666 [10]
- U-space airspaces have associated with them technical and operational requirements in terms of equipment fit, performance and operating methods.

These technical and operational requirements are determined for the airspace in function of the permitted level of traffic and the risks expected. 2021/664,5,6 [8] are the initial U-space regulations corresponding to the Initial era of U-space, section 1.4.3. These regulations do not include a Tactical conflict resolution service.

As already noted, U-space airspace is not any of the ICAO airspace classes A to G. Flight need not follow IFR or VFR.

EU regulation 2019/947 [4] requires that information on the Geographical Zones be made publicly available, in an electronic format. That requirement is the basis of two services in this ConOps, Drone Aeronautical Information Management, section 3.4.1, in which the Geographical Zone definitions are collected from the different authorities that are permitted to create Geographical Zones, and Geo-awareness, in section 3.4.2 in which the combined Geographical Zone information is published.

The acceptable means of compliance and guidance material for EU regulation 2019/947 [6] further requires that, "The Member States should publish information on UAS geographical zones that are relevant to crewed aircraft operations in Section ENR 5.1 'Prohibited, restricted and danger areas' of the AIP." Hence the U-space airspaces will be published for crewed aviation as restricted areas.

### 2.3.4 Geodetic Altitude Mandatory Zones

The ICARUS project [28] proposes a common altitude reference system. Within zones where there is a risk of altitude confusion, the competent authority may declare a "Geodetic Altitude Mandatory Zone." In a GAMZ, when aircraft exchange altitude information, it shall be exchanged in the form of geodetic height, that is referenced to the WGS84 ellipsoid. To support this expression, a vertical conversion series is foreseen, see 3.19 GAMZ-ness is independent of other properties of the airspace.

It is expected that GAMZ-ness is likely to be one of the technical and operational requirements associated with a U-space Airspace, as mentioned in section 2.3.3

In total, ICARUS proposes four services, some of which map onto services identified in Edition 3 of the ConOps [1].

| ICARUS | ConOps Edition 4 | remarks |
|---|---|---|
| Vertical conversion service | Vertical Conversion Service, 3.19 | Converts between GNSS and Barometric altitudes. |
| GNSS service | Navigation Infrastructure Monitoring, 3.15.1 | Navigation Infrastructure Monitoring Service has more general scope. |
| Real-time geographic information service | Vertical Alert and Information Service, 3.20<br>Geographical Information Service, 3.9<br>Geo-awareness, 3.4.2 | Scope of Icarus service is split between three services in this ConOps. |

| | | |
|---|---|---|
| Vertical Alert Service | Monitoring, 3.10<br>Vertical Alert and Information Service, 3.20 | The provision of height warnings to pilots of crewed and uncrewed aircraft in the ICARUS service is distinct from Monitoring |

**Table 2 ICARUS services**

### 2.3.5 X, Y, Z volumes

UAS pilots range in their experience and training. The least training requirements in EU IR 2019/974 [4] are for pilots to fly A1 operations with a class C0 aircraft, as per EU DR 2019/945 [5]. The pilot shall be "familiarised with the user's manual provided by the manufacturer of the UAS." Addressing UAS pilot needs, especially those with little training, the lower airspace can be described as one three types of volume: X, Y or Z. These volumes describe the conflict resolution services offered in the volume.

| Volume | Conflict resolution service |
|---|---|
| X | None. Avoiding conflict is the responsibility of Pilot / Operator, unassisted by U-space |
| Y | Pre-flight ("strategic") conflict resolution |
| Z | Pre-flight ("strategic") conflict resolution, and<br>In-flight ("tactical") conflict resolution |

**Table 3 X Y Z Volumes**

In X volumes, the operation requires no U-plan. The pilot / operator / UAS should be up to date with the Geo-awareness data to be confident that the flight is completely within X. Permission may be needed to fly and there may be requirements for equipment fit.

For Y and Z an approved U-plan is required. In both Y and Z the pilot / UAS should be connected to U-space during flight to allow sending of position information and receipt of warnings, traffic information and so on.

In terms of the U-space regulatory framework [8], [9], [10] , as introduced in section 2.3.3:

- An X Volume is not a U-space airspace.
- A Y Volume is either a U-space Airspace or a Geo-Zone.
- A Z Volume is beyond the current EU regulation but extends the idea of U-space Airspace to allow higher traffic density.

The descriptions below are for a flight wholly in that airspace. For flights penetrating multiple airspaces, the conditions for each must be applied for that portion of the flight.

#### 2.3.5.1 Airspace access conditions are not expressed in XYZ

Before describing XYZ, it is important to stress that these airspaces differ in the services being offered. XYZ is not a complete description of the access conditions for the respective airspace.

- Access to an airspace may require permission from some authority.
- There may be technical or operational restrictions, for example a requirement that aircraft must conform to or be fitted with equipment that conforms to some standard.



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This information, if applicable, should be included in the publicly available descriptions of Geo-Zones, including U-space airspaces. See section 3.4.

#### 2.3.5.2 X volume

In X volumes flights need no U-plan and receive no separation service.

X is suited to VLOS flight. BVLOS requires appropriate risk assessment with no mitigations from U-space.

##### 2.3.5.2.1 X, Pre-flight

Before flight the UAS operator should make use of a Geo-awareness service, see 3.4.2 to

- Confirm the flight is in X
- Be informed of any restrictions that may apply such as heigh limits or required equipment
- Ensure any necessary permissions have been obtained or are obtained.
- Load geo-zones into the UAS, if appropriate

The UAS operator should in some circumstances be registered, see 3.2. The operator may make use of other services as appropriate (or as mentioned in the SORA for the flight, if there is one), for example: weather, see 3.8.

##### 2.3.5.2.2 X, In flight

No "tactical" separation service is available. The UAS operator remains responsible at all times for ensuring safe operation.

In many cases the UAS needs to be identifiable and will either have to direct remote identification, see EU regulations 2019/947 [4] and 2019/945 [5], or make use of a network identification service, see 3.3.1.

The operator may make use of services as they are available and needed by the circumstances, for example vertical conversion service (3.19), vertical alert and information service (3.20), emergency management (3.12). As aircraft can fly in X without network identification or electronic conspicuity, any traffic information service (3.14) cannot guarantee to include all other aircraft and hence may not be offered.

##### 2.3.5.2.3 X, Post flight

An accident and incident reporting service is available, see Section 3.13.

#### 2.3.5.3 Y volume

The Y volume offers strategic (that is, pre-flight) deconfliction. In order to do this flight in Y volume requires a U-plan. EU regulation 2021/664 [8] describes the "U-space airspace" which offers this.

However, the Y volumes fulfils two roles. In the edition 3 ConOps [1] these were mentioned. Because UAS flight in a Y volume requires an approved U-plan:

- The Y volume can exist to enable flight with strategic deconfliction.
- The Y volume can exist primarily to limit access.

Hence all U-space airspace are Y volumes but not all Y volumes are U-space airspace.

Strategic deconfliction is the process of reducing the probability of there being a conflict to an acceptable level by acting on the plans for the flights. One factor in this process is the level of confidence about how precisely the plan will be followed. In the early stages of “Initial U-space implementation” see 1.4.3, this lack of confidence is expected to result in “wide” spacing of flights.

The strategic conflict detection and resolution processes are described in sections 3.5.2.2 and 3.5.2.3 respectively.

#### 2.3.5.3.1 Technical and Operational Characteristics of the Volume

Each U-space airspace has technical and operational requirements. These are published by the competent authority as part of the Common Information. The authorisation of a U-plan is accompanied by a reminder of these technical and operational requirements.

In EU regulation 2021/664 [8] and its Acceptable Means of Compliance and Guidance Material [11] there is mention of the “terms and conditions.” The operational and technical characteristics are part of the terms and conditions.

#### 2.3.5.3.2 Y, Pre-flight

The UAS operator should in some circumstances be registered, see 3.1. The UAS operator should make use of the geo-awareness service before flight, to load relevant data into the UAS, if appropriate and to confirm that the volume is Y, see 3.4. The airspace may have particular access conditions, which will be published, in which case permission to fly in the airspace may need to be obtained.

Every flight must have an approved U-plan, see 3.5.2. Approved U-plans do not conflict due to the strategic conflict prediction, see 3.5.2.2, and resolution services, see 3.5.2.3.

#### 2.3.5.3.3 Y, In flight

The U-plan shall be activated to commence flight, see 3.5.2.6

The flight shall make use of the following services unless their use is waived for the specific airspace:

- Network identification service, see 3.3.1
- Traffic Information service, see 3.14
- Emergency Management service, see 3.12
- Monitoring service, see 3.10, including Conformance Monitoring service, see 3.10.1
- Infrastructure monitoring services, see 3.15
- Vertical Alert and Information Service, see 3.20

#### 2.3.5.3.4 Y, Post flight

The U-plan shall be ended by the operator, see 3.5.2.5. An accident and incident reporting service, see 3.13, is available. The operator may consult the digital logbook, see 3.16

### 2.3.5.4 Z volume

A Z volume is a volume in which there is a tactical conflict resolution service. Three versions of Z are defined:

- Za in which Air Traffic Control manage all the traffic. Such airspaces may exist at an airport. The expectation is that ATC will take benefit of U-space services in managing UAS.
- Zu in which U-space will provide a tactical conflict resolution service

- Zz in which U-space will provide a tactical conflict advisory service

Za is an existing controlled airspace. This 'Za' label is for the UAS community only. Za is not a U-space airspace as described in EU regulation 2021/664. Flight of UAS in airports is increasingly common.

Zu and Zz have not been described in EU legislation at the time this is written. They are the logical extension of Y allowing higher densities of operations.

*Edition 3 of the ConOps [1] did not mention Zz and defined Zu ambiguously. In this, Edition 4 of the ConOps, Zu has a more precise definition and Zz is new.*

#### 2.3.5.4.1 Za, Pre-flight

The UAS operator should in some circumstances be registered, see 3.1. The UAS operator should make use of the geo-awareness service before flight, to load relevant data into the UAS, if appropriate and to confirm that the volume is Za, see 3.4.

Every flight must have an approved U-plan 3.5.2. The plan will need to be approved by ATC by means of the procedural interface with ATC, see 3.17. That procedural interface may result in various conditions being specified.

#### 2.3.5.4.2 Zu & Zz, Pre-flight

The UAS operator should in some circumstances be registered, see 3.1. The UAS operator should make use of the geo-awareness service before flight, to load relevant data into the UAS, if appropriate and to confirm that the volume is Zu or Zz, see 3.4.

Every flight must have an approved U-plan, see 3.5.2. Approved U-plans do not conflict due to the strategic conflict prediction, see 3.5.2.2, and resolution services, see 3.5.2.3. The U-plan will be subject to dynamic capacity management, see 3.5.2.5

Strategic conflict resolution in Zu and Zz *may* operate with a higher residual risk of conflict than in Y, as there is a tactical process afterwards.

#### 2.3.5.4.3 Za, In flight

The flight shall be activated to commence flight, see 3.5.2.6

The flight shall make use of the following services unless their use is waived for the specific airspace:

- network identification service, see 3.2.1. Other surveillance may be mandated.
- collaborative interface with ATC, see 3.18

#### 2.3.5.4.4 Zu, Zz, In flight

The U-plan shall be activated to commence flight, see 3.5.2.6

The flight shall make use of the following services unless their use is waived for the specific airspace:

- Network identification service, see 3.3.1
- Tactical Conflict Prediction, see 3.6.1, and Tactical Conflict Resolution, see 3.6.2
- Traffic Information service, see 3.14
- Emergency Management service, see 3.12
- Monitoring service, see 3.10, including Conformance Monitoring service, see 3.10.1

- Infrastructure monitoring services, see 3.15
- Vertical Alert and Information Service, see 3.20

In Zu, the Tactical Conflict Resolution service issues instructions that the UAS must follow. In Zz the Tactical Conflict Resolution service issues advice. Because of the different likelihood of resulting action, the tactical conflict resolution advice in Zz may be issued earlier than would be the case for the tactical conflict resolution instructions in Zu.

#### 2.3.5.4.5 Za, Zu, Zz, Post flight

The U-plan shall be ended by the operator, see 3.5.2.5. An accident and incident reporting service, see 3.13, is available. The operator may consult the digital logbook, see 3.16

### 2.3.6 Permanent and Temporary structures

In "conventional" air traffic control, airspace structures are changed on the basis of four week periods known as AIRAC cycles. The reader is directed to ICAO Annex 15 [56] for more information. Planned changes are normally announced one AIRAC ahead, meaning that changes require up to 8 weeks notice. Short term changes are announced in NOTAMs, see ICAO Annex 15. Pilots should review NOTAMS before flight.

In EU IR 2021/664 [8], Dynamic Airspace Reconfiguration and Dynamic Airspace Restriction are introduced. These allow reductions/restrictions of the U-space airspace with minutes of notice. The Geo-awareness services facilitate the rapid dissemination of the information electronically.

Dynamic Airspace Reconfiguration is further examined in section 3.17.1.

### 2.3.7 Synthesis

The following table explains the relationship of the different U-space volumes to EU regulations and ICAO airspace classes. Note below SVFR is a form of VFR and is usually not mentioned as a separate flight rule.

| ICAO class | 2019/947 UAS Geographical Zone | 2021/664 U-space airspace | U-space ConOps | Flight rules | Remarks |
|---|---|---|---|---|---|
| G above VLL, ABCDEF | No | No | Not U-space | IFR (4,5) & VFR | For U-space users such airspace would probably be marked a Y volume and any U-space U-plan penetrating this airspace will either not be approved or will be subject to conditions or warnings. |
| ABCDE | No | No | Za | IFR (4) & VFR | Za if and only if the flight's entry into the airspace is enabled by a U-space planning process that includes ATC approval. |

| ICAO class | 2019/947 UAS Geographical Zone | 2021/664 U-space airspace | U-space ConOps | Flight rules | Remarks |
|---|---|---|---|---|---|
| G VLL | No | No | X | VFR & IFR (5) | Conditions apply<br>UAS fly below VFR limits. UAS fly in a way that limits the risk to VFR and IFR traffic |
| Restricted Area | Yes (1) | No | X | VFR | Special conditions may apply: Geo-zones can exist to manage which UAS flights are allowed and/or how they operate. See (2) |
| Restricted Area | Yes (1) | No | Y | Dependent on the restriction | Potentially a no fly zone for UAS |
| Restricted Area | Yes (1) | Yes | Y | See 6 & 7, below | No tactical separation service supplied by U-space |
| Restricted Area | Yes (1) | Yes (3) | Zu | UFR<br>See 6, below | Tactical separation service supplied by U-space. |
| Restricted Area | Yes (1) | Yes (3) | Zz | See 6 & 8, below | Tactical separation **advice** supplied by U-space |

**Table 4: Equating subdivisions of the airspace: Volumes, Geographic Zones and Airspace classes**

Notes:

1) 2019/947 [4] article 15 does not state that geographic zones are restricted areas. U-space airspaces created as a result of 2021/664, 665, 666 are expected to be restricted areas due to the obligation on crewed traffic to be conspicuous.

2) 2019/947 [4] article 15 allows Geographical Zones to exist for different reasons. Restrictions may be placed on flights, or exemptions made.

3) 2021/664 [8] & [11] describes something approximating Y. Zu and Zz are considered as extending Y

4) IFR only in A.

5) IFR unlikely in G in many countries

6) UFR, a possible new flight rule, is defined here as “how to fly in Zu”. In Zu there is U-space tactical conflict resolution, hence UFR will include obeying U-space tactical conflict resolution. It is expected that Zu only supports UFR and all aircraft in Zu must follow UFR. UFR is discussed in section 4.2.

7) An airspace which is a U-space airspace according to EU 2021/664 [8] & [11], most closely matching the U-space ConOps volume Y, is one aimed at supporting BVLOS operations by means of strategic conflict resolution. Hence flights in the airspace do not follow UFR as flown in Zu, as tactical support is limited to traffic information. EU 2021/664 foresees entry of VFR or IFR traffic into U-space airspace as


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being an emergency procedure in which U-space traffic “take appropriate measures.” Hence it should be noted IFR and VFR traffic are not catered for in Y volumes.

8) The flight rule in Zz is not UFR as flown in Zu.

### 2.3.8 Structure

Y and Z volumes, sometimes known as U-space airspaces, can have attached to them different requirements (equipment fit, procedures, performance) for flight. EU regulation 2021/664 [8] also mentions that U-space service providers may be authorised for some U-space airspaces but not others.

The AMU-LED project [45] proposed a structure with two layers with different levels of performance above and below. The arrangement would allow (higher risk) passenger carrying operations in the upper region to be provided services by suitably qualified service providers without requiring all traffic to operate at this higher level of performance and resulting cost.

A similar proposal is to create corridors for higher performance traffic.

## 2.4 Ground Infrastructure for UAM

The term **vertiport** is used here to mean an aerodrome of Urban Air Mobility. Two forms are presented, first the vertiport for passenger operations and then the vertiport for cargo operations by small UAS. The term vertiport is used in a general sense in this document. The content of this section builds on the state of the art in 2022. R&D, commercial proposals, standards and regulations for vertiports are evolving rapidly.

Some sources propose a terminology that distinguishes between larger, well equipped vertiports and smaller less equipped. The term Vertistop has occasionally been used in this context. Vertistop is a registered trademark of Difass International SPA.

### 2.4.1 The Vertiport predominantly for passenger operations

#### 2.4.1.1 Overview

Vertiports are landing and take-off sites for passenger carrying VTOLs and will be equipped with a number of facilities, including charging facilities for electrically operated vertical take-off and landing (eVTOL) aircraft as well as passenger boarding, disembarkation, and waiting areas. Non passenger carrying drones, for example for cargo operations, are expected to operate from other sites since decentral locations are preferable for such operations and infrastructure and safety requirements differ, though they may occasionally visit “passenger” vertiports.

A number of companies are presently developing vertiport concepts and infrastructure and these are largely inspired by heliports, including the touchdown and lift-off (TLOF) area, the final approach and take-off (FATO) area, the safety area around the FATO and stands as applicable. Additionally, while the aircraft is moved between TLOF and stand without depending on its power and wheels, ground movement equipment (GME) needs to be accommodated in the vertiports. GME serves as towing equipment in the form of a wheeled vehicle to move the aircraft horizontally on the vertiport surface, which can be either manually operated or remotely controlled or supervised by a member of the technical ground crew.



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Vertiports may be located in any area, but realistically predominantly in urban areas and close to airports, permitting air taxi operations within cities and between cities and airports. An important consideration and requirement is the integration into the existing airspace; this concerns the airspace category in and around the area the vertiport is located and the safety of drone operations to and from the vertiport which may need to be separated or segregated from piloted aircraft. Operations at vertiports will be managed through U-space. The management; sequence building, landing clearances, hold instructions, taxi clearances, etc, will be mostly without human intervention.

#### 2.4.1.2 Aircraft

Whilst a number of aircraft types will undoubtedly be used in urban air mobility, we make the assumption that vertiports will be used by and designed for eVTOL and hybrid VTOL aircraft. Noise and local air quality considerations as well as the non-availability of landing sites for aircraft taking off in any other way than vertically have informed this assumption. Since eVTOL aircraft require charging facilities and have very limited endurance (so that holdings are not a desirable feature) this has a number of repercussions for the vertiport layout.

#### 2.4.1.3 Vertiport facilities

The present design concept of vertiports, which is based on the EASA Guidance Material for Design of VFR vertiports [39] and largely inspired by current standards and recommendations for heliport design (e.g., ICAO Annex 14, Volume 2), provides the following facilities:

- Touchdown and Lift-off (TLOF) area(s);
- Final Approach and Take-off (FATO) area(s);
- Safety Area(s) around the FATO(s);
- Stands
- Facilities for re-energizing of aircraft batteries;
- Areas for taxiing (under own power) and ground movement (not under own power) of VTOL aircraft between the FATO and TLOF; and
- Passenger embarking, disembarking, and waiting areas.

For capacity and contingency reasons, it is desirable to provide more than one TLOF/FATO since the TLOF/FATO will be occupied by the incoming or outgoing flight for a specified period of time. FATO and safety area are always placed together within vertiport environment, but TLOF and stand can be placed elsewhere. Different options are expressed in Figure 5 for:

- Air taxiing, with TLOF being at the same place as the stand, where aircraft moves hovering over the vertiport surface on its own power, i.e. the aircraft does not lift-off or touch down at the FATO.

- Ground movement, where TLOF and FATO being at the same place with a stand in a different location and where ground movement of the aircraft is needed e.g., for longer distances. A VTOL aircraft can be moved under own power or by a vertiport movement system.

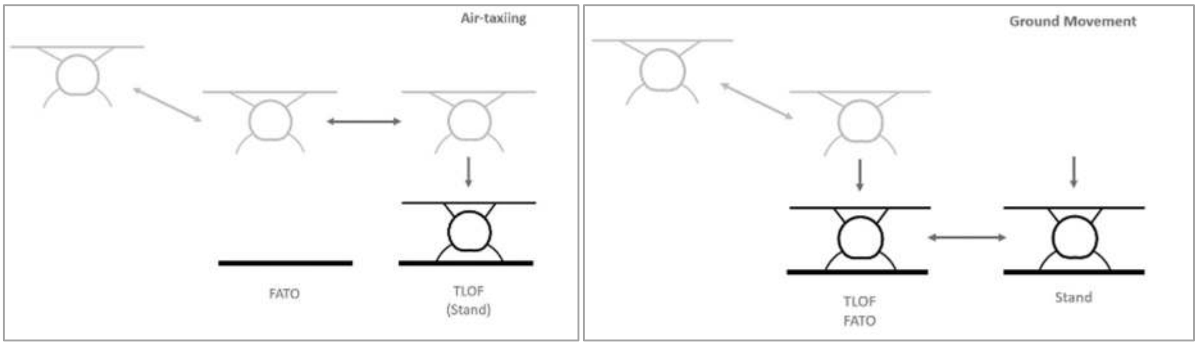


**Figure 5: Air taxiing and Ground movement vertiport configuration**

#### 2.4.1.4 Vertiport access and operations

Operations are performed under the authority of the vertiport operator. Whilst detailed responsibilities are yet to be defined and agreed, the vertiport operator can be expected to

- specify the minimum operational and equipage requirements for aircraft using the vertiport and ensuring compliance,
- indicate the operational status of the vertiport and the availability of landing / departure / parking capacity,
- provide information and services, e.g. provide ground obstacle maps and/or landing/departure routes, potentially also local meteorological information.

Vertiports will probably have defined procedures including arrival, departure, holding, diversion, ground operations (charging, ground movement).

Aircraft in the U-space surrounding the vertiport will be under responsibility of one or various U-space service providers. The presently favoured view is that the USSP(s) also authorize landing and take-off operations at the vertiport, based on the availability of slots and infrastructure indicated by the vertiport operator. Note that different concepts are imaginable, for example a vertiport authority which clears aircraft for take-off and landing similarly to tower control. Yet the interface with USSP(s) in the surrounding airspace in terms of control authority would become complex to manage. (Due to a number of possible setups and solutions as presented above, the concept of traffic management at the vertiport should be further investigated and could be subject to following research projects.)

When considering vertiports for passenger VTOL aircraft operations, EASA is distinguishing different kinds of vertiports (see Figure 6: Vertiport Classification from Operations Perspective [23]).

As per EASA SC VTOL, VTOL aircraft certified in the category enhanced, need to satisfy the requirement of and hence be able to continue to the original intended destination or a suitable alternate vertiport after a critical failure for performance [24]. This enhanced category of VTOLs covers those aircraft which will carry passenger on-board.

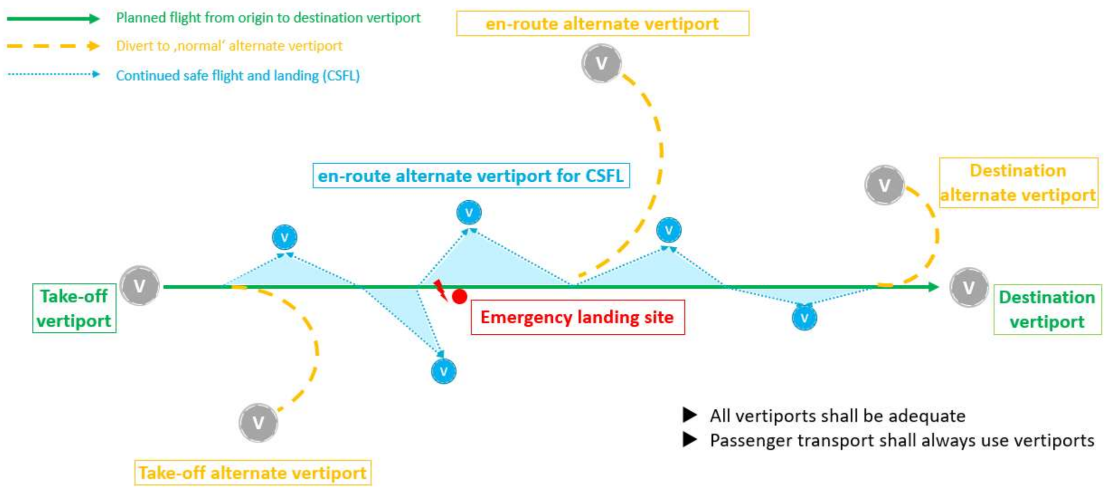


**Figure 6: Vertiport Classification from Operations Perspective [23]**

The grey circles are normal aerodromes, heliports or vertiports, with the full range of facilities and services required for the operation, so that the VTOL aircraft can take-off from. The blue circles are aerodromes for continued safe flight and landing (CSFL) which may be heliports or vertiports, that only have a minimum set of facilities and services (to be specified), from which the VTOLs may not be able to take off.

- **Take off and destination vertiport**: Each flight originates from a take-off vertiport and is planned and conducted to the destination vertiport.
- **Alternate vertiport**: This can be either an alternate take-off vertiport, where the VTOL aircraft would be able to land should this become necessary shortly after take-off, or an alternate en-route vertiport, where the VTOL aircraft would be able to land in the event that a diversion becomes necessary with normal aircraft performance while en-route, or an alternate destination vertiport, where the VTOL aircraft would be able to land should it become either impossible or inadvisable to land at the intended destination vertiport.
- **Alternate en-route vertiports for CSFL**: The alternate en-route vertiport for CSFL complies with the same minimum design requirements as the alternate en-route vertiport. But it only has to fulfil a minimum set of services with respect to the aircraft and CSFL operations.
- **Emergency landing site** is excluded from these considerations as emergency landing may be carried out at any possible location, not necessarily at an aerodrome/operating site.

The procedures to manage the availability of alternate vertiports are yet to be defined and will be informed by the, presently unknown, occurrence rates of technical failures and other causes lead to the need for alternate vertiports. The presently favoured view is that vertiports will not nominally operate at maximum capacity and thus leave some availability to accommodate unforeseen operations on an ad-hoc basis.

#### 2.4.1.5 Vertiport location, airspace

Whilst vertiports with lower traffic demand may not have a designated area of airspace assigned/attached, we assume that the majority of vertiports is surrounded by a Vertiport Traffic Zone (V-TZ).

Flight planning and authorisation are performed by the USSP providing service to the UAS operator wishing to land at the vertiports. This includes booking of vertiport access. Details have yet to be defined but it may well be that *InterUSS* [19] will be used not only for booking access to the airspace but also to the vertiport resources (see ASTM standard F3548-21 [18]).

Vertiport access booking is part of the U-Plan but does not authorise the aircraft to take-off or land. For this, the take-off/landing clearance is required which will be obtained shortly prior to the actual operations. The details of clearance provision in U-space have yet to be defined. Experimental work shows that stepwise clearances, with clearance limits similar to traditional aviation, seem to have a number of advantages when compared to clearing the whole mission at take-off. These advantages include better accommodation of uncertainty, capacity aspects, lost-link procedures, and other contingencies. EASA's Prototype Technical Design Specifications for Vertiports [53] echoes this view.

For the initial concept and use cases, we assume vertiports to be located in airspace surrounded by class G (uncontrolled) airspace. This would cover some vertiports located in urban areas but exclude vertiports in the vicinity of airports which are surrounded by class D airspace. In an evolution vertiports could be imagined in the premises or the vicinity of an airport (i.e., airspace class C or D). In this case, air taxi operations will require some form of interaction with ATM, which may be through the U-space service Collaborative interface with ATC, see 3.18. VTOL aircraft need then to be clearly displayed for ATC on the HMI for ATCOs situational awareness. This integration with ATM needs to be further researched.

### 2.4.2 Vertiports predominantly for cargo operations

Much of the description of the passenger vertiport applies to vertiports for cargo flights, but there are some simplifications other than the absence of passengers.

#### 2.4.2.1 Optimisation

There may be cases where a vertiport is used by only one aircraft operator or by a small number of aircraft operators working in close cooperation with the vertiport operator. Examples might include "business to customer delivery" or if a number of hospitals/medical facilities have set up an air delivery service between themselves. The close linkage between the vertiport operator and the aircraft operator(s) may influence the way flights are scheduled at the vertiport, allowing emphasis of "network" optimisation.

'General' use of vertiport by aircraft operators without shared business interests diminishes the opportunities for such over-arching optimisations. We can expect each aircraft operator to optimise their own flights with the vertiport operator optimising vertiport operations.

#### 2.4.2.2 Location

Two modes of cargo flight can be identified linked to the type of operation which impact vertiport location.

- The flight takes off and lands with the cargo on board. The cargo vertiport is at a source/sink of cargo, such as a warehouse, logistics centre, "fulfilment centre" or "dark store." The location of the vertiport is determined by the location of the source/sink of cargo.
- The cargo is collected and then delivered during the flight. Aircraft leave and return to the vertiport without cargo. The vertiport is only concerned with flight operations. The vertiport position can be optimised for flight efficiency, safety and social acceptance

### 2.4.3 The impacts of vertiport in U-space

Vertiports are often going to be a limited resource and hence will constrain flight planning, both for normal operations and in contingency planning. A service will be needed to share the current and planned availability. Other services will need to take this availability into account.

Processes at the vertiport may inject uncertainty into operations. For example, a flight may take off when the FATO is clear, but any number of improbable events can result in the FATO not being clear at the planned take-off time and hence the take-off is delayed.

## 2.5 U-space infrastructure and the role of a mandated actor

Edition 3 of the U-space ConOps [1] identified the motivations for including a state mandated actor in U-space. These were to provide services that are considered unlikely to be provided through market means, and to meet the unique needs of other state mandated actors such as the security services. This section argues that a state mandated actor may also fill a role providing U-space infrastructure.

### 2.5.1 The Common Information Service of EU regulation 2021/664

The reader is directed to the European "Drone regulations" EU IR 2019/947 [4] and EU Delegated Regulation (DR) 2019/945 [5] and their associated Acceptable Means of Compliance and Guidance Material [6],[7] as well as the "U-space regulations" EU IR 2021/664 [8], 2021/665 [9] and 2021/666 [10] as well as the associated Acceptable Means of Compliance and Guidance Material [11]

EU IR 2019/947 article 15 allows for the designation of UAS Geographical Zones and requires that information on them be made available, electronically.

EU IR 2021/664 defines a kind of UAS Geographical Zone called a U-space Airspace and among other things, the regulation lists those services that must be provided with in it. One of these is the Common Information Service and it consists of (paraphrasing)

- The geographic boundaries of the U-space airspace, horizontally and vertically.
- The technical capabilities and performance required for aircraft allowed to fly there as well as any required flight procedures.
- The list of U-space Service Providers certified to provide services in that U-space airspace and any limitations. The terms and conditions of those service providers
- Associated geography: any adjacent U-space airspaces. Any UAS geographical zones "relevant" to this U-space airspace.
- Any restrictions limiting the volume available for UAS flight.
- The result of any Dynamic Airspace Restriction
- EU IR 2021/665 [9] adds traffic information regarding crewed aircraft known to ATC to the definition of the Common Information Service.



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Common Information includes the information distributed by the Geo-awareness service, see section 3.4.2. Common Information should be supplied to anyone that asks for it while Geo-awareness is supplied only as part of the relationship between a U-space Service Provider and a UAS operator.

According to EU IR 2021/664 article 5 (6) "Member States may designate a single common information service provider to supply the common information services on an exclusive basis in all or some of the U-space airspaces under their responsibility."

The situation in U-space airspaces where there is no single CISP is outlined in the acceptable means of compliance [11] in GM-1 to Article 5, part d, which says "In the absence of a single CIS provider, common information is directly exchanged between the relevant operational stakeholders in a distributed communication architecture, whereby each data provider communicates directly with another USSP for sharing information. Each USSP needs to communicate with other data providers. A clear allocation of common information elements between Member States, ATS providers and USSPs would allow data users to find target data quickly and efficiently. In the absence of a single CIS provider, there is no need for additional certification; the provision of common information elements by ATS providers and USSPs will be covered by their respective certificate and the provisions of Regulation (EU) 2021/664 and Regulation (EU) 2021/665 amending Regulation (EU) 2017/373."

Hence the options are one CISP or none. Which is in effect may differ per U-space airspace in a given state.

### 2.5.2 The Infrastructure of U-space

The U-space regulations 2021/664 [8], 2021/665 [9] and 2021/666 [10] indicate and imply that there will be a number of data flows between different participants in U-space. Notably:

1. The Common Information includes the geographic zones and U-space airspaces. The geographic zones are created, updated and removed by authorised actors including Air Traffic Control organisations, including through the Aeronautical Information or by means of NOTAMS. U-space airspaces can be subject to change following operational decisions by Air Traffic Control in the "dynamic airspace reconfiguration" process.
2. The Traffic Information service requires a service provider to provide information about all traffic in the vicinity of any UAS to which it is providing traffic information. Hence the USSP needs access to the tracks of flights known to other USSP. Traffic information can include tracks of aircraft derived from Air Traffic Control surveillance. Hence there needs to be a flow of relevant ATC surveillance data to USSP.
3. The Conformance Monitoring Service requires that other airspace users may be warned in some conditions. That may include warning Air Traffic Control.
4. The Flight Authorisation Request service should take into account crewed aircraft in a state of emergency, information that may come from ATC.
5. The Flight Authorisation Request service needs to be able to safely deconflict flight authorisation requests with those of other USSPs.

These data exchanges should meet a number of criteria. They should be timely as they are generally used during flight operations. They should be safe and secure; there should be no doubt as to the source of the information and the consumer, each should be known to and trusted by the other. The data exchange mechanisms should not expose any participants to significant risk of cyber attack. The data exchange mechanisms should be reliable.



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The U-space regulations [8],[9],[10] enable normal operations. Nothing is said about the data exchange requirements stemming from the needs of the competent authority in monitoring and auditing the correct functioning of U-space, or when investigating accidents and incidents. Similarly the needs of security services may imply additional actors with their own data exchange needs.

#### 2.5.2.1 Discovery and Synchronisation Service

From the list above, items 2 and 3 are covered by ASTM standard F3411 [44] and items 4 and 5 by ASTM standard F3548 [18]. Neither standard is currently mandated in Europe but both are acceptable means of compliance. Both rely on the same mechanism, the Discovery and Synchronisation Service, or DSS.

The basic mechanism of the DSS can be explained thus

- At least one trusted actor runs an instance of the DSS. It is foreseen that more than one will run and that the different instances will synchronise between themselves. In the reference implementation, the InterUSS [43], this is done using the Cockroach database which implements the "Raft Consensus Algorithm" [6]
- The DSS stores a four dimensional map of the airspace in the form of a grid of 4D boxes.
- Participants in U-space access the DSS and express an interest in collections (one or more) of these 4D boxes. Their interest is noted within the DSS.
- When another participant expresses an interest in a 4D box, it learns how to contact the other(s) interested in the same box.
- Direct bilateral negotiation is then expected between the participants.

For traffic information the relationship between participants is expected to be a publish-subscribe idiom. For flight deconfliction in U-space according to 2021/664 first to file has priority hence there is in effect a system of reservation. The standard F3548 foresees a bilateral negotiation.

The key question is who implements the DSS. It may occur that at least one instance should be created at the mandate of the competent authority, because with no DSS, the conflict detection of F3548 will not function. Other DSS may be operated by USSP or other participants in the system, however a USSP is only really interested in a particular U-space airspace if a flight concerning that USSP is planned or is operating in that U-space airspace. A competent authority mandated DSS instance may be considered to be part of the duties of the Common Information Service Provider.

#### 2.5.2.2 Other "backbone" functions of U-space

There are other services needed to enable the correct functioning of U-space. Many can be implemented as replicated synchronised services. Any state could rely on these services being provided by one or more participants in U-space or they could mandate an instance exists. Such a mandated instance might be considered part of the duties of the Common Information Service Provider if it exists.

[6] see https://thesecretlivesofdata.com/raft/

##### 2.5.2.2.1 Trust

Since 2019 ICAO has been working on the Trust Framework[7] and this will make use of "Public Key Infrastructure" to identify participants. This requires a trusted, reliable, secure "certificate directory. "

##### 2.5.2.2.2 Swim Registry

There needs to be a registry of SWIM services. This is closely linked to the Common Information described in the U-space Regulation which requires publication of the certified USSP. Currently a European registry exists[8] but we may see competent authorities wanting to operate a national registry for service providers that are certified to operate in their country.

#### 2.5.2.3 Accident and incident investigation, auditing

The Legal recording service 3.11 is absent from the U-space regulations [8]. Instead, there is an obligation for service providers to log inputs, outputs and other significant information. The regulation doesn't mention how this data is subsequently obtained by the competent authority. One very likely mechanism is that the information is requested and delivered electronically. The competent authority may operate its own system to collect this data or may delegate the activity to a trusted actor.

#### 2.5.2.4 Exceptional conditions, status and state messaging, contingencies

EU regulation 2021/664 article 10(6) [8] requires that USSP make "proper arrangements" to resolve conflicts. The Guidance Material [11] to the regulation mentions ASTM F5348.

These arrangements should be robust. Due to scheduled or unscheduled events, service providers involved in U-space may at times go off-line or be suffering from degraded performance. Such changes to the network will probably need to be signalled to the other relevant participants in U-space, for example through the SWIM registry. There will likely be contingency procedures associate with some of these state changes, some of which may require "special permission" for example, if a USSP A has an arrangement that USSP B will takeover active flights when A fails, there would be a need to revise every entry in the DSS relating to A, changing it to B. Such a change might not "normally" be authorised and may require an escalation process to a trusted actor.

As different contingency scenarios are identified, a central trusted actor may be selected to have a definitive role in some situations where safety would otherwise be difficult to demonstrate.

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[7] see https://www.icao.int/Meetings/DRONEENABLE2/Documents/Presentations/1-5-1%20Voss.pdf

[8] https://eur-registry.swim.aero/home

# 3 U-space services

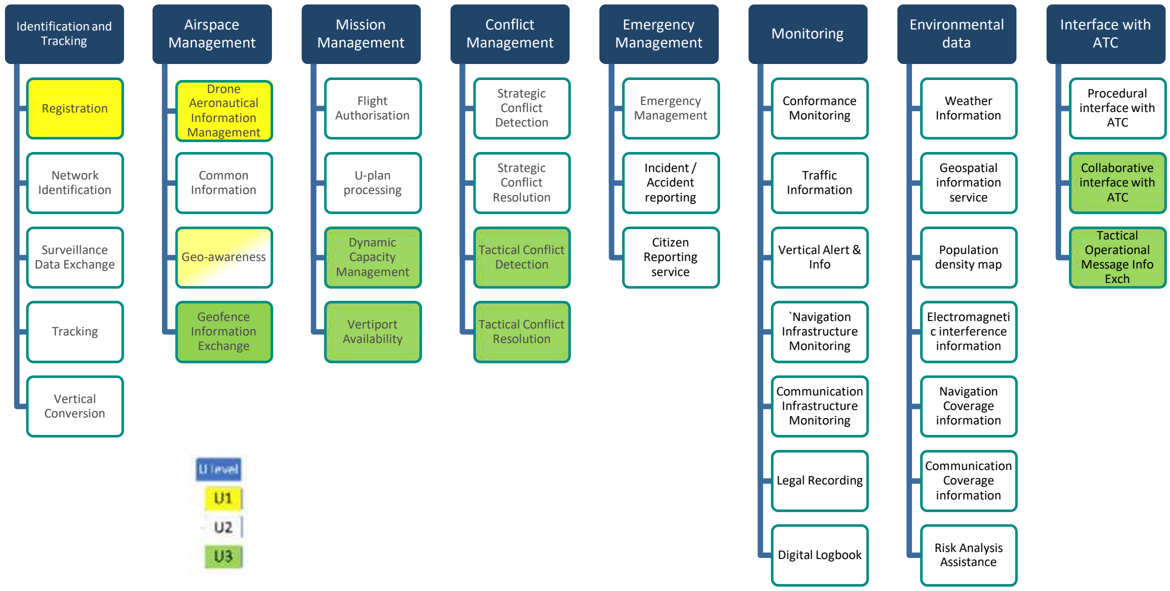


**Figure 7 U-space services**

Geo-awareness is a U1 service whose functions are increased in U2.

## 3.1 Introduction

### 3.1.1 Definition of "U-space service"

In everyday English a **service** is something done by somebody (or some thing) for someone else. The term has many more specific meanings in particular fields. This ConOps, like the previous editions, is intended to describe how U-space works; in this document the term "service" is used quite broadly and includes many functions, of varying importance.

The services in this ConOps, Edition 4, are very consistent with those in Edition 3 [1]. The range and granularity of the services is intentional, as in Edition 3, to explain how U-space works. In contrast, EU IR 2021/664 [8] describes the minimal set of services that it regulates. These EU IR 2021/664 services are examined in section 3.21.

In computing the term "service" often refers to an information (or state) exchange; some of the services described here are much more complex than one data exchange; and some services described here may be considered by some readers as being parts of other services, or as merely data used in various processes. That view can be seen in the work done by the GOF2 [46] and AURA [47] projects.

Table 7 proposes a mapping from the regulation to the list of services here and to those referred to in previous editions of the ConOps as well as an indication of hierarchy, if any.

While using the term service in quite a general way, this document follows the conventions of "use cases" in that services are initiated by the person (or system) to which they deliver a result. For



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example this document would describe a user might subscribing to a warning service, rather than a describing a service which (spontaneously) warns people.

### 3.1.2 Structure of this section

The headings in Figure 7 are merely for grouping and are not indicative of a hierarchy. The services of Figure 7 are described in this section in the order they are shown in Figure 7. Section 3.21 concludes with a comparison of Edition 3 and Edition 4 terminology as well as a comparison with the EU regulations.

## 3.2 Registration

EU regulation 2019/947 [4] article 14 obliges the state to register operators of most classes of UAS and that some UAS. Hence there needs to be a state appointed registrar who maintains a registry.

EU 2019/947 [4] article 14 lists what information is expected in the registry. The registry should generate unique registration numbers associated with registry entries. The registry should form part of a multi-national network which is coordinated to ensure registration numbers are unique.

Registry entries will need to be able to be created, read, updated and deleted. There will need to be search functions. Some data consistency rules will need to be enforced, such as avoiding multiple registrations of the same information. There will need to be agreed processes to determine who is permitted to query and change the contents of the registry. Registration information may also change with time (e.g. lapse) in some cases. There will need to be means to carry out less frequent processes such as the registrar removing or changing a record following a court order.

The U-space Blueprint [2] and Roadmap [3] mention an 'e-registration' service to emphasise the digital implementation of the registry.

To achieve Registration, there should be some secure and high availability registry (data store), with appropriate means available for different classes of user to input/update/check/remove their own data or (when permitted) query the contents of the registry. The Registry will also need to be connected to other systems so as to validate names of people, businesses, addresses and other information given as inputs. The registry will probably need to be able to take part in multi factor authentication and support processes for "forgotten password" and similar to an appropriate degree of security, both of which may require that messages or emails can be sent.

The registrations (the contents of the registry) will be queried by authorised officials (for example law enforcement) in combination with the Network Identification service in order to find the details of an aircraft which may be currently airborne. Hence the registry implementation must be capable of rapid response. The multi-national network of registries should be interconnected to allow network identification queries to function in any collaborating state for any registration known in any collaborating state.

**Registration Assistance** was identified as a U-space service in the U-space ConOps edition 3 [1]. This was foreseen as a service that might support something like a legal requirement for businesses selling UAS to ensure that the owners are registered. Services may be offered to assist routine registrations, presenting a user interface that is simplified and/or partly filled in with standard information. Descriptions of this kind of "helper" are no longer included in the ConOps but are left to the imagination and ingenuity of the reader.



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## 3.3 Surveillance in U-space

Surveillance is the term commonly used in Air Traffic Control for the process by which the positions of aircraft are known on the ground. The term is used in the same sense here. Surveillance is the S in CNS.

EU regulation 2021/664 [8] and [11] article 8 describes the Network Identification service as a way of U-space being informed of where UAS are. This service is complemented by the requirement for Electronic Conspicuity in EU2021/666 [10]. These two provisions require that all aircraft flying in U-space airspace shall regularly communicate their current position to U-space. This is done in three ways:

- UAS communicate with their contracted U-space Service Supplier via the Network Identification service – 2021/664 article 8
- Aircraft in receipt of an ATC service have their surveillance communicated from ATC to U-space, following 2021/666
- Crewed aircraft not in receipt of an ATC service must make themselves conspicuous to U-space, following 2021/666

Hence the Network identification service is the basis of drone surveillance in the U-space airspace.

Surveillance in U-space is the basis for the following services:

- The Network Identification service
- Monitoring
- Traffic Information
- Tactical Conflict Prediction
- Surveillance data exchange

The performance of the system and the services consuming surveillance data, especially separation can be quantified if position reports contain an indication of the uncertainties in the reported figures and tracks have known quality. U-space airspaces will have associated with them minimum performance for surveillance.

### 3.3.1 Network identification

EU 2021/664 [8] and [11] article 8 describes the Network Identification service as having two distinct aspects.

- A service is described whose function requires the position of all UAS to be known.
- Based on that there is a requirement for the position of all UAS to be supplied to U-space.

These two aspects are explained separately below.

#### 3.3.1.1 The Network Identification service as an Identification service

EU 2021/664 [8] and [11] article 8 describes a service by which authorised users and systems can obtain information about a currently active UAS. The amount of information depends on the user or system but the list of what should be output includes – quoting from paragraph 2 of article 8:

*a) the UAS operator registration number,*

b) *the unique serial number of the uncrewed aircraft or, if the uncrewed aircraft is privately built, the unique serial number of the add-on,*
c) *the geographical position of the UAS, its altitude above mean sea level and its height above the surface or take-off point,*
d) *the route course measured clockwise from true north and the ground speed of the UAS*
e) *the geographical position of the remote pilot or, if not available, the take-off point,*
f) *the emergency status of the UAS.*

The rate of update is determined by the competent authority, as may be other performance criteria for surveillance.

The term "route course" should be interpreted as current heading. Intent is not shared.

In addition to the Surveillance uses mentioned in Section 3.3 and that the data is to be shared with other U-space service providers (see [11],) the use of this service to substitute for the "Direct Remote Identification" provision of UAS in Open operations – see EU 2019/947 [4]. That is, it allows a person to identify a UAS that he/she is aware of, for example a policeman to identify a UAS that he/she can see.

#### 3.3.1.2 Dependent surveillance as part of Network Identification

EU 2021/664 [8] and [11] article 8 requires UAS in U-space to regularly inform U-space of enough information to supply the Network Identification service. The rate is determined by the competent authority.

Examining the list of elements that must be supplied in Section 3.3.1.1:

- Some elements might not be known to the aircraft, such as the geographical position of the remote pilot. Hence the position report information sent form the UAS to U-space may combine elements with different sources: the aircraft, the remote piloting station.
- Some elements are not likely to change during flight, such as the UAS operator registration number and the take-off point.
- The messages sent from the UAS to U-space may vary over time. In particular there is Item d), '*the route course measured clockwise from true north and the ground speed of the UAS*,' can come from three different means:
    - The U-space service receiving reported positions from the UAS could perform Tracking and infer the motion vector,
    - The UAS can send its own measurements of heading and velocity. The velocity is likely to come from examination of previous positions,
    - The UAS can sent its intended (planned) heading and ground speed.

Neither the regulation [8] nor the acceptable means of compliance [11] indicate how the information is to be sent to U-space. It is assumed that "within the UAS" the aircraft will be in almost continuous contact with the remote piloting station and that the pilot will be informed of (at least) the position of the aircraft. Hence the position reports could be sent to U-space from either the aircraft, the remote piloting station or a combination of elements from each.

The position report submission aspect of Network Identification will require processes to start and end the submission. The submission process should be secure. Start of submission will involve secure identification of the operator and aircraft. Start of submission and should follow very shortly after



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activation of the flight – see 2.2.4.2. The ending of submission precedes the Termination of the flight – see 2.2.4.7.

### 3.3.2 Tracking

EU 2021/664 [8] and [11] does not mention Tracking, though it might be inferred.

Tracking is a statistical process that uses the observations of where the object has been (the position reports) and builds a model of where the object is most likely to be now, and how it is most likely to be moving, hence where it is most likely to be in the near future. Tracking can be made to work with multiple sources of observations for the same object, known as Multi Sensor Fusion Tracking.

Tracking is a standard activity in surveillance, especially in air traffic control. Tracking enhances the value of radar, for example. In the U-space context we expect Network Identification to be the basis of surveillance. The expected performance of the system will be that the observations are provided every “few” seconds with a latency of less than a second. Tracking should allow the current position to be inferred and presented as a smooth motion in any application.

Tracking implies a computing cost. Experience in current air traffic control is that Tracking aids human cognition. Some services such as Tactical Conflict Prediction require tracks to work correctly. Any source of uncorrelated reports, such as a drone detection system, will require tracking in order to correlate the tracks with the other surveillance and/or flight plans.

There appear to be at four (or more) ways tracking can feature in U-space.

- As a service performed by the U-space Service Provider receiving the reported positions and motions of the UAS. (by the producer)
- As a ‘shared’ service at some point within the interconnected U-space service providers as they exchange surveillance data. (centrally)
- As a service performed by the U-space Service Provider making use of the reported positions and motions of the UAS. (by the consumer)
- As a process applied in the Remote Piloting Station, if at all (downstream of U-space).

It is assumed that the Monitoring (3.10) and Tactical Conflict Prediction (3.6.1) services require tracks rather than observations. Traffic Information (3.14) benefits from being supplied tracks rather than observations. Tracking is also needed to allow cooperation between U-space and drone detection systems.

### 3.3.3 Surveillance Data Exchange

EU 2021/664 [8] and [11] article 8(4) requires U-space service providers to share surveillance data [Network Identification] with

- other U-space service providers, in order to ensure the safety of operations in the U-space airspace
- the air traffic services providers concerned
- when designated, the single common information service provider

EU 2021/664 article 11(2) requires U-space to be able to display

- information about crewed aircraft and UAS traffic shared by other U-space service providers and relevant air traffic service units, including that mentioned in EU IR 2021/665 as coming from ATC

Hence U-space service providers must share surveillance data and accept surveillance data shared with them.

## 3.4 Airspace Management

EU regulation 2019/947 [4] allows for the creation of UAS Geographical Zones (Geo-zones) for the facilitation, restriction or exclusion of UAS operations.

EU regulations 2021/664,5,6 describe a kind of UAS Geographical Zone in which U-space services are used, called a U-space airspace.

### 3.4.1 Drone Aeronautical Information Management

The Drone aeronautical information management service is concerned with bringing together temporary and permanent changes to the drone "flying map." It is the drone equivalent of the Aeronautical information management service.

The slowly changing elements are the UAS Geographic Zones which may result from different sources. A (fictitious) example might be a prohibition of drones flying over schools. If such a prohibition exists, the education ministry, or the local (e.g., city) authority may use the drone aeronautical information service to publish the geographic bounds of schools.

Rapid changes in the information are expect from:

- Dynamic Airspace Reconfiguration. This process is described in EU regulation 2021/664 Article 4 [8] and EU regulation 2021/665 [9]. U-space airspaces that are adjacent to controlled airspace can have their boundaries changed by ATC under some conditions.
- The police in some countries (and perhaps others) are empowered to temporarily forbid UAS flight in a region.

The Drone Aeronautical Information Management service may be part of a state's Aeronautical information management service or may be kept separate for any number of reasons, for example cost transparency or ease of implementation.

Operating the Drone Aeronautical Information Management service will involve:

- Operating a service for authorised (presumably trained, perhaps certified) creators of Geo-Zones.
- Collecting and possibly assisting or checking the inputs from occasional or less experienced creators of Geo-zones.
- Vetting and training (and certification) of organisations to establish that they are trusted to make updates directly in the system.
- The provider of the service may have to negotiate at times with those providing inputs which are unduly cautious (restricting drone flight unnecessarily) or incautious, etc.
- Updating and synthesising the overall situation and making it continuously available.

### 3.4.2 Geo-awareness

Geo-awareness makes the UAS operator, and other interested parties, aware of what has been gathered by the Drone Aeronautical Information Service.

#### 3.4.2.1 U1

EU 2019/947 article 18(f) says that competent authorities are responsible for "making available in a common unique digital format information on UAS geographical zones…" Regulation 2019/947 does not describe this as a U-space service, but it is taken in this document as being the definition of U1 Geo-awareness.

#### 3.4.2.2 U2

EU 2021/664 article 9 is within chapter IV and is addressed to the U-space service provider. Article 9 requires a geo-awareness service that provides the following information to UAS operators concerning the U-space airspace:

- applicable operational conditions and airspace constraints,
- UAS geographical zones,
- temporary restrictions applicable to airspace use.

Article 9 further states that U-space service providers must provide this information in a timely manner so that contingencies and emergencies can be addressed by UAS operators. The information must include the time at which it was updated through a version number and/or a valid timestamp.

#### 3.4.2.3 Common Information Service

Chapter II of EU IR 2021/664 is addressed to the state. Article 5 is within chapter II and describes the Common Information Service. The full text of the article is not reproduced here – see [8]. The text of article 5 mentions the content, the quality, the scope of the provision and the means of the provision of the common information as well as related obligations.

The content mentioned in 2021/664 article 5(1) is, essentially:

- The geographic bounds of the U-space airspaces and Geographic zones,
- Technical and operational constraints associated with those U-space airspaces,
- The providers of services within those U-space airspaces.

The AMC/GM to the regulation [11] illuminates this further.

EU IR 2021/665 adds to the definition of Common Information by saying that it includes traffic information coming from ATC.

The differences between Common Information service of EU regulation 2021/664 Article 5 and the Geo-awareness service of Article 9 of the same regulation are that

- Common Information is available to all while Geo-awareness is provided by a U-space Service Provider to its customers.
- While Geo-awareness gives the geographic bounds of the U-space airspaces and Geographic zones, the Common Information is more than this, as it includes the Technical and operational constraints associated with those U-space airspaces.



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- The U2 Geo-awareness service has a greater emphasis on timeliness and performance than the Common Information service.
- The Common Information includes some Traffic Information – that coming from ATC.

One use case for Common Information is as part of a planning process. Once a UAS operator has determined the path for a proposed flight, then the UAS operator can use the Common Information Service to determine if any part of the flight is in U-space airspace, and if it is, what requirements there are to fly in that U-space airspace and which USSPs are certified to provide services in that U-space airspace. EU IR 2021/664 states that a competent authority may nominate a single provider of common information, which would provide a single point of reference for such a process. Section 2.5.1 considers the Common Information Service as part of the infrastructure of U-space.

#### 3.4.2.4 Summary

| Service | Provider | Consumer | Scope |
|---|---|---|---|
| Geo-awareness (U1) | State appointed | Anyone | Nationwide |
| Common Information Service | Either: State appointed<br>Or: All U-space service providers | Anyone | U-space airspace (1) |
| Geo-awareness (U2) | U-space service provider | Client of USSP | U-space airspace |

**Table 5 Geo-awareness services in EU regulation**

Note (1): The Common Information Service is mentioned in 2021/664 as being available in U-space airspaces. If it were available nationwide it might be the same as U1 Geo-awareness.

### 3.4.3 Geo-Fence Information Exchange service

The Geo-Fence Information Exchange service has been identified in the AURA project [47] as the means to communicate the result of Dynamic Airspace Reconfiguration from ATC to U-space. It can be considered to be a part of the Collaborative Interface with ATC.

## 3.5 Mission management

This section describes the Flight Authorisation service and the U-plan Processing service. As elements of these the following are also discussed:

- strategic conflict detection service
- strategic conflict resolution service
- dynamic capacity management service
- vertiport availability service
- u-plan preparation and optimisation service
- environmental data services
- risk analysis service

The UAS flight authorisation service is mandated under EU Regulation 2021/664 Article 10 [8] [11]. Flight authorisation in 2021/664 only has very limited scope. The Flight Authorisation service described here was referred to as the Operation Plan Processing service in Edition 3 [1] and has a larger scope.

| Action | EU Regulation 2021/664 | Edition 4 |
|---|---|---|
| Specific operations risk assessment | No | Some support |
| Obtaining permission to fly | No | No |
| Checking the operator is registered | Yes | Yes |
| Listing geo-zones penetrated by the flight | Yes | Yes |
| Obtaining permission to enter a geo-zone | No | In some cases |
| Confirming the flight has permission to enter a geo-zone / confirming the flight conforms to geographic bounds | No | In some cases |
| Uniquely identifying each flight | Yes | Yes |
| Storing and making available the flight intent for use by other services before, during and after the active phase | Yes | Yes |
| Strategic Conflict Resolution | Yes | Yes |
| Dynamic Capacity Management | No | Yes, when appropriate |
| If the flight penetrates a region controlled by ATC, coordinating the flight with the ATC for that region | No | Yes |

**Table 6 Relative scopes of the Flight Authorisation Service of 2021/664 and this ConOps**

### 3.5.1 U-plan Preparation / Optimisation service

It is assumed that many UAS operators will have a tool to develop plans for flights and send those plans for authorisation. This tool may be a service provided by a USSP and is referred to as the U-plan Preparation / Optimisation Service. Different versions of this service could be imagined for different business sectors. These tools are expected to be very valuable to UAS operators, however the details of how they work is out of the scope of this ConOps.

Supporting the U-plan Preparation / Optimisation service, various services providing geographic data used in planning may be offered:

#### 3.5.1.1 Population density map

The Population density Information service collects and presents the relevant density map for the drone operation. This map is used to assess ground risk.

Proxies for instantaneous population density information such as mobile telephone density (to be confirmed) might be found to be reliable.

#### 3.5.1.2 Electromagnetic interference information

The service collects and presents relevant electromagnetic interference information for the drone operation. The service shows where there may be a risk to the C2 link or other aspects of drone function due to radio frequency emissions.

#### 3.5.1.3 Navigation Coverage information

The service to provide information about navigation coverage. This can be specialised depending on the navigation infrastructure available (e.g. ground or satellite based). This service is used to plan operations that rely on such coverage. It may show regions with known issues or regions in which augmentation is available.

#### 3.5.1.4 Communication Coverage information

This service provides information about the communication coverage. It can be specialised depending on the communication infrastructure available (e.g. ground or satellite based). This service is used to plan operations that rely on such coverage. For example, this might be a map of the calculated or measured signal strength of mobile internet based on mobile telephony standards such as 3G, LTE 4G, 5G and so on.

#### 3.5.1.5 Risk Analysis Assistance

Preparation of Specific operations involves SORA (see Annex I to EASA ED Decision 2019/021/R - Acceptable Means of Compliance (AMC) and guidance material (GM) to Commission Implementing Regulation 2019/947 [3]) which requires analysing risks associated with the operation. It is expected that a service will be offered to support this analysis using the draft U-plan as well as information coming from the Drone Aeronautical Information Management service (Section 3.4), various Environment services and the Traffic Information service (Section 3.14)

The risk analysis assistance service may also provide access to “per flight insurance” services.

### 3.5.2 Flight Authorisation service

Edition 3 of the ConOps [1] referred to this as part of the Operation Plan Processing. To follow EU regulation 2021/664 [8], the name Flight Authorisation service is used.

The Flight Authorisation service is deployed in U2. It receives U-plans and uses these for a number of safety-related activities. The Flight Authorisation service must be deployed in a robust and reliable manner because of its safety criticality.

The description of operations presented here is as if the system providing the flight authorisation service is a single integrated instance. This is the operational view. The implementation may be otherwise – that choice is out of the scope of this ConOps.

The Flight Authorisation service maintains a pool of data containing the histories of all submitted U-plans that have not yet been archived. Archiving occurs at some time after the U-plan is ended (after flight) or is cancelled (without ever flying). The U-plans in this pool are considered to be commercially sensitive and may additionally be restricted for other reasons – such as for state operations. Hence access to this pool is controlled.

The role that submits a U-plan to the Flight authorisation service is the drone operator representative. To do this they probably use an U-plan preparation / optimisation service or tool. The submission will be by some secure means.

The sum of all the U-plans known in the Flight authorisation service is “the traffic.” The impact of a U-plan being submitted is to an extent felt by all other drone operators as a change in the traffic. To maintain commercial secrecy while multiple instances of the flight authorisation service collectively build a pool, the pool might only contain the minimum information, as proposed in ASTM F3548-21 Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability [18].

The Flight authorisation service is the doorway through which a number of services are reached. The following can be taken as an approximate list of the steps taken by the Flight authorisation service when a U-plan is received.

- Syntax check. Does whatever has arrived resemble a U-plan enough to be processed?
- Semantic check. Are all the expected pieces of information present?
- If OK so far, generate a unique identifier for the U-plan.
- Authorisation-check using the Registration service, see 3.2. Is there some reason this operator or this pilot or this drone should not be flying?
- Check the 4D trajectory supplied in the U-plan is credible. (e.g. no gaps)
- Weather warning, using the Weather information service. Is there a weather warning for the time and place of the operation?
- Geo-Fencing, height limits and other boundary checks, using the Drone aeronautical information service and the 4D trajectory. For any geo-fences that are penetrated, is there a corresponding permission in the U-plan? For any conditional access, are the conditions met?
- Procedural interface with ATC. If any controlled areas are penetrated by the 4D trajectory then the procedural interface with ATC is triggered for each.
- The Strategic conflict-management service is invoked. See Sections 3.5.2.2 and 3.5.2.3
- If appropriate, the Dynamic capacity management service is invoked. See Section 3.5.2.5

Figure 9 shows the process outlined above as a flow chart. Figure 8 shows the simpler process of the EU regulation 2021/664, expected in the Initial U-space implementation (2023-2030) described in section 1.4.3.

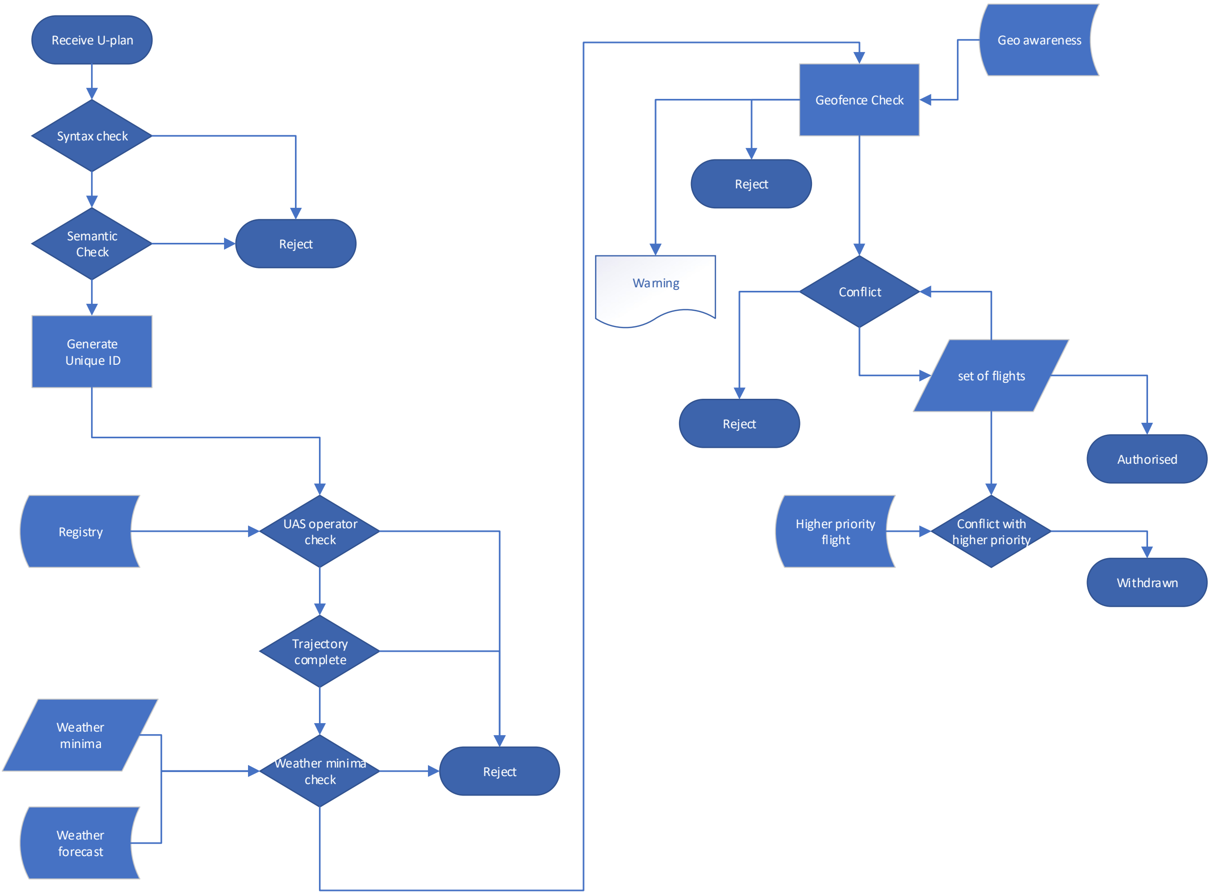


**Figure 8 Flight authorisation in EU IR 2021/664**

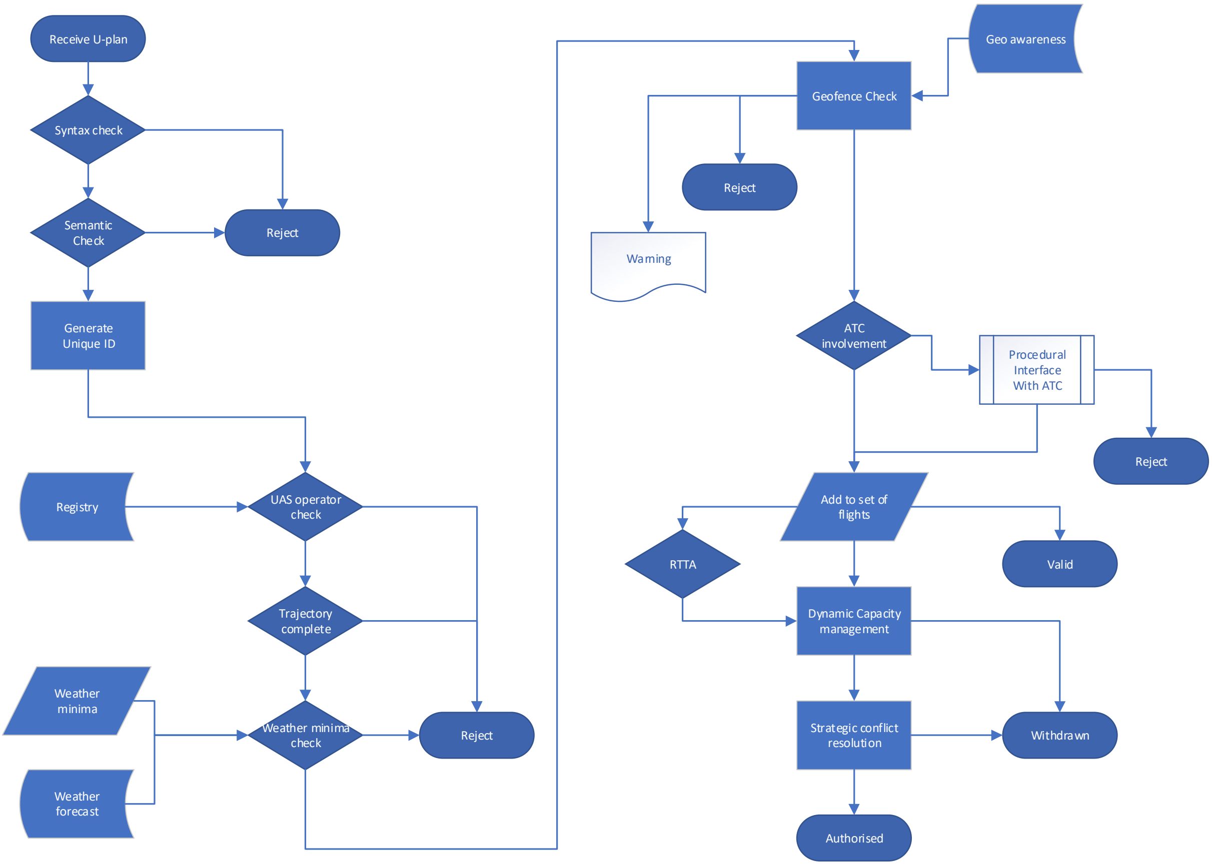


**Figure 9 Flight Authorisation flow chart including RTTA**

The response from the processing should be a copy of the accepted U-plan including its unique identifier, together with any conditions, for example from the procedural interface with ATC, or an explanation of any problems that have prevented acceptance.

The flight authorisation service will also offer a validation mode in which the U-plan is checked, but not submitted (i.e. not added to the set of operations.) This mode supports risk assessment processes as well as optimisation. Some parts of the process – such as the procedural interface with ATC – will not be fully executed in validation mode.

Once a U-plan has been accepted by the Flight authorisation service, the operator may send further messages to:

- Cancel the U-plan,
- Change the U-plan,
- Ask for the current status of the U-plan.

Further an operator can query the service to get a list of all the U-plans known that have been submitted by that operator and their status.

The status of a U-plan can change after the U-plan is accepted, see Section 2.2.3.3, due to

- A change in the airspace structure,
- A conflict with another U-plan,
- Capacity being exceeded and this plan being subject to a measure to reduce demand.

The operator should be notified directly by the Flight authorisation service if such an event occurs, and it changes the status of the U-plan.

The status of a U-plan also changes when it is activated. A further status change occurs on receipt of end-of-flight.

The following table summarises the different interactions that involve the Flight authorisation service.

| Role / Node | Action | notes |
|---|---|---|
| Drone operator representative | Submits U-plans, changes, cancellations<br>Activates and terminates U-plans<br>Receives positive or negative acknowledgements<br>Queries U-plans or status<br>Receives status change warnings | May use an U-plan preparation / optimisation service or tool. |
| Aeronautical Information Service<br>(may be supplied via Common Information Service) | Supplies aeronautical publications<br>Supplies NOTAMs | This service and these publications already exist for the benefit of existing aviation. |
| Drone Aeronautical Information Service (Common Information Service) | Supplies X, Y , Z volumes and other drone specific information | |
| Registration service | Confirms the validity of the operator, any pilot training, the type of drone mentioned in any plan | |
| Weather Information service | Supplies weather forecasts and warnings | |
| Procedural interface with ATC | Triggers a coordination for a flight to penetrate a controlled area. | |
| Strategic Conflict Prediction service<br>Strategic Conflict Resolution service | Detects and resolves conflicts before flight<br>May trigger a state change | |
| Dynamic Capacity Management service | Detects and resolves demand and capacity imbalances<br>May trigger a state change | |
| Network identification service | Queries U-plans, U-plan identifiers and U-plan states<br>Creates / feeds / destroys flight surveillance session(s) associated with a U-plan | |
| Monitoring service<br>Including<br>Conformance Monitoring service | Retrieves a plan<br>Updates the current position of a plan<br>Signals non-conformance, which may change the state of a plan | |

Table 9: Flight Authorisation service Roles and Actions

#### 3.5.2.1 U-plan processing service

Once a U-plan is activated, the U-plan processing service links the U-plan with the stream of surveillance data, see section 3.3. The combination is a version of the plan with reduced uncertainties. It may be used in Conformance Monitoring, Tactical Conflict Prediction and exchanged with Drone surveillance systems.

#### 3.5.2.2 Strategic Conflict Prediction

The Strategic conflict prediction service may be invoked by the Flight authorisation service, before the flight takes place, because a new U-plan has been submitted or because a previously submitted U-plan has changed.

##### 3.5.2.2.1 The 4D trajectory

The 4D trajectory of the U-plan is made of a series of one or more four dimensional volumes. Each volume has three dimensions in space as well as an entry time and an exit time. The trajectories of UAS flights are considered as having two basic modes of flight. The UAS could be active in an area, for example photographing crops in a field, or it could be travelling somewhere. These are expressed as volumes which are occupied for an extended period or volumes which are visited briefly.

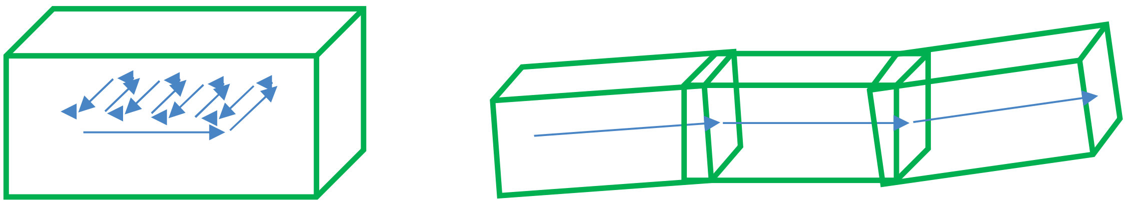

**Figure 10 Area-based and Linear 4D trajectories, in green.**

The 4D trajectory submitted in the U-plan by the UAS operator consists only of the 4D volumes, shown in green in Figure 10. The blue lines shown in Figure 10 are only to help the reader understand their purpose.

A U-plan may contain either or both linear and area-based volumes.

Each 4D volumes expresses the uncertainties of that segment of the flight. These uncertainties come from various sources:

- The capabilities of the aircraft, for example turning radius and the expected effect of the forecast weather.
- The imprecision of the navigation technology, for example GNSS receivers are typically limited by the precision of their internal clocks, while GNSS suffers from effects such as “dilution of precision” and multipath error.
- The range of take-off times. Each volume expresses the earliest possible entry time in the volume and the latest possible exit time from the volume. Because of this the volumes may overlap in time – the flight might be in more than one volume.

The uncertainty expressed in the volumes is bounded at 95%. It is assumed that the probable position of the aircraft in any dimension will follow some distribution. The region of interest is limited to 95% which for a Gaussian distribution would be two standard deviations. This figure comes from the Reich collision risk model which has long been used in aviation. See “Aircraft Collision Models” by Shinsuke Endoh, MIT Flight Transport Lab Report R82-2 [48].

In its deliverable "Algorithm for analysing the collision risk," [25] the BUBBLES project described the trajectory of UAS as being a box or a corridor. The box corresponds to the area based trajectory in Figure 10, the corridor to the linear trajectory. The expectation in this ConOps is that the linear trajectory will consist of a series of volumes rather than a single corridor as this will allow more efficient use of the airspace. At any moment, volumes that the flight has exited, or has not yet entered can be considered as not currently occupied. This liberates airspace compared to a corridor model in which the whole length of the flight is considered occupied as long as the aircraft is airborne. Hence the series of volumes described here. Obviously, the series of 4D volumes must be contiguous or overlap in order to allow the flight to progress. There can be no gaps.

It is expected that for any airspace the competent authority may publish minimum and/or maximum dimensions for the volumes in a 4D trajectory. It is particularly expected that the range of earliest possible entry time and latest possible exit time will be limited in the interests of efficient use of the airspace. For a drone flying at 20ms$^{-1}$, a take-off time ±30 seconds represents an uncertainty on the current position of the aircraft 1.2km in length. Allowing ±1 minute doubles this to 2.4km.

#### 3.5.2.2.2 Detecting conflict between trajectories

EU IR 2021/664 [8] and its Acceptable Means of Compliance and Guidance material [11] require that the 4D trajectory submitted by the UAS operator is enlarged by in each dimension by an amount referred to as a Deviation Threshold. The size of this deviation threshold is determined by the competent authority and is particular to each U-space airspace. Deconfliction then considers the 4D trajectories plus the deviation thresholds while conformance monitoring considers only the 4D trajectories. Figure 11 shows the idea of deviation thresholds in a two-dimensional diagram.

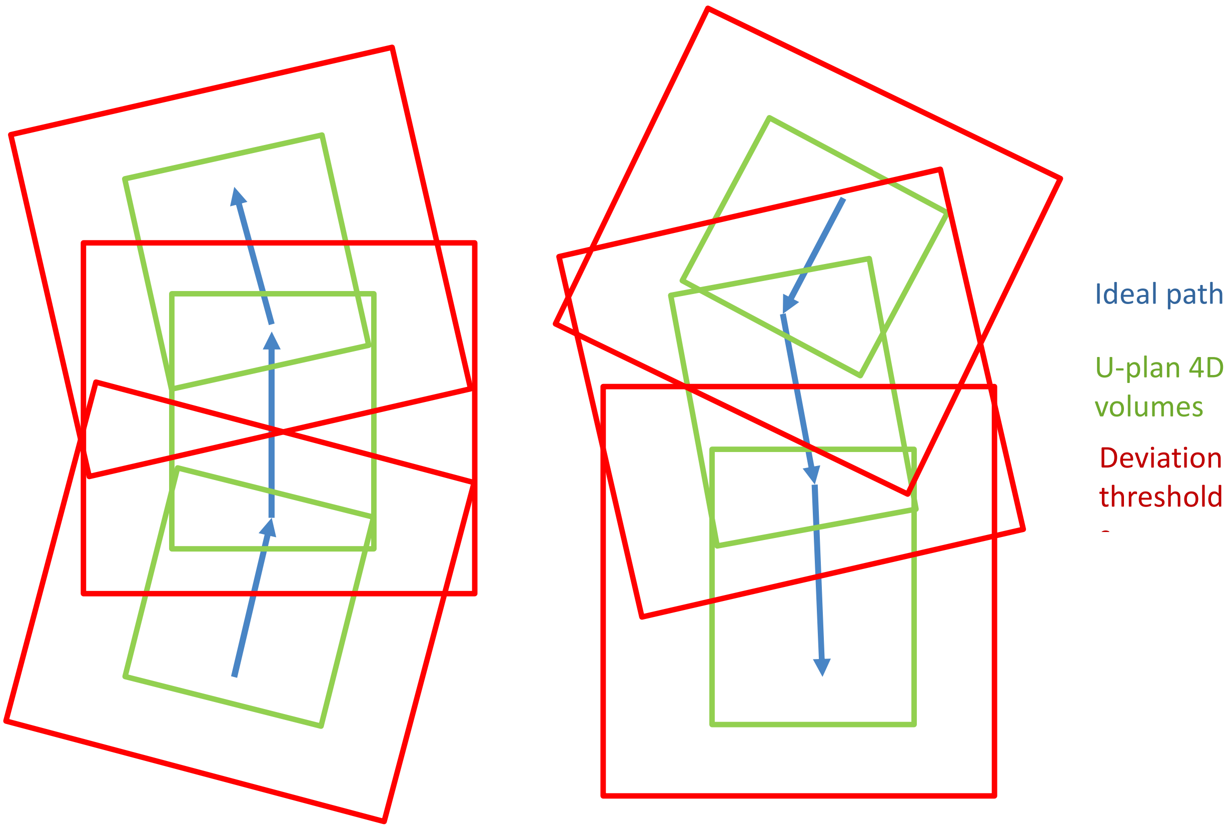


**Figure 11 Deviation thresholds for two non-conflicting U-plans**

The U-space regulation 2021/664 [8] specifies that deconfliction means that every trajectory "is free of intersection in space and time with any other."

Currently UAS operators consider flight details commercially sensitive. ASTM F3548-21 [18] is a "Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability" and describes how different USSP can discover conflicts between flights while revealing the minimum information. The standard describes the use of a "discovery and synchronisation service" DSS, for which there is a reference implantation, the Inter-USS [19], published by the Linux foundation and available on Github. In very simple term the DSS maintains a four-dimensional grid of cells and USSP express an interest in cells. When a USSP expresses an interest in a cell they are informed the contact details of any other party having an interest in that cell. The DSS can be replicated across multiple instances.

#### 3.5.2.3 Strategic Conflict Resolution

Strategic conflict resolution is undertaken by changing one of the pair of conflicting trajectories so that there is no longer "intersection." It is expected that the strategic conflict resolution service will search for non-conflicting alternatives by applying automatically generated changes from a standard set of "recipes" to the filed plan(s) and testing the result, e.g. take-off delay. Those that resolve the problem and do not cause another problem will be proposed to the operator who will refine the plan further before resubmitting or changing it.

ASTM F3548-21 [18] proposes that when it is found that two USSP have an interest in the same 4D cell, they contact each other and negotiate.

EU IR 2021/664 article 10 proposes a simple approach: the first authorised plan reserves the airspace in which it flies. This is qualified by there being two priorities of flight and a higher priority will take precedence over the lower, but within the same priority, the earliest to be authorised is accepted and others are rejected. This rejection can be understood as signalling to the UAS operator that their plan needs to be changed.

#### 3.5.2.4 Fairness in strategic conflict resolution

In case of a conflict between two flight plans, the conflict is usually resolved by changing one of the plans. This change may be viewed as a penalty. UAS operators are expected to file plans that are in their best interest, that best optimise their business. Any change will move the plan away from that optimisation - to some degree.

The "first to file" prioritisation of EU regulation 2021/664 systematically penalises types of operations that cannot file long in advance, such as "on demand" services like food delivery.

There is a desire to achieve fairness in strategic conflict resolution. What exactly fairness means is currently the subject of research, as is how it might be achieved, such as RTTA: see 2.2.3.2.3. Many other approaches could also be imagined, see "Market Design for Drone Traffic Management" [27] for an overview.

#### 3.5.2.5 Dynamic Capacity Management

Dynamic Capacity Management aims to match demand with capacity and has two threads. Demand may be regulated to match capacity, or capacity may be changed to match demand.

U3 brings Tactical Conflict Resolution, in type Z airspace. The level of confidence in how well this service will work can be matched to the difficulty of the task the service faces by limiting the number of flights in a particular volume of air, which is the job of the Dynamic Capacity Management Service.

#### 3.5.2.5.1 Inner working

This section condenses the work done by the DACUS project. See the Drone DCB concept and process [29].

There will be a process to predict times in the future when an airspace will be "full" or "saturated". The details of this process are out of the scope of this document but it will be related to the probability that flights lose safe separation, or that some social acceptability metric (e.g. noise) has reached its limit. The parameters for this decision may be set as a function of other characteristics of the airspace.

When this process determines that the airspace is full, what follows is based on a parameter known as the "reasonable time to act" (RTTA), and considerations of priority – see Section 2.2.3.2.

The solution is generally to propose a delay for flights or to propose rerouting them away from the full airspace. If this has to happen:

- All high-priority operations continue unhindered, as far as possible.
- Apart from high priority operations, all operations for which an U-plan was submitted after the RTTA for the flight are the first candidates to be proposed a plan change due to the airspace being full at the time they are planned to cross. If the above will not solve the problem, lower-priority operations are examined to find those causing the greatest risk of conflict, hence whose removal would cause the largest overall reduction in risk to the airspace.
- If the above will not solve the problem, all U-plans take part in a process that proposes changes to those with the lowest priority, working upward until the problem is solved.

#### 3.5.2.5.2 Invocation

The Dynamic capacity management service is expected to appear in U3. It is invoked by the Flight authorisation service. It has no independent use. It is invoked if and only if the airspace requires it.

The Dynamic capacity management service uses the probabilistic 4D models calculated by the Flight authorisation service.

#### 3.5.2.5.3 Modulating capacity in response to demand

A number of approaches can be followed that will change capacity in response to demand.

- There may be a traffic organisation scheme in which traffic is collected into certain regions while others are generally not used, for example for noise abatement reasons. There could be traffic level triggers that allow the unused regions to come into use.
- Similarly, prediction of or experience of "hotspots" may trigger a revision of any traffic organisation scheme; for example measures that produce more homogenous traffic such as one way systems or speed-controlled zones.
- Longer-term trends might lead to changes in the technical requirements for the volumes concerned. For example, higher-precision tracking and navigation may allow closer spacing between aircraft and may be mandated for a volume that is frequently subject to demand regulation measures.



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This ConOps does not include any study of traffic organisation. The exploration of methods to increase capacity in response to demand is left for future research.

#### 3.5.2.6 Flight authorisation states

The U-plan has a number of distinct phases in its life. Different observers may identify different states of the U-plan depending on their particular interests.

1 Draft. There is a business need and a U-plan is being developed.
2 Approved. The U-plan has been filed, strategically deconflicted and so on. Resources (e.g., airspace, vertiport) are now committed to this flight.
3 Active. The services used in flight are operating. Tracking, emergency management, etc.
4 Ended. The flight is over.

There are a few other states that can usefully be added to that set. Flights may have been approved but then due to changes in circumstances, for example a higher priority flight is in conflict with the U-plan, this approval might be withdrawn. Flights might be already activated and then the same change in circumstances make them activated but not safe. Flights may invoke contingency procedures which means that they are flying but not following the original plan.

## 3.6 Tactical conflicts

Tactical conflict prediction and resolution avoid conflict by changing the flight while it happens. These can be implemented as advisory services or as systems giving instructions. The descriptions here assume that the services are implemented on the ground and not as a function distributed among the aircraft.

It is expected that an aircraft to aircraft system for avoiding conflicts during flight, known as "detect and avoid" or "sense and avoid", will either be used when there is no Tactical Conflict Resolution service or act as a safety net in addition to (i.e. after) Tactical Conflict Resolution.

### 3.6.1 Tactical Conflict Prediction

The Tactical conflict prediction service requires that the positions of all aircraft be known and frequently updated in the airspace volume being served, and further that the precision with which these positions are known can be reliably determined. The Tactical conflict prediction service is highly linked with the Tracking service (see 3.3.2) and the Vertical Alert and Information Service (see 3.20) to provide common-reference altitudes of all aircraft. The service may also take intent into account, as obtained from the U-plans in the U-plan processing services (see 3.5.2.1) Based on current motion and (where available) intents, the service predicts conflicts and provides alerts to the operators/pilots and to the USSP.

A Tactical Conflict is a prediction that two aircraft "come too close together" or "lose separation." The predicted positions/motions of the aircraft are uncertain as each is based on previous observations of position and motion that have limited accuracy, which are then used in approximate models of the behaviour of the aircraft to predict the current and future positions/motions. In function of the uncertainties of the positions of the aircraft, the loss of separation considers a volume around the calculated position of the aircraft with the view that the aircraft is probably somewhere within the volume. The BUBBLES project [54] follows conventional logic by naming this the "Near Mid-Air-Collision" (NMAC) Volume. In Figure 12, from the BUBBLES project, the NMAC volume is surrounded by three larger volumes; the Collision Avoidance threshold - at which any on-board collision avoidance system should trigger, the separation threshold, which the strategic and tactical conflict detection and resolution services should protect, and the tactical conflict threshold which is the distance at which the tactical conflict detection should trigger a resolution. These distances are not shown to scale.

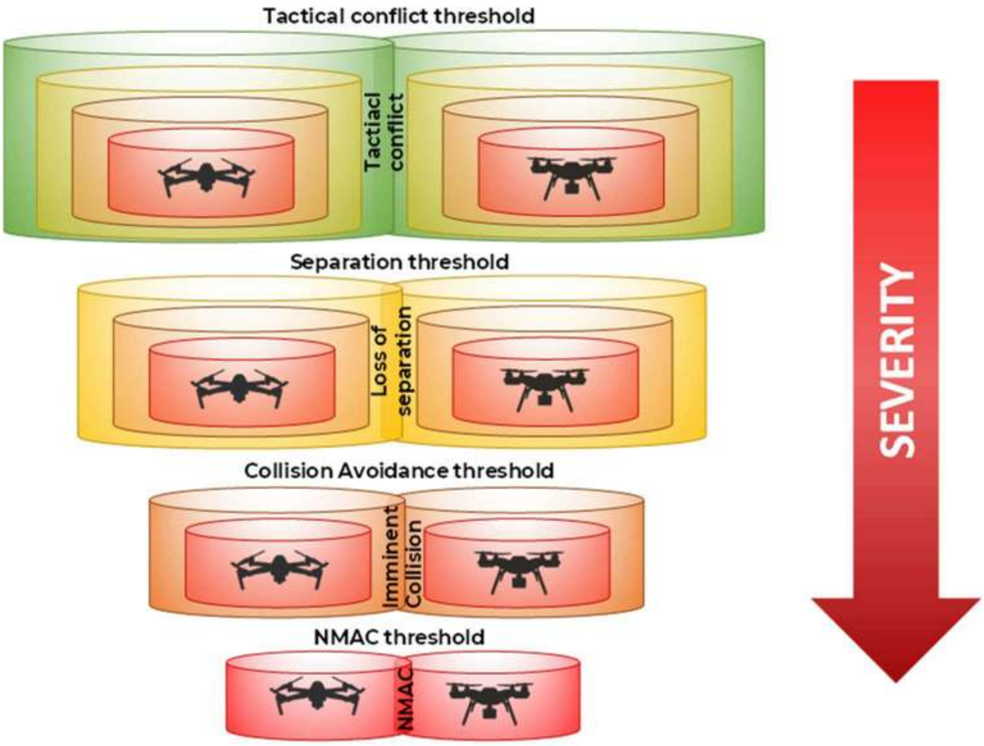


**Figure 12 Near Mid-air-collision volume and other thresholds - from BUBBLES**

### 3.6.2 Tactical Conflict Resolution

On receiving a conflict alert from the Tactical conflict prediction service, the Tactical conflict resolution service issues advice (Zz volume) or instructions (Zu volume) to aircraft to change their speed, level or heading as needed to resolve these conflicts. The advice / these instructions should reach the pilot (or piloting system) rapidly and reliably.

The Tactical conflict prediction and resolution services can work more effectively if they make use of models of the flight envelope and characteristics of each aircraft concerned. Further efficiency gains may be made if the service is aware of the intent (that is the U-plan) of each flight.

The Tactical conflict resolution service is a client of the Tracking service (see 3.3.2), the Flight authorisation service (see 3.5.2) and the Drone aeronautical information management service (see 3.4).

A much more detailed examination of Tactical Conflict Resolution appears in deliverables of the BUBBLES project, notably “Algorithm for analysing the collision risk,” D4.1 [25] and “Guidelines to implement separation minima and methods,” D4.2 [26]. The BUBBLES project provides describes a method to derive the separation minima from such factors as the CNS performance and target level of safety.

## 3.7 Vertiport availability service

As described in section 2.4.1, whether a vertiport is available to be landed at will be information to be considered in the planning for contingencies for UAS which consider that Vertiport as an alternative landing site. Due to the possibility that the vertiport might be used as an emergency landing site, the vertiport availability is not guaranteed for flights that have planned its use.

The vertiport availability service provides information to a UAS operator on whether a vertiport FATO is occupied or available during a requested period.

The vertiport availability service is a planning service.

Use of the vertiport will imply contractual arrangements and the agreement of permission to land including any relevant arrival procedures, contingency processes, technical constraints and so on. Ideally the vertiport availability service will support these exchanges.

## 3.8 Weather Information

Article 12 of Reg. 2021/664 mandates the provision of a weather information service. This service will collect and present relevant weather information for the drone operation. This includes hyperlocal weather information when available/required.

Weather Information may be used for air worthiness decisions – for example are the capabilities of an individual aircraft likely to be exceeded by the forecast wind, and/or for traffic management – for example does the visibility exceed mandated minima.

## 3.9 Geographical Information Service

The Geographical Information Service (GIS) provides a 3D model of terrain and obstacles for use during planning, updated continuously for use during flight. GIS extends the Geospatial Information (GI) service referred to in Edition 3 [1].

Sources of data could include digital surface models combined with a ground obstacle database, or from direct mapping of the obstacles. The map data quality will be announced and assured by the service provider.

## 3.10Monitoring

Subject to appropriate data-quality requirements, this broad service retrieves data from the tracking service and combines it with information related to:

- the flight plan, from the U-plan processing service, in order to achieve the Conformance Monitoring service (see 3.10.1),
- obstacles, from the Geographical Information Service, in order to provide the Vertical Alert and Information Service (see 3.20),
- other aircraft from the Traffic Information service to provide an air situation status report for authorities, service providers, and operators, including pilots,
- geo-fences from the Geo-awareness service in order to provide geo-awareness compliance monitoring and warnings (see 3.4.3),

- weather information from the Weather Information service to provide weather limit compliance monitoring.

Alerts from the Monitoring service should be emitted in a manner compatible with all drone operations, hence audio alerts are preferred.

Monitoring is a client of the Tracking and Drone aeronautical information management services and of the different environmental services.

### 3.10.1 Conformance Monitoring service

Article 13 of EU IR 2021/664 requires that a Conformance monitoring service be in place to "enable UAS operators to verify whether they comply with the requirements set out in article 6(1) of the same regulation [referring to the obligations of UAS operators] and the terms of the UAS flight authorisation." Furthermore, article 15(g) of EU IR 2021/664 mandates legal recording of flights and article 15(d) requires incident and accident reporting. All of these requirements are discussed in this section.

The monitoring service supplies conformance monitoring.

## 3.11 Legal Recording

The aim of the legal recording service is to support accident and incident investigation. The service should record all inputs to U-space and allow the full state of the system at any moment to be determined. A second use of legal recording is as a source of information for research and training. Finally, post-processing of legal recording data by dedicated (e.g. AI-based) algorithms can identify high risk situations and adapt parameters for risk assessment of future operations.

In view of the commercial sensitivities of drone operators, it is likely that access to the recordings will be restricted.

## 3.12 Emergency Management

The Emergency management service of U-space has two aspects:

- assistance to a drone pilot experiencing an emergency with their drone,
- communication of emergency information to those who may be interested:
    - pilots whose drones may be affected,
    - crewed aviation, air traffic services,
    - police, military and similar

The assistance given to a pilot may include:

- enabling the reporting of an emergency,
- detection and alert of an emergency (when possible),
- proposals for action to be taken to minimise risk,
- reminders of contingency plans or emergency response plans.

The Emergency management service needs to be configured for the "current operation." The pilot will need to identify their drone and/or drone U-plan if any. If the drone is not using the position report submission service then the pilot will need to give the location of the flight during 'log-on'. Emergencies communicated to the drone pilot are those likely to come near their operation and hence pose a risk to it.

The Emergency-management communication channel should be monitored at all times by the drone pilot. Human factors should be considered during the deployment of this service; the channel may be inactive much of the time and the pilot may be under stress during any emergency. The U-space service will add value by filtering the information sent on the communication channel to maintain relevance for the pilot.

The Emergency management service consumes information from the Tracking, Monitoring and U-plan processing services – if active for the operation concerned. If the flight has an U-plan, the Emergency management service will warn the pilot when a geo-fence-with-immediate-effect has been created which affects the current flight.

## 3.13Incident / Accident reporting

An Incident/accident reporting service is a requirement of Article 15(d) of Reg. 2021/664. This service allows drone operators and others to report incidents and accidents. It allows these reports to mention drone identifiers and U-plan identifiers to help later investigation.

The service maintains the reports for their whole life-cycle. The system is secure and only gives access to authorised persons.

The Accident and Incident reporting service is a client of the Legal Recording service (see 3.11) and hence indirectly all parts of U-space. There may be some linkage between the Emergency Management service and the Accident and Incident reporting service; some Emergency events may trigger automatic creation of an Accident/incident report.

U-space should also allow citizens to report what they have observed when they believe incidents or accidents involving drones have occurred. The user-interface should be designed to encourage the reporting of sufficient information to identify the flights concerned.

## 3.14Traffic Information

A traffic information service is mandated in EU IR 2021/664, article 11. This service provides the drone pilot or operator with traffic information and warnings about other flights – crewed or uncrewed - that may be of interest to the drone pilot. Such flights generally have some risk of collision with the pilot's own aircraft.

Traffic information is also the presentation of "air situation." There is some commercial sensitivity to drone flight information and an air situation display may be restricted. Note that an air situation display presents an image to the user; it is foreseen that tracks will be shared between U-space and ATM through the Surveillance data service – see 3.3.3. The traffic information should be subject to Vertical Conversion Service (see 3.19) when it is available in order to present information that is meaningful to the recipient.

The Traffic information service also gives access to the traffic densities expected in the near future at any location, as calculated from U-plans that have been submitted.

## 3.15 Infrastructure monitoring

Services exist to report the current state of critical infrastructure.

### 3.15.1 Navigation Infrastructure Monitoring

The service to provide up to date status information about navigation infrastructure. This service is used before and during operations. The service should give warnings of loss of navigation accuracy. Specifically, the GNSS service retrieves data from EDAS (the EGNOS Data Access Service), from the Reference Stations database and, through the USSP API, from the U-Space Tracking and Monitoring service (see Section 3.3.2) provided by the USSP. Once all the necessary data have been obtained, the service can provide GNSS signal monitoring, Position Velocity and Time (PVT) and Integrity calculation.

This service may also distribute correction information coming from augmentation services, and even RTK (real time kinematic) augmentation as appropriate.

### 3.15.2 Communication Infrastructure Monitoring

The service to provide up to date status information about communication infrastructure. This service is used before and during operations. The service should give warnings of degradation of communications infrastructure.

## 3.16 Digital Logbook

The digital logbook service extracts information from the legal recordings to produce reports relevant for whoever is using the service. It shall give users access to their own information only.

Drone operators and pilots will be able to see summaries of information for flights they have been involved in; start and end times, places, aircraft id, and so on.

Drone pilots will be able to see histories of and statistics about their flight experience.

Drone operators will be able to see histories / statistics for their aircraft.

The digital logbook service needs to be securely implemented. Various query functions should be available.

Authorised users, such as accident investigators or police may have general access to all data.

## 3.17 Procedural interface with ATC

The procedural interface with ATC is a mechanism for coordinating the entry of a flight into controlled airspace. The interface works before the flight takes place. The U-plan processing service will invoke the service and through it:

- ATC can accept or refuse the flight,
- ATC can describe the requirements and process to be followed for the flight.

### 3.17.1 Dynamic Airspace Reconfiguration (DAR) Service

Project PJ34/AURA [47] has studied the interaction between ATC and U-space and proposes the Dynamic Airspace Reconfiguration (DAR) Service.

In the medium to long-term, there is an assumption that the number of UAS operating in controlled airspace will be much higher than the number of crewed aircraft (e.g., ratio of 10:1). This service aims at managing such a UA dense operating environment in shared ATM/U-Space airspace (Y volume).

The service is eligible in a known traffic environment of cooperative operations in lower-level controlled airspace. A portion of the overall operational environment where the majority of crewed and uncrewed interactions are likely to occur and where the demands on the interface and utilisation of its services are likely to be greatest. This corresponds to airspace classes A – D and also to class E when all the air traffic is electronically conspicuous.

The service enables operational integration through the delegation of portions of airspace for either crewed or uncrewed operations through a process called **Dynamic Airspace Reconfiguration (DAR)**. While partially resembling a form of traditional airspace segregation, there are several aspects which diverge from this conventional concept and align closer to a form of separation.

- **Enables wide-scale, high volume access** for UA to certain parts of controlled airspace, increasing the available airspace for UAS to operate in, rather than conventional segregation which typically curtails or restricts the movement of airspace users to specific set regions/corridors.
- **High granularity and fidelity** DAR, which, unlike large, pre-defined blocks of segregated airspace, enables better utilisation of the controlled airspace for a mix of crewed and uncrewed airspace users.
- **Highly dynamic and responsive to demand**, reconfiguring the airspace both tactically and strategically. In contrast to conventional segregated areas, this concept is able to respond in almost real-time to changes in demands on the airspace.

**ATC manages DAR**, delegating portions of the controlled airspace for U-space services to manage according to crewed and uncrewed traffic demands.

- Portions of controlled airspace where **ATC have control** are termed '**blue**' volumes. For example, there could be pre-defined blue volumes within controlled airspace whose airspace matches crewed Standard Instrument Departure Routes (SIDs) and Standard Terminal Arrival routes (STARs).
- Portions of controlled airspace where **ATC have delegated management of the airspace to U-space** are termed '**orange**' volumes. For example, areas within the controlled airspace not in proximity to the airport or crewed flight paths which are clear of other hazardous objects.

Orange volumes are geo-caged to prevent uncrewed operations straying outside their flight paths and infringing on blue volumes of ATC controlled airspace. There are safety buffers between blue and orange volumes.

In the event that crewed operations seek to operate in airspace which is currently a U-space airspace delegated volume and uncrewed operations seek to operate in airspace which is currently an ATC controlled volume, these requests are considered by ATC who will implement DAR and alter the airspace structure to allow these operations if possible. This can be done pre-tactically or tactically.


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The result being that crewed operations always occur in blue volumes and uncrewed operations always occur in orange volumes within CTA.

ATC will not perform active monitoring over all UA operations within the CTA, as it can be assumed that USSPs will take over this responsibility in orange areas. ATC will only monitor a UA flight which has direct implications on the operations of crewed aircraft.

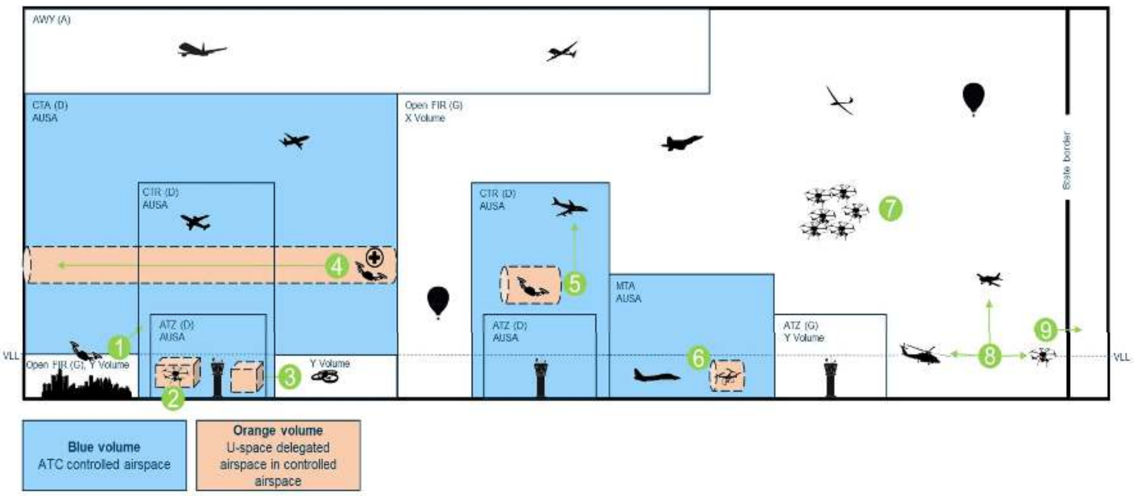


**Figure 13 AURA scenario with airspace predominantly controlled by ATC**

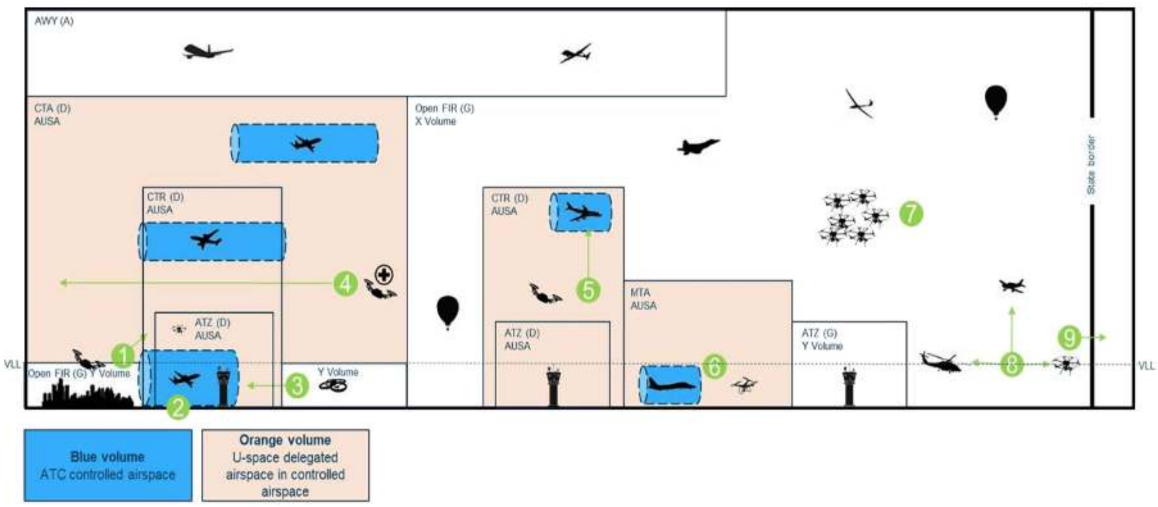


**Figure 14 AURA scenario with airspace predominantly U-space**

The subject is further discussed in the AURA project deliverables [47].

## 3.18Collaborative interface with ATC

The collaborative interface with ATC is introduced in U3 and is a service offering communication between ATC and U-space or the appropriate representative of a drone flight, which could be the remote pilot, the drone itself in case of automated flight or in some cases the USSP. The collaborative interface with ATC is expected to used while a drone is close to or in a controlled area. The communication to a pilot may be verbal or textual / graphical and to U-space will be by means of a data exchange model. The Collaborative interface allows flights to receive instructions and clearances in a standard and efficient manner, replacing the ad-hoc solutions used prior to this service's being used.

The Procedural Interface with ATC is the normal method for obtaining approval to enter a controlled area. ATC may refuse to accept flights as they choose. The collaborative interface is not a means for avoiding such approval.

In addition to communications, the Collaborative Interface with ATC provides for safe operation by giving ATC access to U-space surveillance data.

### 3.18.1Tactical Operational Message Info Exchange

The project GOF2 [46] has proposed several information exchange models, which are in annex to this ConOps. Project PJ34/AURA [47] has studied the interaction between ATC and U-space and has adopted the information exchange models of GOF2. AURA has highlighted the need for an information exchange to exchange operational messages. This service is considered here to be a sub-part of the Collaborative interface with ATC.

## 3.19Vertical Conversion Service

The Vertical Conversion Service (VCS) and the Vertical Alert and Information Service (see Section 3.20) are both elements of the proposed ICARUS suite of services not mentioned in Edition 3 [1]. The VCS ensures the conversion of altitudes between barometric and geodetic reference systems to both crewed and uncrewed aircraft in Geodetic Altitude Mandatory Zones (GAMZ). It uses other services and ICARUS sub-services to calculate the geometric height a crewed plane is flying at, and the barometric height of a drone and shares these with other aircraft in the vicinity.

The Vertical Conversion Service retrieves weather data from weather service providers, from the USSP (Weather information service) and from the Weather Reference Station database. It also obtains GNSS data and barometric data etc. about crewed aviation through interfaces with ATM.

## 3.20Vertical Alert and Information Service

The ICARUS project [28] has defined the Vertical Alert and Information service (VALS) which alerts pilots of crewed and uncrewed aircraft in any Geodetic Altitude Mandatory Zones (GAMZ) to any risk of collision with ground obstacles, using APIs (Application Programming Interfaces) from the Air Navigation Service Provider (ANSP) and the USSP respectively. This is done through using the GIS (Section 3.9), Navigation Infrastructure Monitoring (Section 3.15.1), and VCS (Section 3.19) services that provide it with the position of the crewed aircraft and the drone, and their barometric and geometric heights. For UAS the service is part of the monitoring service. For crewed aircraft is requires separate provision – or monitoring of crewed aircraft.

## 3.21 Service names in comparison with EU regulation and the previous ConOps

This section draws on the ConOps edition 3 [1] and seeks to align the material with EU regulation. The following table lists the U-space services which are then described each in its own section. In each row is the relationship with EU regulation. Note that EU IR 2019/947 [4] & [6] does not refer to U-space services but does make obligations that are answered by what this document refers to as U-space services. EU IR 2021/664 [8] does refer to U-space services, but only describes a small number used by the operator. ConOps edition 3 broke the services down into their different functions.

| Edition 4 service | section | Edition 3 Service | U-level | 2019/947 & 945 | 2021/664, 665 & 666 |
|---|---|---|---|---|---|
| Registration | 3.2 | Registration ( e-registration ) | U1 | 947 Article 14 | |
| | | Registration Assistance | U1 | | |
| Network identification *(see note below)* | 3.3.1 | e-identification | U1 | Partial match with remote identification | 664 Article 8 Network Identification |
| | | Position report submission subservice | U2 | | 664 Article 8 Network Identification |
| Tracking | 3.3.2 | Tracking | U2 | | Not mentioned but might be inferred in the description of the Traffic Information Service in 664 |
| Surveillance Data Exchange | 3.3.3 | Surveillance Data Exchange | U2 | | 664 Article 8 Network Identification<br>Reception of ATM surveillance data by U-space is part of the Traffic Information Service |
| Drone Aeronautical Information Management | 3.4 | Drone Aeronautical Information Management | U1 | 947 Article 15 | 664 Article 5 Common Information Service<br>(CIS has larger scope than DAIM) |
| Geo-awareness | 3.4.2 | Geo-awareness | U1 | Partially: 947 Article 15 | 664 Article 9 Geo-awareness service |
| | | Geo-Fence provision (includes Dynamic Geo-Fencing) | U2 | | |

| Edition 4 service | section | Edition 3 Service | U-level | 2019/947 & 945 | 2021/664, 665 & 666 |
|---|---|---|---|---|---|
| U-plan Preparation / Optimisation service | | U-plan preparation / optimisation | U2 | | |
| Risk Analysis Assistance | | Risk Analysis Assistance | U2 | | |
| Flight Authorisation service | 3.5.2 | U-plan processing | U2 | | Partly covered in Article 10 UAS flight authorisation service |
| Strategic Conflict Prediction | 3.5.2.2 | Strategic Conflict Resolution | U2 | | Article 10 UAS flight authorisation service |
| Strategic Conflict Resolution | 3.5.2.3 | | | | Article 10 UAS flight authorisation service |
| Dynamic Capacity Management | 3.5.2.5 | Dynamic Capacity Management | U3 | | |
| Tactical Conflict Prediction | 3.6.1 | Tactical Conflict Resolution | U3 | | |
| Tactical Conflict Resolution | 3.6.2 | | | | |
| Monitoring | 3.10 | Monitoring | U2 | | Partially covered by Article 13 Conformance monitoring service |
| Legal Recording | 3.11 | Legal Recording | U2 | | Article 15(g) |
| Emergency Management | 3.12 | Emergency Management | U2 | | Article 13 Conformance monitoring service |
| Incident / Accident reporting | 3.13 | Incident / Accident reporting | U2 | | Partially covered by Article 15(d) |
| | | Citizen Reporting service | U2 | | |
| Traffic Information | 3.14 | Traffic Information | U2 | | Article 11 Traffic information service |
| Navigation Infrastructure Monitoring | 3.15.1 | Navigation Infrastructure Monitoring | U2 | | |
| Communication Infrastructure Monitoring | 3.15.2 | Communication Infrastructure Monitoring | U2 | | |



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| Edition 4 service | section | Edition 3 Service | U-level | 2019/947 & 945 | 2021/664, 665 & 666 |
|---|---|---|---|---|---|
| Digital Logbook | 3.16 | Digital Logbook | U2 | | |
| Weather Information | 3.8 | Weather Information | U2 | | Article 12 Weather information service |
| Geographical Information Service | 3.9 | Geospatial information service | U2 | | |
| Population density map | 3.5.1.1 | Population density map | U2 | | |
| Electromagnetic interference information | 3.5.1.2 | Electromagnetic interference information | U2 | | |
| Navigation Coverage information | 3.5.1.3 | Navigation Coverage information | U2 | | |
| Communication Coverage information | 3.5.1.4 | Communication Coverage information | U2 | | |
| Procedural interface with ATC | 3.17 | Procedural interface with ATC | U2 | | |
| Collaborative interface with ATC | 3.18 | Collaborative interface with ATC | U3 | | |
| Vertical Conversion Service | 3.19 | | U3 | | |
| Vertical Alert and Information Service | 3.20 | | U3 | | |

**Table 7: U-space Services cross reference**

Notes:

Network Identification is a U2 service described in EU IR 2021/664 [8] . It partially matches the Remote ID requirement of EU IR 2019/947 [4]

EU IR 2021/664 [8] lists seven services. They are:

1. Common Information Service
2. Network Identification service
3. Geo-awareness service
4. UAS flight authorisation service
5. Traffic information service
6. Weather information service



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7. Conformance monitoring service

Numbers 2 to 7 are to be provided by U-space service providers (USSP). Number 1 may be provided by a designated Common information service provider (CISP), or if none is designated, then it is also provided by USSPs. Numbers 1, 2, 3, 4 and 5 are mandatory in all U-space airspaces. The competent authority may mandate number 6 and or number 7 in any U-space airspace.

The definitions of the EU IR 2021/664 services are extremely brief. More detail is provided in the associated Acceptable Means of Compliance and Guidance Material [11].

The following diagrams put the U-space services of this ConOps into the perspective of the obligations of EU IR 2019/947 and the services in 2021/664. Pink → Regulation, Green → U-space ConOps Edition 4, Blue → other.

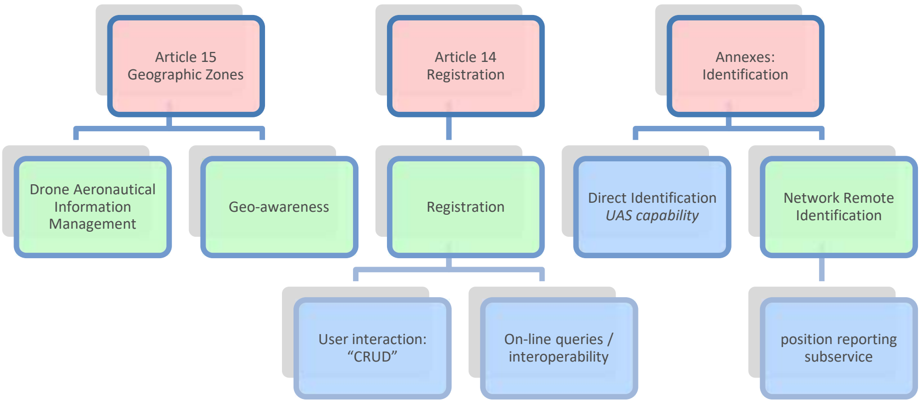


**Figure 15 EU IR 2019/947 and U1 U-space services**

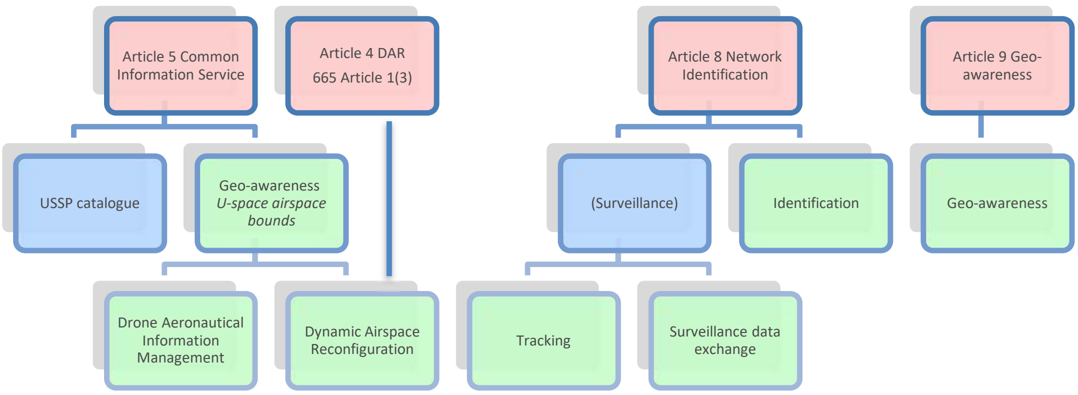


**Figure 16 EU IR 2021/664 (default), 2021/665 and U2/U3 services (1)**

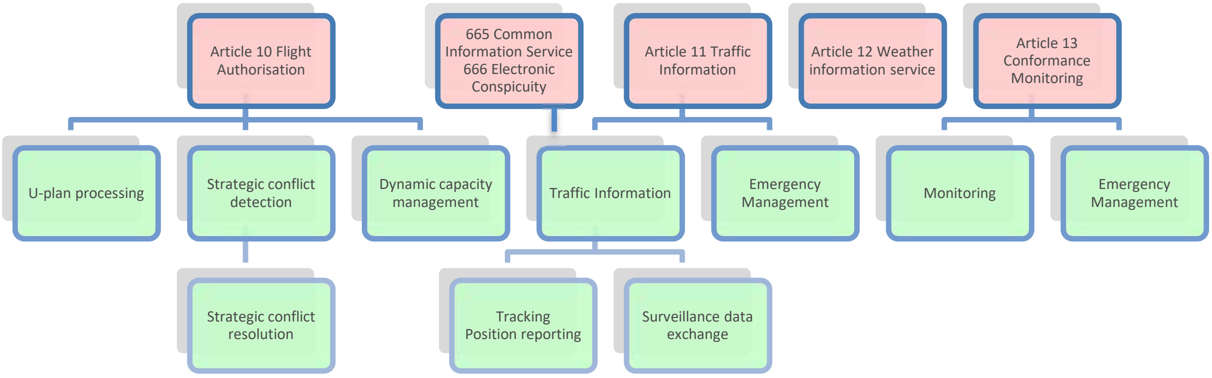


**Figure 17 EU IR 2021/664 (default), 2021/665, 2021/666 and U2/U3 services (2)**

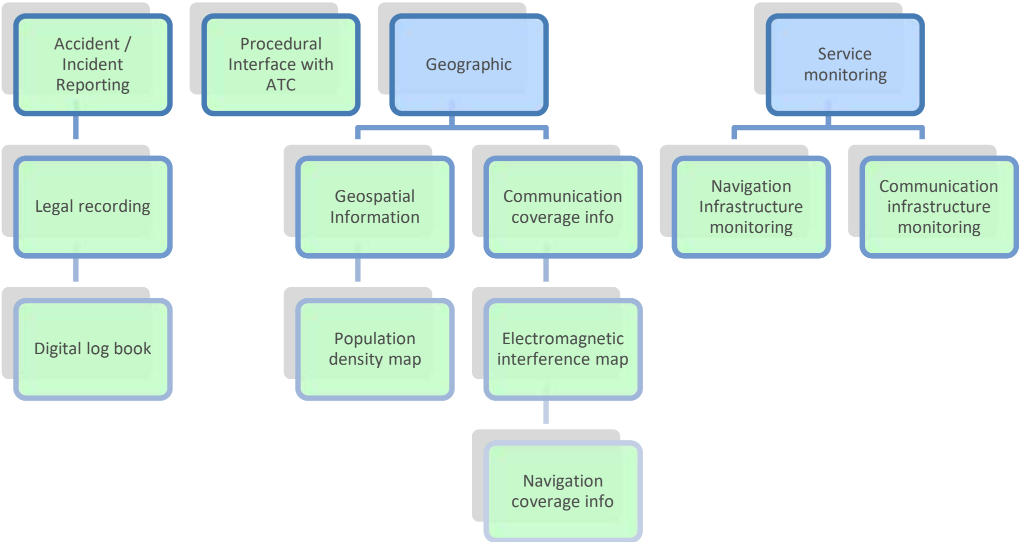


**Figure 18 U2/U3 services not linked to European regulations 2019/947 or 2021/66[456].**

Figure 15 to Figure 18 show the complex relationship between EU regulations and the ConOps services. Some ConOps services appear more than once. This complexity results from the different purposes and needs of a concept of operations and a regulation, and also the obligation on Edition 4 of the ConOps to evolve from Edition 3 which has been widely used in the research community.

# 4 Flight rules

This section briefly introduces the topic of the rules of the air for flights receiving U-space services. This topic is the subject of ongoing work as this edition of the ConOps is being prepared and this section will be enlarged in the next edition.

## 4.1 Rules of the Air

ICAO Rules of the Air date back to October 1945 when the first international recommendations for Standards, Practices and Procedures for the Rules of the Air were established and ultimately amended into Annex 2 [13]. The Standardised European Rules of the Air (SERA) [12] includes the transposition of Annex 2 into European law. The legislative framework for SERA includes Regulations (EU) 923/2012 [12], amendment Regulations (EU) 2016/1185 [52] and the Aviation Safety (Amendment) Regulations 2021 [51] applies to all European Union states and the United Kingdom (as per the EU Withdrawal Act 2018 [50]). Additional flight rules are also applied at the state-level (for example the UK's Air Navigation Order [49]), which are designed to align with SERA and ICAO standardisation.

There are two distinct flight rule categories defined in Annex 2 [13] and SERA [12] :

- Visual Flight Rules (VFR); flown in Visual Meteorological Conditions (VMC),
- Instrument Flight Rules (IFR); flown in either Visual or Instrument Meteorological Conditions (IMC).

Special VFR is more of an exception-based rule set, for VFR flights that do not meet the requirements for VFR (typically VFR minima) when operating in controlled airspace.

### 4.1.1 Avoidance of collisions

Annex 2 [13] Section 3.2 explains the rules of the air related to avoiding collisions.

- Section 3.2.1 requires that aircraft not come too close to other aircraft
- Section 3.2.2 on right of way describes decisions and actions based on assessments of the relative positions and motions of other aircraft

In Visual flight rules, there is the expectation that the pilot of each aircraft is aware of what is around their aircraft by means of sight.

Annex 2 [13] chapter 5 describes instrument flight rules. In essence the flight either benefits from a separation service or traffic information.

## 4.2 UFR

*This section contains a proposal which is currently of low maturity.*

U-Space Flight Rules (UFR) are intended to apply uniquely to airspace users in receipt of U-Space services within U-Space airspace. Aircraft and pilots that adhere to standardised U-Space equipment interfaces, and operate within U-Space Airspace Volumes, are expected to operate under UFR.



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The aim of UFR is to be a flight rule that works for remotely piloted aircraft, without the pilot being able to look out of the window. Instead, the pilot should be informed about the relative positions of aircraft by other means.

The principle behind UFR is to enable aircraft operations that cannot conform to VFR, SVFR or IFR in all operational conditions. Whilst in some operating cases it is possible for UAM to operate under VFR if piloted as visual line of sight (VLOS), however, more advanced UAM use cases may not be capable of "see and avoid" procedures if the aircraft are uncrewed. Likewise, UAM may be accommodated by IFR in some instances, however, their separation minima may not be suitable for effective operations in more congested airspace, such as the CTR. The aircraft participating under UFR are therefore required to be supported by a set of U-Space services for a particular airspace volume. The required U-Space services and their interface with other ATS depends on the airspace classification.

UFR is for operations in U-space volumes for airspace users that are consuming U-space services. UFR is based on deconfliction service(s) for separation provision (safety layer 1). These would be strategic deconfliction or both strategic and tactical deconfliction. On-board technologies (DAA/SAA) for collision avoidance would provide a further safety net (safety layer 2).

It shall be expected that aircraft conforming to UFR are required to:

- be Electronically Conspicuous to the ground system(s) and to other aircraft within the U-Space Airspace,
- be in receipt of a traffic information service(s), as required, with respect to other aircraft,
- adhere to any [Digital] ATS clearance/instruction deemed necessary by the controlling authority,
- have any air traffic separation service managed by a U-Space service.

Aircraft operating under UFR are not expected to receive voice communications from ATS units.

U-Space Mandatory Zone: aircraft operating in a U-Space Mandatory Zone (UMZ) shall be required to make their position known to U-Space through a defined procedure. States shall be responsible for defining the required process for making aircraft Electronically Conspicuous to U-Space.

# 5 Examples of using U-space services

Five flights are expanded here to show how the Operating Environment, Services and Flight Rules apply. The DACUS project's deliverable on the Drone DCB Concept and Process [29] has identified three general types of operations with different characteristics:

> ***Surveillance operations*** *are distinguished by mostly larger trajectory patterns and possibly repeating schemes to effectively monitor larger areas or points of interest. It is expected that most of these operations will not be performed in close range of any structures and therefore will be deployed in higher altitudes within very low-level airspace. Typical examples for this type are aerial mapping, traffic monitoring or applications in public safety and security;*
>
> ***Inspection operations****. They refer to all business models that practically require a close approach to the point of interest and for the whole execution of the mission task, e.g., the automated recognition of structural damage to a surface with optical methods. Contrary to surveillance operations, this type of mission can be expected to stay inside a defined and foreseeable containment area that is comparably small and near the observed structure. Further examples for this case are the inspections of solar power, cell towers or target-oriented photography;*
>
> ***Transport operations****. They are characterized by a point-to-point flight scheme and the actual transport of goods or persons. The cruise flight in this type is mostly distant to structures but straight forward and optimised on efficiency to reach a certain destination. It is likely that loading and unloading requires an approach to the ground and/or solid structures. Besides the industrial and private transportation of goods, this operation type also covers medical transport (e.g., medication or first responder equipment) or the carriage of persons in personal air vehicles.*

Five examples will consist of:

- Architectural photography, an example of Inspection, VLOS
- Aerial mapping, an example of Surveillance
- Power line inspection, an example of Inspection, BVLOS
- Pharmaceutical delivery, an example of Transport
- Air taxi, remotely piloted, an example of Transport

These five examples build in complexity.

## 5.1 Architectural photography

The photography mission is VLOS. The building to be photographed stands in an area that is enclosed by a fence, hence people can be excluded. The ground around the building is approximately the same altitude all over with respect to mean sea level. The missions are flown “by hand” by a pilot / photographer wearing first-person-view goggles. An observer stands beside the pilot and scans the sky visually. The flight is planned because it takes place in a Y volume (see 2.3.5.3) an airspace for which planning is mandatory.

The plan consists of a single 4D volume, from ground level to 50m above ground, covering a square on the ground of side 200m with the building at the centre, lasting from 7pm to 8pm local time. The operation will involve what appears to be unpredictable flight within the volume including periods when the aircraft is on the ground for battery changes.

### 5.1.1 Pre-flight

The drone-photographer is asked if she can take pictures of a hotel which stands in its own gardens. The photographer studies the location using the Geo-awareness service 3.4.2, considers the customer's wishes and decides the work can be done as an "open" category mission.

The photographer uses a relatively simple U-plan Preparation / Optimisation service 3.5.1 to prepare and submit the plan mentioned above; an hour long period in a "box" around the hotel during the 'golden hour.' The plan is sent the day before flight.

The plan is received by the Flight Authorisation service, 3.5.2. An acknowledgement comes back confirming the conditions applicable to the flight, notably which services should be used (see 2.3.5.3.3), what the technical requirements are. These same conditions are published per airspace but the acknowledgement serves as a reminder and makes the conditions contractual.

On the day of flight, the photographer and her assistant drive to the hotel. They check the status of the plan and if it has passed RTTA with no conflicts see 2.2.3.2.3.

### 5.1.2 In flight

Using the Flight Authorisation service, 3.5.2, the photographer activates her flight and commences the tactical services required for the airspace, in this case

- network identification service, 3.3.1
- traffic information service, 3.14
- emergency management, 3.12
- monitoring, 3.10

With the assistant, the pilot flies the drone and takes pictures.

In this example flight there are no unexpected events.

### 5.1.3 Post flight

Using the Flight Authorisation service, 3.5.2, the photographer ends her flight. The tactical services end.

The photographer and her assistant pack up and leave.

Later the photographer checks the details of the flight from the digital logbook.



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## 5.2 Aerial mapping

The drone operator has received an order from a regular customer to collect the data to enable the production of an aerial map of a region of about 1km x 1km. The work consists of taking a large number of photographs of the specified region from different angles ensuring that every point on surface has been photographed from three angles[9]. The precise location at which each photograph is taken must be recorded. The work involves a drone carrying quite a lot of equipment for positioning and image recording.

The flight is flown following a pre-programmed trajectory that scans over the region of interest. It is flown as a BVLOS flight, within an area, even though the aircraft may be visible to the operator much of the time. The interventions available to the operator are to deviate following a tactical separation instruction, to return to base and to restart the mission from the last ‘good’ point.

The airspace in which the flight occurs is Zu.

### 5.2.1 Pre-flight

The operator uses a relatively sophisticated U-plan Preparation / Optimisation service, 3.5.1, to develop a U-plan (or series of U-plans) that meet the needs of the mapping task. That tool makes use of the Geo-awareness service, 3.4.2, a Population density map service, 3.5.1.1, and a Risk Analysis Assistance service, 3.5.1.5, to minimise the risks associated with the operation. The Operator has a Light UAS operator Certificate (LUC), see EU regulation 2019/947 [4]. The U-plan Preparation / Optimisation service also checks for risks to the flight by making use of services providing Electromagnetic interference information, 3.5.1.2, Navigation Coverage information, 3.5.1.3 and Communication Coverage information, 3.5.1.4.

Once the U-plan seems optimal from a business and risk consideration, the U-plan Preparation / Optimisation service submits the U-plan to the Flight Authorisation service, 3.5.2. The U-plan describes large blocks of airspace being occupied in sequence. The operator is informed that the U-plan is accepted.

At RTTA the operator is informed that the flight is involved in a demand-capacity imbalance at one point and has been suspended. The system proposes several solutions. The operator prefers to change the sequence of scanning the area of interest and submits a revised plan which is accepted.

### 5.2.2 In flight

Using the Flight Authorisation service, 3.5.2, the operator activates the U-plan and commences the tactical services required for the airspace, in this case

- network identification service, 3.3.1
- monitoring, 3.10, including conformance monitoring service, 3.10.1
- tactical conflict prediction service, 3.6.1

[9] Detail invented for the sake of the story.

- tactical conflict resolution service, 3.6.2
- traffic information service, 3.14
- emergency management, 3.12
- weather information, 3.8
- navigation infrastructure monitoring, 3.15.1
- communication infrastructure monitoring, 3.15.2
- vertical alert and information service, 3.20

The pilot prepares the UAS and starts the flight.

During the flight the pilot monitors the flight operations and the achievement of business objectives while U-space information is overlaid on the flight display. The pilot receives tactical separation instructions form U-space in a form that can be directly uploaded to the aircraft.

The pilot's flight management system records which business objectives have been met and collects any which have not been met due to tactical interventions to allow the generation of a new U-plan to "fill the gaps."

### 5.2.3 Post flight

Using the Flight Authorisation service, 3.5.2, the pilot ends the flight. The tactical services (listed above) end.

After the aircraft has been powered off and made secure the pilot checks the digital logbook, 3.16, to confirm the details.

## 5.3 Power line inspection

The operator has a contract to inspect a number of power lines periodically. Following the schedule in the contract as well as the weather and any reports of exceptional situations, the operator plans a line inspection flight. The flight is BVLOS consisting of three parts. The aircraft flies to the start point of the inspection. The flight then follows the powerline while cameras and other sensors relay information back to the operator. When the operator's attention is drawn, the flight may linger at a point on the line. Finally, the aircraft flies to a landing site. The airspace is all Y volume. The operation is specific category. The operator has an existing SORA approved for this flight.

### 5.3.1 Pre-flight

The operator has flown this inspection before. The operator uses an U-plan Preparation / Optimisation service, 3.5.1, to recheck and if necessary, update the U-plan for the inspection. That tool makes use of the Geo-awareness service, 3.4.2, the Weather Information service, 3.8, and a Risk Analysis Assistance service, 3.5.1.5, which helps the operator check that the SORA is still applicable.

The U-plan Preparation / Optimisation service submits the U-plan to the Flight Authorisation service, 3.5.2. The U-plan describes a sequence of tubes of airspace being occupied in sequence, with growing uncertainty in the entry and exit time as the flight continues. The operator is informed that the U-plan is accepted.

At RTTA the operator is informed that the flight conflicts with more than one other flight and has been suspended. The system proposes several solutions including a delayed start. The operator updates the U-plan to match the proposed delayed start and it is accepted.

### 5.3.2 In flight

Using the Flight Authorisation service, 3.5.2, the operator activates the U-plan and commences the tactical services required for the airspace, in this case:

- network identification service, 3.3.1
- monitoring, 3.10, including conformance monitoring service, 3.10.1
- traffic information service, 3.14
- emergency management, 3.12
- weather information, 3.8
- navigation infrastructure monitoring, 3.15.1
- communication infrastructure monitoring, 3.15.2
- vertical alert and information service, 3.20

The pilot prepares the UAS and starts the flight.

During the flight the pilot monitors the flight operations and inspects the power line while U-space information is overlaid on the flight display. At times the operator pauses to record additional details.

### 5.3.3 Post flight

Using the Flight Authorisation service, 3.5.2, the pilot ends the flight. The tactical services (listed above) end.

After the aircraft has been powered off and made secure the pilot checks the digital logbook, 3.16, to confirm the details.

## 5.4 Pharmaceutical delivery

The drone operator has a contract with a number of hospitals, medical laboratories, clinics and a few pharmacies in a city. Each location has a vertiport suitable for the small UAS used by the operator. The operator has developed a network of routes between these vertiports. In some cases there are multiple routes between the vertiports. These routes follow regions of lower ground risk.

The operations are a mix of planned in advance and on demand services, always over known routes between known end points. The flights are certified category operations. The airspace is a mix of Zu and Y.

### 5.4.1 Pre-flight

The operator receives a request for an urgent delivery of pharmaceuticals from a pharmacy to a clinic. There happens to be a suitable UAS sitting waiting at the pharmacy. A pharmacist is collecting the pharmaceuticals as the operator prepares the U-plan. The expected activation time of the flight is in three minutes. The operator uses an U-plan Preparation / Optimisation service, 3.5.1, which is programmed with the vertiport and route-network. That tool makes checks the possible routes using



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the Geo-awareness service, 3.4.2 and the Weather Information service, 3.8. To choose the fastest route, the U-plan Preparation / Optimisation service calls the Flight Authorisation service in "test" mode for each route with different start times to find the fastest. A suitable combination of start time and route is identified and submitted to the Flight Authorisation service, 3.5.2. At RTTA the operator is informed that the flight is conflict free. The pharmaceuticals are loaded on board and the UAS checked. The destination is advised of the arrival time.

### 5.4.2 In flight

Using the Flight Authorisation service, 3.5.2, the operator activates the U-plan and commences the tactical services required for the airspace, in this case:

- network identification service, 3.3.1
- monitoring, 3.10, including conformance monitoring service, 3.10.1
- tactical conflict prediction service, 3.6.1
- tactical conflict resolution service, 3.6.2
- traffic information service, 3.14
- emergency management, 3.12
- weather information, 3.8
- navigation infrastructure monitoring, 3.15.1
- communication infrastructure monitoring, 3.15.2
- vertical alert and information service, 3.20

The pilot starts the flight. During the flight the pilot monitors the flight operations while U-space information is overlaid on the flight display. In the Y volumes the pilot monitors traffic information, in Zu, the pilot receives tactical separation instructions form U-space in a form that can be directly uploaded to the aircraft.

As the UAS approaches the clinic, the flight management system warns the clinic of the imminent arrival. A member of staff is standing by as the UAS lands.

### 5.4.3 Post flight

Using the Flight Authorisation service, 3.5.2, the pilot ends the flight. The tactical services (listed above) end.

The aircraft has been powered off and made secure and then the pharmaceuticals are unloaded.

## 5.5 Passenger carrying, remotely piloted, scheduled.

In the first of two passenger carrying operations, a scheduled services is considered.

A UAS operator focusing operations on making the best use of the vertiport may adopt the approach of operating flights according to a schedule. (See 2.2.2.3, third case.) Flights follow a predetermined route network visiting known vertiports. The air operations are carefully planned to turn around quickly so as to maximise the utility of the vertiport. Passengers buy tickets to occupy seats on scheduled flights.



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The planning is made long in advance. The operations are certified. The airspace is a Zu volume. Vertiports will have associated arrival and departure routes which will be determined by the needs of safety and social acceptability.

### 5.5.1 Pre-flight

The operator plans an entire day at a time, fitting together all the flights so as to optimise vertiport use. Each flight is planned with some margin for tactical changes, but that margin is limited in the interest of maximising the optimisation. The operator uses an U-plan Preparation / Optimisation service, 3.5.1, of great sophistication which models the vertiport operations and multiple flights by the whole fleet of aircraft.

So as to minimise the risk of conflict, flights are planned using four dimensional volumes of the minimum size.

The U-plan Preparation / Optimisation service submits plans to the Flight Authorisation service, 3.5.2. At RTTA for each flight the operator is usually informed that the flight is conflict free. In cases where there is a conflict, strategic conflicts are generally solved by speed and route changes, attempting to keep take-off and landing times undisturbed. When this is not possible, the U-plan Preparation / Optimisation service, 3.5.1, may update many flights to coordinate the overall schedule.

The pre-flight phase will include the boarding of passengers. Systems or an agent at the vertiport will signal to the remote pilot that the passengers are on board, the doors are closed.

### 5.5.2 In flight

Using the Flight Authorisation service, 3.5.2, the operator activates the U-plan and commences the tactical services required for the airspace, in this case:

- network identification service, 3.3.1
- monitoring, 3.10, including conformance monitoring service, 3.10.1
- tactical conflict prediction service, 3.6.1
- tactical conflict resolution service, 3.6.2
- traffic information service, 3.14
- emergency management, 3.12
- weather information, 3.8
- navigation infrastructure monitoring, 3.15.1
- communication infrastructure monitoring, 3.15.2
- vertical alert and information service, 3.20

The pilot starts the flight. During the flight the pilot monitors the flight operations while U-space information is overlaid on the flight display. The pilot may communicate with the passengers, either directly or via a staff member dedicated to passenger relations.

In Zu, the pilot receives tactical separation instructions form U-space in a form that can be directly uploaded to the aircraft. The pilot strives to maintain the planned arrival time. When the planned arrival time is in jeopardy, the operator may update the plan to operate at higher speed. When tactical manoeuvres delay the flight beyond the planned margin, the operator will replan the operations at the arrival vertiport and perhaps beyond.

The pilot constantly monitors the state of the aircraft and the status of both the nearest vertiport and the destination vertiport. The pilot maintains contingency plans throughout the journey to allow safe landing with different degrees of urgency.

As the UAS approaches the arrival vertiport, the pilot checks the availability of the destination. The aircraft follows a standard arrival path and touches down.

### 5.5.3 Post flight

Using the Flight Authorisation service, 3.5.2, the pilot ends the flight. The tactical services (listed above) end. The aircraft is made secure. A member of the ground staff opens the doors of the aircraft and those passengers who have reached their destination exit the aircraft.

## 5.6 Passenger carrying, remotely piloted, on demand.

In the second of two passenger carrying operations, an on-demand services is considered.

It may be that passengers might use a phone app or web page to investigate and then order air-taxi journeys. The process would probably resemble current ride-hailing apps where the customer requests a start point and a destination and in return is offered a price, an estimated departure time and an estimated arrival time. In this example the start and end points are vertiports of which we assume there are many.

The operations are certified. The airspace is a Zu volume. Vertiports will have associated arrival and departure routes which will be determined by the needs of safety and social acceptability.

### 5.6.1 Pre-flight

On receiving a request, the ride hailing app will investigate availability of the vertiports and the candidate aircraft. Optimisations involving multiple passengers may be possible but are out of the scope of this simple example. The ride-hailing app is likely to interface with the UAS operator's U-plan Preparation / Optimisation service, 3.5.1, which is programmed with the vertiport and route-network and is likely to call the Flight Authorisation service in "test" mode for possible each route to find the best trade-off between speed, cost and so on.

Once the passenger has converted the enquiry into an order, the U-plan can be submitted to the Flight Authorisation service, 3.5.1. If the flight is in conflict, then the business logic of the app / operator will determine what solution to follow – one involving more time or more cost.

The plan is simultaneously submitted to the departure and arrival vertiports.

At RTTA, which is presumably very soon after the U-plan is submitted, the operator is usually informed that the flight is conflict free. In cases where there is a conflict, strategic conflicts are solved as previously described using the business logic of the operator to balance cost vs time while meeting the constraints agreed with the vertiports. On occasions this whole process will fail to meet the expectations of the customer and a process of apology may be needed.

The customer arrives at the departure vertiport and is guided on to the aircraft. Systems or an agent at the vertiport will signal to the remote pilot that the customer is on board, the doors are closed.


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### 5.6.2 In flight

Using the Flight Authorisation service, 3.5.2, the operator activates the U-plan and commences the tactical services required for the airspace, in this case:

- network identification service, 3.3.1
- monitoring, 3.10, including conformance monitoring service, 3.10.1
- tactical conflict prediction service, 3.6.1
- tactical conflict resolution service, 3.6.2
- traffic information service, 3.14
- emergency management, 3.12
- weather information, 3.8
- navigation infrastructure monitoring, 3.15.1
- communication infrastructure monitoring, 3.15.2
- vertical alert and information service, 3.20

The pilot starts the flight. During the flight the pilot monitors the flight operations while U-space information is overlaid on the flight display. The pilot may communicate with the passenger(s), either directly or via a staff member dedicated to passenger relations.

In Zu, the pilot receives tactical separation instructions form U-space in a form that can be directly uploaded to the aircraft. The pilot strives to maintain the planned arrival time. When the planned arrival time is in jeopardy, the operator may update the plan to operate at higher speed. When tactical manoeuvres delay the flight beyond the planned margin, the operator will replan the operations at the arrival vertiport and perhaps beyond.

The pilot constantly monitors the state of the aircraft and the status of both the nearest vertiport and the destination vertiport. The pilot maintains contingency plans throughout the journey to allow safe landing with different degrees of urgency.

As the UAS approaches the arrival vertiport, the pilot checks the availability of the destination. The aircraft follows a standard arrival path and touches down.

### 5.6.3 Post flight

Using the Flight Authorisation service, 3.5.2, the pilot ends the flight. The tactical services (listed above) end. The aircraft is made secure. A member of the ground staff opens the doors of the aircraft and those passengers who have reached their destination exit the aircraft.



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# 6 Social acceptability

This section provides some suggestions on how to improve the societal acceptance of the UAM operations. Societal acceptance of Urban Air Mobility is a key requirement for the economic growth foreseen in the European Drones outlook study to happen [30].

As defined in section 1.1 a ConOps is the description of the characteristics of a proposed system from the viewpoint of an individual who will use that system. The system is the U-space supporting the UAM operations and the individuals that will use the system are all the involved stakeholders, specially including the citizens.

The section follows a similar structure to the ConOps. First a description of the (urban) operating environment is given, including most relevant knowledge extracted from public surveys. Then the Phases of the flight is used to propose actions to improve societal acceptance. Airspace and ground infrastructure contain some hints about their design. Finally, a subsection on U-space and its services proposes requirements coming from the public.

## 6.1 Operating Environment

The operating of UAM operations includes, by definition, urban areas. The limitations in altitude imposed to UAM operations, to avoid interaction with crewed aviation, sets these operations to occur very close to the ground. And the ground in urban areas is mostly populated. In summary, UAM will operate very close to people and buildings.

An increasing number of surveys have been collecting the citizens opinions about uncrewed aircraft since 2015 [31], with special focus in UAM since 2018 [32]. For the European case it is especially relevant the EASA survey [33] and posteriori surveys conducted by other SESAR and EU projects (AiRMOUR, ASSURED-UAM, U-space4UAM, AMU-LED) to European citizens and experts.

According to the surveys the acceptance rate of UAM terms, such as drones, air-taxis, UAM, aerial delivery, etc., is between 45% to 85%. In the EASA survey the term urban air mobility reached was labelled as positive by 83% of the responders.

In all surveys the rate of acceptance is higher for medical urgent services and for public services, such as search and rescue, critical infrastructure maintenance and emergency response. In fact, most police departments are already including drones as a new tool on their services.

The public observes as main benefits:

- Fast services,
- Environmentally friendly, and
- Providing extended connectivity to the busy urban transport systems.

Some surveys taken from 2021 move the focus of the questions from the citizens as passive observers to potential customers of the UAM services. The willingness to use drone delivery services is in 58% while the passenger experience is only attractive to 27% of the citizens of the EASA survey.

Demographics tests of surveys demonstrate the influence that age, gender, education, economical wellness and knowledge have in the level of acceptance. Elders are less positive than young people.

Men show more enthusiasm in adopting UAM than women. Economic wealthiness and educational degree have a direct relation with UAM acceptance. Same applies for the level of knowledge about the UAM technologies, the more knowledge, the higher acceptance. As an example, the rate of willingness to use drone delivery services for the 66 experts participating in the first CORUS XUAM workshop was % while the passenger experience is only attractive to 27% of the citizens of the EASA survey.

Although most than 90% of the people declared to have heard about drones, only a 2% declared to have personal experience in 2017. The sources of information are generally mass media (news, movies, social media, etc.)

Changes on public's opinion have occur when they are involved in UAM operations. In Dublin, the Manna experience in delivery using drones, resulted in one of the highest acceptance rate (84%) of drone delivery [34]. Drones for public services obtain acceptance of 92-97%. The AMU-LED project detected 75% changes in opinion when comparing the answers before and after the participation in UAM air-taxis demonstration [35]. An increase of the acceptance is also reported by U-space4UAM after conducting 215 demonstration flights.

Surveys show also the public's concerns. With slight differences on the percent, all point to the same concerns:

- Malfunction / safety
- Nuisance / environment
- Misuse / security and privacy

Safety concerns are raised in higher degree by airspace users and experts. Safety is the main focus of AESA regulation and U-space provision. Citizens show also concerns about malfunctioning aircraft falling. In general, after the participation in a flight demonstration the level of concern decreases.

Nuisance includes a number of negative effects for the environment, wildlife and people's health. Airspace users and experts have long experience in this area. With UAM the noise, affecting today only populated areas close to airports, can expand all across the cities. The electric power of most UAM aircraft improves the gas emissions and noise footprint. But the shorter distances from UAM aircraft to citizens has the contrary effect. UAM aircraft are also more silent and slower than commercial aviation, reducing the negative effects to wildlife and people, but many unknowns are still to be investigated.

Misuse of drones, especially of small ones with cameras, are seen as a security breach. Citizens image them in the hands of thieves, terrorists or spies, compromising their home, life or privacy. In the era of Internet, the effect of potential cyber-attacks on good-intentioned aerial vehicles are also part of this concern. While safety and nuisance concerns are well-known concerns in aviation, misuse is in generally new to air space, with the exception of some well-known episodes of kidnapping of aircraft.

As happened with the degree of acceptance, the exposition and knowledge of UAM has proved to have also an effect on the concerns. In the Dublin experience the concern on privacy raised to 75%. After demonstrations of air-taxis in ASSURED-UAM the noise concern was also higher than before.

Other concerns are informed in special situations:

- In surveys focusing on drone delivery another concern that appears is the damage produced to (or from) the cargo.
- Liability is also a concern in case of incident/accident.

- The limitations introduced by regulation is a major concern for stakeholders after having participated in a demonstration.
- Finally, a full level of automation is an issue generally raised by the lack of confidence in artificial intelligence.

## 6.2 Phases of flight

While social acceptability benefits and the concerns are raised during the tactical phase of flight, it is the strategic phase that is key to increasing these benefits and to mitigating these concerns.

Long-term decisions that affect the societal acceptance are taken by the UAM operator at the moment of aircraft design or acquisition. Currently electric powered aircraft are the best option to reduce gas emissions and the noise footprint, but still decisions about materials use in the design, such as the reuse of components and recycling, can produce much eco-friendly UAM. Aircraft colour and blades protection have also a role in visual impact and wildlife protection.

More decisions of strategical long-term phase are related to airspace design and are given in the next subsections.

Strategic pre-flight phase is responsible of creating the U-plan. Below the list of operational decisions that can help in performing a more societal-friendly mission [36]:

1. Limit the minimum altitude,
2. Respecting no-fly zones for drones/times,
3. Flight most direct routes to minimise energy and annoyance,
4. Alternate routes to spread noise,
5. Avoid/limit hovering drone flights,
6. Set speed limits according to the area being crossed,
7. Review the urban land use below the flight trajectory.

Decisions such as the flight altitude and flight waiting points (hovering) are very relevant for noise impact and also for avoiding privacy concerns. Aircraft shall avoid flying by any home window, and to stop for no evident reason above a private property. Experimental UAM operations in the city were obtained by virtual and augmented reality and used to evaluate annoyance to humans. Visual, auditive and safety perception improved always with higher altitudes [37].

To better preserve the environment, direct routes at high altitude are preferred. Meaning high altitude overflying all urban buildings in the line of site of the drone. High altitude avoids annoyance and privacy concerns, allow direct routes and consumes less energy. The only exception is but for short-length flights, to which a high altitude may be less convenient for energy consumption.

Some of the actions, such as the studying ground land usage, are mandatory during the safety assessment, but unless a no-fly zone, using convenient safety mitigations may allow that the mission can finally proceed in top of populated areas. Different speeds and altitudes can be defined to preserve the wellness of all crossed areas.

When a route becomes too much used by sequences of flights, the operator shall study alternative routes, that even not so energy safe, can help to distribute better the noise. It is well known that permanent noise disturbances may affect the health of humans and natural life. Searching for alternate paths for instance for a 2-way trip is a good planning measure.



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Finally, the post flight phase is very relevant also for environment. A good maintenance execution of the batteries of the aircraft will lead to longer life and less residuals generation. In the same way, the correct maintenance and when necessary, replacement of blades will reduce the noise of the future flights.

## 6.3 Airspace

The legal requirements of the airspace structure and how these affect the capacity are presented in section 2.2.1.1. But no further comments are given with respect to societal acceptance.

Other SESAR projects, such as Metropolis and Metropolis 2, have propose and study several airspace organizations and evaluate them in terms of efficiency. From corridors to free routing, and radial to perpendicular routes. Segregating by altitudes the different traffic according to their performance (speed and also noise) is the most convenient way for reducing the noise annoyance. For instance, U-space4UAM proposed altitude limits of 20 m height for hobbyist while commercial UAM shall fly from 20 m to the U-space airspace upper limit.

Airspace design shall be coherent with city organization to which UAM is serving. Flying over existing urban transportation vials (rails, highways, rivers and streets) is proposed as safety measure, but it has several benefits for societal acceptance:

- Perceived noise increment is minimised since the existing urban transportation vials are already accepted noisy areas and the added noise is less perceived.
- UAM can contribute to the multimode transport system and alleviate the busy urban traffic.
- Avoids the problem of overflying private properties addresses. Private properties can raise private concerns. Also, some countries grant the owner with full rights up to a give height over their terrains. In those cases, an aerial flight may require of owner's permission, including tolls to use such right [38].

## 6.4 Ground infrastructure

Section 2.4.1.3 presents the EASA design concept for vertiports [39]. Section 2.4.1.5 present the concept of Vertiport Traffic Zone. This concept embeds the need of protecting all approach areas and the set of rules to be defined to ensure safety. Section 2.2.2.3 presents the limitations to the U-plan (on access, capacity and operation) imposed by vertiports. But none of them addresses the problem about societal impact of these infrastructures.

Vertiports will concentrate a high number of operations. Moreover, vertiports are the areas at which flight altitude of UAM operations will be lowest, eventually including stationary phases. In consequence annoyance of traffic to near neighbours is, after safety, probably the most urgent element to address and solve to make UAM become a reality.

A number of works have proposed the best location of vertiport [40]. In general, they consider the potential demand sources, the efficiency for the UAM integration into the multimode transportation system and the capacity offered by U-space.



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Focusing on air-taxis, ASSURED-UAM studied the best conditions for urban ground infrastructure. Major agreements of the experts participating was achieved in the necessity of converting existing urban infrastructure to cost-effective UAM infrastructure (62%). The involvement of cities to issue specific regulation for the use of land were also considered important by 59% of the responses.

In summary, vertiports shall be located close to current ground transportation hubs to maximise their efficiency, utility and acceptability. Areas such as train and bus stations are large wide areas with potentially few obstacles. They have close by parking areas and are already busy and noisy. The city knowledge from urban planners is key to propose vertiport facilities on the roof or close to existing transportation hubs

## 6.5 U-space infrastructure and services

Section 8.3 shows "General public" as a stakeholder of U-space. General public represents those who may hear, see or otherwise be concerned by a UAM flight. For them the U-space is expected to provide traffic information (see Figure 20). Surveys show that it is essential that any citizen can get access to UAM traffic to mitigate the privacy concern.

In addition, citizens are also the ultimate beneficiary of UAM flights, as drone delivery client or as UAM passenger. The roles "UAS delivery client" and "UAM passenger" are also direct stakeholders of U-space, and their acceptability are economical.

The general public are an indirect user of the UAM for HEMS flights. These flights are performed by law enforcement or emergency responders, but the final goal is always the society.

# 7 Architecture

This section is used to give to the reader an overview of U-space architecture and required evolutions for UAM. It is not aiming to provide details but the high-level elements and views which are supporting the concept development and understanding with a focus on UAM.

This section contains the following:

- Architecture principles
- Architecture Framework
- Stakeholders and Roles
- Operational processes and Information Exchanges
- A generic system breakdown
- An explanation of the U-space Portal

## 7.1 Architecture principles

The architecture principles taken into consideration when defining the U-space architecture are:

**Service-oriented architecture**: A service-oriented approach will be applied to ensure that the solutions are built based on a set of services with common characteristics.

**Modular**: the architecture will be decomposed into self-contained elements (Functional Blocks) which contain a meaningful set of functionalities with the required inputs/outputs, that can be re-used or replaced.

**Safety-focused**: The architecture shall always consider the safety of its stakeholders or of other people and places that may be affected by U-space operations.

**Open**: a system architecture shall be developed which is component-based and relies on published or standardised interfaces based on SWIM principles to make adding, upgrading or swapping components easier during the lifetime of the system. Some other expected benefits of an open architecture are to facilitate re-use, to increase flexibility, to reduce costs and time to market, to foster competition, to improve Interoperability and to reduce risks.

**Standard-based**: whenever there are exchanges of information, the interfaces must be defined and based on open standards.

**Interoperable**: the main purpose of the interoperability is to facilitate homogeneous and non-discriminatory global and regional UAS operations.

**Technology agnostic**: to allow platform independent design, the architecture shall be described independently of the later implementation specifics, e.g. platforms, programming languages and specific products which shall be consistent with the operational architecture.

**Based on evolutionary development** (incremental approach): architecture work is an incremental and iterative process, building upon the previously consolidated baseline.

**Automated**: the architecture will be developed to facilitate the delivery of safe and secure U-space services with a high degree of automation of the processes as manual operations will be too labour intensive.

**Allowing variants**: the architecture work will allow variants and alternative solutions to be described. The principles listed in this document and later in the CONOPS aim for ensuring interoperability between different implementation options.

**Deployment agnostic**: architecture work will not constrain different deployment choices according to the business and regulatory framework established.

**Securely designed**: architecture work will address security issues such as cyber-security, encryption needs and consequences, and stakeholder authentication. It is needed to follow the SWIM principles that is to use a central or federated Public Key Infrastructure (PKI) for identity management.

## 7.2 Architecture Framework

Architecting has become a decisive process for the successful development of projects aiming to capture all the relevant information from different facets to end-up with a complete, consistent and coherent content. Starting from CORUS project achievements, CORUS-XUAM team has worked to provide U-space stakeholders with a reference architecture from which to build up a realizable U-space for UAM and that will support the future decision making.

Every architecting approach needs an architecture framework, which has a common set of principles and practices for structuring and describing the enterprise/concept, in this case the U-space for UAM.

As for CORUS project, the European Air Traffic Management Architecture (EATMA[10]) was selected to drive the CORUS-XUAM architecture development work. This choice consolidates previous projects achievements and facilitate the integration of the ATM and U-space architecture since EATMA is also the framework used for the research and development activities of ATM and other U-space related projects.

## 7.3 Stakeholders and Roles

The architecture of a complex system such as that of U-space, brings together different elements and requires operating procedures that involve numerous "players". For this reason, the U-space can be defined as a collection of organisations that share a set of common goals and collaborate to provide specific products or services to customers mainly looking at safety and performance. For this reason, this commitment covers various types of organisations, regardless of their size, ownership model, operational model, or geographical distribution. It includes people, information, processes, and different technologies.

[10] EATMA Guidance Material
https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5b2deab5c&appId=PPGMS

In these paragraph two terms are distinguished which help the reader to easily understand the U-space system. These terms are Stakeholders and Roles. In particular:

A U-space **Stakeholder** is an individual, team, or organisation with interest in, or concerns relative to, the U-space undertaking. Concerns are those interests, which pertain to the undertaking's development, its operation or any other aspect that is critical or otherwise important to one or more stakeholders.

Stakeholder **Role** (aka role) is representing an aspect of a person or organisation that enables them to fulfil a particular function. Therefore, the role element is the means in EATMA to represent the human being.

The mapping from stakeholder to role can be many depending on the scenario to which it refers. In the following table the stakeholders identified in the overall architecture are mapped with the correspondence of roles as indicated in the Operational Framework document:

| Stakeholder |
| --- |
| **UAS operator:** is the legal entity, performing one or more UAS operations and is accountable for them. |
| **UAM operator:** is the legal entity, performing one or more UAM operations and is accountable for them. A UAM operation is an air transportation operation that carries passenger and/or goods. UAM is a safe, secure and sustainable air transportation system for passengers and cargo in urban environments, enabled by new technologies and integrated into multimodal transportation systems. The transportation is performed by electric aircraft taking off and landing vertically, remotely piloted (in such a case it is a specialisation of **UAS operator**) or with a pilot on board.<br><br>One of the responsibilities is the booking and potentially it can be considered a new stakeholder to highlight business choices for UAM Booking, in that case it supplies the booking services. Specialisations are envisaged for the urban air transport such as Air taxi booking service provider (allowing the general public to book a journey in an air taxi. It offers mobility as a service (MaaS) and Air delivery booking service provider (allowing anyone who wants to, to book a delivery by air). |
| **UAS manufacturer:** has an interest in aircraft and equipment certification processes. The UAS manufacturer or representative may have a role in U-space registration, for example as the provider of UAS characteristics and serial numbers. |
| **U-space Service Provider (USSP):** This stakeholder provides one or more of the U-space services as listed in the U-space regulation [8] chapter iv.<br><br>A USSP may have suppliers, for example a software supplier. At the level of granularity presented in the document, such suppliers are considered as subcontractors to the USSP and are not identified as having a distinct role. |
| **Common Information Service Provider:** where applicable, provides the services mentioned in the the U-space regulation [8] article 5.<br><br>The CIS is concerned with the provision of the necessary information for the well-functioning of the ecosystem. Its objective is to ensure that the information comes from trusted sources and that it is of sufficient quality, integrity and accuracy as well as security so that the USSPs and other users such as ASNPs can use this information with full reliability when providing their services. |
| **Supplemental Data Service Provider (SDSP):** provides access to supplemental data to support U-space services. E.g., Weather Data Service Provider, Ground risk observation service provider. |

| Stakeholder |
|---|
| **CNS Service Providers (CNS): a** provider of Communication, Navigation or Surveillance services. |
| **Air Traffic Service provider:** is a provider of air traffic services to airspace users. It can be ATS Aerodrome or ATS Approach service provider. |
| **Aeronautical Information Service Provider (AISP):** The provider of a service established within the defined area of coverage responsible for the provision of aeronautical information/data necessary for the safety, regularity and efficiency of air navigation. It has the task of producing the Aeronautical Information Publication, a collection of data describing the geography and procedures of for flying in a given country. |
| **(Airfield/Airport) Aerodrome operator (civil, Military):** The aerodrome operator is distinct from the ANSP and has business concerns and legal responsibilities which make them interested in / concerned by UAS flight and U-space procedures. |
| **Vertiport operator:** will provide services at a vertiport. Service provision might vary between vertiport for private use and public use. It encompasses passenger and Cargo transport<br>This one operates the facility in a safe and efficient manner including the scheduling of arrivals and departures as well as supplying U-space with information about the aerodrome's status and capacity to accommodate incoming aircraft. |
| **Competent Authority:** Generic term to encompass national or local civil aviation authority, or some entity delegated by them.<br>• *Roles:* Registrar, Authorised viewer of air situation, Airspace access authorization Workflow Representative, Capacity Authority |
| **Authority for safety and security** (police, fire brigade, search and rescue orgs): Authorities involved in preparation and supervision of the operations of law enforcement such as police, security, military, homeland security that are responsible for law enforcement methods.<br>*Roles:* Police or security agent, UAS specific aeronautical information originator |
| **Emergency Responders:** Organisations involved in preparation and execution of emergency operations such as fire brigade, emergency, first aid, Search and Rescue (SAR). |
| **Local and specific authorities:** city / region / prefecture / county / canton / state - support the definition of operating procedures and rules. |
| **U-space Coordinator:** (Defined in the Guidance Material to EU IR 2021/664) The U-space coordinator coordinates the Local and Specific Authorities. |
| **UAS delivery client:** The clients of the delivery service |
| **UAM passenger:** Generic beneficiary of safe, secure and sustainable air transportation system for living being e.g. the air-taxi passenger rides in an air taxi UAM operation. |
| **Airspace User (other than UAS/UAM):** include scheduled airlines, charter companies, cargo and air freight service providers, the business and leisure aviation sectors and all forms of non-military air travel, from hot air balloons through police helicopters to general aviation pilots.<br>*Roles*: Pilot, Authorised viewer of air situation |
| **General Public:** representing those who may hear, see or otherwise be concerned by a UAS<br>• *Roles*: Citizen, Authorised viewer of air situation |

**Table 8: U-space stakeholders**

Figure 19 shows as a whole the stakeholders identified in the previous table, aggregating those with "similar" characteristics together with those who are involved in the U-space, but in an "indirect" way, such as UAS delivery clients and air taxi passengers.

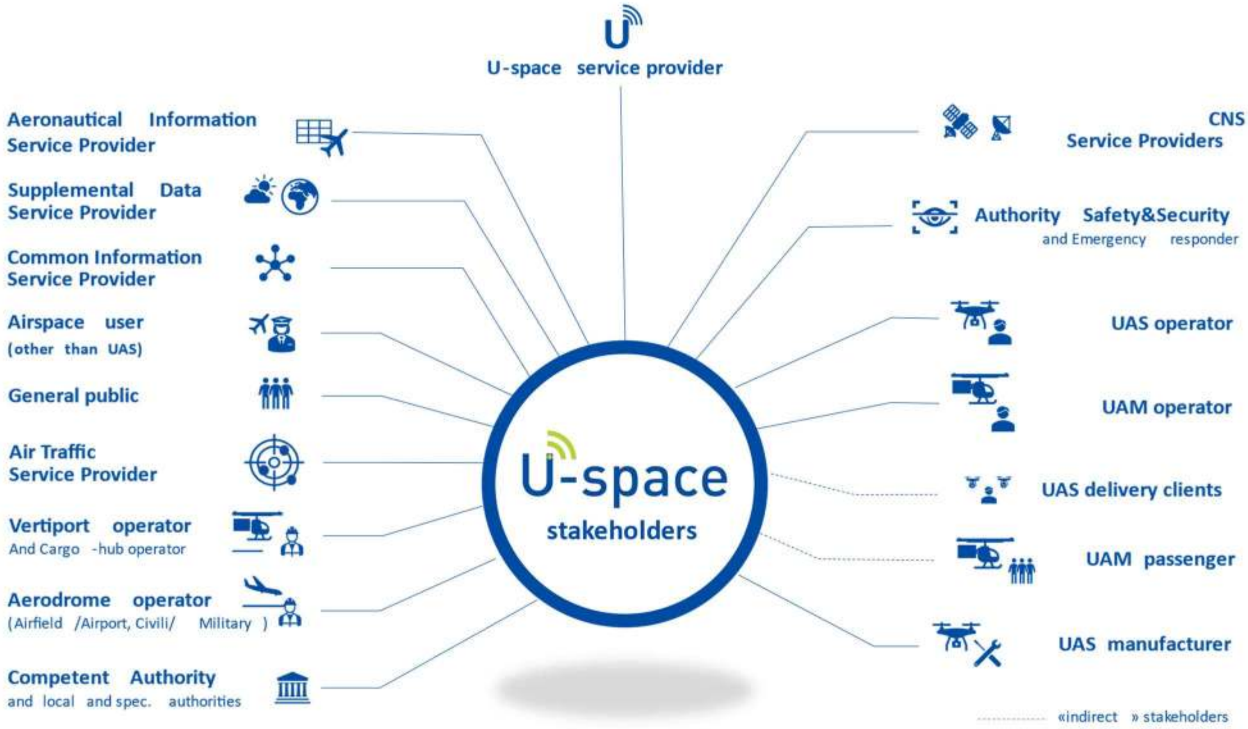


**Figure 19: U-space Stakeholders, shown in aggregation.**

## 7.4 Operational processes and Information Exchanges

From an operational point of view, Figure 20, below shows, independently of any physical realisation, high level operational processes (the blocks which represent the stakeholder and relevant activities) and information exchanges among these processes (the arrows between blocks). Figure 20 mainly focuses on U-space traffic management operations.

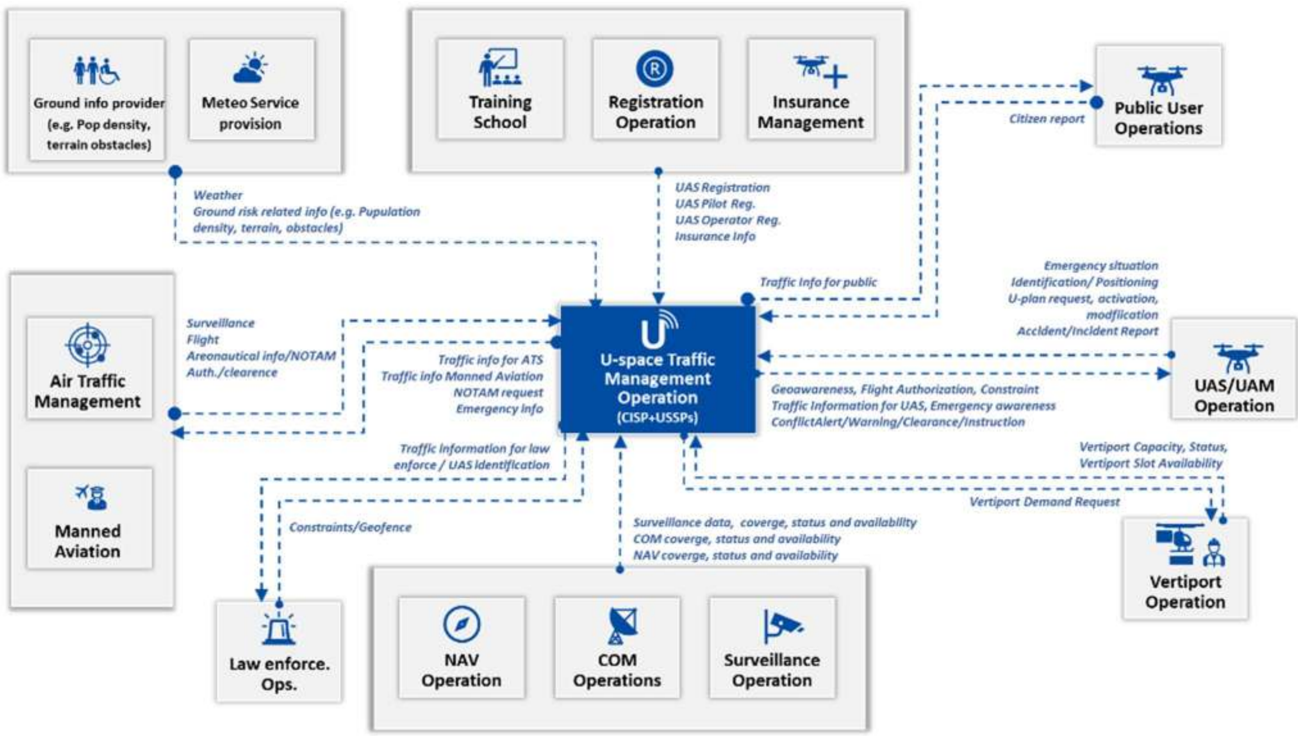


**Figure 20: information exchanges, informal presentation**

Information exchanges will be focused in order to provide the right information at right people and time, in order to comply with safety, security and privacy requirements. These interactions, named Information Exchanges, describe then the operational needs that are required to be covered in implementation with the provision and consumption of data by technical systems through U-space services.

## 7.4.1 An example of an operational process

In addition to the static information diagram shown in Figure 20, it is crucial to understand the sequence of activities that have to be performed by the stakeholders in a specific scenario. Like this, the responsibilities of each stakeholder would be defined.

So far 12 business process models or operational processes have been developed in the context of CORUS-XUAM. Several of them continue the work presented in the U-space ConOps Ed.3, but others have been newly defined due to the entrance of the UAM, whose vertiports would play an important role in the U-space. All these business process models can be consulted in the Section 7.6 U-space Portal.

Figure 21 illustrates an example of the process defined for the departure from a vertiport is shown.



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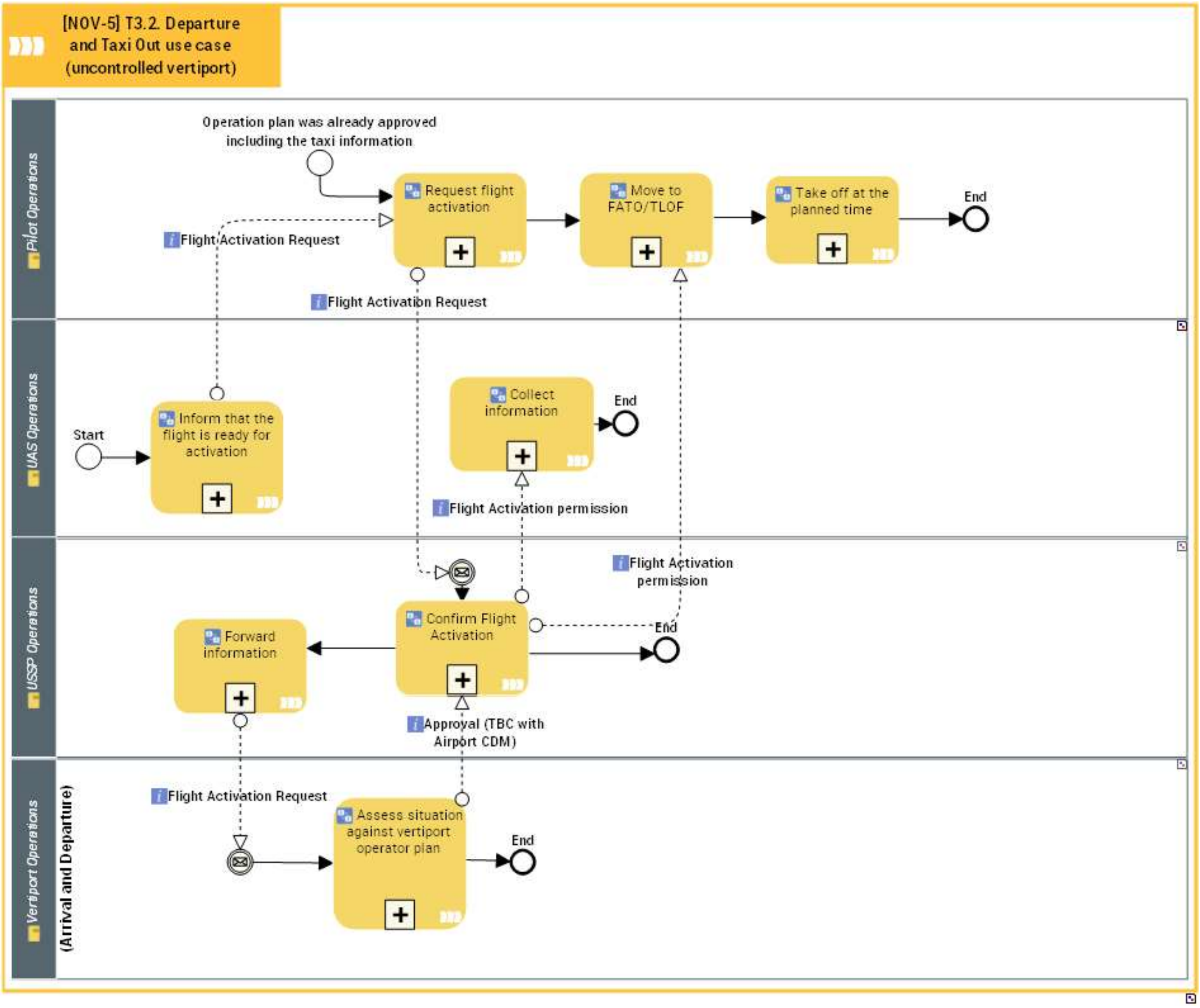


Figure 21: Operational use case for the departure from a vertiport

## 7.5 A generic system breakdown

Being service oriented and having recognised different business models possible, a range of deployment architectures can be imagined for U-space.

The main arguments are around the deployment of U-space services and the possibility to have distributed responsibility or centralised responsibilities for Common Information services and the interoperability among several USSPs. Deployment solutions envisage the possibility of centralised or distributed alternatives. This document does not push any position on what shall be centralised and what can be executed in distributed way.

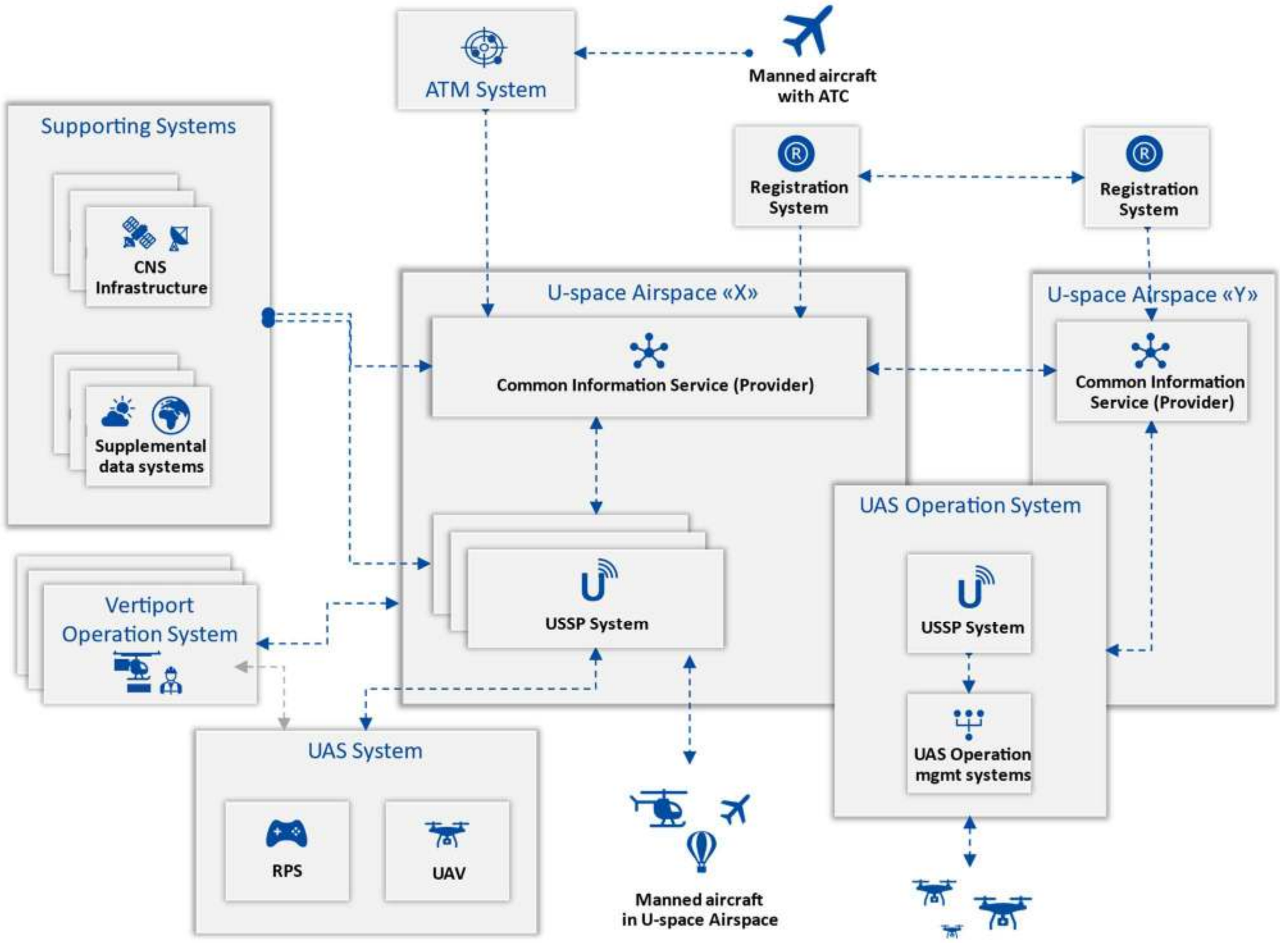


**Figure 22: Generic U-space system breakdown**

Figure 22 provides an overview of possible interfaces among systems for both monolithic and federated options.

Supplemental data system is encompassing the MET, Terrain and Obstacles ones. CNS Infrastructure represents the physical systems for Communication, Navigation and Surveillance including the services providing information about status and coverage. ATM System includes mainly the AIM system and Air Traffic service unit systems. More details on the EATMA portal.

Validation and demonstration activities will provide evidence of these architecture options.

## 7.6 U-space Portal

In order to have a common understanding of the U-space architecture, it becomes essential to have only one single point of truth accessible for the U-space architects. This assures completeness, consistency and coherency of the content developed by the different projects in the most efficient way. So having access to the architecture designed by CORUS-XUAM becomes a critical milestone for the future work to be performed on U-space.

Therefore, in continuation with CORUS work, CORUS-XUAM team has decided to show the architecture in a web based portal (https://www.eatmportal.eu/working/signin). This portal shows the CORUS-

XUAM SU-space architecture. Therefore, it will allow the future U-space architects to easily access the reference material to continuously enhance and develop in a consistent way the future U-space.

The portal will include content from the different EATMA layers and the relationships between the elements, easing the verification of the traceability between the different levels of the architecture (business, operational, service and system).



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# 8 Regulatory context

A detailed examination of the regulatory context of this ConOps can be found in annex to this document in the "CORUS-XUAM ConOps Annex: regulatory and legal impact study." This section summarises that document.

The European regulatory context for "Uncrewed" aviation at the time this document is written is described here as it influences the contents of this document.

Aviation is subject to national law. National law for aviation is greatly shaped by international treaties.

All European states except Liechtenstein have ratified the Chicago Convention on International Civil Aviation, the founding document of ICAO. Some national exemptions exist to specific ICAO regulations.

All European Union member states, as well as some other European countries, follow the regulations developed by EASA, the European Aviation Safety Agency.

"Crewed" aviation is well described in the regulations issued by the two (see references [12], [13], [14], [15], for example) and corresponding national law. "Uncrewed" aviation is partly covered by these aviation regulations. Specific regulations for "uncrewed" aviation have been developed by EASA. These are:

- 2019/947[11] [4] *on the rules and procedures for the operation of unmanned aircraft* and its corresponding acceptable means of compliance and guidance material (AMC-GM) [6]
- 2019/945 [5] *on unmanned aircraft systems and on third-country operators of unmanned aircraft systems* and its corresponding AMC-GM [7]
- 2021/664 [8] *on a regulatory framework for the U-space.*
- 2021/665 [9] *amending Implementing Regulation (EU) 2017/373 as regards requirements for providers of air traffic management/air navigation services and other air traffic management network functions in the U-space airspace designated in controlled airspace*
- 2021/666 [10] *amending Regulation (EU) No 923/2012 as regards requirements for manned aviation operating in U-space airspace*
- The Acceptable Means of Compliance and Guidance Material (AMC-GM) for 2021/664, 5, 6 [11].

Key points of these European regulations are:

Flights are categorised by risk. The lowest risk are known as Open category, then Specific, then Certified. There are requirements on the aircraft in order for a flight to be in a given category. See section 2.2.2.1

Geographic zones may be created to manage (limit or enable) drone flight. These resemble Restricted Areas. Some geographic zones will require the use of U-space services by UAS operators. These zones

[11] European regulations are named for the year they are issued and a sequence number. Either the year or sequence number may be written first. 2019/947 may be referred to as 947/2019

are referred to as U-space airspaces, see 2.3.3. Four U-space services are always mandated: Network Identification, Geo-awareness, Flight authorisation and Traffic information. The competent authority may also mandate either of two others; Weather information and Conformance monitoring. A mapping of the services described in EU regulation 2021/664 to those described in this ConOps can be found in Table 7.

Current EU regulation seems to cover initial U-space operations with "low" traffic. The expected evolution of U-space is described in Section 1.4.



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The following acronyms appear in the text

| Acronym | Expansion | remarks |
|---|---|---|
| AGL | Above Ground Level | Height measured relative to the ground directly below. |
| AIP | Aeronautical Information Publication | A publication issued by or with the authority of a State and containing aeronautical information of a lasting character essential to air navigation (ICAO Annex 15 [56]). |
| AIRAC | Aeronautical Information Regulation And Control | See ICAO Annex 15 [56] |
| AMC-GM | Acceptable Means of Compliance – Guidance Material | AMCs are non-binding standards adopted by EASA to illustrate means to establish compliance with the Basic Regulation and its Implementing Rules.<br>Guidance Material provides solutions to reach that goal. |
| API | Application Programming Interface | Software solution which allows two applications to communicate. |



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| Acronym | Expansion | remarks |
|---|---|---|
| ASTM | American Society for Testing and Materials | |
| ATC | Air Traffic Control | Used to inform that the control service is provided by an ATC unit. |
| ATS | Air Traffic Services | Three services are provided by Air Traffic Controller, depending on the airspace class and knowledge of the traffic: control, information and alert. |
| BVLOS | Beyond Visual Line Of Sight | UAS operation where the aircraft is beyond visual line of remote pilot's sight. |
| C2 link | Command and Control Link | Radio or satellite link between the remote pilot station and the aircraft. |
| CCC | ConOps Coordination Cell | A forum for research and demonstration projects that gave input to this document. |
| CIS | Common Information Service | Common information service is a service consisting in the dissemination of static and dynamic data to enable the provision of U-space services for the management of traffic of uncrewed aircraft. |
| CNS | Communication Navigation Surveillance | Are the foundation of the aviation operational performance, enabling airspace capacity. |
| CSFL | Continued Safe Flight and Landing | Continued safe flight and landing means an airplane is capable of continued controlled flight and landing, possibly using emergency procedures, without requiring exceptional pilot skill or strength. |
| CTR | Controlled Traffic Region | Volume of controlled airspace set for protecting departures and arrivals to or from an aerodrome. |
| DCB | Demand and Capacity Balancing | Process used to minimise disruption and optimises operations using powerful, accurate forecasting that balances demand with capacity allowing to anticipate and mitigate disruption. |
| DFR | Digital flight rule | A term used in what is currently research at NASA<br>See https://ntrs.nasa.gov/citations/20205008308 |
| EASA | European Union Aviation Safety Agency | The European Union Aviation Safety Agency (EASA) is an agency of the European Union (EU) with responsibility for civil aviation safety. |
| EATMA | European ATM Architecture | EATMA is the European ATM architecture reference. |


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| Acronym | Expansion | remarks |
|---|---|---|
| EC | European Commission | The European Commission (EC) is part of the executive of the European Union (EU), together with the European Council. It operates as a cabinet government, with 27 members of the Commission (directorial system, informally known as "Commissioners") headed by a President. It includes an administrative body of about 32,000 European civil servants. The Commission is divided into departments known as Directorates-General (DGs) that can be likened to departments or ministries each headed by a Director-General who is responsible to a Commissioner. |
| EDAS | EGNOS Data Access Service | The EGNOS Data Access Service (EDAS) offers ground-based access to EGNOS data through the Internet on a controlled access basis. EDAS is the single point of access for the data collected and generated by the EGNOS ground infrastructure - mainly Ranging and Integrity Monitoring Stations (RIMS) and Navigation Land Earth Stations (NLES) - distributed over Europe and North Africa. See https://egnos-user-support.essp-sas.eu/new_egnos_ops/services/about-edas |
| EGNOS | European Geostationary Navigation Overlay Service | Europe's regional satellite-based augmentation system (SBAS). It is used to improve the performance of global navigation satellite systems (GNSSs), such as GPS and Galileo in the future. EGNOS was deployed to provide safety of life navigation services to aviation, maritime and land-based users. See https://egnos-user-support.essp-sas.eu/new_egnos_ops/egnos-system/about-egnos |
| EU | European Union | The European Union (EU) is a political and economic union of member states that are located on the European Continent. |
| EVTOL | Electric Vertical Take Off and Landing | Electric powered aircraft capable of vertical take-off and landing. |
| FATO | Final Approach and Take-off | Area designed to allow take-off and landing of VTOL aircraft. |
| GAMZ | Geodetic Altitude Mandatory Zones | A region of airspace in which Geodetic Altitudes should be used. See 2.3.4 |
| GCS | Ground Control Station | Part of a UAS. Synonymous with Remote Piloting Station |
| GME | Ground Movement Equipment | |
| GNSS | Global Navigation Satellite System | With a global coverage, the system allows satellite navigation everywhere on earth. |
| HEMS | Helicopter Emergency Medical Service | Helicopter in charge of moving patients from an area to another. It could be from an accident scene to a healthcare facility such as hospital or between two hospitals for instance. |



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| Acronym | Expansion | remarks |
|---|---|---|
| HMI | Human Machine Interface | The Human Machine Interface allows interactions between a machine and a human in charge of using it. |
| ICAO | International Civil Aviation Organization | A United Nations agency in charge of proposing and recommending principles and techniques in order to foster and harmonize aeronautical practices in the world. |
| IFR | Instrument Flight Rules | Defined in ICAO Annex 2 [13] |
| JARUS | Joint Authorities for Rulemaking on Unmanned Systems | Group of experts from the National Aviation Authorities (NAAs) and regional aviation safety organizations. Its purpose is to recommend a single set of technical, safety and operational requirements for the certification and safe integration of Unmanned Aircraft Systems (UAS) into airspace and at aerodromes (source JARUS LinkedIn page). |
| LUC | Light UAS operator Certificate | Certificate issued to a UAS operator by a competent authority (see COMMISSION IMPLEMENTING REGULATION (EU) 2019/947 of 24 May 2019 on the rules and procedures for the operation of unmanned aircraft, part C). |
| Maas | Mobility as a service | A shift from personally owned transport to mobility consumed as a service |
| MET | METeorology | What is related to meteorological data and information. |
| MSL | Mean Sea Level | Heights above Mean Sea Level have equal gravitational potential. |
| NOTAM | Notice to Airmen | See ICAO Annex 15 [56] |
| OECD | Organisation for Economic Co-operation and Development | Intergovernmental organization which goal is to stimulate economic progress and world trade. |
| POB | Pilot On Board | A (hopefully) unambiguous term to indicate an aircraft which has its pilot on board. May appear as POBA; Pilot On Board Aircraft. Contrasts with UAS |
| PVT | Position Velocity Time | Third mode of motion, position-velocity-time (PVT) mode, allows the same ease of coordination as contour mode, but removes velocity discontinuities. |
| RPS | Remote Pilot Station | Part of the UAS or RPAS, such as the RP (remote pilot) or the RPA (remotely piloted aircraft). RPS encompasses, at least, the functionalities allowing the remote pilot to steer and navigate the remotely piloted aircraft. |
| RPS | Remote Piloting Station | Part of a UAS. Sometimes also called Ground Control Station |
| RTTA | Reasonable Time To Act | RTTA is an agreed amount of time before the activation of the U-plan. |
| SAR | Search And Rescue | Organisation and operations of localisation and rescue of people in distress. |


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| Acronym | Expansion | remarks |
|---|---|---|
| SDSP | Supplemental Data Service Provider | Provides access to supplemental data to support U-space services. E.g., Weather Data Service Provider, Ground risk observation service provider. |
| SERA | Standardised European Rules of the Air | SERA is the transposition into law of ICAO Annex 2 (Rules of the Air) and parts of ICAO Annex 3 (Meteorology), Annex 10 (Communication Procedures), Annex 11 (Air Traffic Services) and Doc 4444 (PANS-ATM). (Source https://www.caa.co.uk/). |
| SESAR (JU) | Single European Sky ATM Research (Join Undertaking) | The SESAR Joint Undertaking is an institutionalised European partnership between private and public sector partners set up to accelerate through research and innovation the delivery of the Digital European Sky (source sesarju.eu). |
| SORA | Specific Operation Risk Assessment | Methodology to assess the safety risk of a UAS operation in the specific category. |
| SVFR | Special Visual Flight Rules | Special VFR flight' means a VFR flight cleared by air traffic control to operate within a control zone in meteorological conditions below VMC (Source SERA). |
| TLOF | Touchdown and Lift-Off | A load bearing area on which a helicopter may touch down or lift off (Annex 6 Part III). |
| UAS | Uncrewed Aerial System | Also expanded as 'Unmanned Aerial System.'<br>A UAS may carry passengers but in normal operations is being piloted remotely or autonomously.<br>The term "system" denotes a combination of the vehicle and other parts needed to make it work such as the remote piloting station |
| UAV | Uncrewed Aerial Vehicle | See UAS |
| UFR | U-space flight rule | Defined in this document. See section 4<br>May be the same as DFR. |
| UMZ | U-space Mandatory Zone | Zone in which aircraft shall be required to make their position known to U-Space through a defined procedure. |
| USSP | U-space Service Provider | This stakeholder provides one or more of the U-space services as listed in the U-space regulation[8] |
| UTM | UAS Traffic Management | UTM is a traffic management ecosystem for UAS operation. |
| VALS | Vertical ALert and information Service | Alerts pilots of crewed or uncrewed aircraft in any Geodetic Altitude Mandatory Zones (GAMZ) to any risk of collision with ground obstacles. |
| VCS | Vertical Conversion Service | Ensures the conversion of altitudes between barometric and geodetic reference systems to both crewed and uncrewed aircraft in Geodetic Altitude Mandatory Zones. |
| VFR | Visual Flight Rules | Defined in ICAO Annex 2 [13] |
| VLL | Very Low level | Part of airspace from ground to 500 feet above the ground. |



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| Acronym | Expansion | remarks |
|---|---|---|
| VLOS | Visual Line Of Sight | UAS operation where the aircraft is in sight the remote pilot. |
| VTOL | Vertical Take-Off and Landing | Aircraft capable of vertical take-off and landing (e.g., helicopter). |
| V-TZ | Vertiport Traffic Zone | Is a zone around a vertiport designed for protecting vertiport arrivals and departures. This zone is a U-space airspace. |

**Table 9 Acronyms**

The following terms appear in the text

| Term | Meaning | Source / remarks |
|---|---|---|
| Aircraft | Vehicle that derives lift from the air | May have the pilot / aircrew on board or not. |
| Below | In the direction towards the gravitational centre of the earth | |
| Conflict | Loss of adequate separation between two (or more) aircraft | For clarity, when this term is used in this document in a general sense, then it refers to a conflict between two aircraft. When an object is identified then it will mean a loss of separation between an aircraft and that object. E.g. "conflict with giraffe" |
| Conspicuous | Visible to or able to be detected by some implied or identified observer, typically a pilot. | The VFR pilot is expected to see other aircraft and remain well clear of them. Such aircraft are conspicuous to the pilot. U-space makes use of non-visual means to achieve conspicuousness or as it is also written, conspicuity. |
| Crewed aircraft | Aircraft with a human pilot (air crew) on board | May also be written as 'manned aircraft,' but the term manned is ambiguous about whether the human on board is able to pilot the aircraft. No gender is implied. |
| Drone | Aircraft without a human pilot (air crew) on board | May be any size. Synonym of Uncrewed aircraft and UAV |
| U-plan | A plan for a flight in U-space | = U-Plan.<br>Operations in U-space may include recharging / refuelling / battery-changing stops which may be inserted into the operation unpredictably. An U-plan may include more than one take-off / landing. |
| Uncrewed aircraft | Aircraft without a human pilot (air crew) on board | Synonym of Drone. Sometimes shortened to UA. See UAS. |
| U-plan | A plan for a flight in U-space | = U-plan.<br>The term "flight plan" is avoided to stress that the format of the U-Plan is not that described in ICAO Doc 4444. |

**Table 10 Terminology**

# U-space ConOps: Architecture Annex

| | |
|---|---|
| Deliverable ID: | D4.2 |
| Dissemination Level: | CO |
| Project Acronym: | CORUS-XUAM |
| Grant: | 101017682 |
| Call: | SESAR-VLD2-03-2020 |
| Topic: | U-space capabilities and services to enable Urban Air Mobility |
| Consortium Coordinator: | EUROCONTROL |
| Edition Date: | 14 Apr 2023 |
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# CORUS-XUAM

CORUS-XUAM

This Concept of Operations is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 101017682 under European Union's Horizon 2020 research and innovation programme.

## Abstract

U-space is Europe's traffic management system for Uncrewed Aerial Systems (UAS), also called drones. The ConOps explains how U-space works from a user's point of view. This is the fourth edition of the ConOps and differs for three reasons. This edition attempts to meet the needs of Urban Air Mobility, including both goods and passenger air transport in urban areas. The European Union has passed various regulations relating to U-space which have to be considered. Research projects have completed details missing in the previous editions which are incorporated.

Meeting the needs of UAM focuses on processes at the vertiport, airspace structure and flight rules, particularly as initial passenger carrying operations with "electric vertical take-off and landing" (EVTOL) vehicles are expected to have a pilot on board.

The European Union regulations, primarily 2021/664, 665 and 666 define U-space in terms of seven services, six functional plus "common information." This ConOps supports that view.

Some research projects bring more precise descriptions of services or processes already mentioned, for example dynamic capacity balancing (DACUS), and some projects bring new services like altitude conversion services (ICARUS).

This fourth edition of the U-space ConOps aims to be more succinct than previous editions.

# Table of Contents

## List of Tables



## List of Figures

# 1 Introduction

## 1.1 Purpose

This document is used to give to the reader visibility of the final work of architecture development in CORUS-XUAM which required for ConOps document.

This document is providing indeed high-level views which are supporting the concept development mainly and proving examples and initial contents for a future reference architecture, not in the scope of CORUS-XUAM.

Main purpose of this document is to baseline high level architecture views based on comments received on the intermediate version and outcomes of the validation with the U-space Community.

Not all the different views composing the CORUS-XUAM architecture are shown in this document. It is intended to show all of them in the eATM Portal (U-space R&D).

## 1.2 Scope

The scope of this annex is the same as the one of the U-space ConOps.

It presents the description of the U-space architecture for Very Low-level operations from a business and operational viewpoint, supporting the incremental versions of the business process diagrams. In addition, it provides an overview of the service and system viewpoints to support bottom–up coherencies of the concept of operations.

The objective of developing CORUS-XUAM architecture is to support the definition of a Concept of Operation (the CORUS-XUAM ConOps) and thus provides the foundation for U-space. The architecture addresses VLL and all U-space service levels. It addresses VLL operations in both uncontrolled (Class G) and controlled (Classes A, B, C, D, E and F) airspace, such as in and around airports for building inspections, aircraft maintenance, ILS and or VOR/DME calibration, calibration of runway lighting etc.

## 1.3 Document Structure

**Chapter 1 – Introduction;** it is the synopsis of this document.

**Chapter 2 – Drivers;** it addresses main inputs and architecture principles taken into consideration for developing the U-space architecture in CORUS-XUAM.

**Chapter 3 –Strategic Architecture;** it presents architecture elements and views to describe the U-space architecture from a strategic point of view. It provides the description of the U-space Capability Model.

**Chapter 4 –Business Architecture;** it presents architecture elements and views to describe the U-space architecture from a conceptual point of view. It provides the description of the business process diagrams.

**Chapter 5 –Service Architecture;** it presents architecture elements and views to describe the U-space architecture from a service-oriented point of view. It provides the list of the identified services and their links that present how the services realise the business and supports the strategy.

**Chapter 6 –System Architecture;** it presents architecture elements and views to describe the U-space from a system point of view. It provides the description of possible breakdown of the U-space in systems (in some cases with a further possible breakdown in functional blocks) and their relationships.

**Chapter 7 – References**; it lists relevant documentation.

## 1.4 Intended readership

The primary readership for this document is those who have a responsibility for the management and maintenance of the U-space Architecture and its content. These readers can be divided into the following groups:

- CORUS-XUAM Members – Those who are responsible for the development of the Architectural content and those who are involved in other CORUS-XUAM activities which may review/complement and take as input the architecture developed.
- U-space Project Managers – The managers of other relevant SJU projects which may be interested in the content that is collected within the CORUS-XUAM architecture and in providing feedback for ensuring the overall quality and consistency of the U-space Architectural content.
- S3JU - who wants to have the visibility of the CORUS-XUAM work and contribute to the architecture definition.
- U-space Community – Those who are stakeholders of the U-space which are interested in the ConOps and architecture principles and descriptions.

## 1.5 Terms, acronyms and abbreviations

The following acronyms appear in the text:

| Acronym | Expansion | Remarks |
|---|---|---|
| ATC | Air Traffic Control | Used to inform that the control service is provided by an ATC unit. |
| ATS | Air Traffic Services | Three services are provided by Air Traffic Controller, depending on the airspace class and his knowledge of the traffic: control, information and alert. |
| CIS | Common Information Service | Common information service is a service consisting in the dissemination of static and dynamic data to enable the provision of U-space services for the management of traffic of unmanned aircraft. |
| CNS | Communication Navigation Surveillance | Are the foundation of the aviation operational performance, enabling airspace capacity. |
| DCB | Demand and Capacity Balancing | Process used to minimise disruption and optimises operations using powerful, accurate forecasting that balances demand with capacity allowing to anticipate and mitigate disruption. |
| EATMA | European ATM Architecture | EATMA is the European ATM architecture reference. |
| EU | European Union | The European Union (EU) is a political and economic union of member states that are located on the European Continent. |
| EVTOL | Electric Vertical Take Off and Landing | Electric powered aircraft capable of vertical take-off and landing. |

| Acronym | Expansion | Remarks |
|---|---|---|
| FATO | Final Approach and Take-off | Area designed to allow take-off and landing of VTOL aircraft. |
| ICAO | International Civil Aviation Organization | A United Nations agency in charge of proposing and recommending principles and techniques in order to foster and harmonize aeronautical practices in the world. |
| MET | METeorology | What is related to meteorological data and information. |
| NAF | NATO Architecture Framework | Architecture framework developed by NATO, which is used as the main reference of EATMA. |
| RPS | Remote Pilot Station | Part of the UAS or RPAS, such as the RP (remote pilot) or the RPA (remotely piloted aircraft). RPS encompasses, at least, the functionalities allowing the remote pilot to steer and navigate the remotely piloted aircraft. |
| RPS | Remote Piloting Station | Part of a UAS. Sometimes also called Ground Control Station |
| R&D | Research and Development | First stages of the development of a concept before its industrialisation. |
| SDSP | Supplemental Data Service Provider | Provides access to supplemental data to support U-space services. E.g., Weather Data Service Provider, Ground risk observation service provider. |
| SESAR (JU) | Single European Sky ATM Research (Join Undertaking) | The SESAR Joint Undertaking is an institutionalised European partnership between private and public sector partners set up to accelerate through research and innovation the delivery of the Digital European Sky (source sesarju.eu). |
| UAS | Uncrewed Aerial System | Also expanded as 'Unmanned Aerial System.'<br>A UAS may carry passengers but in normal operations is being piloted remotely or autonomously.<br>The term "system" denotes a combination of the vehicle and other parts needed to make it work such as the remote piloting station |
| USSP | U-space Service Provider | This stakeholder provides one or more of the U-space services as listed in the U-space regulation [10] |
| UTM | UAS Traffic Management | UTM is a traffic management ecosystem for UAS operation. |
| VALS | Vertical ALert and information Service | Alerts GA pilots, UASs and their pilots in any Geodetic Altitude Mandatory Zones (GAMZ) to any risk of collision with ground obstacles. |
| VCS | Vertical Conversion Service | Ensures the conversion of altitudes between barometric and geodetic reference systems to both manned and unmanned aircraft in Geodetic Altitude Mandatory Zones. |
| VFR | Visual Flight Rules | Defined in ICAO Annex 2 [11] |
| VLL | Very Low level | Part of airspace from ground to 500 feet above the ground. |

**Table 1: Acronyms**

The following terms appear in the text

| Term | Meaning | Source / remarks |
|---|---|---|
| Aircraft | Vehicle that derives lift from the air | May have the pilot / aircrew on board or not. |
| Below | In the direction towards the gravitational centre of the earth | |
| Crewed aircraft | Aircraft with a human pilot (air crew) on board | May also be written as 'manned aircraft' |
| UAS | Aircraft without a human pilot (air crew) on board | May be any size. Synonym of Un-crewed aircraft and UA |
| Uncrewed aircraft | Aircraft without a human pilot (air crew) on board | Synonym of UAS. Sometimes shortened to UA. |
| U-plan | A plan for a flight in U-space | |

**Table 2: Terminology**

# 2 Drivers

## 2.1 U-space Blueprint, European ATM Master Plan and U-space ConOps ed.3 Architecture document

As the U-space blueprint [1] makes clear, a U-space Concept of Operations (ConOps) is required, especially for Very Low-Level UAS operations[1] and should describe the services and interfaces that are necessary to enable full development of the economic potential of UASs while ensuring adequate levels of safety.

The U-space blueprint [1] defines four levels of services, as shown below. Each level is a package of related services. CORUS-XUAM will make use of this terminology.

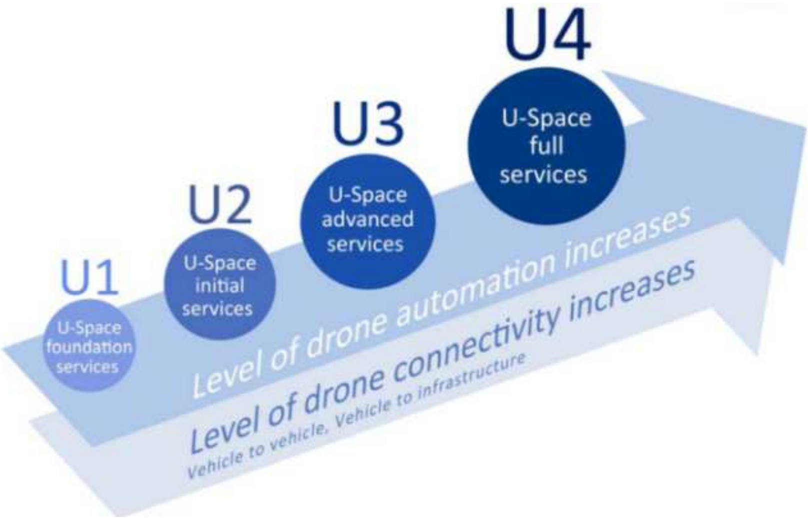



**Figure 1: U-space levels**

The U-space blueprint [1] lists several services, clustering them into "levels" that differ in terms of their deployment timeline. The following table summarises the document.

| Level | Name | Target |
|---|---|---|
| U1 | U-space foundation services | 2019 |
| U2 | U-space initial services | 2022..25 |
| U3 | U-space advanced services | 2025..30 |
| U4 | U-space full services | 2030+ |

**Table 3: U-space Blueprint service levels**

[1] Including operations beyond visual line of sight (B-VLOS), as well as in visual flight rules (VFR) environments. In accordance with the call, instrument flight rules (IFR) integration will not be addressed.

The U-space Blueprint is a brief document. The European ATM Master Plan UAS roadmap document provides more detailed description of services and UAS capabilities which constituted one of the main top-down input taken into consideration in the CORUS ConOps ed.3 architecture [4] development, which has served as the baseline for the CORUS-XUAM architecture presented in this document and in the eATM Portal (U-space R&D) [3].

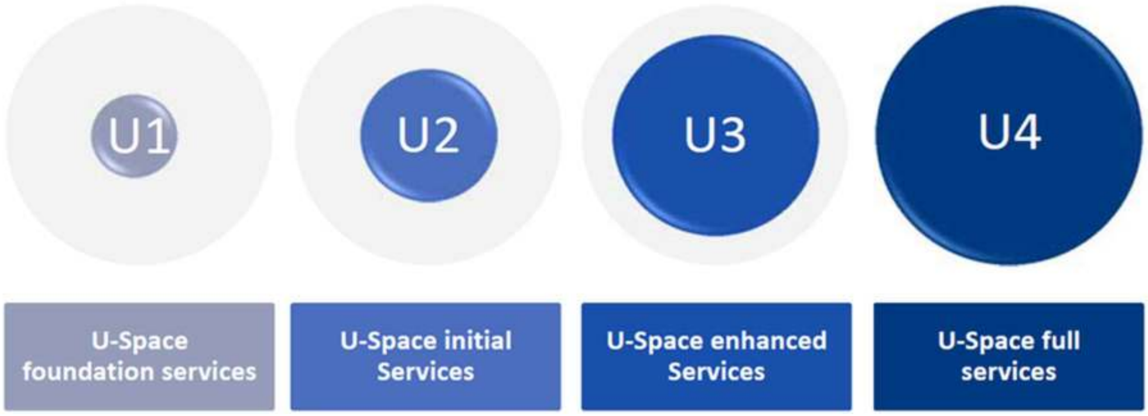



**Figure 2: Services in each of the U-space levels**

CORUS-XUAM takes these inputs and seeks to:

- Explain how these services are used to ensure safe, efficient operations.
- Provide, where appropriate, more precise descriptions of the services
- Refine the lists of services - as far as is possible today.
- Maintain the lists of services during the life of CORUS-XUAM, interacting with other projects or actors who have contributions to make to those definitions.

## 2.2 CORUS-XUAM-XUAM Internal Drivers

CORUS-XUAM splits the work in several work packages. CORUS-XUAM internally developed among the others the definition of business process diagrams, environment, requirements, services, constraints to operation in relation with failure and emergency. All these are important inputs that fed the development of the U-space architecture.

## 2.3 Other U-space projects

The CORUS-XUAM project has no hard dependencies on other U-space projects in the sense of waiting for deliverables from those projects. However, as CORUS-XUAM aims to describe the U-space ConOps, it is transversal for these other U-space projects. Therefore, there have been coordination sessions to understand the outcome of the projects, the feedback on the progress of the U-space ConOps and to include in the U-space architecture their most promising findings.

# 3 Strategic Architecture

This section provides high-level description of the U-space Strategic Architecture.

The strategic layer describes the U-space's abilities and performance measures such as validation targets and validation results; it describes the business capabilities.

The main element of the Strategic Layer in the U-space architecture is the Capability, whose definition is the following:

- **Capability:**

  *Capability is the ability of one or more of the enterprise's resources to deliver a specified type of effect or a specified course of action to the enterprise stakeholders.*

  *A Capability represents a high-level specification of the enterprise's ability. As such, the whole enterprise can be described via the set of Capabilities that it has.*

  *A Capability is a statement of "what" is to be carried out and does not refer to "how" or "by whom" they are carried out. Consequently, capabilities are free from considerations of physical organisation or specific choices of technology.*

  *'Capabilities' is an important business concept that describes the abilities or competencies of an organization. They are typically quite stable, and while business processes, functions and roles change quite frequently, capabilities change less frequently. When they do change, it is typically in response to a strategic driver or change. Capabilities can be mapped back to strategic goals and objectives.*

  *They provide a useful starting point to derive lower-level elements such as processes and functions, applications and technology assets.*

## 3.1 U-space Capability Model

The Capability Model is the view that describes the entire U-space enterprise in the form of a set of decomposed capabilities. A capability is the perceived outcome realised by the undertaking of activities by stakeholders.

Building from the U-space Capability model defined in the U-space ConOps v3 [4] , this latest iteration is produced with the inputs from the CORUS-XUAM consortium, other U-space projects and the alignment with the evolution of the EATMA Capability Model.

The model has 3 levels of granularity; the main one (level 1) is composed by the ICAO building blocks, the level 2 decomposes the ICAO building blocks into different domains, while the level 3 addresses the most detailed capabilities, which trace to other architectural elements (e.g., services).

The white level 3 capabilities are the ones identified either as pure U-space capabilities or shared between ATM and U-space; while the grey ones are, so far, only considered ATM capabilities.

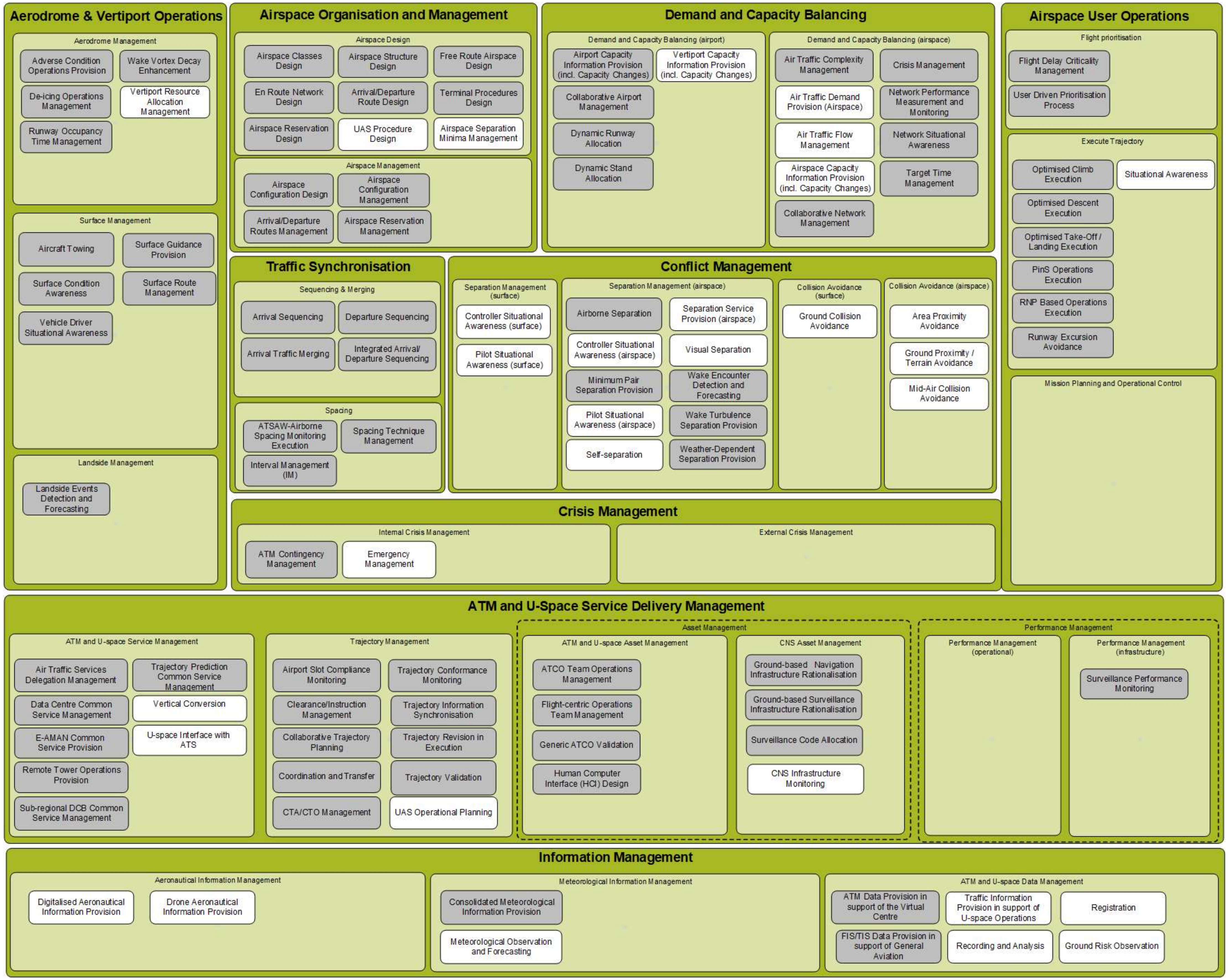



**Figure 3: U-space Capability Model.**

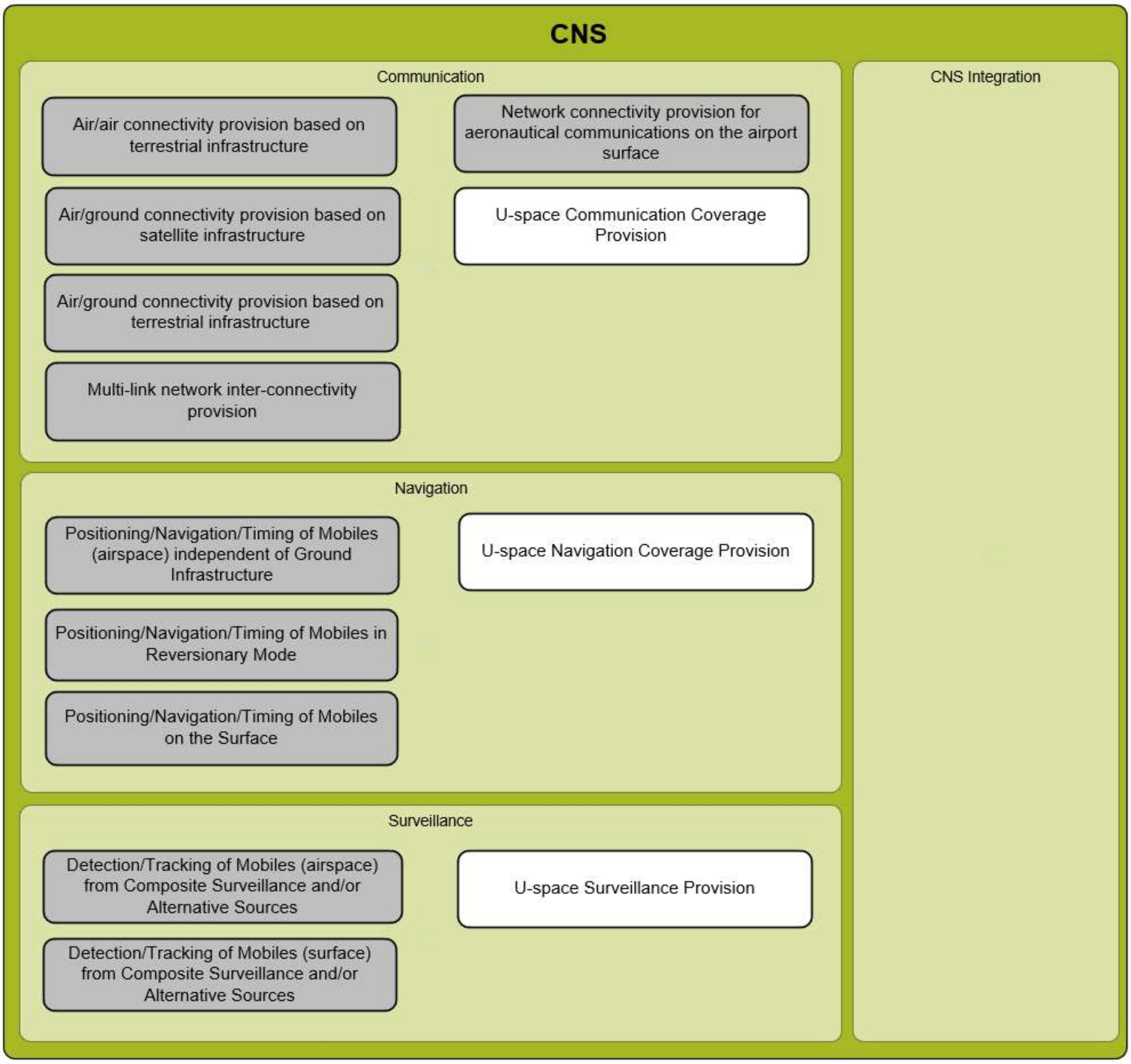



**Figure 4: U-space CNS Capabilities**

## 3.2 U-space Capabilities

| Capability Level 3 | Description |
|---|---|
| **Air Traffic Demand Provision (Airspace)** | The ability to determine the air traffic demand (present, future) in airspace. |
| **Airspace Capacity Information Provision (incl. Capacity Changes)** | The ability to determine the capacity (present, future) of airspace, including ad hoc changes due to circumstances (e.g. weather) |
| **Air Traffic Flow Management** | The ability to detect / monitor demand capacity imbalances (present, future) in the airspace and solve the imbalance issues acting on load/demand. |
| **Airspace Separation Minima Management** | The ability to define and manage the separation minima and separation methods for a specific airspace (U-space) |
| | |

| | |
|---|---|
| **Area Proximity Avoidance** | The avoidance of infringement into airspace by airborne vehicles not authorised or expected to enter the airspace |
| **CNS Infrastructure Monitoring** | The ability to monitor the status of the CNS infrastructure |
| **Controller Situational Awareness (airspace)** | The ability to visualise the air traffic situation through the position and identification of aircraft. |
| **Controller Situational Awareness (surface)** | The ability to visualise the traffic situation on the ground through the position and identification of aircraft and vehicles. |
| **Digitalised Aeronautical Information Provision** | The ability to provide and exchange aeronautical information as digital data sets, in an interoperable manner and mutually understood manner. |
| **Drone Aeronautical Information Provision** | The ability to provide aeronautical and coherent information for manned and unmanned operators relevant to U-space. This includes predefined restricted areas or available aeronautical information. |
| **Emergency Management** | The ability to manage solutions for emergencies in U-space. It includes the exchange of information among the relevant actors and drone auto-diagnosis. |
| **Ground Collision Avoidance** | Prevention of aircraft collision during taxi or push-back (including collisions with parked aircraft) or on the runway/landing spot or while one is on the ground and the other in the air close to the ground. |
| **Ground Proximity / Terrain Avoidance** | Prevention of aircraft collision with the terrain and obstacles while is in the air close to the ground.<br>The avoidance of collision with the terrain by an airborne vehicle. |
| **Ground Risk Observation** | The ability to provide static and dynamic information about ground risks for UAS operations (e.g. terrain and obstacle elevation, population density, other ground traffic such as trains, vessels, cars) at the scale of interest of small UASs. |
| **Meteorological Observation and Forecasting** | The ability to provide meteorological observations, forecast and warning information in support of ATM and U-space decision making. |
| **Mid-Air Collision Avoidance** | The avoidance of collision between mobile airborne vehicles. |
| **Pilot Situational Awareness (airspace)** | The ability to visualise own aircraft position and surrounding traffic information in context (e.g. airspace status). |
| **Pilot Situational Awareness (surface)** | The ability to visualise own aircraft position and surrounding traffic information in context (e.g. airport layout). |
| **Recording and Analysis** | The ability to record U-space such as relevant event and traffic scenes and to provide reports, statistics, playback. It encompasses e.g. logbooks, legal recordings, playback for incident and accident investigations. |
| **Registration** | The ability to provide the registration of the operator, drone and pilot with the appropriate information according to Regulation. |
| **Self-separation** | The ability to separate own aircraft from surrounding traffic. |
| **Separation Service Provision (airspace)** | The ability to separate aircraft when airborne in line with the separation minima defined in the airspace design (incl. aircraft separation from incompatible airspace activity, weather hazard zones, terrain-based obstacles). |
| **Situational Awareness** | The ability to provide traffic information for user situational awareness coming from any kind of monitoring. |
| **Traffic Information Provision in support of U-space Operations** | The ability to provide traffic information for user situational awareness coming from any kind of monitoring. |
| **UAS Operational Planning** | The ability to plan UAS missions considering all relevant information, such as meteorological information, aeronautical information, applicable rules and traffic information. |
| **UAS Procedure Design** | The ability to interface with ATC to define a set of procedures for some mission types where there may be an impact on ATC; the procedures ensure clear and unambiguous UAS operation and provide an appropriate flow of information between the UAS operators and ATC. Such procedures |

| | |
|---|---|
| | will allow UAS to fly in controlled airspace and near airports with more flexibility and procedural approval/rejection based on agreed rules. |
| **U-space Communication Coverage Provision** | The ability to facilitate (providing the link, coverage provided and monitoring) the air-air, air-ground and ground-ground communication. |
| **U-space Interface with ATS** | The ability to interoperate with ATC with mechanisms which ensure proper effective coordination when UAS operations using U-space services impact ATS. |
| **U-space Navigation Coverage Provision** | The ability to facilitate (providing the link, coverage provided and monitoring) the planning, recording and controlling the movement of an aircraft from one place to another. |
| **U-space Surveillance Provision** | The ability to facilitate the provision of ground and air surveillance data from different sources to track and fuse for determining the position of the aircraft. |
| **Vertical Conversion** | The ability to convert barometric to geodesic heights and vice-versa. |
| **Vertiport Capacity Information Provision (incl. Capacity Changes)** | The ability to determine and provide the capacity (present, future) of the vertiport, including ad hoc changes due to circumstances (e.g. weather) |
| **Vertiport Resource Allocation Management** | The ability to allocate resources of vertiports to accommodate UAS requests. |
| **Visual Separation** | The ability to maintain own separation during visual approach/departure. |

**Table 4: Capability descriptions**

# 4 Business Architecture

The operational layer contains the elements needed to describe the business concepts and is independent from any physical implementation. It includes descriptions of business actors and processes.

Even if six different architectural elements compose this layer in the EATMA framework [6], only five are used for the CORUS-XUAM architecture so far.

- **Node:**

  *A logical entity that performs Activities. Note: nodes are specified independently of any physical realisation. They represent the actors in the operational layer. Nodes interact through Information Exchanges in which they exchange Information Elements.*

- **Information Exchange:**

  *The collection of information elements that are exchanged between two nodes. An Information Exchange defines the types of Information Elements exchanged and which Nodes are involved in the Information Exchanges.*

  *It is important to note that Information Exchanges are realised by Services. This means that the Services are identified from the Information Exchanges, which also represent the operational need for exchanging information.*

- **Activity:**

  *A logical process, specified independently of how the process is carried out.*

  *Activities represent WHAT has to be done to complete a Capability.*

  *Activities are logically grouped within Nodes (and hence, associated to the Stakeholder that implements that node) Activities may be realized by people, or aspects may be automated and performed by functionality (Functions and Services) provided by Technical Systems.*

- **Information Flow:**

  *A flow of information from one Activity to another.*

  *An Information Flow defines the types of Information Elements sent from one Activity to another. It is always modelled as a one-way flow.*

  *Information Flows may be aggregated into one or more Information Exchanges between Nodes, thus enabling the description of more complex two-way interactions*

- **Information Element:**

  *A formalised representation of information. An Information Element is carried by one or more Information Exchanges (between Nodes).*

## 4.1 Nodes and Information exchanges

| Node | Description |
|---|---|
| **USSP Operations** | Performs all the operational activities related to management of UAS traffic.<br><br>This includes the activities required at strategic level, in execution and post flight to ensure a safe execution of UAS flights.<br><br>It is as well encompassing activities to maintain/monitor physical condition of the supporting infrastructures, creating and maintaining a good relationship with local / national authorities, ATM and communities.<br><br>It also includes assurance that the scale of equipment and facilities provided are adequate for the activities which are expected to take place, as well as provision of staff, where necessary, that are competent and, suitably qualified. |
| **UAS Operations** | Represents all the activities undertaken by those organisations and individuals who have access to and operate in the airspace which is available for UAS operations in accordance with international and national procedures.<br><br>The main types of UAS Operations are:<br><br>· Civil UAS Operations /Organisation. The most extensive organization for UAS Operations is run by Legal Entities which uses UASs for their business activities. The daily operations of these companies require a lot of flexibility.<br><br>· Recreational UAS Operations. Another important segment of UAS Operations which are constituted by single individuals which are aimed to use UASs for recreational purposes.<br><br>· Special UAS Operations /Organisation. Organizations for UAS Operations which require special conditions to operate, such as military/law enforcement. The daily operations of these companies require special condition of privacy in respect to the other organisations. |
| **Pilot Operations** | It performs all the activities related to the preparation, execution and post-flight where pilot and the flying system are involved. |
| **Registration Operations** | Performs all the operational activities related to the registration of UAS ownership, UAS pilot and UAS operators licensing according to the law.<br><br>It is as well encompassing activities to maintain registrations, to share them with interested parties, as well as provision of staff, where necessary, that are competent and, suitably qualified. |
| **Law Enforcement Operations** | Performs all the operational activities related to the law enforcement. Most of the activities relies on U-space services to provide required law enforcement actions (e.g. e-identification). |
| **CISP Operations** | It performs all the activities related to the provision of Common Information for U-space. It is also responsible, if applicable, of the exchange of information of ATM and U-space. |
| **Public Users Operations** | Performs all the operational activities related to public when wants to be informed about UAS traffic. These activities are mainly derived from privacy and safety issues of an individual/community. |

| | |
|---|---|
| **Insurance Management** | Performs all the operational activities related to insurance management. Even if the process can be considered outside the scope, for registration purposes it is important to mention these activities especially for the required exchanges in the e-registration process. |
| **Meteorological Service Provision** | Performs all the operational activities related to the weather information provision.<br><br>Provides at least the weather data and where necessary hyper local weather data to ensure safe UAS operations.<br><br>In most instances a weather provider will provide a wider scope of weather data relevant to the ATM stakeholders/ATM community. |
| **Ground Info Provider Operations** | Performs all the operational activities related to the provision of ground related information, e.g. Terrain and Obstacles information. |
| **Surveillance Operations** | Performs all the operational activities related to the provision of Surveillance information |
| **Navigation Operations** | Performs all the operational activities related to the provision of Navigation information |
| **Communication Operations** | Performs all the operational activities related to the provision of Communication information |
| **ER/APP ATS (U-space)** | Performs all the en-route and approach ATS operations. |
| **Aerodrome ATS (U-space)** | Performs all the aerodrome ATS operations. |
| **Flight Deck** | Performs all the on-board AU operations including flight execution/monitoring according to agreed trajectory, compliance with ATC clearances/instructions, etc. |
| **AIM** | Performs all the operational activities related to the provision of Aeronautical Information |
| **Training School** | Performs all the operational activities related to the training schools. Provides information required for the registration process. |
| **Regulator Operations** | Performs all the operational activities related to the regulator. |
| **Vertiport Operations** | Responsible for providing permission for departing and arriving in the vertiport as well as for providing relevant information to other USSPs. |

**Table 5: Nodes**

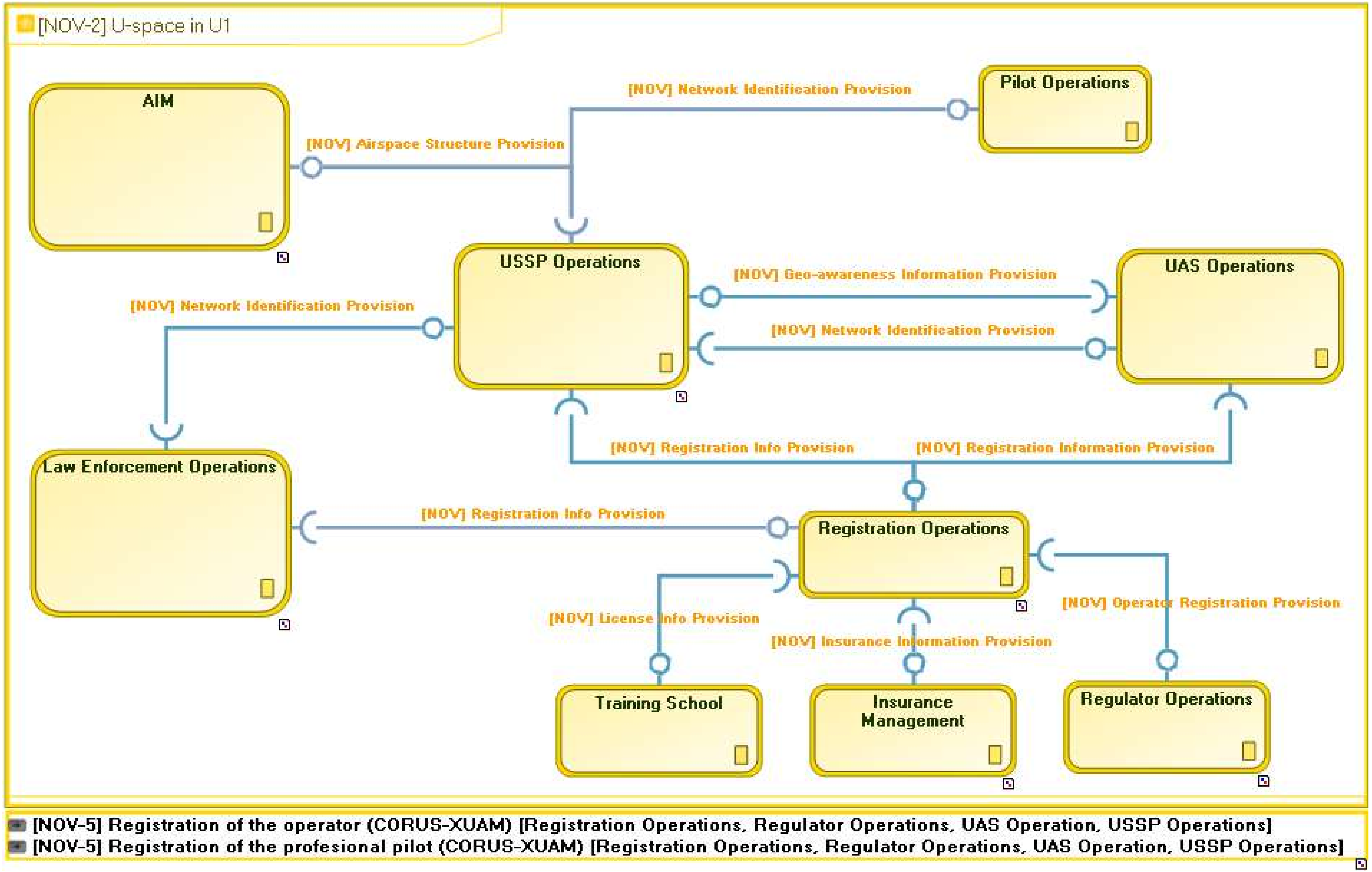



**Figure 5: U-space information exchanges needs in U1**

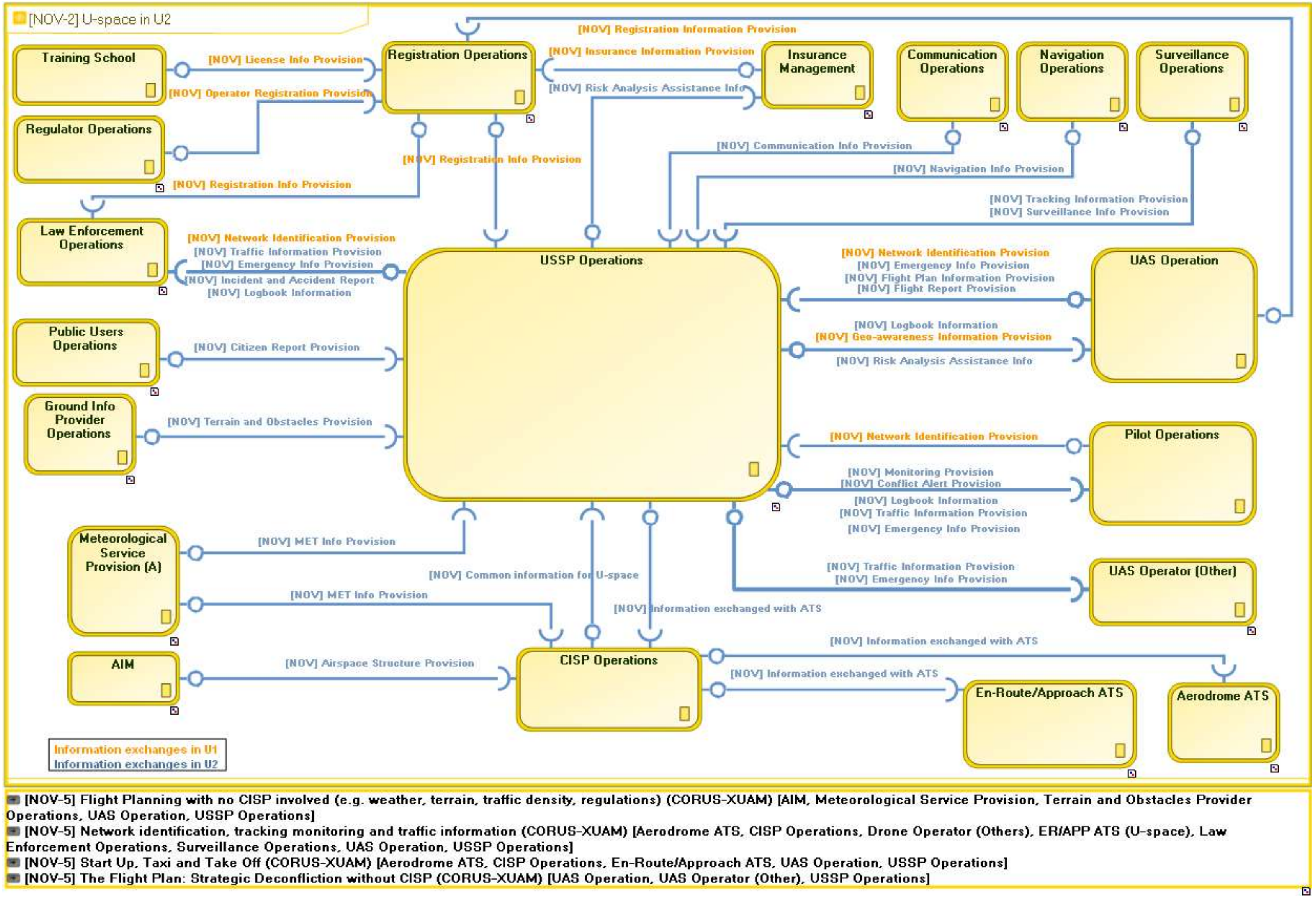
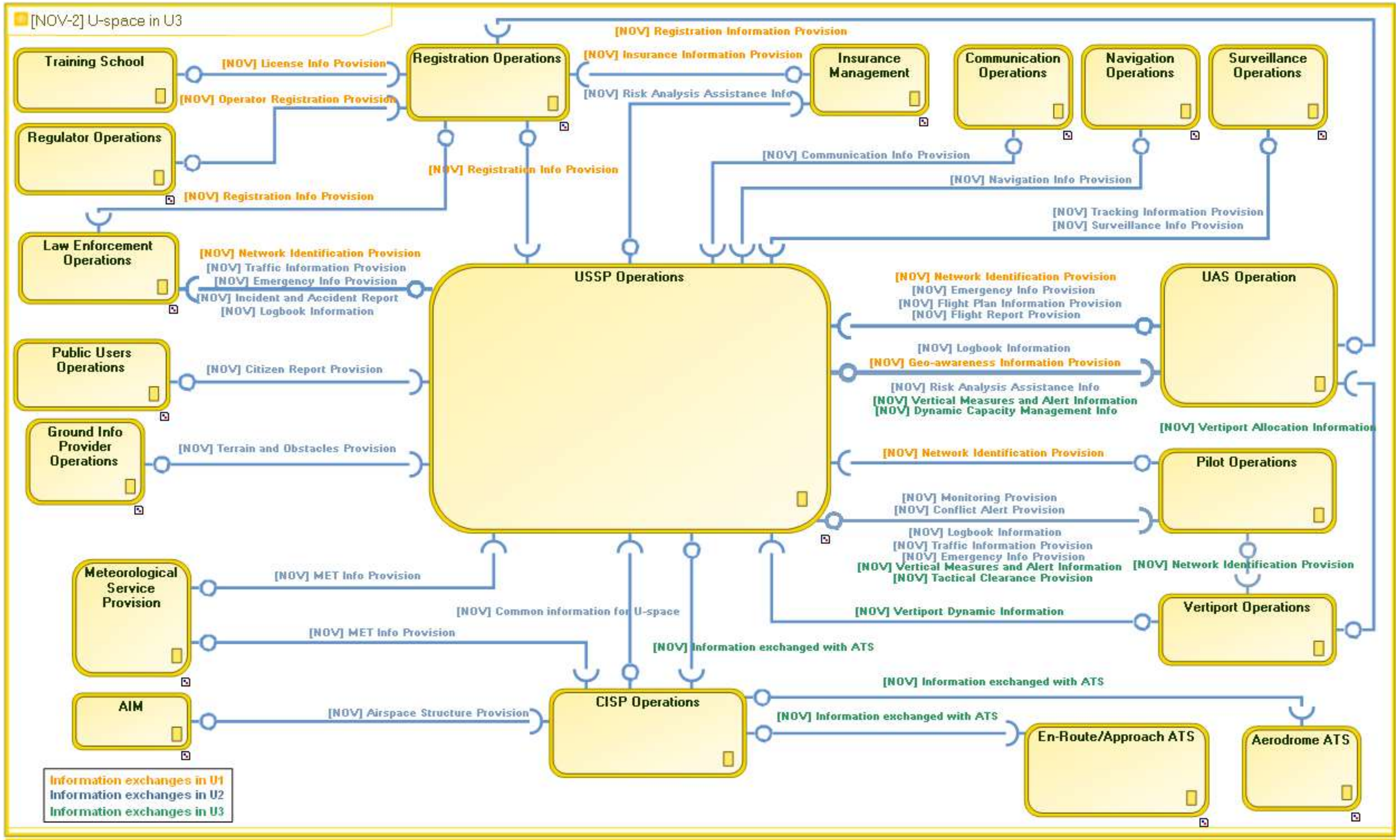



**Figure 6: U-space information exchanges needed at U2**




[NOV-5] Departure from a controlled vertiport towards an uncontrolled vertiport (with ATC interaction) and vice-versa [CISP Operations, Pilot Operations, TWR Operations, UAS Operations, USSP Operations, Vertiport Operations]
[NOV-5] Flight Route with ATS clearance (CORUS-XUAM) [170E6B755AEC4AA6, CISP Operations, ER/APP ATS (U-space), Manned Aviation, UAS Operation, USSP Operations]
[NOV-5] Landing on a controlled airfield/airport/aerodrome (CORUS-XUAM) [Aerodrome ATS, Drone Operator (Others), Participant, Participant, UAS Operation, USSP Operations]
[NOV-5] Nominal arrival to a vertiport (U3) [Pilot Operations, UAS Operations, USSP Operations, Vertiport Operations]
[NOV-5] Post-flight operations (CORUS-XUAM) [CISP Operations, UAS Operation, USSP Operations]
[NOV-5] T3.2 Passenger ticketing and boarding (U3) [Public Users Operations, UAS Operations, Vertiport Operations]
[NOV-5] T3.2 Strategic DCB Planning Measures Management (U3) [Law Enforcement Operations, Meteorological Service Provision (A), Regulator Operations, TWR Operations, USSP Operations, Vertiport Operations]
[NOV-5] T3.2. Departure from and arrival to uncontrolled vertiports (no interaction with ATC) [Pilot Operations, UAS Operations, USSP Operations, Vertiport Operations]
[NOV-5] Tactical de-confliction in Zu airspace with one USSP involved (CORUS-XUAM) [Pilot Operations, UAS Operations, USSP Operations, Vertiport Operations]

**Figure 7: U-space information exchanges needed at U3**

At this level of abstraction and from a conceptual point of view the USSP Operations is described just as a single node, without entering in the technical possible variants of deployment, which may include more than one.

## 4.2 Business Processes for U-space

The business processes of the U-space ConOps are depicted via the business process diagrams as represented in the Operational Layer as NAF Operational Views – 5 (NOV-5) [5].

They represent the dynamic behaviour of the Nodes (swim lines) showing in a sequenced way what Activities (yellow boxes) they perform and so which and when the Information Elements are sent between the participants.

As a result of the consortium, fifteen different business processes have been designed representing the use cases explained in the CORUS-XUAM ConOps. They represent one possible way of proceeding, but not constraining the process to these procedures.

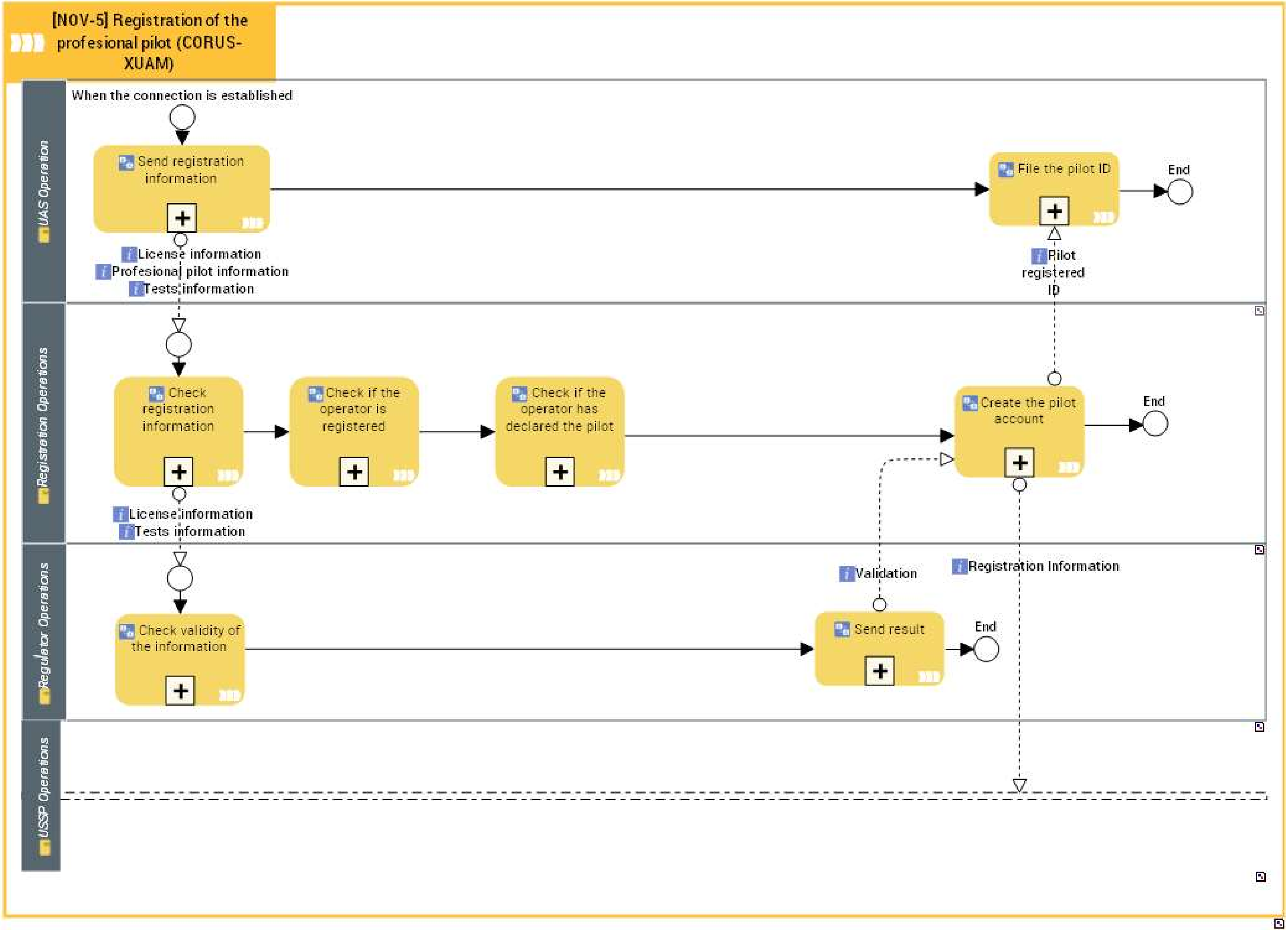



**Figure 8: Registration of the Professional Pilot**

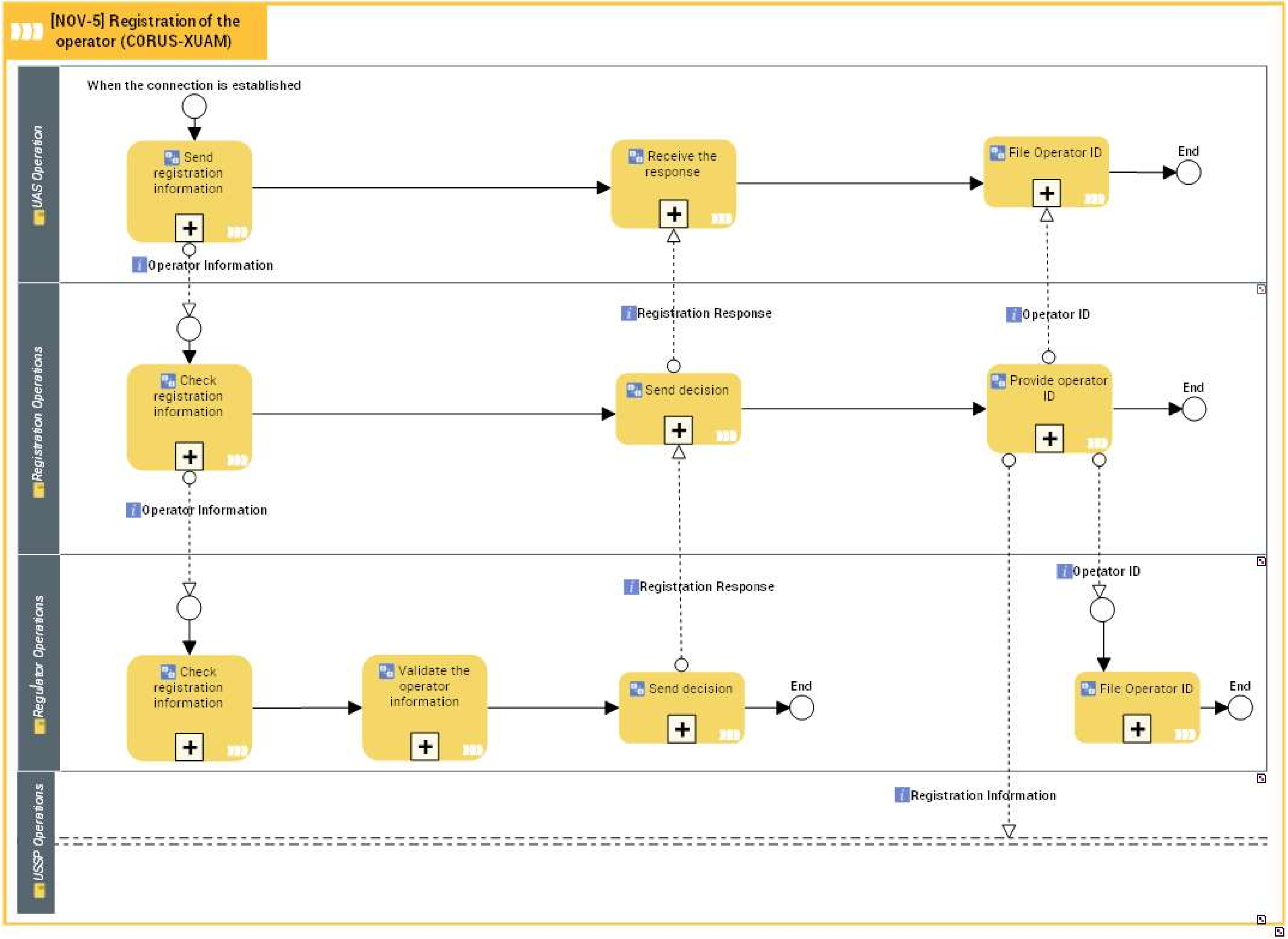



Figure 9: Registration of the UAS Operator

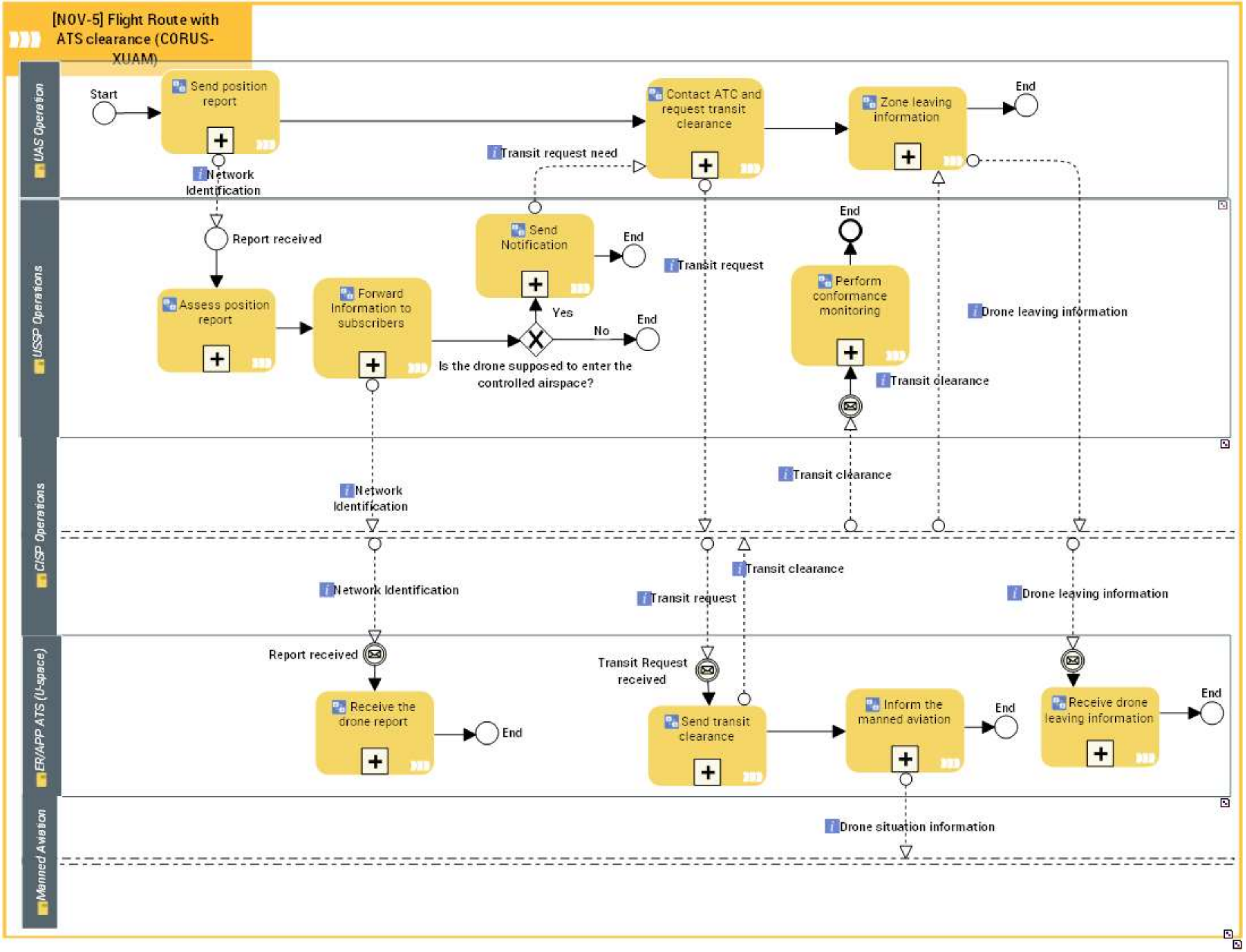



**Figure 10: Flight Route with ATS clearance**

Founding Members

EUROPEAN UNION EUROCONTROL

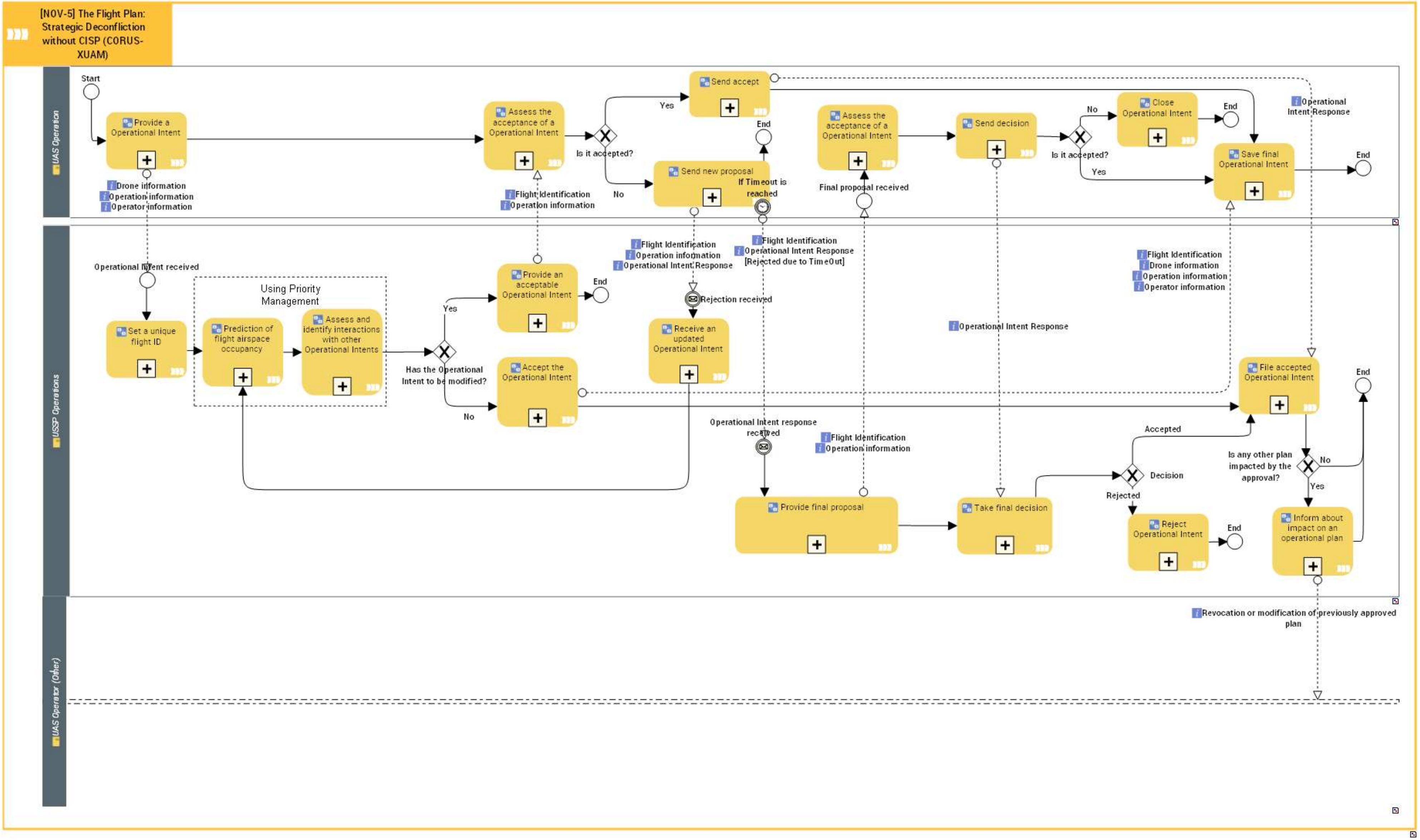



**Figure 11: The Flight Plan with Strategic Deconfliction**

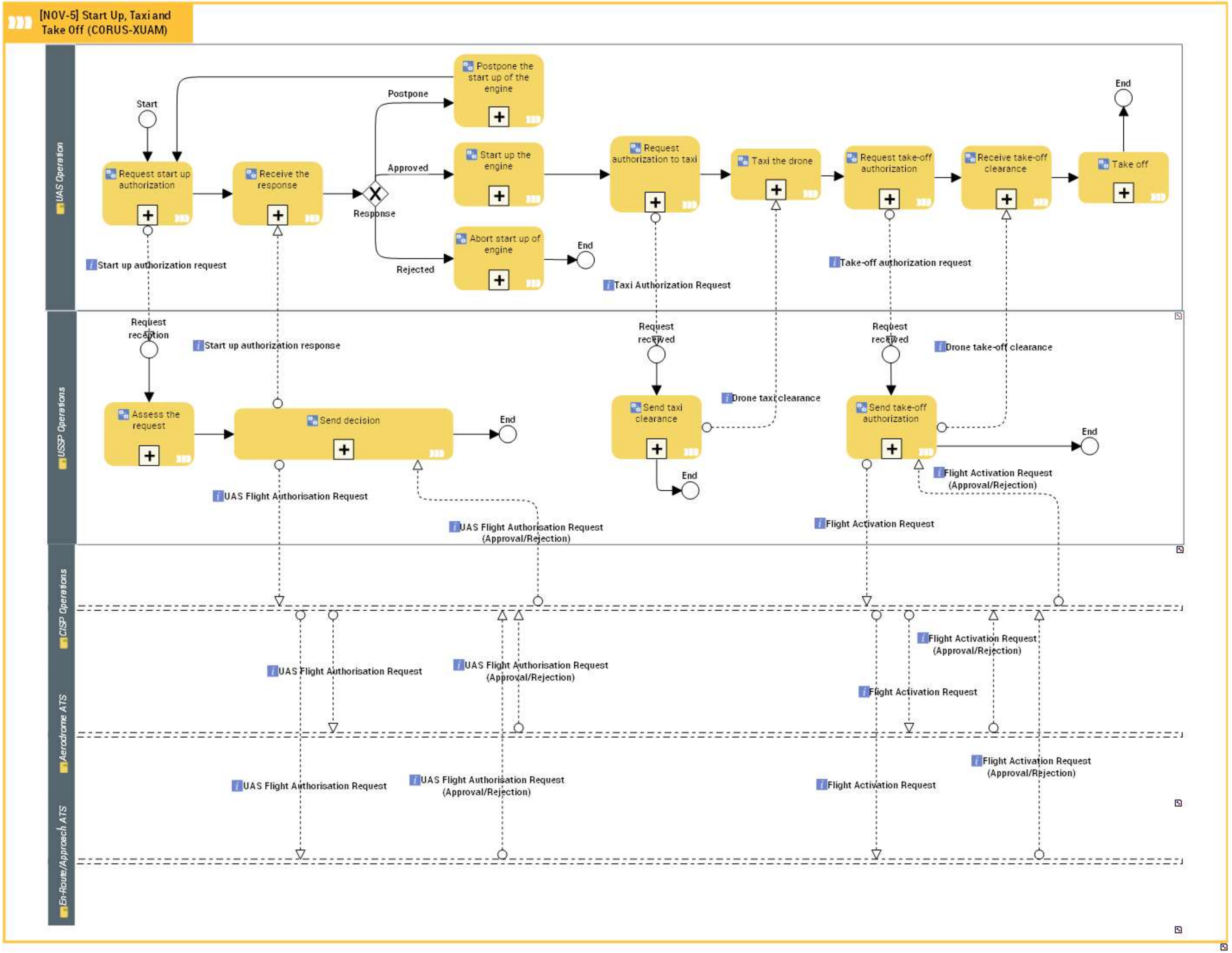



**Figure 12: Start Up, Taxi and Take Off**

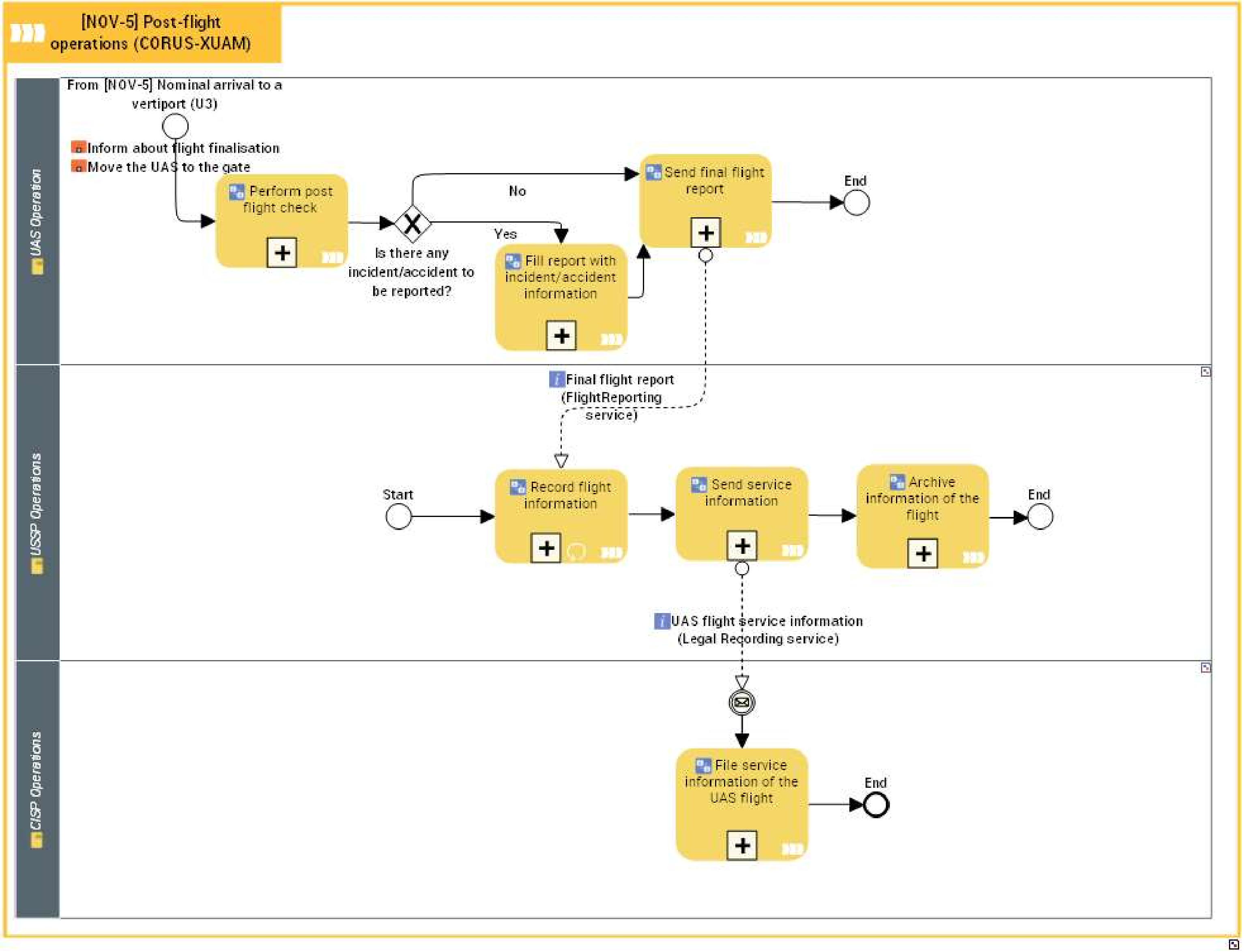



Figure 13: Post-flight Operations



Founding Members

EUROPEAN UNION EUROCONTROL

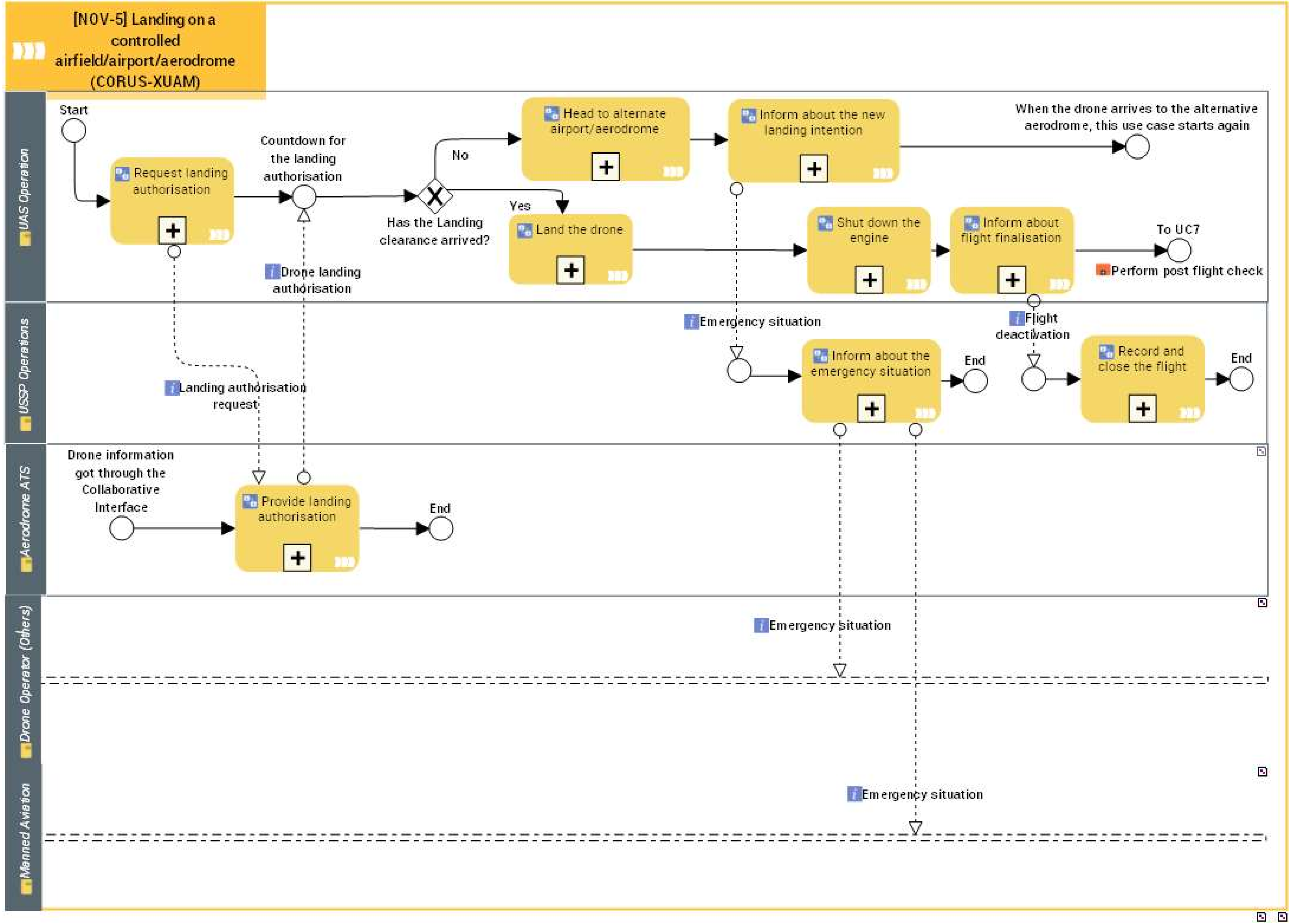



**Figure 14: Landing on a controlled airfield/airport/aerodrome**

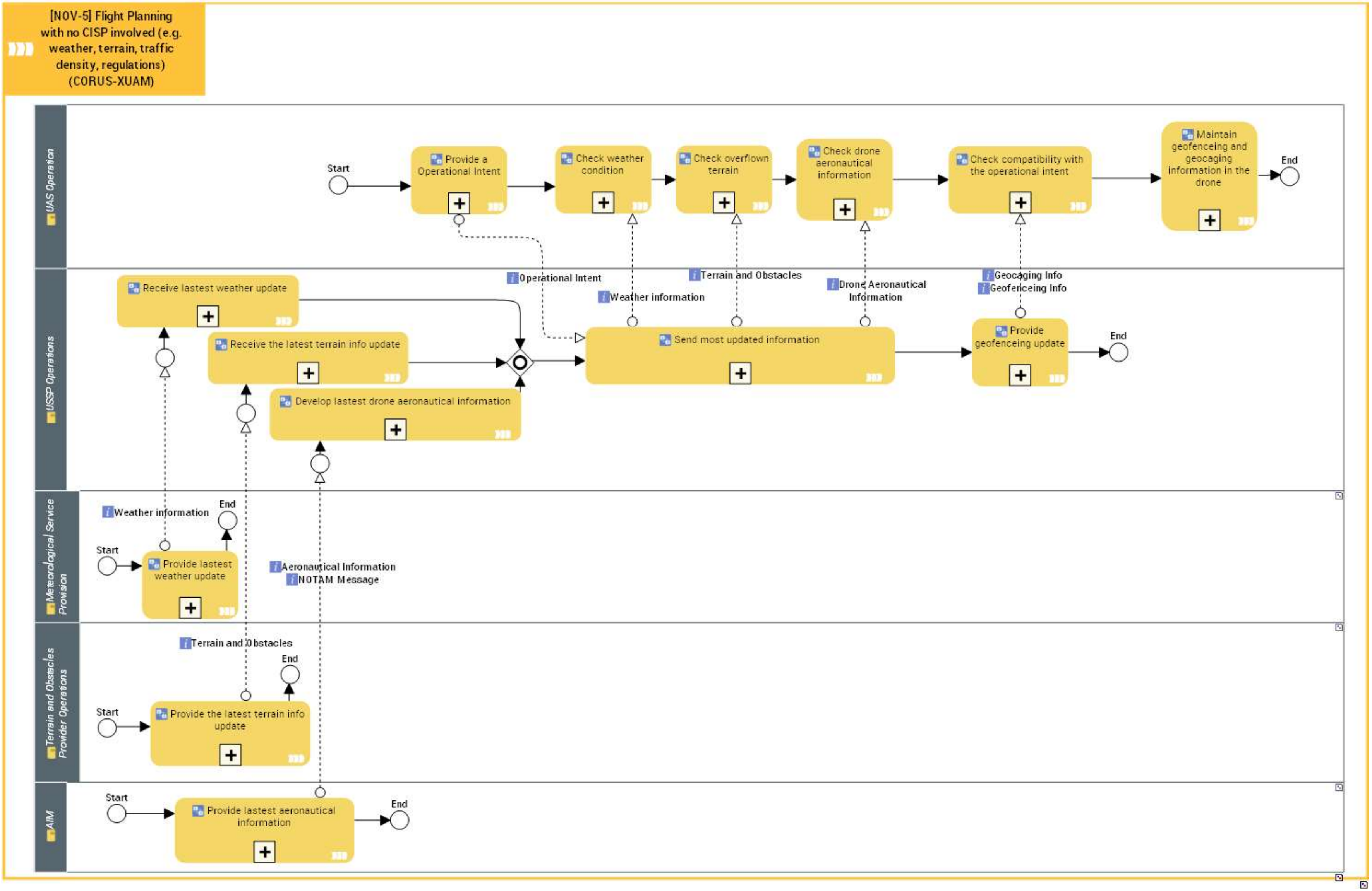



Figure 15: Flight Planning with no CISP involved (e.g., weather, terrain, traffic density, regulations)

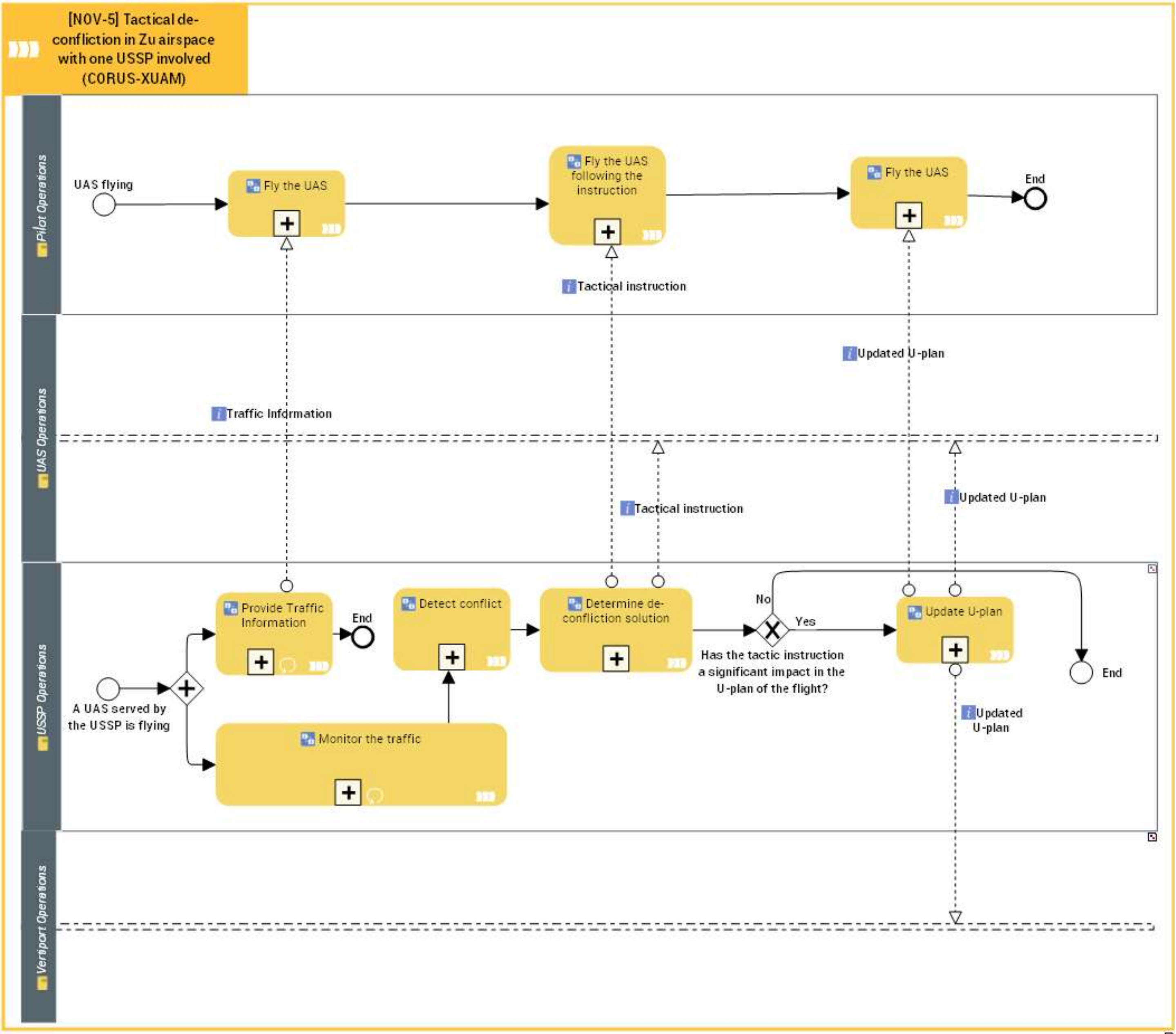



Figure 16: Tactical de-confliction

32

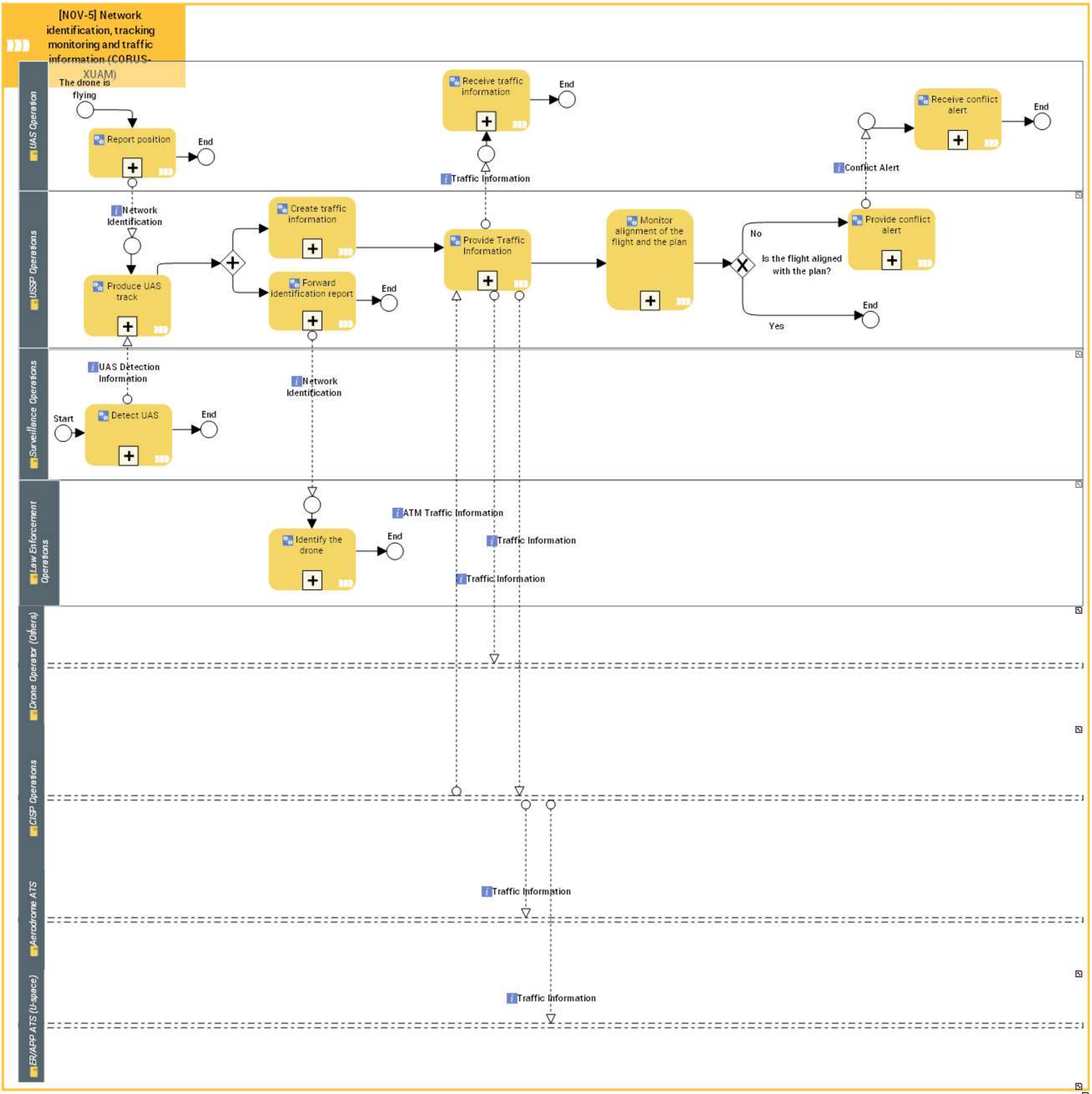



**Figure 17: Network identification, tracking monitoring and traffic information**



Founding Members

EUROPEAN UNION EUROCONTROL

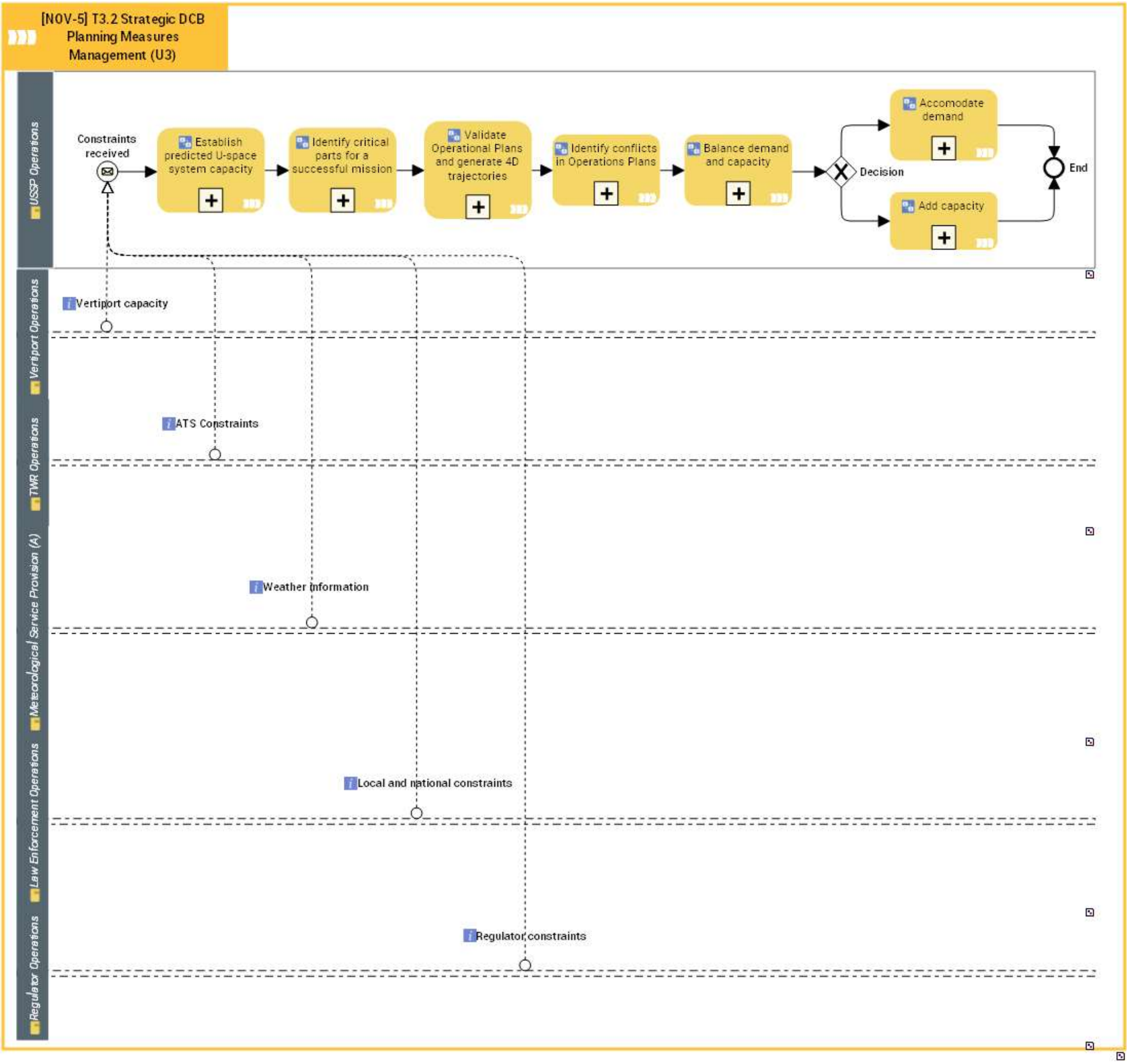



Figure 18: Strategic DCB Planning Measures Management (U3)

### 4.2.1 U-space when the Vertiport is involved

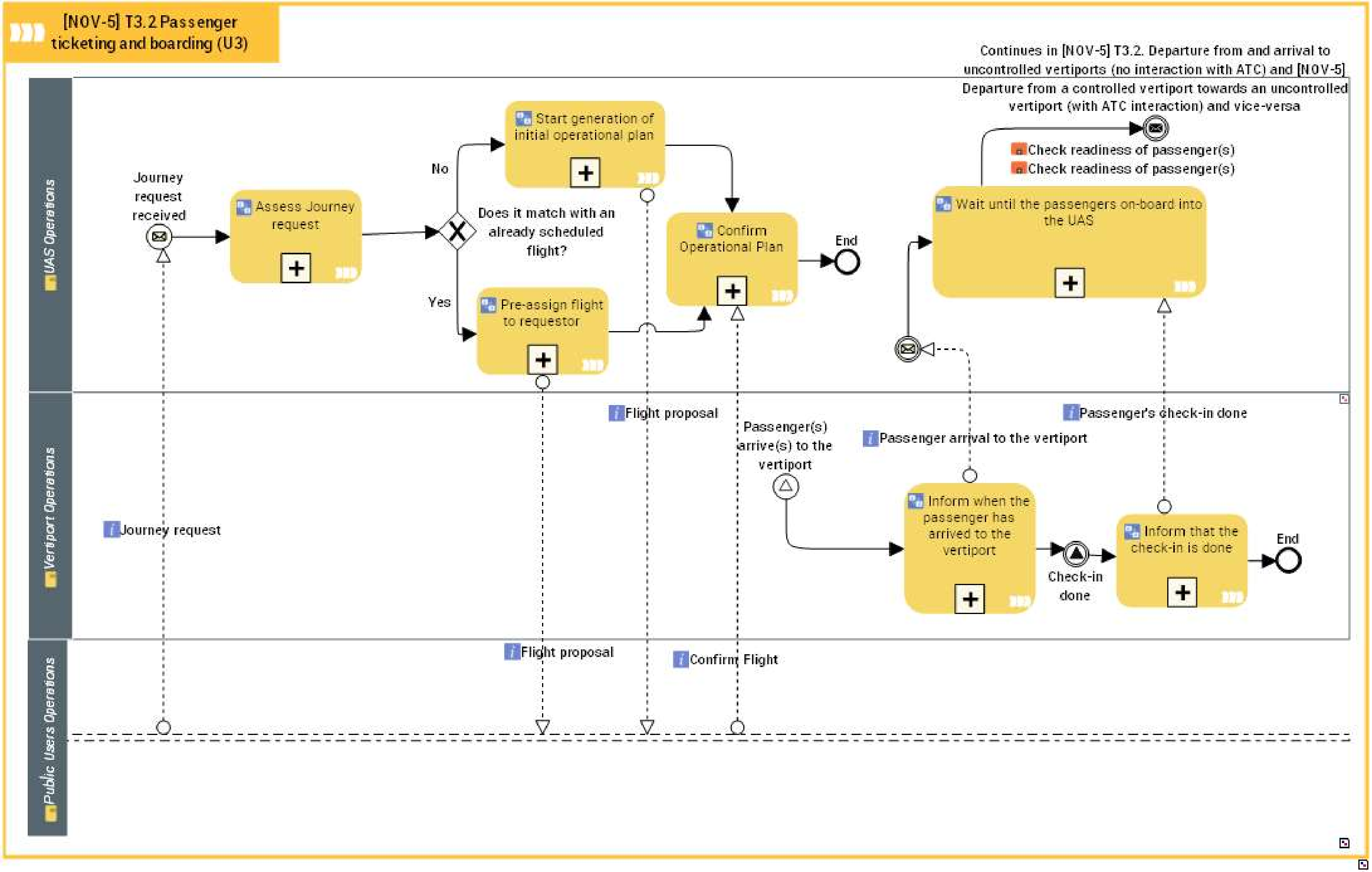



Figure 19: Passenger ticketing and boarding (U3)

35

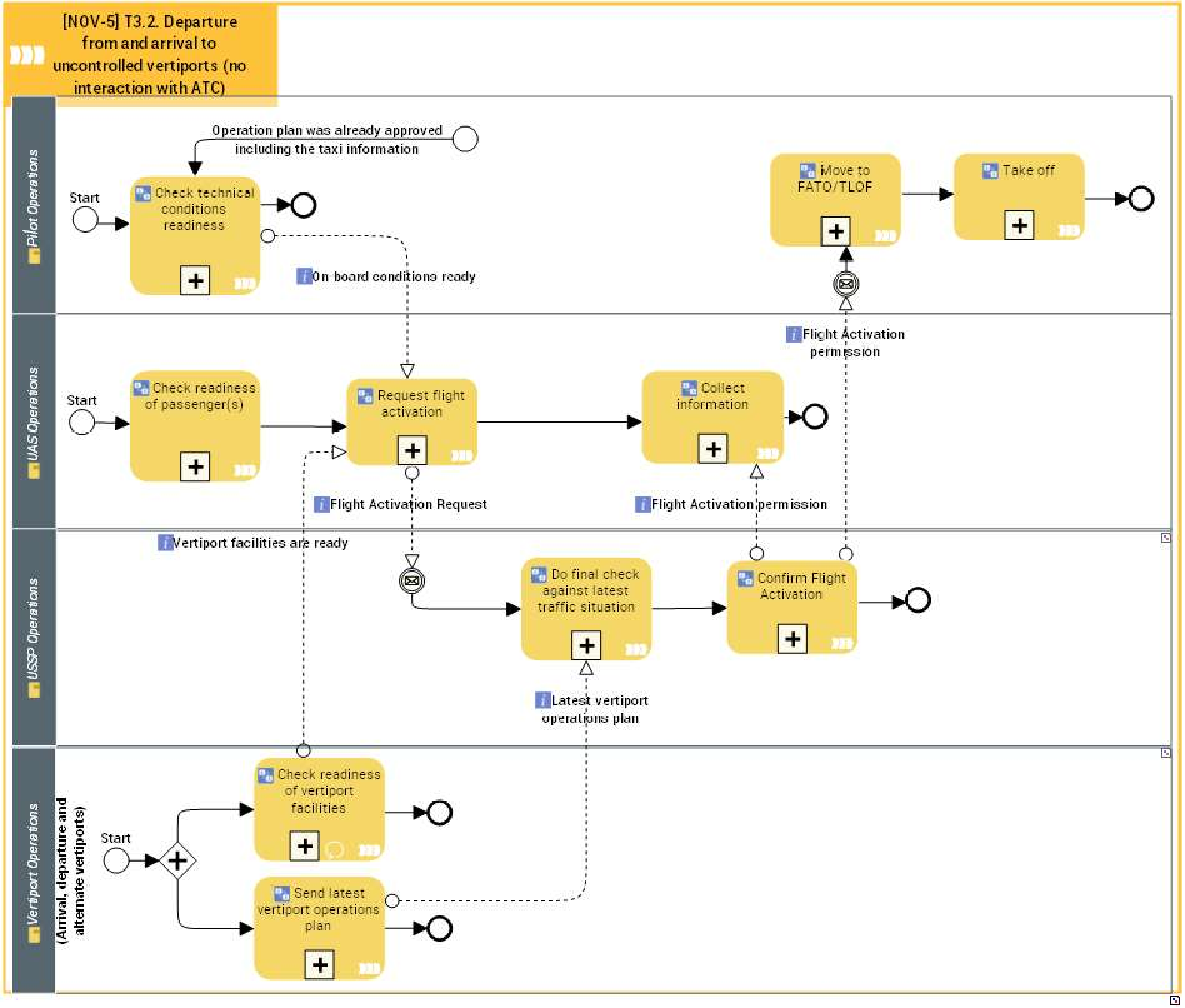



**Figure 20: Departure from and arrival to uncontrolled vertiports (no interaction with ATC)**

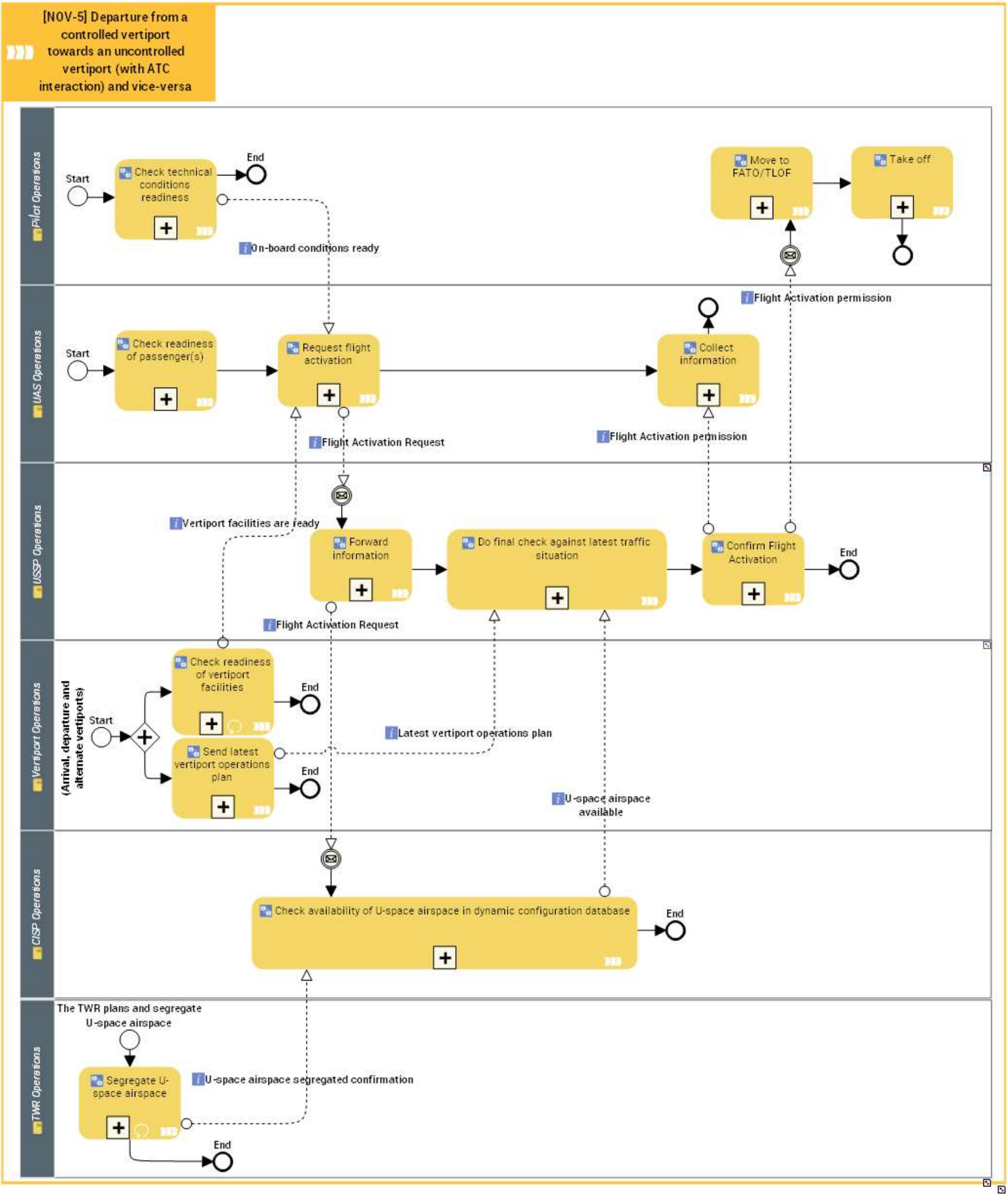



**Figure 21: Departure from a controlled vertiport towards an uncontrolled vertiport (with ATC interaction) and vice-versa**

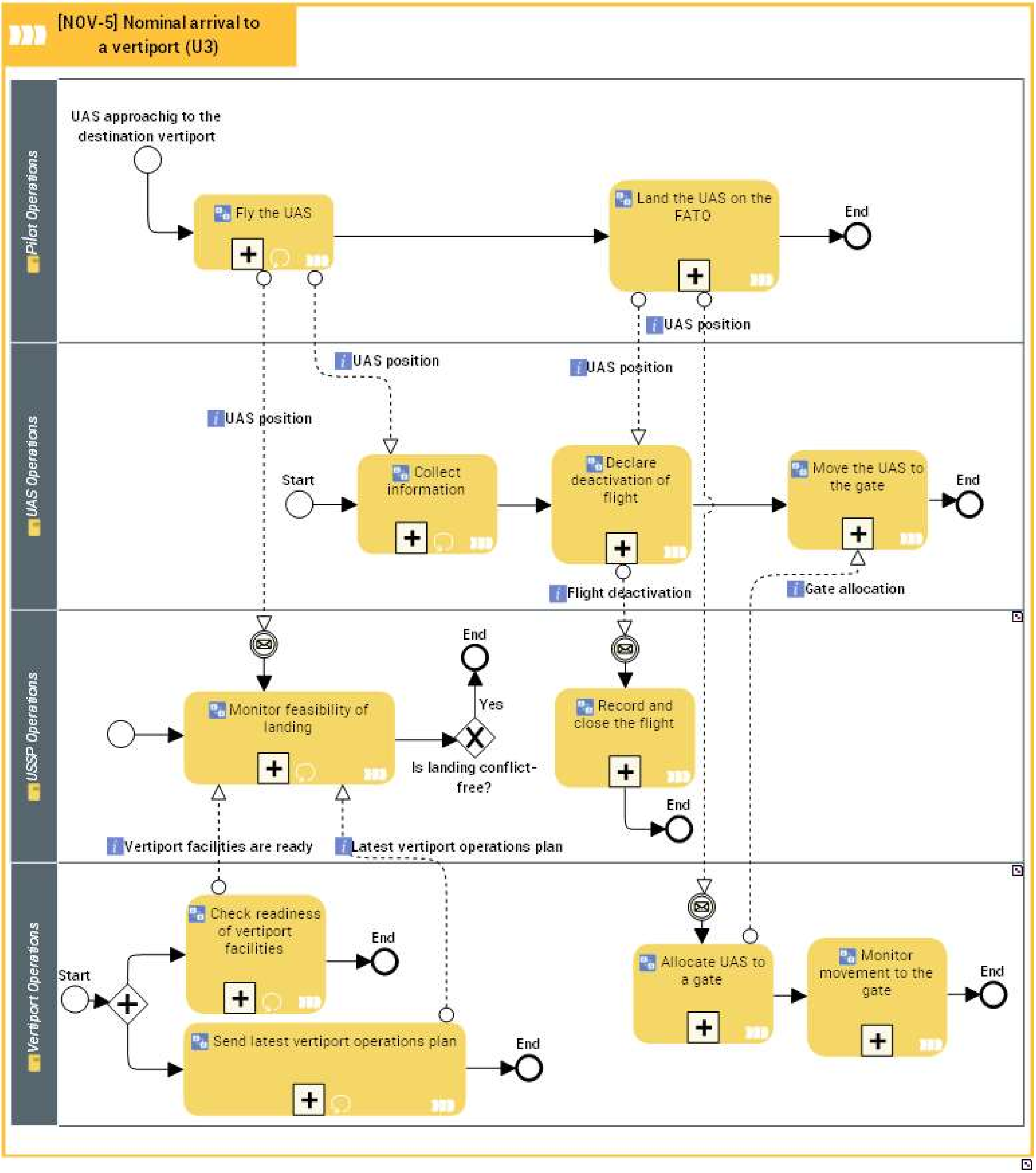



Figure 22: Nominal arrival to a vertiport (U3)

# 5 Service Architecture

The service layer provides a link between the operational need and technical solution by describing services.

Only one element from this layer is used in this iteration of the architecture document.

- **Service:**

  *The contractual provision of something (a non-physical object), by one, for the use of one or more others. Services involve interactions between providers and consumers, which may be performed in a digital form (data exchanges) or through voice communication or written processes and procedures.*

  *Services are key to describe the relationships between the different aspects (business, operational and solution) of the Architecture.*

The section 5.1 reports the list of **30 services for U-space for the different U-phases**.

The services have been grouped in:



- Core **U-space services**, which can be further classified in Principal and Operator U-space services according to the split of responsibilities in the deployment architecture. They are services strongly linked to U-space domain among USSPs and for the end-users.
- U-space Supporting services, which encompass **Infrastructure and Supplemental Data services**. They are services providing additional data to stakeholders that can use it to offer more valuable services to their service consumers, which would be normally the end-users. They are typical services that are not necessarily specific to U-space and can be consumed in another domain as well. On

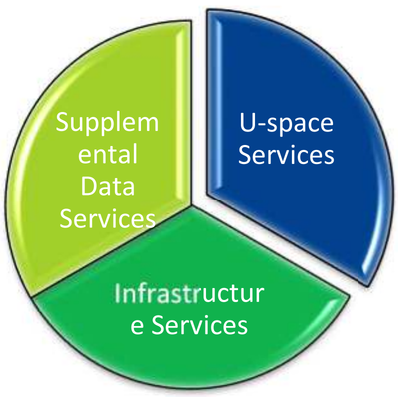



**Figure 23: Service portfolio classification**

It should be noted that the activity performed in CORUS-XUAM is not providing details about the signature of the services (out of scope) and that specification activity may result in optimisation to merge/split services or introduce other services (e.g., related to technical infrastructure such as Service Registration, Service Discovery or related to market evolution).





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## 5.1 U-space services

| *U1 services* | Core U-space | Supplemental | Infrastructure |
|---|---|---|---|
| *Geoawareness* | X | | |
| *NetworkIdentification* | X | | |
| *Registration* | X | | |
| *UASAeronauticalInformationManagement* | | X | |

Table 6: U1 U-space Services

| *U2 services* | Core U-space | Supplemental | Infrastructure |
|---|---|---|---|
| *CommonInformationService* | X | | |
| *CommunicationCoverageInformation* | | | X |
| *CommunicationInfrastructureMonitoring* | | | X |
| *ElectromagneticInterferenceInformation* | | X | |
| *EmergencyManagement* | X | | |
| *FlightAuthorisation* | X | | |
| *GeographicalInformation* | | X | |
| *IncidentAccidentReporting* | X | | |
| *LegalRecording* | | X | |
| *Monitoring* | X | | |
| *NavigationCoverageInformation* | | | X |
| *NavigationInfrastructureMonitoring* | | | X |
| *PopulationDensityInformation* | | X | |
| *ProceduralInterfaceWithATC* | X | | |
| *RiskAnalysisAssistance* | | X | |
| *SurveillanceDataExchange* | | | X |
| *TrafficInformation* | X | | |
| *WeatherInformation* | | X | |

Table 7: U2 U-space Services





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| *U3 services* | Core U-space | Supplemental | Infrastructure |
|---|---|---|---|
| *CollaborativeInterfaceWithATC* | X | | |
| *DynamicCapacityManagement* | X | | |
| *TacticalConflictPrediction* | X | | |
| *TacticalConflictResolution* | X | | |
| *VerticalAlert* | X | | |
| *VerticalConversion* | X | | |
| *VertiportDynamicInformationService* | X | | |
| *VertiportResourceAllocationManagement* | X | | |



**Table 8: U3 U-space Services**

At a first glance, infrastructure and most of the supplemental services are expected to be deployed at U2, while the core U-space services are spread in all three phases. Furthermore, a first interface with ATS with limited features is expected at U2, while a more dynamic is expected at U3.

It should be noted as well that the list is not an exhaustive list of possible services, and that further research and innovation will probably help identifying and developing more services.

In addition, the descriptions of the different services can be found in both the main body of the U-space ConOps and the eATM Portal (U-space R&D) [3].

A possible allocation of services to the different stakeholders for the different U-phases is presented in the section *6.2 Evolution of service provisioning* in U-space and in the main part of the *U-space ConOps.*





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## 5.2 Services aim to achieve Capabilities

A Service is a mean to achieve or to access a Capability. Therefore, there is a need to trace the identified Services to the Capabilities composing the Capability Model.

| | Air Traffic Demand Provision (Airspace) | Airspace Capacity Information Provision (incl. Capacity Changes) | Air Traffic Flow Management | Airspace Separation Minima Management | Area Proximity Avoidance | CNS Infrastructure Monitoring | Controller Situational Awareness (airspace) | Controller Situational Awareness (surface) | Digitalised Aeronautical Information Provision | Drone Aeronautical Information Provision | Emergency Management | Ground Collision Avoidance | Ground Proximity / Terrain Avoidance | Ground Risk Observation | Meteorological Observation and Forecasting | Mid-Air Collision Avoidance | Pilot Situational Awareness (airspace) | Pilot Situational Awareness (surface) | Recording and Analysis | Registration | Self-separation | Separation Service Provision (airspace) | Situational Awareness | Traffic Information Provision in support of U-space Operations | UAS Operational Planning | UAS Procedure Design | U-space Communication Coverage Provision | U-space Interface with ATS | U-space Navigation Coverage Provision | U-space Surveillance Provision | Vertical Conversion | Vertiport Capacity Information Provision (incl. Capacity Changes) | Vertiport Resource Allocation Management | Visual Separation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Geoawareness | | | | | X | | | | | | | | | | | | X | X | | | | | X | | | | | | | | | | | |
| NetworkIdentification | | | | | | | X | X | | | X | | | | | | X | X | X | | | | X | X | | | | | | | | | | |
| Registration | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | |
| UASAeronauticalInformationManagement | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | |
| CommunicationCoverageInformation | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | |
| CommunicationInfrastructureMonitoring | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CommonInformationService | | | | X | | | | | X | X | | | | | X | | | | | | | | | | | | | | | | | | | |
| ElectromagneticInterferenceInformation | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | |
| EmergencyManagement | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | |
| FlightAuthorisation | X | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | | | | |
| GeographicalInformation | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | |
| IncidentAccidentReporting | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | |
| LegalRecording | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | |
| Monitoring | | | | | X | | | | | | | X | | | | X | | | | | | | | | | | | | | | | | | |
| NavigationCoverageInformation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| NavigationInfrastructureMonitoring | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| PopulationDensityInformation | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | |
| ProceduralInterfaceWithATC | | X | | | | | | | X | | | | | | | | | | | | | | | | | | | X | | | | | | |
| RiskAnalysisAssistance | | | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | |
| SurveillanceDataExchange | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | | |
| TrafficInformation | | | | | | | X | X | | | | | | | | | X | X | | | X | | | X | | | | | | | | | | X |
| WeatherInformation | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | |
| CollaborativeInterfaceWithATC | | | | | | | X | X | X | | | | | | | X | | | | | X | X | | | | | | | | | | | | X |
| DynamicCapacityManagement | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| TacticalConflictPrediction | | | | X | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | X |
| TacticalConflictResolution | | | | | | | | | | | | | | | | X | | | | | X | X | | | | | | | | | | | | X |
| VerticalAlert | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | |
| VerticalConversion | | | | X | | | | | | | | | | | | | | | | | X | | | | | | | | | | X | | | X |
| VertiportDynamicInformationService | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | |
| VertiportResourceAllocationManagement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | |

**Table 9: Mapping of Services to Capabilities**

## 5.3 From the conceptual needs to services

As stated previously, the operational layer describes at a conceptual level (independent from any physical implementation) how the Nodes interact between them. These interactions, named Information Exchanges, describe then the operational needs that must be covered at the System layer (implementation) with the technical systems. The service layer provides this link between the operational and technical layer. Once the operational/conceptual needs are described, the services shall be identified. Consequently, there is a direct relationship between the Information Exchanges and the Services. Examples of these links, for CORUS-XUAM, are shown in the following table.

| Information Exchange | Service |
|---|---|
| Registration Info Provision | Registration |
| Insurance Information Provision | |
| License Info Provision | |
| Registration Information Provision | |
| Operator Registration Provision | |
| Network Identification Provision | NetworkIdentification |
| Flight Plan Information Provision | FlightAuthorisation |
| Conflict Alert Provision | Monitoring |
| Monitoring Provision | |
| Logbook Information | DigitalLogbook |
| Geo-awareness Information Provision | GeoAwareness |
| Emergency Info Provision | Emergency Management |
| Airspace Structure Provision | UASAeronauticalInformationManagement |
| Tactical Clearance Provision | TacticalConflictResolution |
| | TacticalConflictPrediction |
| MET Info Provision | Weather information |
| Information Exchanged with ATS | ProcedureInterfaceWithATC |
| | CollaborativeInterfaceWithATC |
| Incident and Accident Report | IncidentAccidentReporting |
| Flight Report Provision | |
| Citizen Report Provision | |
| Traffic Information Provision | TrafficInformation |
| Surveillance Info Provision | SurveillanceDataExchange |
| Tracking Information Provision | |
| Dynamic Capacity Management Info | DynamicCapacityManagement |
| Communication Info Provision | CommunicationCoverageInformation |
| | CommunicationInfrastructureMonitoring |
| Navigation Info Provision | NavigationCoverageInformation |
| | NavigationInfrastructureMonitoring |
| Risk Analysis Assistance Info | RiskAnalysisAssistance |
| Terrain and Obstacles Provision | GeographicalInformation |
| Common Information for U-space | CommonInformationService |
| Vertical Measures and Alert Information | VerticalAlert |
| | VerticalConversion |
| Vertiport Dynamic Information | VertiportDynamicInformationService |
| Vertiport Allocation Information | VertiportResourceAllocationManagement |

**Table 10: Mapping of Information Exchanges to Services**

# 6 System Architecture

The system layer describes all human and technical resources of a system including its internal functional breakdown and its interactions with the surrounding systems.

- **Stakeholder:** STK

  *A stakeholder is an individual, team, or organisation (or classes thereof) with interest in, or concerns relative to, an enterprise [e.g. the European ATM]. Concerns are those interests, which pertain to the enterprise's development, its operation or any other aspect that is critical or otherwise important to one or more stakeholders*

- **Capability Configuration:**

  *A Capability Configuration is a combination of Roles and Technical Systems configured to provide a Capability derived from operational and/or business need(s) of a stakeholder type.*

- **Role:**

  *An aspect of a person or organisation that enables them to fulfil a particular function.*

  *They represent the use of a human resource (person) in a Capability Configuration.*

- **Technical System:**

  *Technical Systems are artefacts that represent the technical part of Capability Configurations. Interaction between Technical Systems can be described via Services.*

## 6.1 Stakeholders and Roles

First, a clarification of the difference between stakeholder and role is needed in order to set the appropriate understanding of both elements. Many times, roles are considered only as the facet that a stakeholder could have at a certain moment. Often the sentence "a stakeholder is playing the role of…" is listen when talking about these two elements.

As a brief differentiation, in the EATMA framework [6], the **stakeholder** is considering the individual or **organisation** that is interested in an enterprise, while the **role** usually represents the **human being** performing functions.

The U-space stakeholders and the possible U-space roles allocated to them are presented in the section 8.3 of the U-space ConOps. Therefore, the complementing list of U-space roles and their descriptions are defined hereafter for completeness purposes.

The following table provides a brief description of main roles and their relevant responsibilities.

| Role | Explanation |
|---|---|
| **Accredited registry reader** | This category groups the police, accident investigators, other agents of the authorities or anyone else who might need – and be given permission - to investigate the registry. (or registries).<br><br>How he/she interacts: Who may query registration information. |
| **Accredited registry updater** | This category groups together pilot training schools, LUC issuers, nominated agents of the courts and any others who have the power to create, read, update or delete registry entries in any way – which may be very restricted for some.<br><br>How he/she interacts: User of (operator/school/pilot) registrations. |
| **Airport Operator Representative** | It is responsible for interacting with the system to protect airport perimeter (anti UAS) to contribute to the safe integration of UASs in airspace, especially in airport vicinity. It will be responsible to establish proper coordination with other relevant stakeholders. |
| **ATS Operator** | ATS should have access to the air-situation generated from NetworkIdentification reports, with the usual controller-working-position tools to filter out those of no interest, give conflict alerts and so on. Main roles: Air Traffic Controller, Tower Supervisor, Tower Runway controller, Tower Ground controller, (A)FIS and RIS Operator.<br><br>How he/she interacts: User involved to achieve the interface with ATS. |
| **Authorised viewer of air situation** | This groups actors like U-space operators, city authorities and some others such as researchers who can be trusted with the commercially sensitivities of the overall air-situation.<br><br>How he/she interacts: Who may be allowed to have a situational awareness according to privileges and privacy. |
| **Authorization Workflow Representative** | A person having the rights to participate in the authorization workflow (e.g., when local authority/USSP/NAA must express the approval or does not object). |
| **Capacity Authority** | A person receiving warning and alerts from the monitoring service<br><br>Responsible for setting the minimum safe operating conditions that determine the capacity of an airspace or an aerodrome due to safety<br><br>Responsible for setting noise level limits that limit capacity due to noise footprint and "dose" |
| **Citizen** | Generic person who wants to be aware of UAS operations impacting its privacy.<br><br>How he/she interacts: a kind of authorised viewer of air situation and able to report about events. |
| **Pilot** | It is the pilot of glider, parachutist, paraglider, balloon, GA, military flight which share the airspace (even if occasionally) in VLL operations. |

| | |
|---|---|
| | How he/she interacts: In some environments, user of situational awareness and monitoring alerts. |
| **Police or security agent** | Security actors would be interested in the air situation, to identify operators and to apply relevant procedures.<br><br>Law enforcement Unit, responsible to develop law enforcement methods related to illegal UAS use.<br><br>How he/she interacts: User of registration, e-identification and interested in the situational awareness and monitoring alerts. |
| **Registrar** | A registrar has a legal duty to operate a registry securely, reliably and adequately. The registrar will be a legal person, probably with staff. |
| **UAS Aeronautical Information Manager** | A body that is independent of the Aeronautical Information Office and allows UAS specific aeronautical information to be registered, combines the information, assesses it and then published the result. |
| **UAS crew** | The UAS pilot or any person following the UAS's progress during flight. This term generalises the pilot, any kind of dispatcher, any mission specialist. Additional recipient of messages about flights.<br><br>UAS Pilot Assistant. It is assisting the piloting in its duty.<br><br>Observer. It is assisting the piloting in its duty, e.g., during EVLOS operations. |
| **UAS Manufacturer Representative** | It is responsible for UAS registration and using the system for all other obligations the UAS manufacturer must comply (e.g., UAS model/characteristics/performance publication). |
| **UAS operator representative** | Aka UAS Operator, the operator being registered in operator registry. An operator representative is a legal entity, meaning a natural person or a business. An operator representative has contact details.<br><br>How he/she interacts: User of geo-fence definitions during flight planning, User of situation awareness computed from the dynamic online traffic situation based on relevant maintained tracks, Generalised actor that submits a flight plan, the person receiving warning and alerts from the monitoring service |
| **UAS owner representative** | When any UAS is registered, it will have a registered owner. An owner is a legal entity, meaning a natural or a business. An owner representative has contact details.<br><br>How he/she interacts: User of UAS registration. |
| **UAS pilot** | aka UAS Pilot, Pilot in Command (PIC) or Remote Pilot, it is responsible for the safe execution of the flight according to the U-space rules, whatever it is recreational or professional with one of the different license levels, according to the typology of the UAS used. (Recreational UAS Pilot, Professional UAS Pilot)<br>It expects: |

| | |
|---|---|
| | • more efficient flight preparation, including getting permission (easier, quicker and more efficient);<br>• safer and more efficient flight execution due to improved situational awareness in all operations – VLOS and BVLOS<br>The person being registered in the pilot registry. A pilot is a human being performing the piloting function. The registry should be able to record some information about the pilot's qualification; mentions different levels of qualification.<br><br>The UAS pilot should be able to update some parts of his/her registry entry, such as changing his/her address and he/she may be allowed to create the record initially.<br><br>How he/she interacts: User of geo-fence definitions during flight; User of situation awareness computed from the dynamic online traffic situation based on relevant maintained tracks; User of weather nowcast to assist him in the in-flight phase; the person receiving warning and alerts from the monitoring service. |
| **UAS specific aeronautical information originator** | The person or representative of the organisation that creates UAS specific aeronautical information. This actor is accredited and trained in the processes of creating, updating or deleting UAS specific aeronautical information.<br><br>This is reflecting the possibility to have a different originator of "constraints" for UASs. |
| **USSP Supervisor** | Being the level of automation high, it is not envisaged the role of "Controller". Nevertheless, it has been envisaged a person who will arbitrate or impose a solution in some cases (in case of escalation required) who may intervene manually imposing ad-hoc solutions or taking over other USSP roles. |
| **Vertiport Manager** | Responsible of the vertiport terminal zone. |

**Table 11: Roles**

## 6.2 Evolution of service provisioning in U-space

Once the operational layer, which specifies the responsibilities and the needs for information exchanges, is stable, the work in the system layer starts. In this layer a *possible* realization of the needs through a combination of systems services and humans is defined.

Nonetheless, it is important to remark that:

- The **Capability Configurations realize the Nodes** that were presented in the section 4.1.
- The **Services are realizations of the Information Exchanges** depicted in the section 4.1.

In the following diagram, the "red boxes" represent the Capability Configurations, while the lines represent the services. Please note that the rounded part of the interaction represents the provision of the service, while the semi-circular part represents the consumption of the service.

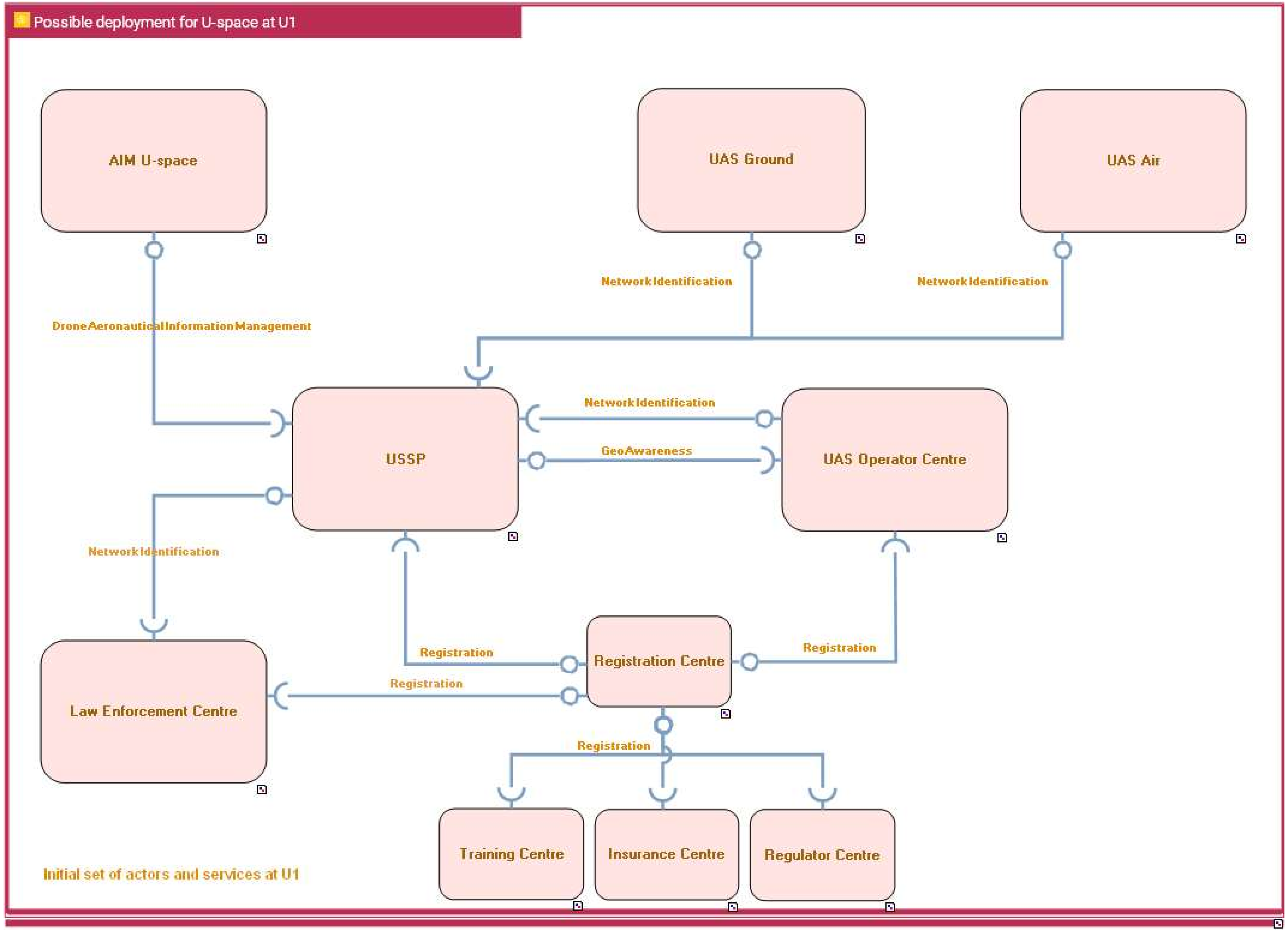


**Figure 24: Possible Service Provision in U-space (U1)**

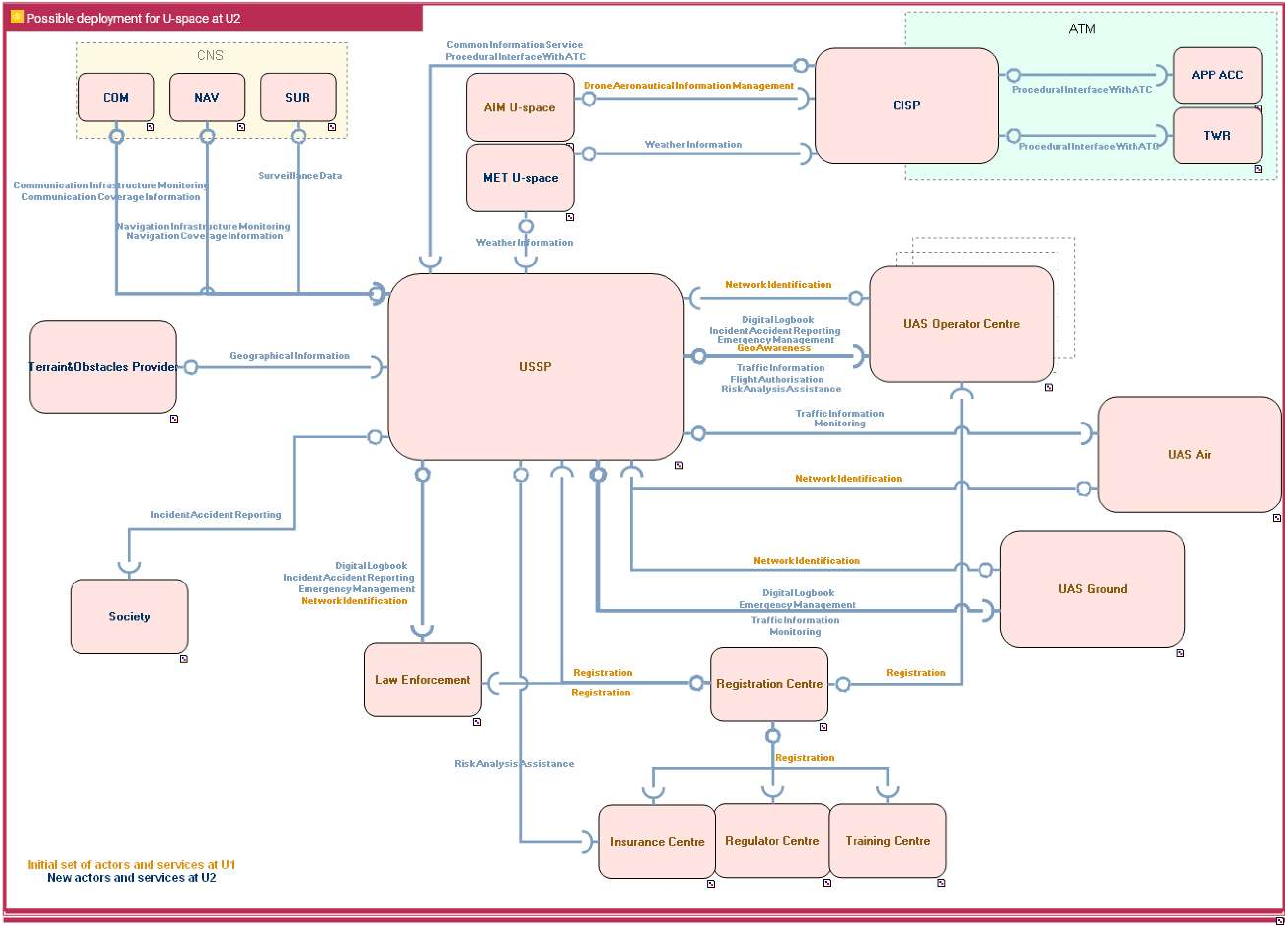


Figure 25: Possible Service Provision in U-space (U2)

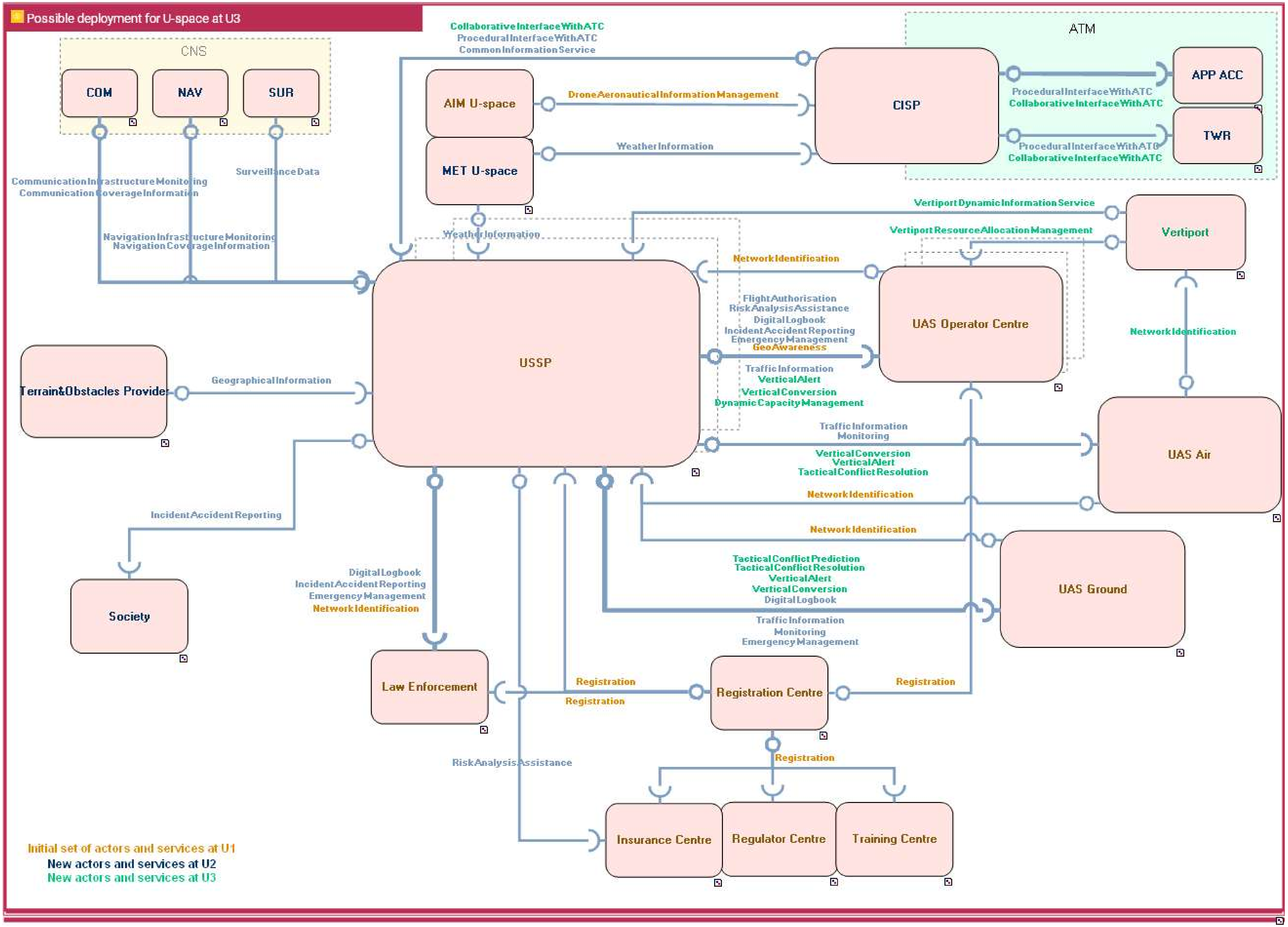


Figure 26: Possible Service Provision in U-space (U3)

This is just an example of which services could be potentially provided and consumed by the capability configurations in each of the different U-phases.

The reader probably has noticed the different colours used in the 3 views. They represent what is expected to be in place at each of the U-phases being:

- Orange: stakeholders and services expected at U1.
- Blue: stakeholders and services expected at U2.
- Green: stakeholders and services expected at U3.

## 6.3 Some of the fundamental U-space systems

The previously presented Capability Configurations are composed by roles and systems. In this section a possible list of Technical Systems is presented. Being an architecture service-oriented other breakdowns are feasible, and the following is not aiming to prevent others.

| System | Description |
|---|---|
| **Aerodrome ATC** | Supports the ATC controllers at an aerodrome and provides the following main functionalities:<br>· surface routing and guidance,<br>· infrastructure (weather, lighting, datalink) management,<br>· safety nets,<br>· aerodrome surveillance,<br>· flight data processing,<br>· departure management. |
| **Centralised Information Service Provider** | The system that manages, consumes and provides the information in the Common Information Service Provider (CISP). |
| **Communication Infrastructure** | U-space support infrastructure for Communication. It encompasses technologies and services that will provide communication among U-space actors. It includes:<br><br>- ground-ground communications among systems and any other stakeholder: UAS Operator/Pilot, ATM, Law Enforcement, Aviation Authority<br><br>- air-ground communications with the UAS itself. |
| **Continuous Operating Reference System (CORS)** | The system that provides GNSS data consisting of carrier phase and code range measurements in support of 3D positioning, meteorology, space weather, and geophysical applications.<br><br>*For further information, please check ICARUS documentation [7].* |
| **Navigation Infrastructure** | U-space support infrastructure for Navigation. It encompasses technologies that could provide signals in space to allow UAS positioning and navigation (e.g., satellite-based or ground-based). |

| | |
|---|---|
| **Registration system** | Aka USSP system which supports with automation the Registration process. |
| **Supplemental Data system** | It is a system which can elaborate/provide supplemental data for U-space services such as a weather system or terrain data model system. |
| **Surveillance Infrastructure** | U-space support infrastructure for Surveillance. It encompasses technologies and sensors to support cooperative and non-cooperative surveillance of UASs |
| **Terrain Data Model system** | U-space support infrastructure for terrain and obstacles data. It encompasses the technologies and the models for data acquisition, elaborations and provisioning. |
| **UAS Operating System** | Where available it supports the UAS operations in their activities assisting the human actor in the fleet management, UAS preparation, the assistance to interface with UAS Traffic Management. |
| **UAS system** | The Unmanned Aerial System (UAS) represents the UAS operating from the end to end, on the airport surface, from a field and in the air. The main groupings of functionalities are the ones dealing with traffic management:<br>• Communication (air ground data link, information domain);<br>• Navigation (Flight management, flight control, position determination);<br>• Surveillance (traffic, weather, terrain);<br>• Other functions (remote displays and controls, alerts, recording, databases, sensors and antennas, information domain display). |
| **UAS Traffic Management system** | Aka USSP system which supports the UAS operators in their activities related to traffic management. It provides the following main functionalities: e-identification, UAS aeronautical information and geofencing, flight planning management, de-confliction, demand capacity balancing, weather data presentation.<br>This system may provide graphical interfaces to the public, the law enforcement units (e.g., police, security agent) and UAS operators/pilots, other airspace users.<br>In some deployment options several instances of UAS Traffic Management systems may exists. Each of them realises completely or partially (a subset of service provision) a UAS Traffic Management system. |
| **USSP system** | Is a generic system which provides U-space services. It can be unique per volume of airspace or possibly broken down in several instances sharing responsibilities and interoperable. One of the possible breakdowns is between Registration and UAS Traffic Management services (i.e., Registration system and DTM system) according to the services provided.<br>A further breakdown is considering the deployment options where the boundary between Principal and Operator USSPs is determined; then it |

| | |
|---|---|
| | results in a Principal USSP system and several Operator USSP systems in case of federated deployments. |
| **Vertical Conversion and Alerting** | The system calculates the conversion between geometric and barometric altitudes, and issues alerts for vertical risks during the execution phase of a flight.<br><br>*For further information, please check ICARUS documentation [7].* |
| **Weather system** | U-space support infrastructure for (hyper local) weather data. It encompasses the technologies and sensors and the evolution of the models for data elaborations. |

**Table 12: Some U-space systems.**

# 7 Data exchange models

This ConOps has been developed by the CORUS-XUAM project in collaboration with 16 other research and demonstration projects. Two of these projects have studied the data exchange models that are needed to make U-space work. Their work is appended here.

The project GOF2 (Gulf of Finland 2) [8] has developed ten data exchange models. Their project has demonstrated the value of these models in the integration of different U-space Service Providers, although they were only able to validate nine of the ten. These models can be found in the document "D2.4 GOF2.0 VLD Updated Service Specifications" which is provided as an annex to this annex. Beware that the Word document contains embedded Word documents. The work is entirely by GOF2 and is reproduced with their kind permission. More information can be found on the project website, https://gof2.eu

The project PJ34 AURA [9] adopted five of the GOF2 data exchange models and had developed an architectural description of their use. Their work can be found in the annex "U-space ConOps: Interface U-space/ATM (AURA sol.2)" which is also provided here as an annex with the kind permission of the PJ34/AURA project. For more information see the project web site https://www.pj34aura.com/

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[5] NATO Architecture Framework V3 AC/322-D (2007)

[6] EATMA Guidance Material, SESAR Extranet Programme Library

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EXPLORATORY RESEARCH

SESAR JOINT UNDERTAKING

# CORUS-XUAM ConOps Annex: regulatory and legal impact study

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## Authoring & Approval

### Authors of the document

| Name / Beneficiary | Position / Title | Date |
|---|---|---|
| **DSNA** | Task co-leader | 18/11/2022 |
| **UPC** | Task co-leader | 18/11/2022 |
| **AOPA** | Task member | 18/11/2022 |
| **ENAIRE** | Task member | 18/11/2022 |
| **EUROCONTROL** | Task member | 18/11/2022 |
| **LFV** | Task member | 18/11/2022 |

### Reviewers internal to the project

| Name / Beneficiary | Position / Title | Date |
|---|---|---|
| **DSNA** | Task co-leader | 06/01/2023 |
| **UPC** | Task co-leader | 06/01/2023 |
| **AOPA** | Task member | 06/01/2023 |
| **ENAIRE** | Task member | 06/01/2023 |
| **EUROCONTROL** | Task member | 06/01/2023 |
| **LFV** | Task member | 06/01/2023 |

### Reviewers external to the project

| Name / Beneficiary | Position / Title | Date |
|---|---|---|
| | | |
| | | |

### Approved for submission to the S3JU By - Representatives of all beneficiaries involved in the project

| Name / Beneficiary | Position / Title | Date |
|---|---|---|
| **DSNA** | Task co-leader | 06/01/2023 |
| **UPC** | Task co-leader | 06/01/2023 |
| **AOPA** | Task member | 06/01/2023 |
| **ENAIRE** | Task member | 06/01/2023 |
| **EUROCONTROL** | Task member | 06/01/2023 |
| **LFV** | Task member | 06/01/2023 |

### Rejected By - Representatives of beneficiaries involved in the project



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| Name and/or Beneficiary | Position / Title | Date |
| --- | --- | --- |
| | | |

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# CORUS-XUAM

CORUS-XUAM

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## Abstract

In 2019, a first proposal for a European concept of operations for unmanned aircraft systems traffic management system was shared. This concept was based on a global view of UAS operations without focusing on specific operations such as urban air mobility operations. CORUS-XUAM ConOps addresses this domain by improving the initial ConOps with a UAM flavour.

What was yet only stammering in 2019 has been enriched so far with regulations from EASA and ICAO on UTM and UAS topics.

On one hand, it is paramount that the next version of the ConOps be compatible with existing regulatory framework and in other hand, that the regulation embeds what is necessary to allow and foster future UAS operations, in particular in urban environment.

This study aims at identifying discrepancies between Conops content and regulations, and at making suggestions to adapt or improve, if required, the regulatory framework.

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# 1 Executive Summary

UAS traffic, mainly with professional purposes, keeps on growing despite the national regulations which tend to limit regular exploitation of UAS, even if lot has been done since first commercial UAS operations showed up.
European UTM regulations will come into force in January 2023, and a new concept of operations encompassing urban air mobility operations will be published few months later.
Despite all participants to the definitions of the ConOps and of the different regulations, both European or international, try to coordinate and stay up to date, differences and gaps remain.
This study has identified these differences between the ConOps and the regulations, and the gaps that shall be fulfilled for an efficient integration and acceptability of UAS traffic.

On the ConOps side, it appears that some definitions are missing (IAM) or could be identical to those found in the regulation (e.g., VTOL aircraft, UAs operator).
The ConOps also does not take over certain topics addressed in the regulation (e.g., remote pilot responsibilities, cross border operations).

Considering the regulations, and it is probably due to the time required to create them all, we identified several gaps (e.g., noise limitations, VTOL unmanned capable aircraft) but also little consideration in the existing ones given to some of the structuring ideas proposed in the CORUS ConOps (e.g., many U-space services including very important ones (emergency service, drone aeronautical information management service), U-space volumes).



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# 2 Introduction

## 2.1 Purpose of the document

This document is a study which purpose is to identify any gaps in the existing European and international regulations that provide the frame to UAS operations, and to verify that the CORUS-XUAM ConOps[1] in line with what has already been defined.

This will lead to make recommendations for the ConOps adaption when necessary and to suggest improvements and/or complements to the regulatory framework for filling in the gaps.

## 2.2 Scope

The scope of the document is the CORUS-XUAM ConOps and the existing regulatory framework of UAS operations and U-space.

Has also been included in that scope what regulates how aircraft shall fly in European skies.

## 2.3 Intended readership

CORUS-XUAM Conops writers and contributors is the main intended readership of this study.

The European Union Aviation Safety Agency (EASA) and International Civil Aviation Authority (ICAO) may also have an interest in the document.

## 2.4 Background

The production of the first three editions of the concept of operations for UAS took into account the existing and limited regulatory framework for UAS, and the procedures, rules and environments already in place for manned/crewed aircraft operations.

The provision of a U-space regulatory framework, complementary regulations on unmanned aircraft systems, on the rules and procedures for the operation of unmanned aircraft, on command-and-control link loss, for instance, requires a review of the ConOps.

## 2.5 Structure of the document

Three main sections composed the document which core is developed in section 3:

Section 3.1 provides a high-level description of the topics addressed in the CORUS-XUAM Conops[1].

Section 3.2 lists the different existing regulations reviewed and the describes what domains are impacted.

Section 3.3 depicts the differences found between the ConOps and the regulations and make some proposals for improvements



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## 2.6 Glossary of terms

| Term | Definition | Source of the definition |
|---|---|---|
| IAM | The safe, secure and sustainable air mobility of passengers and cargo enabled by new-generation technologies integrated into a multimodal transportation system. | NPA 2022-06[19] |
| Manufacturer | Manufacturer" means any natural or legal person who manufactures a product or has a product designed or manufactured and markets that product under their name or trademark | (EU)2019/945[2] |
| Operating site | "Operating site" means a site, other than an aerodrome, selected by the operator or pilot-in-command or commander for landing, take-off and/or external load operations. | NPA 2022-06[19] |
| UAM | The subset of IAM operations conducted in to, within or out of urban environments. | NPA 2022-06[19] |
| UAS operator | Unmanned aircraft system operator' ('UAS operator') means any legal or natural person operating or intending to operate one or more UAS. | (EU) 2019/945[2] |
| VTOL capable aircraft | A power-driven, heavier-than-air aircraft, other than aeroplane or rotorcraft, capable of performing vertical take-off and landing by means of lift or thrust units used to provide lift during take-off and landing | NPA 2022 06[19] |

**Table 1: Glossary of terms**

## 2.7 List of Acronyms

| Acronym | Definition |
|---|---|
| **ACAS** | Airborne Collision Avoidance System |
| **ATC** | Air Traffic Control |
| **ATM** | Air Traffic Management |
| **AMC-GM** | Acceptable Means of Compliance – Guidance Material |
| **BVLOS** | Beyond Visual Line Of Sight |
| **CIS** | Common Information Service |

| Acronym | Definition |
|---|---|
| C2 | Command and Control |
| CNS | Communication Navigation and Surveillance |
| CONOPS | Concept of Operations |
| CR | Change Request |
| DAA | Detect And Avoid |
| EASA | European Aviation Safety Agency |
| EATMA | European ATM Architecture |
| E-ATMS | European Air Traffic Management System |
| EU | European Union |
| EUROCAE | European Organisation for Civil Aviation Equipment |
| FATO | Final Approach and Take-Off area |
| GAMZ | Geodetic Altitude Mandatory Zone |
| HPAR | Human Performance Assessment Report |
| ICAO | International Civil Aviation Organisation |
| ICARUS | Integrated Common Altitude Reference system for U-space (SESAR H2020 project) |
| IFR | Instrument Flight Rules |
| INTEROP | Interoperability Requirements |
| KPA | Key Performance Area |
| LUC | Light UAS operator Certificate |
| MOPS | Minimum Operational Performance Standards |
| MS | Member State |
| NPA | Notice of Proposed Amendment |
| OI | Operational Improvement |
| OPAR | Operational Performance Assessment Report |
| OSED | Operational Service and Environment Definition |
| PAR | Performance Assessment Report |
| PIRM | Programme Information Reference Model |
| PTS | Prototype Technical Specifications |
| RPAS | Remotely Piloted Aircraft Systems |
| QoS | Quality of Service |
| RTTA | Required Time To Act |


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| Acronym | Definition |
|---|---|
| **RWC** | Remain Well Clear |
| **SAC** | Safety Criteria |
| **SAR** | Safety Assessment Report |
| **SecAR** | Security Assessment Report |
| **SESAR** | Single European Sky ATM Research Programme |
| **SERA** | Standardised European Rules of the Air |
| **S3JU** | SESAR3 Joint Undertaking (Agency of the European Commission) |
| **SORA** | Specific Operations Risk Assessment |
| **SPR** | Safety and Performance Requirements |
| **SSDR** | Single Seat DeRegulated |
| **STS** | Standard Scenario |
| **SWIM** | System Wide Information Model |
| **TS** | Technical Specification |
| **TLOF** | Touch-down and Lift Off |
| **UA** | Unmanned Aircraft |
| **UAM** | Urban Air Mobility |
| **UAS** | Unmanned Aircraft System |
| **UAV** | Unmanned Aircraft Vehicle |
| **UFR** | U-space Flight Rules |
| **USSP** | U-Space Service Provider |
| **UTS** | U-space Traffic Services |
| **VFR** | Visual Flight Rules |
| **VLL** | Very Low Level |
| **VLOS** | Visual Line Of Sight |
| **VMC** | Visual Meteorological Conditions |
| **VTOL** | Vertical Take-Off and Landing |

**Table 2: List of acronyms**



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# 3 ConOps and regulatory environment: observations and adjustment opportunities

The former CORUS ConOps and now the current CORUS-XUAM ConOps (Edition 3.10) [1]has been developed in a very active and mobile environment. ICAO panels, SJU, EUROCAE, other SESAR projects, and especially EASA, are proposing a non-stop list of new documents and proposals for Urban Air Mobility that the CORUS-XUAM team aims at considering and homogenizing.

The complexity of the task is huge, but at the same time very challenging. The contrast of the current regulation with the proposed ConOps shows potential conflicts or mismatch. The objective of this task is to find those potential conflicts and convert them into opportunities to improve the ConOps. But also, this task aims at proposing changes in the current and in particular, in the forthcoming regulations under development.

The list of documents that we have reviewed is given below. The order of the documents is given according to their maturity level, and to the time they were produced.

- Regulation for manned aircraft

- (EU) No 923/2012 [10] on easy access rules for Standardized European Rules of the Air (SERA) – and its source ICAO Annex 11 [21].

- Working groups proposing specific amendments to ICAO/State documents

- (ICAO) RPAS Panel documentation for the integration of UAS into airspace (for RPAS flying IFR)
- SSDR: single seat microlight 'de-regulation' [18]

- Regulation on unmanned operations and their classification according to their risk:

- (EU) 2019/945 [2] on unmanned aircraft systems and on third country operators of unmanned aircraft systems
- (EU) 2019/947 [4]on the rules and procedures for the operation of unmanned aircraft
- (EASA) ED Decision 2022/002/R on AMC & GM to Regulation (EU) 2019/947[22]
- (EU) 2020/1058 [3]amending delegated regulation (EU) 2019/945 as regards the introduction of two new unmanned aircraft systems classes
- (EU) 2020/639 [5] Amending Implementing Regulation (EU) 2019/947 as regards standard scenarios for operations executed in or beyond the visual line of sight

- Regulation on U-space:

- (EU) 2021/664 [6], 2021/665 [7] and 2021/666 [8]on the regulatory framework for the U-space
- (EASA) NPA 2021-14 [9]on AMC&GM to the U-space regulatory package

- Regulatory work in UAM

- (EASA) NPA2022-06 [19] on a regulatory framework for new operational and mobility concepts that are based on innovative technologies, like unmanned aircraft systems (UAS) and aircraft with vertical take-off and landing (VTOL) capability-
- (EASA) work in progress for the Prototype Technical Specifications for the Design of VFR Vertiports for Operation with Manned VTOL-Capable Aircraft certified in the enhanced category [11]
- (EASA) public consultation on Guidelines on noise measurement of unmanned aircraft systems lighter than 600kg operating in the specific category (low and medium risk) released on 13 October 2022. [20]

More detailed contents of these documents are provided in section 3.2.

In the current ConOps there are already many references to the current regulation (see e.g., section 2.2.2.2 – Flight priority). In the following section we will detail how the ConOps has made efforts to comply with the current regulation (section 3.1), a brief explanation of the content of the current regulations, highlighting the domains of them that have much impact with the entrance of new aerial mobility asset (section 3.2), and the comparison of both (3.3).

## 3.1 CORUS X UAM ConOps

The ConOps edition 3.10[1] has three major chapters as main contributions:

- Contribution 1 (Chapter 2 – Operational Environment) defines the UA flight phases, proposes a new volume Zz, provides a way to inform UAM operations to other airspace users, and presents basic definitions for vertiports and other ground infrastructure.
- Contribution 2 (Chapter 3 – U-space services) details the list of services offered by U-space.
- Contribution 3 (Chapter 4 – Flight Rules) motivates the need of a new set of flight rules for UAM, proposed to be named as UFR.

Other chapters are either introductory (Chapter 1), descriptive examples (Chapter 5), basic description of some architectural implementation details (Chapter 8) or initial proposals for improving the social acceptance of the CORUS XUAM very large demonstration flights (Chapter 7). There is also pending work that will be proposed in the next edition: One of the pending works is Chapter 9 – Regulatory context, which will be fed from this deliverable. Chapter 6 – Contingency and Safety, is being developed in a parallel task.

Through the document several definitions are presented, some are taken from the regulation, from ICAO or from other projects. CORUS-XUAM also proposes the definitions of some concepts that we found do not always accommodate with current regulation definitions. This document contains proposals on revising some definitions in line with harmonisation.


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### 3.1.1 Contribution 1: Operational Environment

The aviation world has a long tradition of safety. The "Swiss cheese model" illustrates the safety process very well, where each slice of cheese represents a safety barrier relevant to a particular hazard. The application of all these barriers, each at a different time, brings as result the high levels of safety of current aviation.

With the operational environment the ConOps translates the current safety barriers from conventional aviation to the UAM operations. It proposes the needed activities for each different time, situating them at different phases of the flight: Long-term strategic/design, pre-flight/strategic, pre-flight, during flight/tactical, and post-flight. Making parallelism with the life timeline of a conventional flight, the ConOps proposes the activities that are necessary to be taken by each stakeholder, and a new nomenclature to avoid confusion with the original. In this way, the plan for the UAM operation is named as U-plan, the initiation of the tactical phase is done with the U-plan activation and is finished with the U-plan termination.

Important links with current regulation are given in the operational environment chapter: the regulation on U-space and its on-going AMC&GM are very related with the long-term strategic phase. The planification, definition and design of the areas to be defined as U-space airspace is defined in the ConOps as in the hands of member states competent authorities. Also, safety works in this phase are required for drone operators, to register as required by (EU) 2019/947[4], and to have approved vehicles.

The following table provides the links of the flight phases and the regulatory documents that provide some requirements in relation with the flight phase. Notice that some aspects are already raised in the ConOps that are not mentioned by any regulation.

| Flight Phase | Related regulation | Comment / Requirement |
|---|---|---|
| Strategic Long-Term | (EU) 2021/664[6]<br>(EASA) NPA 2021-14[9] | U-space airspace design |
| | (EU) 2019/947[4] | UAS operator registration |
| | (EU) 2019/947[4] | UAS type classification |
| | (EASA) VTOL vertiport prototype[11] | Vertiport and infrastructures |
| Strategic Pre-Flight | (EU) 2019/947[4] | Operation Category<br>Risk Assessment |



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| | | |
|---|---|---|
| | (EU) 2021/664[6] | Authorisation of U-plan |
| | (EU) 2021/664[6]<br>Inspired in (EU) No 923/2012[10] | Priority of U-plans conducting special operations |
| | *none* | Plan for vertiport usage |
| Pre-tactical | (EU) 2021/664[6] | U-space strategic services |
| | (EU) 2021/664[6] | U-plan permission removal if higher priority U-plan |
| | *none* | U-plan that crosses airspace boundaries |
| | *none* | U-plan permission removal by dynamic capacity management and the concept of Reasonable Time to Act |
| | *none* | U-plan uncertainty quantification |
| Tactical | *none* | U-plan includes the time window for the activation request |
| | (EU) 2021/664[6] | U-space tactical services |
| Post flight | (EU) 2021/664[6] | U-space Legal recording service |

**Table 3 Links between flight phases and existing regulations or proposals**

The long-term strategic phase of the operational environment has an enormous role in the safety of the operations. In addition to the operational plan, two aspects are introduced in the ConOps: the airspace and the ground.

For the airspace, the ConOps proposes the harmonization of the **airspace classes** (from ICAO Annex 11 and SERA (EU) No 923/2012)[10] with the U-space regulatory pack and the CORUS ConOps Volumes.

Table 2 of the ConOps is a summary of the harmonization work. Below an inverse table shows how the Volumes may be integrated in the current legislation, including the new Zz volume proposed in the new ConOps. Zz is similar to Zu, except that the tactical separation service provides only advice to pilots. U-space airspace volumes are highlighted in green. Current U-space regulation is mainly addressing volume Y for the moment.

| Volume | ICAO/SERA Airspace class | Remark |
|---|---|---|
| X | G | In G only UAS flying in VLOS (VFR) and limited to VLL |
| X or Y | Restricted Area<br><br>(Declared UAS Geographical Zone) | No other aircraft expected |
| Y | Restricted Area<br><br>(Declared UAS Geographical Zone) | Manned aircraft not expected or require electronic conspicuity according to U-space regulation. |
| Zu / Zz | Restricted Area<br><br>(Declared UAS Geographical Zone) | Manned aircraft not expected or require electronic conspicuity according to U-space regulation. Managed by Tactical services. |
| Y/Za | ABCDE | UAS needs ATC approval |

**Table 4 U-space volumes and possible implementation in ICAO/SERA airspace classes**

In addition, the common altitude reference proposal is based on the proposals from the ICARUS SESAR project. The proposal is that U-space will use geodetic altitude with reference to WGS84. Four U-space services will support any on-the-fly translation from barometric altitude. For this the ConOps proposes to add U-space as Geodetic Altitude Mandatory Zone (GAMZ), a new concept to add in regulation, similar to Transponder Mandatory Zone.

Neither the ConOps nor the regulation said anything about the flow management and network structure inside the volumes.

On the **ground** UAM will only be possible if cities are able to allocate space and infrastructure for vertiports (passengers and/or cargo). While the cargo vertiports are simpler than the passenger vertiports, both need to provide capacity information to the U-space, so this could correctly manage the flight authorizations and the emergencies.

For passenger transport in urban areas, the VTOL vertiport prototype is used in this ConOps. General definitions of the areas for touchdown and lift-off, approach, and take-off, stands, embarking and waiting are given. The ConOps proposes the vertiport operators as authorities and responsible of the definition of the procedures and the provision of services to operators and information to U-space. For VTOLs certified in the enhanced category, the U-plan will contain emergency procedures supported by a ground infrastructure consisting in several vertiports (nominal and alternates) and emergency landing sites. The concept of Continued Safe Flight and Landing applies for passenger UAM.

### 3.1.2 Contribution 2: U-space services

The ConOps V3.10 provides an update of the list of services proposed, with some renaming and regrouping to match with the U-space regulation pack. Below a summary list of the renamed services and the reference to the regulation article that justifies the change.

| Previous name | Updated name<br><br>ConOps Edition 3.10 | Article |
|---|---|---|
| e-registration | Registration | 2019/947 art 14[4] |
| e-identification<br><br>Position report submission | Network identification | 2021/664 art 8[6] |
| [Dynamic] Geo-fencing | Geo-awareness | 2021/664 art 9[6] |
| Operational plan processing | Flight Authorization Service | 2021/664 art 10[6] |
| - | Strategic Conflict Prediction | 2021/664 art 10[6] |

**Table 5 New U-space services names**

In addition, two U1 services (Registration Assistance and Operational Plan Preparation/Optimization) have been eliminated.

All services above are U1 and U2, thus most services of U3, not yet considered in the regulation, are kept without changes. The only exception is the split of the Tactical Conflict Resolution into two services: one for Prediction and another for Resolution, mimicking the sibling services for strategical phase.

The description of other services has been updated according to the regulation when they were described. The list of these services is:

- Surveillance data exchange
- Drone aeronautical information management
- Legal recording
- Traffic information
- Weather information

New services are defined in relation to vertiports and to a common altitude reference:

- Vertical Conversion (U2)

- Vertical Alert & information (U2)
- Vertiport Availability (U3)

Finally, what the regulation refers as Conformance Monitoring, in the ConOps still appears as two separated services: Monitoring, and Emergency Management.

As a summary, figure X shows the new proposed services and their organization by functionalities and phases:

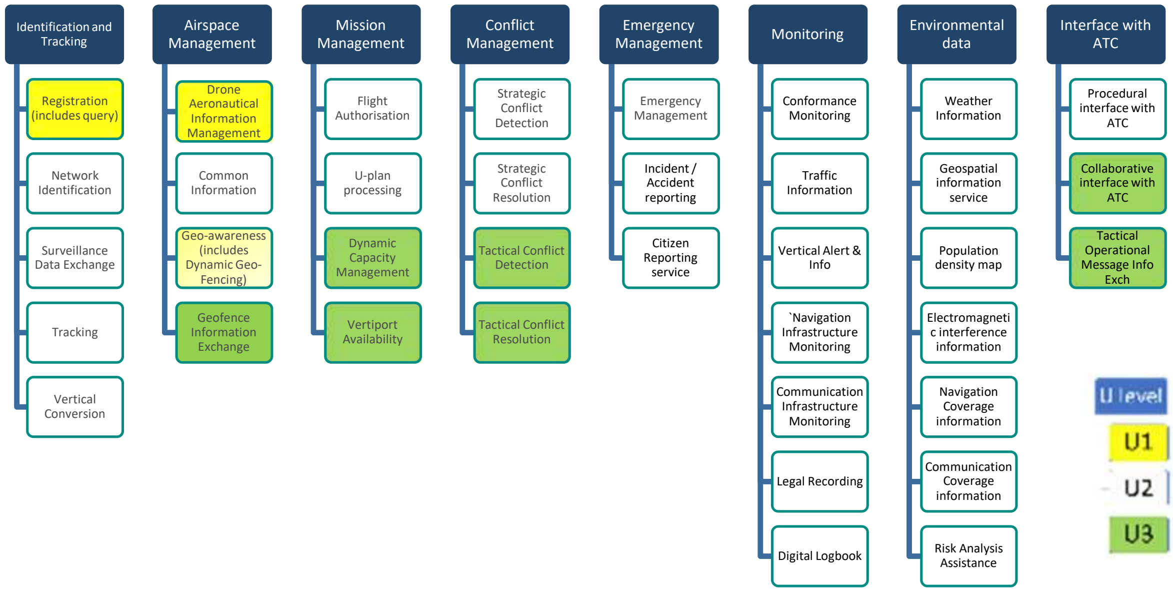


**Figure 1 U-space services of ConOps 4**

### 3.1.3 Contribution 3: U-space Flight Rules (UFR)

Although some unmanned aircraft, equipped with required avionics, are classified as IFR and able to fly in controlled airspace, the high increase of the number of UAM aircraft and their characteristics make them not suitable for either VFR or IFR. Current regulation allows the mix of VFR and IFR traffic in some airspace classes, making the integration of unmanned traffic even more complicated. In both flight rules the pilot remains the last responsible of the safety of the aircraft, but IFR provides additional services to help pilots in their duty.

The ConOps proposes that the rules of the air in the U-space airspace needs a different approach, in which all participants (manned and unmanned) will share the same rules. These new rules basically follow the information and separation services given uniquely by U-space. Even any clearance or information originated from ATC will be communicated to an UFR aircraft by means of the U-space.

To be able to enter U-space and follow the UFR all aircraft are requested to:

- Be electronically conspicuous
- Receive the traffic information about other aircraft in the volume
- Adhere to ATS instructions received via U-space
- Use the separation services provided by U-space

## 3.2 Existing regulatory Environment

The following two sections aim at setting the scene of the current international and European regulatory frameworks, and at identifying the relationships with the ConOps. If any gaps appear, they will be raised.

Hence, the text below will:

- List the set of documents that have been reviewed, with a description of the main theme for each. The documents reviewed are those available, adopted or on NPA format, in October and November 2022, which could have links on one way or another with U-space and/or urban air mobility.
- Identify the domains of the ConOps that are impacted.
- Identify the domains where information and regulation are missing.

### 3.2.1 Current regulations

#### 3.2.1.1 (EU) 2019/945 on unmanned aircraft systems and on third country operators of unmanned aircraft systems

COMMISSION DELEGATED REGULATION (EU) 2019/945 of 12 March 2019[2] on unmanned aircraft systems and on third-country operators of unmanned aircraft systems is a European regulation.

- This Regulation lays down the requirements for the design and manufacture of unmanned aircraft systems ('UAS') intended to be operated under the rules and conditions defined in Implementing Regulation (EU) 2019/947[4] and of remote identification add-ons. It also defines the type of UAS whose design, production and maintenance shall be subject to certification.

- It also establishes rules on making UAS intended for use in the 'open' category and remote identification add-ons available on the market and on their free movement in the Union.

- This Regulation also lays down rules for third country UAS operators, when they conduct a UAS operation pursuant to Implementing Regulation (EU) 2019/947 [4]within the single European sky airspace.

  It applies to all UAS categories of operations as described in (EU) 2019/947[4].

  This regulation provides many definitions such as the ones of UA, UAS or UAS operator.

  The annex provides an exhaustive description of the requirements for UAS of class C0, C1, C2, C3 and C4.

  Part 13 of the annex lays down the methods of measurement of airborne noise, Part 14 details the labelling that UA must show (measures shall be used for the determination of the A-weighted sound power levels and given in dB). Part 15 provides the limits of noise of UA classes C1 and C2 (Class C3 is missing in the table where maximum sound power level is defined). Maximum noise limits are from 85 dB(A) to 81 dB(A), decreasing on forthcoming years, plus some extra noise allowed for vehicles with higher mass.

#### 3.2.1.2 (EU) 2020/1058 amending delegated regulation (EU) 2019/945 as regards the introduction of two new unmanned aircraft systems classes

COMMISSION DELEGATED REGULATION (EU) 2020/1058 of 27 April 2020[3] amends Delegated Regulation (EU) 2019/945 as regards the introduction of two new unmanned aircraft systems classes is a European regulation.

(EU)2019/945 articles are updated to reflect adoption of two additional UAS classes, C5 and C6. It also adds to (EU)2019/945[2] definitions of:

- Command unit ('CU').
- C2 link service.
- Night.

The annex content is the same to the one of (EU)2019/945 [2]with class C5 and C6 add-ons.

#### 3.2.1.3 (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft

This Regulation lays down detailed provisions for the operation of unmanned aircraft systems as well as for personnel, including remote pilots and organisations involved in those operations.

The document provides:

More information about the categories of UAS operations (articles 3 to 6), in particular which operations are in the certified category. Lots of UAM UAS operations will be conducted in that category. The annex details the operations in the open and specific categories and provides the requirements for a Light UAS operator Certificate (LUC).

Requirements for remote pilots operating in the open and specific categories (article 8 and 9).

Requirements for conducting an operational risk assessment (article 11, SORA is not mentioned!).

Requirements for conducting a UAS operation (e.g., UAS operator registration (article 14), definition of geographical zone services (article 15), tasks of the competent designated authority (article 17 and 18), as shown in figure 2.


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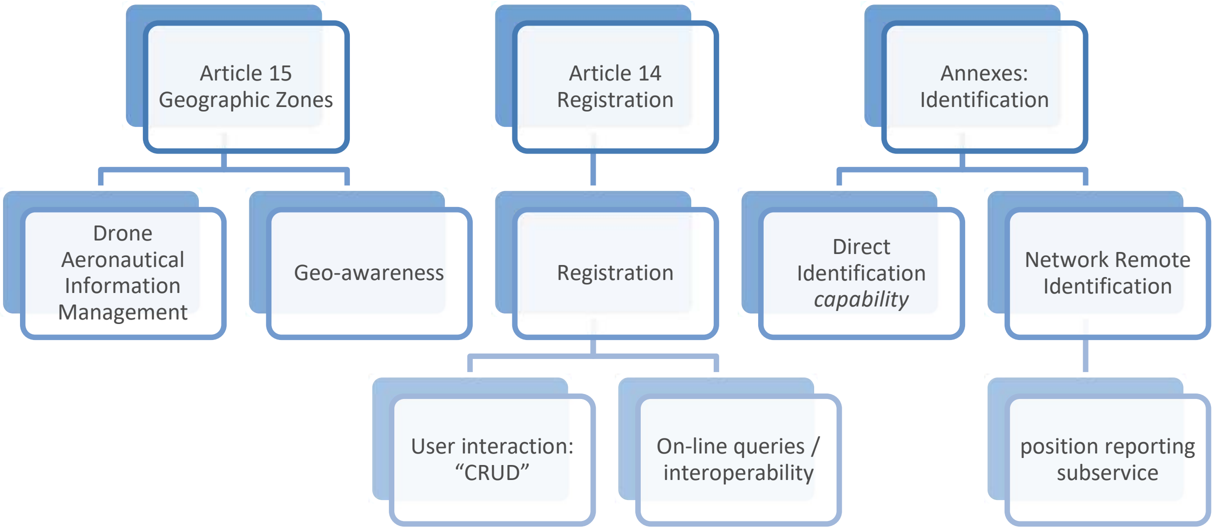


**Figure 2 U-space services and (EU) 2019/947 articles**

#### 3.2.1.4 (EU) 2020/639 Amending Implementing Regulation (EU) 2019947 as regards standard scenarios for operations executed in or beyond the visual line of sight

COMMISSION IMPLEMENTING REGULATION (EU) 2020/639 of 12 May 2020 amends[5] (EU) 2019/947 [4]by integrating two standard scenarios for operations executed in or beyond the visual line of sight.

They are detailed in the appendix 1.

STS-01:

- Describes an operation in VLOS over controlled ground area in a populated environment. This scenario could typically occur in an urban environment but would not be part of what is called UAM. However, operation that would take benefit of STS-01(e.g., building inspection, photography) would probably interfere with UAM operations.

- Shows responsibilities of UAS operator and remote pilot and remote pilot training and skills requirements.

STS-02:

- Describes an operation in BVLOS with or without airspace observers over a controlled ground area in a sparsely populated environment. This scenario could also occur in an urban environment, possibly when most people are sheltered (e.g., at night). As for STS-01, it is likely that that kind of operation is not part of UAM (except for carriage a specific goods for instance) but would probably interfere with UAM operations.

- Shows responsibilities of UAS operator, remote pilot, and airspace observer as well as remote pilot training and skills.

Appendix 3 provides requirements for entities conducting practical skill training and assessment of remote pilots for operations covered by a standard scenario.

Appendix 5 lists the minimum content of the operation manual for a standard scenario.

This amendment also defines for instance the observer, the contingency volume and the ground risk buffer.

**(EU)2019/945[2] and 2019/947[4] were already published when CORUS ConOps edition 3 was shared in October 2019. These parts of the regulation had been considered for that version of the ConOps. Amendments of 2019/945 by (EU) 2020/1058[3] and of 2019/947[4] by (EU)2020/639[5] were published later, hence both UAS classes 5 and 6 and standard scenarios STS-01 and STS-02 are not addressed in that version of the ConOps.**
**Reviewing those amendments may bring additional possibilities for UAM operations, and there also is a need to check that UAM operations are in line with the content of 2019/945[2] and 947[4].**

#### 3.2.1.5 Commission implementing regulations 2021/664, 665 and 666

Commission implementing regulations (EU) 2021/664[6], 665[7] and 666[8] pave the way of a U-space regulatory framework.

2021/664:

- Lays down rules and procedures for the safe operations of UAS in the U-space airspace, for the safe integration of UAS into the aviation system and for the provision of U-space services.
- Introduces the definitions, descriptions and/or role of a U-space airspace, U-space service, airspace risk assessment, common information service and dynamic airspace reconfiguration.
- Provides the general requirements for UAS operator and U-space service providers.
- Provides the list of minimum U-space services that shall be provided in a U-space airspace/UAS geographical zone. See figure X and figure Y.
- Shows conditions for obtaining a USSP or CIS certificate.

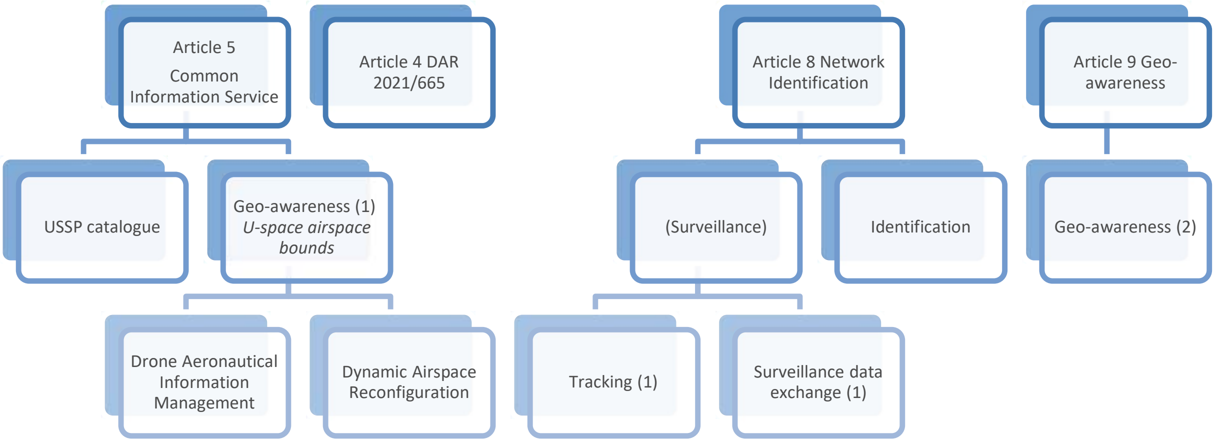


**Figure 3 Common Information service, Dynamic Airspace Reconfiguration and U-space services referenced by (EU) 2021/664 articles 4-5, 8-9**

2021/665:

- Amends Implementing Regulation (EU) 2017/373[24] as regards requirements for providers of air traffic management/air navigation services and other air traffic management network functions in the U-space airspace designated in controlled airspace.
- Introduces the dynamic reconfiguration of the U-space airspace allowing temporary manned traffic transit through a U-space airspace and proper coordination (article 1 (3)).

2021/666:

- Amends Regulation (EU) No 923/2012[10] as regards requirements for manned aviation operating in U-space airspace.
- Introduces electronic conspicuity of manned aircraft operating in airspace designated as U-space airspace and not provided by an air traffic control service (article 2 c)).

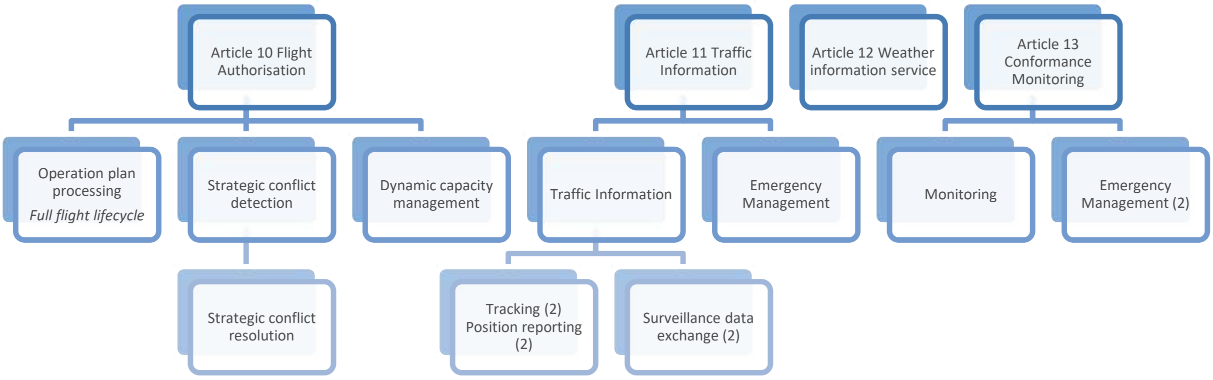


**Figure 4 U-space services referenced by (EU) 2021/664 articles 10-13**

**2021/664[6], 665[7] and 666[8] are setting the basement of the regulatory framework for U-space. In particular, three important requirements are raised:**

- **At least four mandatory services shall be provided in a U-space airspace (UAS flight authorisation service, traffic information service, network identification service and geo-awareness service).**
- **Two are proposed as optional if deemed useful by the member state (weather information service and conformance monitoring service).**
- **Manned and unmanned operations shall be segregated in controlled airspace.**
- **Manned aircraft shall be conspicuous in U-space airspace.**

**The ConOps addressing UAM operations already describes several U-space services, including the compulsory four. Nevertheless, there may be differences in the way the services are named and their roles.**
**In addition, The ConOps has a long-term vision which could go beyond EASA's.**
**That review aims at identifying the differences.**

### 3.2.1.6 NPA 2021-14

This Notice of Proposed Amendment 2021-14[9] proposes acceptable means of compliance and guidance material to support the U-space regulation, meaning it deals with Regulations (EU) 2021/664[6], (EU) 2021/665[7], (EU)2021/666[8].

The document provides explanation(why) and a lot of details on the regulation contents and gives guidance on how these regulations could be implemented.

Topics addressed in the document are the following:

- U-space airspace

- Dynamic airspace reconfiguration
- U-space stakeholders such as USSP, CIS or UAS operators' roles, responsibilities, and certification
- U-space services
- Competent authorities

**AMC-GM bring additional information and details to 2021/664[6], 665[7] and 666[8]. Reviewing this document complements the review of these regulations.**

#### 3.2.1.7 Easy Access Rules for Standardized European Rules of the Air (SERA)

The Standardised European Rules of the Air are transposing, adapting, and complementing the ICAO annex 2 for Europe.

It aims at establishing the common rules of the air and operational provisions regarding services and procedures in air navigation that shall be applicable to general air traffic within the scope of Regulation (EC) No 551/2004[25].

This Regulation:

- Shall apply in particular to airspace users and aircraft engaged in general air traffic:
    - Operating into, within or out of the Union.
    - Bearing the nationality and registration marks of a Member State of the Union and operating in any airspace to the extent that they do not conflict with the rules published by the country having jurisdiction over the territory overflown.
- Shall also apply to the competent authorities of the Member States, air navigation service providers, aerodrome operators and ground personnel engaged in aircraft operations.
- Shall not apply to model aircraft and toy aircraft. However, Member States shall ensure that national rules are established to ensure that model aircraft and toy aircraft are operated in such a manner as to minimise hazards related to civil aviation safety, to persons, property or other aircraft.

The topics addressed in SERA with which the ConOps could have links somehow are the following:

- Instrument and visual flight rules
- VMC minima
- Collision avoidance
- Flight plan
- Airspace classification
- Air traffic services (control, information, alert)
- Interference, emergency, contingencies, and interception
- Voice communication procedures

Appendix 1 deals with the "signals" and is likely to have no application in the "unmanned" world, at least not in this form.

Appendix 2 addresses the unmanned free balloons.

**Rules of the air are one of the biggest challenges for UAS provided their specificities and obvious non full compliance to existing ones for manned aviation. All existing rules that could be applied to UAS operations would help to mix operations. On the contrary, those that are inconsistent shall be identified and new rules of the air for UAS operations proposed.**

#### 3.2.1.8 EASA "Prototype Technical Specifications for the Design of VFR Vertiports for Operation with Manned VTOL-Capable Aircraft "certified in the enhanced category

This PTS[11] focuses on the design of VFR vertiports for operation with manned VTOL -capable aircraft certified in the enhanced category. As a reminder, SC VTOL category 'Enhanced' are used for the commercial air transport of passengers, including VEMS operations, or for the commercial and non-commercial air transport of cargo taking place outside congested areas. Thus, only the first part, with the transport of passengers, concerns the urban air mobility.

It provides a lot of details and requirements about the geometry of vertiports (e.g., FATO, TLOF, stands, visual aids and markings).

Also are described the shapes of approach, transitional and take-off climb surfaces, with obstacle limitations.

**General information on vertiports is of utmost importance in the frame of urban air transportation, as points of departures, arrivals, and as contingency and emergency landing facilities.**

#### 3.2.1.9 EUROCAE MOPS ED-269 and ED-270 on Geofencing and Geo-caging

These two standards, very related one to the other, detail the UAS on-board function that, based on the data provided by the State (or entitled trusted sources) on UAS geographical zones, detects a potential breach of airspace limitations and assists the remote pilot in preventing that breach.

Differences between the two functions are (Sect. 1.3):

- The **Geofencing** function prevents the UA to penetrate in a forbidden zone.
- While the **Geo-caging** function prevents the UA to exit out of a zone pre-defined by the operator

Both define two levels of automation in case of breach detection:

- When the function is limited to alerting the pilot is called Geo-awareness.
- When the function prevents the breach by engaging an adequate manoeuvre without any pilot action is called Geo-caging / Geofencing.

The function can be implemented as a set of hardware and/or software components inside the UAS, this is, in the remote pilot station and/or on board the UA itself. The function shall be fed by data (e.g., data about the applicable airspace restrictions) provided by a ground service. The expected characteristics of the output and interface of the ground service are also defined by these MOPS.

Section 3.1 provides the list of functions that include alarms, reactions, and safety buffers for the fence volumes.

Appendix 1 details the margin distances on the volume limits that shall be defined and implemented by the manufacturer, considering the accuracy of the UAS position/altitude measurement in comparison with the geographical zone limits.

The topics addressed in ED-269[12] and ED-270[13] with which the ConOps could have links somehow are the following:

- Flight Authorisation
- Geo-awareness and geo-fence services, but not mention of Geo-caging
- Monitoring service
- Flight Information Service

**The goal by reviewing these MOPS is to refine in the ConOps the description of the Geo-XXX services that could be relevant for UAM operating in U-space (standards for defining the geographical shape of the geofence, informative/automatic reactions, safety buffer, distance to alarm, etc.)**

#### 3.2.1.10 RPAS Panel documentation

All documents of the RPAS Panel are relative to IFR unmanned aircraft with one remote pilot in control (IFR-RPAS).

- RPASP/16-WP/15(24/09/2020)[14]

The document reviewed is the working paper RPASP/16-WP/15 dated on 24/09/2020, from the Remotely Piloted Aircraft Systems Panel (RPASP), sixteenth meeting. It addresses lost C2 link and detect and avoid procedures.

Only the part on C2 link loss seems to be relevant. The information provided on the DAA procedures embed the Remain Well Clear function (RWC) and suppose the presence of a remote pilot, which would not often be the case with a long-term perspective.

Back to the C2 link loss procedures, the working paper describes the procedures to be followed by an RPAS in case of command-and-control link loss during en-route, departure and arrival phase. The unmanned vehicle would fly with instrument flight rules mainly in controlled airspace.

**The goal by reviewing this document is to capture information that could be relevant for UAS operating in U-space and which would be affected by the same failure.**

- RPAS/19-WP/5(17/02/2022)[15]

This document presents the results of simulation of loss of C2-link, including human-in-the loop, and proposes how to add the loss of C2 procedures in the aeronautical chart. The working group also proposes the Special loss of C2 procedures in some specific airports.

**No new relevant information to add to the previous document**

- RPAS/19-WP/6(22/02/2022)[16]

The document lists the regulated procedures that need to be reviewed for IFR-RPAS, such as visual self-separation, separation minima, ability to flight instrumental procedures, ACAS (DAA & RWC).

**Not mature enough proposals to be able to consider them for the ConOps**

- RPAS/19-WP/7(22/02/2022)[17]

This working group document proposes amendments to ICAO Annex 10 Vol II on Aeronautical telecommunications by introducing prefix REMOTE in RPA call sign

**The goal by reviewing this document can be useful in the description of the Interface with ATM service and on the requirements for UAM flying in Za volume.**

#### 3.2.1.11 SSDR: single seat microlight

The British Microlight Aircraft Association Technical Information Leaflet[18] introduces the characteristics and general usage requirements of that kind of aircraft which weight is limited to a maximum of 330kg in its maritime version, with only one person on-board.

This document has been taken on-board the regulatory framework reviewing process as we initially thought it could be of interest if we consider microlight aircraft as possibly close to unmanned taxi drone.

**Unfortunately, we did not find any useful information, for our task, in this document.**

#### 3.2.1.12 “” NPA2022-06” “Introduction of a regulatory framework for the operation of drones Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the ‘specific’ category”

EASA developed NPA 2022-06[19] to encompass in existing regulations usage of a new category of aircraft, VTOL capable aircraft, in a manned or unmanned configuration. These aircraft are expected to operate for urban air mobility. It is explained that these VTOL capable aircraft are different to helicopter, hence operating them requires an update of several document such as (EU) No 748/2012[26], (EU) 2019/945[2] or (EU) 923/2012[10].

The operational objective of the proposal is to establish a coherent regulatory framework to enable the airworthiness for UAS subject to certification which are operated in the ‘specific’ category and of operations with manned VTOL-capable aircraft.

The scope of the proposed amendments to Commission Regulation (EU) No 748/2012[26] includes UAS subject to certification independently of the category in which they are operated (‘specific’ category or ‘certified’ category).

Despite many parts dedicated to the unmanned configuration (text is “reserved”) are still missing, airworthiness, maintenance and certification of personnel and components processes, and requirements (ML-UAS and CAO-UAS) are provided.

**Expectations in reviewing NPA2022-06 are to find information on vehicles and possibly procedures applicable to what would be used for urban air mobility operations.**

#### 3.2.1.13 (EASA) public consultation on Guidelines on noise measurement of unmanned aircraft systems lighter than 600kg operating in the specific category (low and medium risk) released on 13 October 2022.

This document extends the noise requirements of UAS flying, provided in EU 2019/947[4] and EU 2018/1139[27] for the Open category operations, to the Specific category. The procedures to measure the noise consider level flight (with tests at 50 m of altitude from the recording equipment) and stationary flight (tests at 25 m above measurement point). Environmental conditions, AUS mass and speed and recording equipment are detailed and corrections to apply when these cannot be met are also given. SUBPART D shall contain the limits of the noise, but this section is still not published.

#### 3.2.1.14 (EASA) ED Decision 2022/002/R on AMC & GM to Regulation (EU) 2019/947 that amends AMC-GM for (EU) 2019/947

In the AMC-GM for (EU) 2019/947[22], the following domains could be of particular interest for the ConOps.

- Definitions for the following terms:
    - Dangerous goods (AMC1 article 2 and GM1 article 2 (11))
    - Privately built (GM1 article 2 (16))
    - Uninvolved persons (GM1 article 2 (18))
    - Controlled ground area (GM1 article 2(21))
    - Flight geography, Flight geography area, Contingency volume, Operational volume, Ground risk buffer, Contingency area (GM1 article 2 (28 to 33))
    - Responsibilities of the airspace observer (GM1 article 2 (25))
- Description in detail of the rules for conducting an operational risk assessment with many applications examples on operations in the specific category, including examples of scenarios STS-01 and STS-02.
- Full description of SORA methodology.
- Operational conditions for UAS geographical zones (article 15):
    - Means to inform manned aviation of UAS geographical zones
    - Cross-border UAS geographical zone(s)
    - Data integrity and quality
    - General aspects
    - Exemption(s) for the open category
    - Common unique digital format
    - Publication of information on UAS geographical zones in the aeronautical information products and services
    - Publication of maps of UAS geographical zones

## 3.2.2 Domains impacted by the regulations and gaps

### 3.2.2.1 Domains identified

The different reviews of the ConOps and above selected documentation show that several domains are already addressed:

- Airspace (manned and U-space) and related ATM or U-space services content.
- Roles and responsibilities of ATM and U-space stakeholders.
- Rules of the air, including weather consideration.
- Operation infrastructures (for VFR manned VTOL capable aircraft operation; unmanned VTOL should come later).
- UAS contingency procedures: UAS Command and control link failure procedure for IFR-RPAS, which is a sub-category of UAS.
- Detect and avoid equipment.
- Requirements for VTOL capable aircraft operations (mainly manned, unmanned parts should come later) and airworthiness.
- Definitions (e.g., Geo-awareness, geo-fencing, geo-caging).

#### 3.2.2.2 Gaps

Despite detailed differences are introduced in sections 3.3.1 and 3.3.2, the paragraph below proposes to list the main thematic that are still missing, both in current regulations and/or in the Conops:

In the ConOps:

- Cross border operations (AMC1 article 13 of Easy Access Rules for UAS)
- Remote pilot (UAS.OPEN.060 and UAS.SPEC.060) (and other stakeholders) responsibilities (only roles are depicted).
- UAS equipment failure procedures and U-space equipment and services failure procedures (is MEDUSA adapted to UAM environment?).
- Rules of the air for UAS (UFR are, for the moment, more rules of “ATS” services (control, information, and alert provision).
- Better description of manned aircraft operations in U-space (e.g., connection to U-space, requirements).

In the regulation:

- EASA regulation does not mention U-space volumes as defined in the ConOps; most U-space projects refer to these volumes.
- VTOL capable aircraft operations in IFR, VTOL capable aircraft unmanned operations and Vertiport operations for unmanned VTOL.
- Rules of the air for UAS.
- Social acceptability: (EU) 2019/945[2] and (EU) 2020/1058[3] provide information on UAS noise limitations for UAS of classes C1, C2, C3, C5 and C6. **Guidelines on noise measurement of unmanned aircraft systems lighter than 600kg operating in the specific category** provides noise measurement and flight test procedures for UAS lighter than 600kg in the specific category. These may cover operations of UAS transporting goods without flying over assembly (ies) of people.

  Missing issues:

  - Noise limitation level(s) for UAS operating in the specific and the certified categories.
  - Any consideration of UAS flights (whatever the size or the category of operation) impact on privacy.

- Lowest altitude limitation and characteristics of the landing areas to preserve privacy and reduce noise impact.

## 3.3 Comparison between ConOps and regulation

This section describes the differences identified between the CORUS X UAM ConOps and the regulatory documents listed in the section 3.2.1. For each item, this section suggests changes to apply on the existing regulation framework (if required) or on the CORUS X UAM Conops in order to adapt or improve their compatibility.

### 3.3.1 Differences and possible impacts on ConOps

This section lists all the differences grouped by document and suggests the possible associated impacts on the CORUS X UAM ConOps.

#### 3.3.1.1 (EU) 2019/945 on unmanned aircraft systems and on third country operators of unmanned aircraft systems

(EU) 2019/945[2] provides the following definitions:

Article 3(4) of the UAS operator: "unmanned aircraft system operator' ('UAS operator') means any legal or natural person operating or intending to operate one or more UAS".

**Should we use, in the architecture section, the exact definition provided in the regulation?**

(Article 3(13)) "manufacturer" means any natural or legal person who manufactures a product or has a product designed or manufactured and markets that product under their name or trademark".

**Should we try to combine both definitions and adapt it to "UAS manufacturer" in the architecture section?**

It also set in (Article 40) requirements for UAS operated in the "certified" and "specific" categories. This explains why UAS used for UAM shall be certified. Article 40 has been updated by regulation 2020/1058[3].

**Should we mention these conditions in section 2.2.2.1?**

#### 3.3.1.2 (EU) 2020/1058 amending delegated regulation (EU) 2019/945 as regards the introduction of two new unmanned aircraft systems classes

See above remark for article 40.

#### 3.3.1.3 (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft

Article 6/(b) lists the type of UAS operations that require to be classified in the "certified category".

**The ConOps should precise the conditions met for certified category of UAS operation in section 2.2.2.1**.

#### 3.3.1.4 (EU) 2020/639 Amending Implementing Regulation (EU) 2019/947 as regards standard scenarios for operations executed in or beyond the visual line of sight

The Appendix 1/Chapter 2/ UAS.STS-02.050 sets the "Responsibilities of the airspace observer".

**If The ConOps intends to introduce remote pilot responsibilities, it should also consider the role of airspace observers in the U-space ecosystem and their interaction with the system.**

#### 3.3.1.5 (EU) 2021/664, 665 and 666 on a regulatory framework for the U-space (amending (EU) 2017/373 & (EU) 2012/923)

We noted discrepancies with U-space volumes requirements:

- The U-space ConOps edition 3 describes some U-space "Volumes" in which different services should be used. For Y and Z an approved plan is required, but not for X volume. In X volumes flights need no plan and receive no separation service, which implies that X volume cannot be considered as U-space airspace volume if we consider the EU regulation 2021/664[6].
- EU regulation 2021/664[6] defines U-space volumes as volumes where 4 mandatory services and two optional services are provided, being one of the mandatory services the UAS flight authorisation service. As stated in Article 10 "The U-space service providers shall provide UAS operators with the UAS flight authorisation for each individual flight, setting the terms and conditions of that flight, through a UAS flight authorisation service" and as no flight authorization is required in Volume X, this is in direct conflict with the EU regulation 2021/664[6].

In addition, the ConOps[1] introduced the idea of RTTA whereas the regulation uses the notion of first filed – first served. There is a difference in the way fairness could be managed: is it fair to penalize businesses that cannot accommodate impacts on their U-plans very shortly before activation or to penalize businesses that have no other choice but to fill U-plans close to the operation start?

#### 3.3.1.6 NPA 2021-14

NPA 2021-14[9], through article 3, 2.3.4, includes a guideline for MSs to define U-space airspace, considering in the risk assessment aviation and non-aviation issues (i.e., environment). They are combined to set the TLS.

**The ConOps focuses only on operation risks and could also add airspace design consideration.**

In Article 4, 2.3.5, it states clearly that ATC is responsible for Dynamic U-space Airspace reconfiguration.

**The ConOps[1] only mentions two dynamic services (capacity and geo-awareness) and as source of contingencies. ConOps could mention the "Dynamic U-space Airspace reconfiguration" as functionality of the "Collaborative Interface with ATC" service of U-space.**

In Article 5, a more extensive definition of the CIS is provided, compared to the one in the ConOps.

**The ConOps[1] could incorporate a summary of the CIS characteristics or refers to the AMC and GM articles.**

Article 6(5) mentions to limit the time window (max-min) for the request of activation of the approved operation.

**The ConOps[1] proposes the RTTA (only minimum) but not for the activation, only for the submission. ConOps could harmonize time window concepts in CONOPS: strategic (RTTA), pre-tactical (activation), + for departure (tactical window).**

#### 3.3.1.7 Easy Access Rules for Standardized European Rules of the Air (SERA)

**The ConOps[1] is globally missing a lot of information developed in SERA such as alerting service (unless it is part of U-space emergency service) or emergency contingencies and interception services. UFR would need further development.**

**Wake turbulences are mentioned nowhere in the ConOps.**

#### 3.3.1.8 EASA "Prototype Technical Specifications for the Design of VFR Vertiports for Operation with Manned VTOL-Capable Aircraft "certified in the enhanced category

PTS VPT-DSN.B.110 "Vertiport reference point" mentions Operations from uncertified vertiport.

**We did not address the required certification, or not, of the vertiport, in the ConOps[1]. Should we?**

**In addition, it is likely that vertiports for operation with unmanned VTOL, whatever the category, would have more or less the same requirements. Although this regulation has no direct effect on the concept of operations, it may considerably affect the development of UAM.**

#### 3.3.1.9 EUROCAE MOPS ED-269 and ED-270 on Geofencing and Geo-caging

Sect.3.1 provides details on UAS systems for geo-caging and geofencing that include alarms, react, volumes (buffer, exclusion, etc.).

The ConOps[1] explicitly mentions in Section 1.3.4-Not in scope- the onboard systems are not considered, but the ConOps description of the Geo-XXX services could add a reference to the EUROCAE standards and make clear the difference between the standards (on-board function) and the U-space (services).

**Should we add that the Geo-XXX services description, in addition to provide the geographical shape of the geofence, shall/should include additional information, such as, type of alarms (informative/reactive), safety buffers, distance to alarm, etc.**

#### 3.3.1.10 RPAS Panel documentation

- (RPASP/16-WP/15[14] details a loss of C2-link procedure

**Should ConOps include a similar contingency procedure for loss of C2, either planned in the U-plan approval or as part of the Contingency Management service. Currently drone execute a return to home (RTH), which is not safe if more traffic is around.**

- (RPAS/19-WP/7[17]) introduces the prefix 'remote' in the call sign of an IFR-RPAS as part of the phraseology with ATC.

**ConOps could include mention the necessity of a call sign for Za volumes and Interface with ATC services**.

#### 3.3.1.11 SSDR: single seat microlight

**No relevant information found.**

#### 3.3.1.12 NPA 2022-06 on innovative air mobility with manned VTOL-capable aircraft

The document introduces in paragraph §2 the definition of the Innovative air mobility (IAM) as "the safe, secure and sustainable air mobility of passengers and cargo enabled by new-generation technologies integrated into a multimodal transportation system"".

**ConOps could mention this notion of Innovative air mobility.**

In paragraph §2 again, definition of Urban air Mobility (UAM) as" the subset of IAM operations conducted in to, within or out of urban environments" is shared.

**ConOps could adjust our definition of UAM.**

§2 and 2.3.4.1, definition of VTOL capable aircraft: "a power-driven, heavier-than-air aircraft, other than aeroplane or rotorcraft, capable of performing vertical take-off and landing by means of lift or thrust units used to provide lift during take-off and landing."
… "It is proposed to limit the definition of 'helicopter' to "heavier than-air aircraft supported in flight chiefly by the reaction of the air on up to two power-driven rotors on substantially vertical axes". This would imply that aircraft configurations with more than two power-driven rotors should be initially classified as 'VTOL-capable aircraft' for the purposes of the above-mentioned Regulations."

**The ConOps[1] addresses "VTOL capable aircraft" and provide the definition of VTOL. Suggest changing.**

UAM.OP.VCA.105 Use of aerodromes or operating sites states that "for the purpose of VTOL-capable-aircraft operations, aerodromes (including heliports and vertiports) and operating sites are considered. Vertiports are aerodromes predominantly used by and designed to accommodate VTOL-capable aircraft. Vertiports shall have adequate infrastructure and provide necessary services regarding operations with VTOL-capable aircraft. Operating sites may only have a suitable surface for take-off/landing. Operations with passengers will only be possible to aerodromes. Cargo operations may use operating sites as well. 'Operating site' is defined in Regulation (EU) No 965/2012 as follows: '"operating site" means a site, other than an aerodrome, selected by the operator or pilot-in-command or commander for landing, take-off and/or external load operations.'"

**ConOps to consider operating site as a new facility.**

A general remark on the content of whole document: VTOL capable aircraft is seen as possibly being manned or unmanned. It may engender confusion to manned aircraft pilot when having these aircraft in sight; manned or unmanned and all what it implies?

**ConOps could address that if the same type of aircraft could be manned or unmanned, there could be confusion for manned aircraft pilots. This is valid also for any manned aircraft transformed into unmanned (e.g., cargo). If pilots on-board aircraft flying in U-space airspace are connected to U-space, there could be indication on the HMI that an aircraft is unmanned.**

#### 3.3.1.13 (EASA) ED Decision 2022/002/R on AMC & GM to Regulation (EU) 2019/947 that amends AMC-GM for (EU) 2019/947

### 3.3.2 Differences and possible impacts on regulations

This section lists all the differences grouped by document and suggests the possible associated impacts on the existing regulation framework.

#### 3.3.2.1 (EU) 2019/945 on unmanned aircraft systems and on third country operators of unmanned aircraft systems

The ConOps[1] is in line with (EU) 2019/945[2], hence does not contain information in contradiction with this regulation.

#### 3.3.2.2 (EU) 2020/1058 amending delegated regulation (EU) 2019/945 as regards the introduction of two new unmanned aircraft systems classes

The ConOps[1] is in line with (EU) 2020/1058[3], hence does not contain information in contradiction with this regulation.

#### 3.3.2.3 (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft

**The two following updates of the document are seen of interest:**

- Definition and description of UAM.
- Consideration of rules and procedures for the safe operations of UAS in the U-space airspace, for the safe integration of UAS into the aviation system and for the provision of U-space services as it is described in (EU) 2021/664.

#### 3.3.2.4 (EU) 2020/639 Amending Implementing Regulation (EU) 2019/947 as regards standard scenarios for operations executed in or beyond the visual line of sight

**Regulation (EU) 2020/639 should be updated or adapted with the following ideas:**

- ***Annex Part B/UAS.SPEC.020 Operational declaration/1. b*) should refer to U-space volumes instead of airspace classes.**

- ***Annex Part B/UAS.SPEC.060 Responsibilities of the remote pilot/2 & 3*) should ensure that UAS is connected to U-space system if a part of the flight is included in a U-space volume and this prior to the start of the operation.**

- ***Appendix 1/Chapter 1/UAS.STS-01.030 Responsibilities of the UAS operator/5 & Appendix 1/Chapter 2/UAS.STS-02.030 Responsibilities of the UAS operator/5*) should be adapted so U-space shall ensure the level of performance for any externally provided service necessary for the safety of the flight is adequate for the intended operation in case of a flight in a U-space volume.**

- ***Appendix 1/Chapter 1/UAS.STS-01.030 Responsibilities of the UAS operator/7 & Appendix 1/Chapter 2/UAS.STS-02.030 Responsibilities of the UAS operator/7*) should be adapted to**

**take account U-space high level of automation specifically on data with frequent update (e.g., data related to geo awareness).**

- ***Appendix 1/Chapter 1/UAS.STS-01.040 Responsibilities of the remote pilot/2. d & Appendix 1/Chapter 2/UAS.STS-02.040 Responsibilities of the remote pilot/2. d*) should define the role of UAS flight supervisor as it cannot be assimilated as remote pilot (e.g., the limit of one UAS per remote pilot).**

#### 3.3.2.5 (EU) 2021/664, 665 and 666 on a regulatory framework for the U-space (amending (EU) 2017/373 & (EU) 2012/923)

The three modules on the regulatory framework for the U-space are missing the two volumes Y and Z proposed in the ConOps, such as the Emergency Management service, Infrastructure Monitoring service, Vertical Alert and Information Service, Accident and Incident Reporting service, Tactical Conflict resolution service, Collaborative Interface with ATC and more.

In addition, another notable discrepancy is the fact that (EU) 2021/664[6], 2021/665[7] and 2021/666[8] and (EASA) NPA 2021-14 on AMC&GM[9] define a means of operating in U-space airspace which does not include a Tactical conflict resolution service, but this ConOps develops this service and the way it works.

Hence, there is a clear lack of U-space services in the regulation, some being probably more than useful (e.g., emergency management, Dynamic Capacity Management).

**Regulation does not develop all the services that will be required for an efficient and safe UAS traffic management. Conops has a long-term approach whereas regulations' have a short one.**

#### 3.3.2.6 NPA 2021-14

The regulation is referring to operational environments that are described in the ConOps with volume identifications (X, Y, Za, Zu, Zz).

**Could EASA adopt CORUS volumes descriptions?**

#### 3.3.2.7 Easy Access Rules for Standardized European Rules of the Air (SERA)

**One of the general comments is that SERA[10] will have to embed the level of autonomy of UAS. This impacts many acceptable means of compliance, guidance material and rules of the air.**

Below is shared our more detailed analysis of what we considered the more relevant articles:

- GM1 article 2(45): Area navigation

**UAS will need to be able to comply with the RNP requirements. It is likely that new RNP requirements are set, more constraining for UAS.**

- SERA 2005: Applicability and compliance.

**Rules of the air for aircraft flying in U-space airspace to be defined (Named UFR in the ConOps).**

- SERA 2010: responsibilities.



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- **a): Pilot in command, how do we intend to deal with this in regard of an operator controlling one or more UAV's. PIC is remote, see and avoid doesn't work unless VLOS is used.**
- **b): Is not compatible with ConOps. Parts are adequate, i.e., check "fuel", respect flight rules. A part (c) for UAV is needed.**
- SERA 2015: About PIC.

**Needs to be updated with remote pilot or UAS supervisor consideration.**

- SERA 3105: Sections on minimum heights.

**Need to be updated and adapted for UAS.**

- SERA 3110: Deals with cruising levels.

**This will have to be updated with the common altitude reference systems information.**

- SERA 3115, 3120: Dropping, spraying.

**This is what many UAV will do: dropping, spraying, delivering by winching down goods, Specific UAV part needed**.

- SERA 3201: Deals with collision avoidance.

**This is true in U-space as well, but the part regarding PIC (see above) is different for UAV. DAA will be the ACAS. Update needed.**

- SERA 3210: Deals with right of way.

**Is mainly for manned aviation, this whole section needs to be re-written and added with UAV parts in general and specific.**

- SERA 3215: Deals with lights to be displayed by aircraft.

**This must address UAS specificities (e.g., size, shape) be described here.**

- SERA 3225: Deals with Operation on and in the vicinity of an aerodrome.

**ConOps' parts regarding Vertiport should be included or have a specific point in SERA.**

- SERA 3301: Deals with signals described in appendix 1.

**SERA will need to be updated with UAS operation peculiarities, in particular for autonomous operation.**

- SERA 4001-4005-4010-4015-4020: Deals with flight plan.

**SERA needs to describe U-plan in the same manner.**

- Whole section 5: Visual meteorological conditions, Visual Flight Rules, Special VFR and Instrument Flight Rules.



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**SERA would be required to propose one set of rules for U-space (only UAS) and one set when interacting with manned aircraft in shared airspace.**
**Helicopter's speeds and weather minima for instance are not necessarily adapted for flying in airspace where smaller aircraft such as UAS are flying too.**
**Also, helicopters have rules in relation operating heights and speeds and therefore it may be the case that UAMs will need to comply more with Helicopter rules, but the larger UAS fixed wing aircraft will need to adapt to some of the rules whereas they may not be able to comply with rules that apply to manned flights.**

- SERA 6001: Deals with airspace classification.

**SERA should be updated with U-space volumes description.**

- SERA 6005: Deals with communications.

**U-space rules for communication and e-conspicuity needs to be described in a separate bullet. Ref. mandatory services in U-space. Rules have to be implemented where use of MODE-C and –S transponders for UAS (UAM) is clearly described.**

- Section 7: Deals with air traffic services.

**Needs to be updated with the:**

- **Objectives of U-space services, USSP, also need to be described here,**
- **The cooperation between ATS and UTS.**
- **Interaction between a USSP and the users of U-space.**

**All this to be implemented as described in the CORUS ConOps Ed.4.**

- Section 8: Air traffic control service.
    - **Needs a part where ATC obligations handling UAV is clearly described. Also, what is expected for UAV from the ATC.**
    - **U-space service/objectives as described in Chapter three of the CORUS XUAM ConOps Ed.4 shall be, part of SERA section 8. All relevant parts from EU Regulation 2021/664 most be visible accordingly here.**
- Section 9: Flight information service.

**Traffic (Flight-) information services provided by USSP in U-space as described in the CORUS XUAM ConOps Ed.4 3.14 shall be, part of SERA section 9. All relevant parts from EU Regulation 2021/664 [6]most be visible accordingly here.**

- Section 10: Alerting service.

**Maybe requires having a UAS-U-space flavour.**

- Section 11: Interference, emergency contingencies and interception.

**This section shall also be enriched with UAS – U-space specificities.**

- Section 12: Services related to meteorology – aircraft observations and reports by voice communication.

**SERA will need to take into consideration the absence of pilot on-board the aircraft. Many local weather information can be shared by aircraft equipped on purpose but probably not all items referred in section 12, or also different.**

- Appendix 1: Signals.

**This appendix needs to include to information exchanges between machines.**

- Appendix 3: Cruising levels.

**It is likely that each urban airspace has its own traffic management rules by layers.**

- Appendix 4: ATS Airspace classes – Services provided and flight requirements.

**Corresponding table for U-space airspace classes as found in CORUS ConOps Ed.4 2.3.6. shall be added in this annex. Might lead to a major updated of appendix 4**

#### 3.3.2.8 EASA "Prototype Technical Specifications for the Design of VFR Vertiports for Operation with Manned VTOL-Capable Aircraft "certified in the enhanced category

The ConOps tackles the necessity to have alternate landing site, which are not necessarily vertiport, in case of emergency.

**Despite this PTS[11] is dedicated to manned VTOL operations, shouldn't this be addressed? This is especially the case for VFR operations.**

#### 3.3.2.9 EUROCAE MOPS ED-269 and ED-270 on Geofencing and Geo-caging

Nothing to add.

#### 3.3.2.10 RPAS Panel documentation

The ConOps section 3.2 presents the surveillance in U-space. All aircraft must either have a Network Identification, Transponder or Electronic Conspicuity. Network Identification is mandatory for UAS using U-space services. Manned aircraft can be either under ATC service or not. If they enter U-space the controlled manned aircraft location is communicated from ATC services to U-space, otherwise the Electronic Conspicuity is necessary.

**In case of an IFR-RPAS entering U-space the RPAS panel should make clear which surveillance technology is expected.**

#### 3.3.2.11 SSDR: single seat microlight

No relevant information found.

#### 3.3.2.12 NPA 2022-06 on innovative air mobility with manned VTOL-capable aircraft

The ConOps[1] has no obvious effect on the content of this NPA.

#### 3.3.2.13 (EASA) ED Decision 2022/002/R on AMC & GM to Regulation (EU) 2019/947 that amends AMC-GM for (EU) 2019/947

# 4 Conclusions and recommendations

## 4.1 conclusion

Reviews of current regulations either on UAS, UAS operations, UAS or UAM infrastructures or on U-space and of the CORUS XUAM ConOps show that the concept of operation is ahead the regulation in several domains, although the regulation grows rapidly providing more and more documentation encompassing considerations for urban air mobility.

On the other hand, the ConOps makes the choice to not address some topics such as the responsibilities of each stakeholder, including some of the most important, the remote pilot and the USSP. Regulation tackles this point for instance.

What we can conclude from the review is the obvious need to update the existing regulations with what has been developed the last three years in the domains of the UAS and U-space. This process is the rationale consequence of this new world of UAS and U-space which is evolving fast and will keep integrating technologies, concepts, and ideas in the coming years.

Hence, the ConOps may or should embed additional information on what is deemed useful to the good understanding and acceptance of the concept of operations, existing regulations should be updated with the past and current contributions of the Conops and regulations to come fill in the gaps, one on them addressing rules of the air for UAS, between UAS and with manned aviation.

## 4.2 Recommendations

Section 3 lists all the discrepancies that have been found both in the ConOps and in the different regulation documentations that have been reviewed.

Recommendations below gather what is considered as the most urgent and/or easy to deal with.

In the Conops:

- Update the definitions according to those proposed in the regulations, add definitions considered as relevant for the ConOps and urban air mobility.
- Address the topics that could seem of interest for a concept of operations (e.g., cross border operations, stakeholders responsibilities.
- Maybe better explain how manned aviation would fly in a U-space airspace.
- Try to detail rules of the air for UAS.

For the regulations:

- Embed CORUS Conops and CORUS X UAM Conops proposals or at list equivalent (e.g., U-space volumes and core U-space services).
- Update current regulation documentation with the latest developments.
- Invest in the development of rules of the air for UAS and update accordingly SERA.
- Tackle social acceptance (noise and visual impacts, privacy) in any circumstances.



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# 5 References and Applicable Documents

## 5.1 Reference Documents

[1] CORUS X UAM ConOps D4.1 edition 3.10

[2] (EU) 2019/945 on unmanned aircraft systems and on third country operators of unmanned aircraft systems

[3] (EU) 2020/1058 amending delegated regulation (EU) 2019/945 as regards the introduction of two new unmanned aircraft systems classes

[4] (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft

[5] (EU) 2020/639 Amending Implementing Regulation (EU) 2019947 as regards standard scenarios for operations executed in or beyond the visual line of sight

[6] COMMISSION IMPLEMENTING REGULATION (EU) 2021/664 of 22 April 2021 on a regulatory framework for the U-space

[7] COMMISSION IMPLEMENTING REGULATION (EU) 2021/665 of 22 April 2021 amending Implementing Regulation (EU) 2017/373 as regards requirements for providers of air traffic management/air navigation services and other air traffic management network functions in the U-space airspace designated in controlled airspace

[8] COMMISSION IMPLEMENTING REGULATION (EU) 2021/666 of 22 April 2021 amending Regulation (EU) No 923/2012 as regards requirements for manned aviation operating in U-space airspace

[9] Notice of Proposed Amendment 2021-14 Development of acceptable means of compliance and guidance material to support the U-space regulation

[10]Easy Access Rules for Standardised European Rules of the Air (SERA) or (EU) 923/2012

[11]EASA "Prototype Technical Specifications for the Design of VFR Vertiports for Operation with Manned VTOL-Capable Aircraft "certified in the enhanced category

[12]EUROCAE MOPS ED-269

[13]EUROCAE MOPS ED-270

[14]RPAS Panel documentation RPASP/16-WP/15(24/09/2020)

[15] RPAS Panel documentation RPAS/19-WP/5(17/02/2022)

[16] RPAS Panel documentation RPAS/19-WP/6(22/02/2022)

[17] RPAS Panel documentation RPAS/19-WP/7(22/02/2022)

[18] SSDR : single seat microlight

[19]NPA2022-06 "Introduction of a regulatory framework for the operation of drones Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category"

[20](EASA) public consultation on Guidelines on noise measurement of unmanned aircraft systems lighter than 600kg operating in the specific category (low and medium risk) released on 13 October 2022

[21]ICAO Annex 2

[22](EASA) ED Decision 2022/002/R on AMC & GM to Regulation (EU) 2019/947 that amends AMC-GM for (EU) 2019/947

[23]ICAO Annex 11 Air Traffic Services

[24] COMMISSION IMPLEMENTING REGULATION (EU) 2017/373 of 1 March 2017 laying down common requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight, repealing Regulation (EC) No 482/2008, Implementing Regulations (EU) No 1034/2011, (EU) No 1035/2011 and (EU) 2016/1377 and amending Regulation (EU) No 677/2011

[25] Regulation (EC) No 551/2004 of the European Parliament and of the Council of 10 March 2004 on the organisation and use of the airspace in the single European sky (the airspace Regulation)

[26] COMMISSION REGULATION (EU) No 748/2012 of 3 August 2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations

[27] REGULATION (EU) 2018/1139 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91



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# U-space ConOps (edition4) Annex: Advanced U-space definition


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## Authoring & Approval

### Authors of the document

| Beneficiary | Date |
| --- | --- |
| Douwe Lambers / DFS, Deputy WP 3 Lead | 2022 |
| Ralf Heidger / DFS, WP 3 Lead | 2022 |
| Yannick Seprey / DSNA, Task 3.1 Lead | 2022 |
| Javier García Moreno / CRIDA, Task 3.2 Lead | 2022 |
| David Martin-Marrero / EUROCONTROL, Task 3.3. Lead | 2022 |
| Cristina Barrado / UPC, Task 3.4 Lead | 2022 |
| Andrew Hately / EUROCONTROL, WP 4 lead | 2022 |
| Martin Robinson / AOPA | 2022 |
| Gonzalo Torres Ortín / CRIDA | 2022 |
| Luigi Brucculeri / D-FLIGHT | 2022 |
| Michael Borkowski / DLR | 2022 |
| Karolin Schweiger / DLR | 2022 |
| Robert Geister / DLR | 2022 |
| Marc-Antoine Laclautre / DSNA | 2022 |
| Marta Sanches Cidoncha / ENAIRE | 2022 |
| Daniel Bajiou Mroczkowska / ENAIRE | 2022 |
| Giovanni Riccardi / ENAV | 2022 |
| Aris Anagnostou / EUROCONTROL | 2022 |
| Peter Hullah / EUROCONTROL | 2022 |
| Elina Millere / EUROCONTROL | 2022 |
| Dirk Schaefer / EUROCONTROL | 2022 |
| Norberto VERA VELEZ / EUROCONTOL | 2022 |
| Alicia Cano / HEMAV | 2022 |
| Sergi Tres / HEMAV | 2022 |
| Xavi Baluguer / HEMAV | 2022 |
| Billy Josefsson / LFV | 2022 |
| Mats Nilsson / LFV | 2022 |
| Åsa Taraldsson / LFV | 2022 |
| Valentin Polishchuk / LIU | 2022 |
| Anthony Rushton / NATS | 2022 |
| Guillermo Ledo Lopez / NATS | 2022 |

| | |
|---|---|
| **Colin Hampson / NATS** | 2022 |
| **Zakariya Laftit / Unifly** | 2022 |
| **Enric Pastor / UPC** | 2022 |
| **Sebastian Bomart / VOLOCOPTER** | 2022 |
| **Joern Jaeger / VOLOCOPTER** | 2022 |
| **Arife Aycan Multu / VOLOCOPTER** | 2022 |
| **Barbara Zygula / VOLOCOPTER** | 2022 |

### Reviewers internal to the project

| Beneficiary | Date |
|---|---|
| | |

### Reviewers external to the project

| Beneficiary | Date |
|---|---|
| | |

### Approved for submission to the S3JU By - Representatives of all beneficiaries involved in the project

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|---|---|
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## Abstract

The Advanced U-space Definition document presents a comprehensive overview of the operational, performance, and safety considerations for the successful integration of Urban Air Mobility (UAM) into urban airspace. UAM operations, involving the transportation of people and goods by unmanned aerial systems (UAS), present unique challenges due to the higher traffic densities and ground risks associated with urban areas. The document describes UAM operations and Traffic Integration, focusing on the specific needs of UAM.

This document aims to extend the U-space ConOps, produced by the CORUS project, with Urban Air Mobility aspects, ultimately delivering an "Operational Services & Environment Definition" for U-space in the UAM environment. It is divided into four main chapters: Definition of the Operational Framework, Operational Performance of UAM, Safety and Contingency in UAM Operations, and Social Acceptance of Urban Air Mobility.

The Definition of the Operational Framework covers regulatory matters, system performance characterisation, stakeholders and use cases, ground environments, airspace characterisation in urban environments, systems in support of UAM, operational procedures, CNS characteristics in urban environments, and risk assessment classes.

The Operational Performance section focuses on environment descriptions, assumptions, scenarios, use cases, and performance and operational requirements for UAM operations. The Safety and Contingency chapter include sections on air risk impact assessment, continued safe flight and landing in alternate vertiports, pre-flight de-confliction, and flight rules and airspace classification. It covers strategies for safely redirecting and landing in alternative vertiports in the event of an emergency, as well as how to plan and coordinate flights to minimize conflicts and ensure safe operation.

The social acceptability of UAM is also examined, with recommendations made based on a review of past public surveys and a Societal Acceptance Study conducted during the trials. It makes recommendations for addressing societal concerns related to safety, economics, and politics. Overall, the Advanced U-space Definition document covers the key considerations and serves as a valuable resource for stakeholders looking to effectively integrate Urban Air Mobility (UAM) into urban airspace.

**Keywords**: Urban Air Mobility (UAM), Unmanned aerial systems (UAS), Traffic integration, Operational Framework, Use cases, Performance requirements, Safety and contingency, Ground risks, Airspace design, Rules of the air, Interoperability, ATM systems, Continued safe flight and Landing, Alternate vertiports, Flight planning, De-confliction, Airspace assessment, Social acceptability, Public surveys, Societal acceptance study, Air risk impact assessment.

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# 1 Introduction

## 1.1 Purpose of the document

The CORUS-XUAM project aims to expand the earlier ConOps for U-space [1], produced in the CORUS project, with Urban Air Mobility aspects. The project consists broadly of two parts:

- development of an extension to the ConOps (WP 3 / 4), and
- several very large demonstrators (VLDs) that are addressed in WP 5 – 11.

CORUS-XUAM Work Package 3 and 4 collectively aim to deliver what is in effect an "Operational Services & Environment Description" for U-space although no one document has this title. Approximately the work breaks down as follows

| Task | Aim |
|---|---|
| T3.1 | What is the scope of the work of WP3 & WP4?<br>What U-space operations need to be supported, in what environment, in what level of detail, with what considerations? |
| T3.2 | What, in detail, do these U-space operations mentioned by T3.1 consist of?<br>When the project has something to say about performance, why and what performance is expected? |
| T3.3 | What is the approach to safety?<br>How do safety considerations impact the U-space operations considered in T3.2<br>What non-nominal situations should be considered? |
| T3.4 | What is the approach to social acceptance?<br>How does social acceptance impact the U-space operations considered in T3.2?<br>What are the main concerns of social acceptance and how should they be handled |
| T4.1 | Synthesising the work in WP3 and T4.2, T4.3, T4.4, what is the overall concept of operations for U-space. |
| T4.2 | What are the business processes of U-space that support the operations and environment described by WP3.<br>How in detail do the U-space services form part of these business processes |
| T4.3 | Validation of the work of T4.2 by its formalisation in the EATMA architecture |
| T4.4 | What of the ConOps is outside current regulation, what changes to law or regulation would be needed to make it work. |

Table 1 WP3 & WP4 task purposes

Hence this document provides a framework to allow WP3 to discuss the various aspects of Urban Air Mobility operations and defines scope of what will be described. A framework here means the identification of the goals of UAM operations in a working system, its typical use cases, and eventually also contingency and potential emergency cases, the identification of the stakeholders and actors, the identification of the airspaces, the identification of the involved aircraft, the identification of potential and suitable related tools and systems, a description of the required infrastructure, and last but not least a look at the legislative background, both with a perspective on the status quo, and with a perspective on the desired target situation. This overall framework then drives all the rest of WP3 and WP4.

## 1.2 Intended readership

The intended readers of this document are in no particular order

- CORUS-XUAM WP2 who will disseminate and prepare the exploitation of all of the work done in the project
- Researchers working in U-space in contemporary and subsequent projects

While the main deliverable of CORUS-XUAM will be the ConOps whose production this document exists to enable, this work will potentially be of continuing interest to:

- Operators and potential operators of air vehicles that will make use of U-space
- Potential or current suppliers of air vehicles that will make use of U-space, or suppliers of systems fitted to such vehicles
- Potential and current U-space service providers as well as suppliers of software to such providers
- Potential and current air traffic service providers as well as suppliers of software to such providers whose services will have to interact with U-space
- Regulators and standardisation bodies concerned by U-space or UTM
- Airport operators and potential vertiport operators that will interact with U-space as a U-space servicer user and/or provider"
- City authorities who need to provide the basis for a functioning U-space system and are in need of detailed understanding of UAM/U-space

## 1.3 Structure of the document

This document aggregates the output of the four subtasks of Work Package 3. Each work package produced one chapter in this document.

Chapter 1, this chapter, is a general introduction to the document.

Chapter 2 is the result of Task 3.1: Definition of the Operational Framework for Urban Air Mobility in U-space

Chapter 3 is the result of Task 3.2: Analysis of Operational & Performance Requirements for Urban Air Mobility in U-space

Chapter 4 is the result of Task 3.3: Analysis of Safety & Contingency Requirement for Urban Air Mobility in U-space

Chapter 5 is the result of Task 3.4: Social Impact analysis.

## 1.4 Scope

This document does not define UAM operations, processes, or responsibilities in detail.

It describes the known starting points, existing constraints, system boundary and assumptions on UAM. In addition, it provides a description of the objectives of UAM, the stakeholders and actors within UAM, as well as their goals.

It lists the areas that need to be addressed by the ConOps and puts emphasis on the areas that are considered important, especially in relation to the CORUS XUAM VLDs. It provides structure and focus for the ConOps.

### 1.4.1 Societal context

Various EU declarations [Riga 2015, Warsaw 2016, Helsinki 2017, Amsterdam 2018] have underlined in the last 5 years the political will of the European Commission to enable the commercial use of UAS to the advantage of European air traffic evolution[1], given that the societal acceptance is considered and kept in focus. As a recent study (EASA: study on the societal acceptance of Urban air mobility in Europe, May 19, 2021) [2] has shown the societal interest seems to be focused on a safe usage of UAS and UAM for all kinds of operations, with a priority on use cases in the public interest, in medical supply, transport of injured persons and medical emergency personnel, in disaster management with drones, and long-distance forwarding of heavy cargo.

Throughout Europe, a positive initial attitude to UAM can be found. The top 3 benefits that are expected, are a faster, cleaner, and extended connectivity. In terms of safety, it can be observed that existing aviation safety levels are understood as the benchmark for that kind of new operations. The 3 most important concerns found by the study are safety, environment (e.g., noise), and security. UAM operations may gain more acceptance if they are in line with environmental sustainability, e.g., contribute to carbon-reduced traffic, make use of clean and energy-efficient vehicles, and support environmental and wildlife protection. The noise emission of UAM is expected to be acceptable only if it is at the level of familiar city sounds, which indeed is a challenge. Security and cybersecurity of UAM vehicles are trusted only by about the half of the respondents of the study, so obviously from the societal perspective there is a lot of work to do yet to ensure security and cybersecurity and thus increase the trust of citizens.

Ground infrastructure must be well integrated to fulfil the expectations of European societies. A smooth integration into ground infrastructure has many specific aspects: efficient use of space and resources shall be made, a smooth integration with other transport means must be achieved, cultural heritage shall be preserved, noise levels of vertiports shall be kept at acceptable levels, and environmental impact must be minimized.

European citizens observe the complex evolution of the European and national legislative frameworks. Its partially contradictory and partially incomplete evolution is critically considered and evaluated. Regulatory authorities must work together at all levels to build a comprehensive and clear regulatory framework that allows operations for the public interest and commercial usage of UAM.

The conclusions of the study therefore mention:

- Safety should be addressed primarily, with a safety level equivalent to that of current aviation operations

[1] https://ec.europa.eu/defence-industry-space/eu-aeronautics-industry/unmanned-aircraft_en

- Environmental impacts should be mitigated, including impact on animals and environmental footprint from production and operation of UAM vehicles
- Emission of CO2 or other greenhouse gasses should be avoided, and energy consumption should be kept low
- Noise should be limited to a level equivalent to that of current familiar noises in a city
- Security risks should be prevented, mostly for drones in a first stage
- European, national and local authorities should work together
- Local authorities need detailed information and guidance, as well as involvement in the decision-making
- Use cases with highest benefit for general public to be introduced first (transport of medical goods with manned eVTOLs (with a pilot on-board)), use cases by cargo like last mile delivery could follow
- Aviation safety needs to be taken care by competent authorities through appropriate regulations and design assessment of vehicles, systems and infrastructure. The UAM traffic should be safely integrated in the airspace with conventional aircraft.
- Public acceptance should be secured by different levers, e.g., by:
    - ensuring UAM is affordable to all and used in the public interest
    - well integrated in the local transportation network/system
- Supported by timely, sufficient and transparent information to citizens and local stakeholder groups

### 1.4.2 Political context

The European Commission (EC) is supporting the development of Urban Air Mobility and U-Space in general. The political support for UAM should be seen in the context of improving mobility in cities, as well as in support of European climate objectives. The EC has identified a number of political objectives that have a relation to the development of UAM:

- to enhance mobility while at the same time reducing congestion, accidents and pollution [85][86] [85]
- achieve shorter journey times, while meeting the goal of decarbonising cities [83][84]
- to advance transport services that are safe, quiet, convenient and even more efficient and ecologically sustainable than what we have in our present ground-based options [83][86]
- enable safe & secure transport in general and specifically safe and secure integration of UAS and other autonomous aircraft into our airspace, also respecting privacy.
- create opportunities for new services and business models, particularly in cities [84]
- improve the cost-efficiency of ATM [84]

### 1.4.3 Economic context

While technological progress towards UAM operations/services are starting to receive quite a high attention in the R&D, regulatory and standardisation areas, relevant business cases/models for the deployment of a sustainable ecosystem that enables on-demand, highly automated, passenger or cargo-carrying air transport services is apparently getting less attention. On the contrary, it should be recognised that, especially in early market stages with high risks of investment and in respect to an often-envisioned implementation of transport services in the proximity of urban settlements, it is important that the proposed services and technologies offer the opportunity to provide measurable benefits and add value to society.

The European Commission [82] predicts that by 2035 the European overall UAS sector will have an economic impact exceeding €10 billion per year, mainly in services and by 2050 employ over 100 000 people.

As the use of UAM spreads, the need to balance the advantages and challenges they bring will also increase. For instance, unmanned aircraft can add value when used in gathering and interpreting data in different sectors of the economy. But UAS and UAM can also pose liabilities in terms of data protection, privacy, noise and CO2 emissions.

In this document relevant perspectives to comprehend the current UAM business environment will be briefly addressed focusing on some possible operator models and customer segments, making reference to some concrete business model approaches for UAM.

Scrutinising for example UAM Airport Shuttle Services we should carefully consider that even concepts with sufficient demand might still not be adequate for a robust business case due to potentially incomplete and/or insufficient analysis made on the overall operational environment.

Also, an often-unconsidered business model for a Company Shuttle Service could be analysed, addressing the problem of scaling up UAM services with a dynamically expandable Business-to-Business (B2B) concept.

Last but not least, UAM should also be analysed as an enabler for on-demand cargo-carrying air transport services that is introducing a business model that should be inclusive and integrated with other type of transport services.

These rather different types of implementation concepts could help to develop new financially sustainable business models around UAM. The realisation of commercial UAM services makes also necessary to properly consider economically viable application scenarios which, at the same time, address actual and forecasted air-transport demand along with their sustainability and value-led development.

Current key drivers for the civil market are commercial UAS applications in sensor technology and communication, however, the market size for VTOL vehicles carrying passengers and related services is considered to exceed its value in the long term [6]. In future, the biggest share of profits is considered by brokering Mobility as a Service (MaaS) solutions [7].

Of course, an economically crucial point is seen at the technology's maturation from the level of demonstration into a mass market, allowing for economies of scale and for significantly lower production cost. Mass air transit is expected to become affordable for larger parts of society in the long term only owing to further computation advancements, leading to autonomous operations. Further hesitations may evolve if "the market is not mature enough to identify a clear demand within the civil sector" [8]. More in general it could be assumed that the economic success of UAM is dependent on "the ability of varied stakeholders to reconsider how this emerging technology platform can be best harnessed to serve the broad interests of society" [9] urging for a value-led development of UAM services.

A consolidation of how commercial UAM services will evolve has not yet begun. Consultancies, like Roland Berger see airport shuttle, inner-city air taxi and inter-city connections as its most promising use cases. Looking at the different studies on the modal share of UAM in overall traffic, so far none seems to exceed a maximum share of 4%. Others researches name daily or weekly commute scenarios and discuss non-commute point-to-point as well as non-transportation missions (e.g., sightseeing) further reflecting on possible operational models such as private air transport, personal scheduled transportation, personal unscheduled transportation (on-demand mobility) and commercial scheduled transportation.

In any case, it should be recognised that, at this stage, integrating UAM into the public transport system poses both advantages and disadvantages. UAM services operated by a public transport provider promise to be at costs that make the mobility offer accessible for the broad public. This in return could significantly increase public acceptance as UAM will not be perceived as a transport service only for high income households.

Additionally, an efficient integration with public transport can decrease negative environmental externalities and support sustainable mobility planning.

Vertiports could bring an economic impulse to neighbourhoods and offer new business models. Like at airports, shops, restaurants etc. can be co-located with the vertiport and generate jobs, cashflow and can indeed "uplift" city districts/ areas.

The application scenarios for UAM have to be studied carefully to make sure that UAM is the most beneficial mode for the specific use-case. In general, UAM operation through the public transport provider could be a promising approach especially in the beginning when the related risks could be too high to be eligible for public spending and subvention.

During later stages of development this business model could especially be promising in areas with geographical characteristics that make ground-based transport less attractive.

In any case, we should be aware that this is a complex exercise and that not all influencing factors could be easily considered in the assessment of the respective business models and that several business model approaches could be not properly considered. Business model development for UAM should be considered a sort of iterative process, aiming to increasingly replace hypotheses with empirical facts gathered over time.

In this context, it is clear that so far, the discussion on quantitative economically viable analysis and socially meaningful UAM business models is far from a proper level of maturity. Only a critical analysis of UAM business models can eventually lead to a growing acceptance of the economic use of UAM in public airspace and to further investments necessary for its implementation.

## 1.5 U-space evolution

This section describes how U-space may evolve from early deployments to an environment with fully operational U-space service that caters to all airspace users.

### 1.5.1 Assumptions:

- All services won’t be available at the same time, and the most complicated will arrive last (e.g., tactical conflict resolution).
- Technological improvements and evolutions will allow UAS to fly more and more autonomously.
- U-space services will serve as much unmanned as manned aircraft.
- Required equipment costs will decrease with the time so that the cost for a manned aircraft shall be increasingly acceptable.

- As time progresses the proportion of operations that are unmanned grow to exceed manned operations.
- U-space airspace will become more common with the different volume types eventually being recognized as ICAO airspace classes.
- UAM infrastructure will be built incrementally to support operational needs.
- Airspace design will change to accommodate all operations.

Airbus UTM Blueprint [24] proposes a timeframe of the automation level.

CORUS X UAM would like to propose a vision with a kind of calendar for U-space implementation.

The topics that need to be considered are the following:

- Availability of the U-space services.
- Availability of the required technologies (CNS) and ground infrastructures for drone operations.
- Availability of the "drones effective enough" to perform specific operations (e.g., carry heavy payload, long haul trip).
- Evolution of the airspace design and structure.
- Interactions with manned aviation in controlled and uncontrolled airspace.
- Rules of the air.

What are the different steps considered?

### 1.5.2 Pre U-space era:

States are setting up registries and defining geographic areas [17] but drones fly without any U-space services. Manual coordination with and authorizations from the involved authorities are usually required. The current procedures make VLOS flights possible with some effort. BVLOS flights are limited, time consuming and expensive to set up.

| | |
|---|---|
| Availability of the U-space services | Mainly:<br>• UAM/UAS operation plan preparation<br>• Strategic conflict detection and resolution<br>• Procedural interface with ATC<br>• e-identification<br>• Drone Aeronautical information (current AIP) |
| Evolution of the airspace design and structure | None |
| Rules of the air | As main operations are VLOS, see and avoid.<br>For BVLOS, segregation is in place. |

Table 2 U-space characteristics today

### 1.5.3 Initial U-space implementation (2023-2030):

A limited number of services are available. They provide a digital assistance to the authorities in charge of authorizing the operations, and a digital assistance to the operators to plan and declare their operations.

When required, airspace structures are defined, temporarily or permanently, to allow drone operations (e.g., corridors for point-to-point goods or passenger carriage).

In controlled airspace, these airspace structures are temporarily activated on request, by the USP to the ATC.
In uncontrolled airspace, permanent structures boundaries are published in the AIP to manned aviation.
Temporarily structures boundaries and activation slots are also published in the AIP to manned aviation.
U-space airspaces are progressively defined.

| | |
|---|---|
| Availability of the U-space services | Mainly:<br>• Drone operation plan preparation<br>• Strategic conflict detection and resolution<br>• Procedural interface with ATC<br>• e-identification<br>• Drone aeronautical information including AIP and information specifically dedicated to drone operators<br>• Operation plan processing<br>• Geo-fence provision<br>• If needed, first "Vertiport Service |
| Evolution of the airspace design and structure. | No U-space airspaces still defined, but specific structures for drone operations are defined in current airspace classes. |
| Rules of the air | As main operations are VLOS, see and avoid.<br>For BVLOS, segregation is in place. Flow of drone operations does not yet require dedicated rules of the air. |

Table 3 U-space characteristics 2023-2030

### 1.5.4 Intermediate U-space (2030-2050):

U-space airspace volumes have been defined, whether it is in controlled or uncontrolled airspace.

In uncontrolled airspace, as most drone operations are performed in the VLL, U-space airspace is defined from ground to 500 feet AGL. The volume is "X" or "Y", depending on the required level of services.

For specific drone operations which require to fly higher, such as inter-cities passengers or cargo transportation, corridors are in place and published in the AIP.

Remote pilot for VLOS operations is responsible for collisions avoidance with any other aircraft.

Remote pilot for BVLOS operations is responsible for collisions avoidance with any other aircraft thank to adapted mitigations (e.g., DAA).

In controlled airspace, a "red" zone is defined to protect manned operations around an airport. This area is exclusively under the responsibility of the ATC and all drone operations in that area are controlled by ATC. These operations can be declared to a USP and coordinated through the collaborative interface. The remote pilot is directly in contact with an air traffic controller.

This zone can be extended beyond the “airport influence” in the controlled airspace as much as manned operations remain the majority. A system such as the US LAANC can be implemented for unmanned operations below a certain height. The responsibility of the services provision in these volumes (Za) are delegated to a USSP. ATC remains informed of all operations.

The USSP can authorize drone operations by just informing ATC as long as they remain below a certain height.

The other part of the controlled airspace is Za. The airspace remains class A, B, C or D by default, and U-space volume Za is activated on demand by a USP. Segregation of activities is in place.

Za goes from the ground to 1000 feet AGL.

In the “ATM classes”, rules of the air are those described in SERA [13].

In the U-space volume, UFR are to be applied.

| | |
|---|---|
| Availability of the U-space services | Mainly:<br>• drone operation plan preparation<br>• Strategic conflict detection and resolution<br>• Procedural interface with ATC<br>• e-identification<br>• Drone aeronautical information including AIP and information specifically dedicated to drone operators<br>• Operation plan processing<br>• Geo-fence provision<br>• ATC collaborative interface<br>• Monitoring<br>• Emergency management<br>• Traffic information<br>• Tracking |
| Evolution of the airspace design and structure. | U-space airspaces are defined |
| Rules of the air | For VLOS, rule is “see and avoid”.<br>For BVLOS, segregation is still in place. Flow of drone operations does not yet require dedicated rules of the air. |

Table 4 U-space characteristics 2030 - 2040

### 1.5.5 U-space advanced (2050+):

Unmanned operations are now the majority, but manned operations are still numerous for societal considerations, and for leisure.

For that reason, U-space volumes have been increased but the majority of the airspace remains “manned available”.

In controlled airspace, the structures of the airspace around an airport remain the same. The “red” zone is still there.

But the airspace by default is now the U-space volume (Za). Any manned aircraft wishing to fly in that airspace shall be capable to use U-space services and UFR will be applied.

If not, required airspace reservation and the adapted structure must be requested to the ATC through the USSP. In the segregated volume, SERA rules of the air are applicable.

Za is now up to 2000 feet or more. Manned leisure operations are possible. If the manned aircraft is UFR capable, it can proceed. If not and if the unmanned traffic allows it, the manned aircraft can transit across Za thanks to ATC traffic information and clearance.

In uncontrolled airspace, U-space is now up to 2000 feet or higher. Manned aircraft can fly inside “X”, “Y” or “Zu” if UFR compliant. If not, they shall not fly in a U-space airspace.

| | |
|---|---|
| Availability of the U-space services | Mainly:<br>• Drone operation plan preparation<br>• Strategic conflict detection and resolution<br>• Procedural interface with ATC<br>• e-identification<br>• Drone aeronautical information including AIP and information specifically dedicated to drone operators<br>• Operation plan processing<br>• Geo-fence provision<br>• ATC collaborative interface<br>• Monitoring<br>• Emergency management<br>• Tactical conflict detection and resolution<br>• Full services for environment monitoring<br>• tracking |
| Evolution of the airspace design and structure. | U-space airspaces are defined |
| Rules of the air | In U-space airspace, UFR.<br>In ATM airspace, SERA. |

Table 5 U-space characteristics 2035 - 2045

### 1.5.6 U-space 2070+:

U4 is there. The vast majority professional aerial operations are unmanned. Only very specific operations and leisure operations could be manned.

ATM classes of airspace disappeared for the benefit of U-space volumes.

Unmanned and manned operations use U-space services, as manned aircraft are equipped to do so.

Unmanned are capable to autonomously avoid any other aircraft, even if remote pilot of VLOS operations remains capable to avoid collision manually. Rules of the air are UFR.

| | |
|---|---|
| Availability of the U-space services | All services highly automated |
| Evolution of the airspace design and structure. | The sky is a U-space airspace |
| Rules of the air | UFR is applicable everywhere |

Table 6 U-space characteristics 2040+

## 1.6 U-space services definitions

The following section proposes to list, not exhaustively, some of the U-space services already identified by EASA and many SESAR U-space projects.

They are introduced divided into three different parts:

- Administrative services which have no operational purpose, in the sense that they do not impact directly an operation during the flight.
- U-space services, identified as being essential for the good execution of an operation performed in a near future, including those that could be imposed by member state if required
- The other U-space services which will be essential for UAS operations when they become numerous.

### 1.6.1 Administrative services

These services have no impact on the flight as they are triggered before or after the operation occurs.

| U-space service identification | U-space service description |
|---|---|
| Registration | Interaction with the registrar to enable the registrations of the drone, its owner, its operator, and its pilot. Different classes of user may query data, or maintain or cancel their own data, according to defined permissions. |
| Registration assistance | Provides assistance to people undertaking the registration process |
| Digital Logbook | Produces reports for a user based on their legal recording information. |
| Accident / Incident Reporting | A secure and access-restricted system that allows drone operators and others to report incidents and accidents, maintaining reports for their entire life cycle. A similar citizen-access service is possible. |

Table 7 Administrative U-space services

### 1.6.2 U-space services

The services described in this section are those defined in the COMMISSION IMPLEMENTING REGULATION (EU) 2021/664 of 22 April 2021 on a regulatory framework for the U-space.

The regulation defines four mandatory services and two optional services, which are listed in the tables below.

| U-space Service identification and description | Enhanced U-space Service description at solution level |
|---|---|
| Network identification<br>Should provide the identity of UAS operators, and the location and flight vector of UAS during normal operations and in contingency situations and share relevant information with other U-space airspace users. | e-identification<br>e-identification enables information about the drone and other relevant information to be verified without physical access to the unmanned aircraft. |
| | Tracking and position reporting<br>Receives location reports, fuses multiple sources and provides tracking information about all flight movements |
| UAS flight authorisation<br>Should ensure that authorised UAS operations are free of intersection in space and time with any other notified UAS flight authorisation within the same portion of U-space airspace. | Strategic conflict resolution<br>Checks for possible conflicts in a specific operation plan, and proposes solutions, during operational plan processing. |
| | Operation plan preparation/optimisation<br>Provides assistance to the operator in filing of a operation plan. This service functions as the interface between the drone operator and the operation plan processing service |
| | Operation plan processing service<br>A safety-critical, access-controlled service that manages live operation plans sub-mitted via the operation plan preparation service (OPPS) and checks them against other services. The service manages authorisation workflows with relevant authorities, and dynamically takes airspace changes into account. |
| | Risk analysis assistance<br>Provides a risk analysis, mainly for Specific operations, combining information from other services – drone AIM, environment, traffic information, etc. This can also be used by insurance services. |
| Geo-awareness<br>Should provide UAS operators with the information about the latest airspace constraints and defined UAS geographical zones information made available as part of the common information services.<br>"This provides geo-fence and other flight restriction information to drone pilots and operators for their consultation up to the moment of take-off. It includes existing aeronautical information, such as:<br>restricted areas, danger areas, CTRs etc...<br>- information extracted from NOTAMS, and legislation. | Geo-fence provision (incl. dynamic geo-fencing)<br>An enhancement of geo-awareness that allows geo-fence changes to be sent to UAS immediately. The UAS must have the ability to request (or subscribe to), receive and use geo-fencing data. |
| | Navigation Infrastructure Monitoring<br>Provides status information about navigation infrastructure during operations. This service should give warnings about loss of navigation accuracy. |
| | Communication Infrastructure Monitoring<br>Provides status information about communication infrastructure during operations. The service should give warnings about degradation of communication infrastructure. |

| U-space Service identification and description | Enhanced U-space Service description at solution level |
|---|---|
| - temporary restrictions from the national airspace authority.<br>to produce an overall picture of where drones may operate. | Geospatial information service<br>Collects and provides relevant terrain map, buildings, and obstacles - with different levels of precision - for the drone operation. |
| | Population density map<br>Collects and presents a population density map for the drone operator to assess ground risk. This could be proxy data e.g., mobile telephone density. |
| | Electromagnetic interference information<br>Collects and presents relevant electromagnetic interference information for the drone operation. |
| | Navigation means coverage information<br>Provides information about navigation coverage for missions that will rely on it. This information can be specialised depending on the navigation infrastructure available (e.g., ground or satellite based). |
| | Communication means coverage information<br>Provides information about communication coverage for missions that will rely on it. This information can be specialised depending on the communication infrastructure available (e.g., ground or satellite based). |
| Traffic Information<br>Should alert UAS operators about other air traffic that may be present in proximity to their UAS. | Provides the drone pilot or operator with information about other flights that may be of interest to the drone pilot; generally, where there could be some risk of collision with the pilot's own aircraft |

Table 8 Mandatory U-space services

| U-space Service identification and description | Enhanced U-space Service description at solution level |
|---|---|
| Weather Information<br>Collects and presents relevant weather information for the drone operation including hyperlocal weather information when available/required. | Weather Observation service<br>Responsible to provide real-time weather information for the drone operations and ensures that these are reliable, accurate, correct, up-to-date and available. |
| | Weather Forecast service<br>Responsible to provide forecast weather information for the drone operations and ensures that these are reliable, accurate, correct, up-to-date and available. |

| U-space Service identification and description | Enhanced U-space Service description at solution level |
|---|---|
| Conformance monitoring<br>Should provide real-time alerting of non-conformance with the granted flight authorisation and inform the UAS operators when deviating from it. | Monitoring<br>Provides monitoring alerts (preferably audible) about the progress of a flight (e.g., conformance monitoring, weather compliance monitoring, ground risk compliance monitoring, electromagnetic monitoring) |
| | Emergency management<br>Provides assistance to a remote pilot experiencing an emergency with their drone and communicates emerging information to interested parties. |

Table 9 Optional U-space services

### 1.6.3 Other U-space services identified

These services are seen as essential when UAS traffic will become dense, generating conflicts which will require additional services such as tactical conflict resolution.

| U-space service identification | U-space service description |
|---|---|
| Drone Aeronautical Information Management | "The drone equivalent of the Aeronautical Information Management service. This service maintains the map of X, Y and Z airspaces, and permanent and temporary changes to it. (e.g., a weekend festival will change an area from sparsely to densely populated). |
| Procedural Interface (with ATC or any other authority responsible for a volume of airspace) | A mechanism invoked by the operation plan processing service (OPPS) for coordinating the entry of a flight into an airspace which require an authorization before flight (e.g., controlled airspace, airspace above natural reserve). Through this, the authority can either accept or refuse the flight and can describe the requirements and process to be followed by the flight. |
| Surveillance data exchange | Exchanges data between the tracking service and other sources or consumers of tracks – radar, other drone trackers, etc. |
| Legal Recording | A restricted-access service to support accident and incident investigation by recording all input to U-space and giving the full state of the system at any moment. A source of information for research and training. |
| Citizen Reporting Service | Similar to the Accident and Incident reporting service, this U-space service is to be used by the citizen to inform the law enforcement about not cooperative drone traffic or other suspicious event to be reported. The user interface should be designed to encourage the reporting of sufficient information to identify the flights concerned. |
| Tactical Conflict Resolution | Checks for possible conflicts in real time and issues instructions to aircraft to change their speed, level or heading as needed. |

| U-space service identification | U-space service description |
|---|---|
| Collaborative Interface with ATC | Offers verbal or textual communication between the remote pilot and ATC when a drone is in a controlled area. This service replaces previous ad-hoc solutions and enables flights to receive instructions and clearances in a standard and efficient manner.<br>CORUS has foreseen that this service would include, with time, the procedural interface. |
| Dynamic Capacity Management | Responsible for balancing traffic demand and capacity constraints during operational plan processing. |
| Vertiport dynamic information service | Responsible for managing status, resources (open/closed/availability, capacity) information about the vertiport in real time |

Table 10 Other U-space services identified in several U-space projects

# 2 Executive Summary

Urban Air Mobility (UAM) operations, which involve the transportation of people and goods by unmanned aerial systems (UAS), are expected to occur in many locations for many purposes. These operations are characterized by higher risk due to the higher traffic densities and ground risk associated with urban areas, particularly when it comes to passenger transport. UAM operations in urban areas also need to be socially acceptable, with limitations on noise and nuisance. UAS traffic management as part of U-space is expected to be a key element in meeting the safety, security, and social acceptability goals of UAM.

There is considerable interest in the integration of UAM into existing transport networks for both goods and passengers, as it is anticipated that UAM operations will offer social benefits. This document, the Advanced U-space Definition, describes UAM operations and Traffic Integration and elaborates on the requirements for the U-space Concept of Operations. It is divided into four parts and explains the operations of UAS, with a focus on the specific needs of UAM, including passenger transport by electric, vertical take-off and landing (EVTOL) aircraft. The performance limitations of current batteries for EVTOL aircraft require certain methods of operation to limit risk.

The performance requirements associated with UAM operations are defined, as is the safety framework in which these operations and their associated risks can be considered. The document also explores the need for new airspace design and procedures, particularly in the vicinity of airports and vertiports, and the development of new rules of the air for manually or autonomously operated UAM.

Stakeholders involved in UAM as direct contributors or impacted users of the same airspace will use diverse services to build or contribute to safe, secure, and efficient air traffic management for all types of aircraft. Performance areas, both traditional and innovative, will be monitored to increase the quality of services and improve social acceptability. The integration of different systems, with a focus on interoperability with ATM systems, is also taken into consideration for the successful implementation of Urban Air Mobility.

The Safety and Contingency Requirements for Integrated Operations section focuses on ensuring the safe and efficient operations of Urban Air Mobility (UAM). This chapter is divided into four topics: Air Risk Impact Assessment, Continued Safe Flight and Landing in Alternate Vertiports, Flight Planning and De-Confliction, and Airspace Assessment.

The Air Risk Impact Assessment examines the potential risks and impacts of different flight trajectories, corridors, and vertiport locations while also protecting other airspace users. The Continued Safe Flight and Landing in Alternate Vertiports section outlines strategies for safely redirecting and landing in alternative vertiports in the event of an emergency. The Flight Planning and De-Confliction section discusses how to plan and coordinate flights to minimize conflicts and ensure safe operation. The Airspace Assessment covers the regulations and rules governing unmanned flight, as well as the classification of airspace for integrated operations.

Finally, the social acceptability of Urban Air Mobility (UAM) is examined, and some recommendations made. A review of past public surveys highlights concerns related to safety, economics, and politics, and proposes mitigation actions to address these concerns in UAM trial locations. Results from a Societal Acceptance Study conducted during CORUS-XUAM trial locations indicate an overall positive response to UAM. Conclusions are presented and a list of appendices includes a full list of mitigation actions to address societal concerns.

# 3 Definition of the Operational Framework

## 3.1 Introduction

The chapter is written as part of T3.1 (Definition of the Operational Framework) and acts as a starting point to derive high level operational requirements, safety requirements and for the social impact analysis.

### 3.1.1 Structure of this Chapter

The Operational Framework description encompasses a set of topics which goal is to provide the reader with an extended view of the operational environments as they will impact UAS operations.

Section 2 introduces the document, explaining its context, scope and aims. The scope description goes into some detail on the of social, political and economic contexts are provided as well as a vision of U-space evolution within the next 40 years. Note the glossary and acronyms appear in section 13.

Section 3 introduces the regulatory framework with the current U-space European regulation and some local regulations which may impact drone operations. A description of the rules of the air is provided as well as how they could affect drone operations.

Section 4 tackles system performances with key performance areas and indicators that could be applied in U-space context.

Section 5 proposes an exhaustive list of stakeholders and UAS operations applicable in U-space.

Section 6 describes the ground environment, including infrastructures and constraints to drones operations.

Section 7 deals the airspace characterization in urban environment. Constraints of current structures of the airspace, U-space volume implementation and urban operations are discussed.

Section 8 provides a general view of systems in support of urban air mobility, from Air Traffic Management systems to U-space systems.

Section 9 presents the procedures in the three phases which characterise a UAS operation: pre-operational, pre-flight and flight phases.

Section 10 gives a description of the communication, navigation and surveillance characteristics in urban environment by focusing on how CNS may “drive” UAS operations.

Section 11 proposes ground and air risk classifications.

Section 12 concludes

Section 13 lists the references, glossary and list of acronyms.

Appendices follow containing use cases.

## 3.2 Regulatory framework

This section identifies the regulatory framework that influences Urban Air Mobility and U-space and serves as an input to further elaboration of recommendation for regulatory enhancements in WP4. Please refer to the CONOPS and D4.4 for further assessment of the regulations.

### 3.2.1 EASA regulatory framework of U-space regulation

In 2016, the Warsaw Conference on UAS developed the concept of U-space, a set of digital services enabling the safe growth of UAS routine operations. As a complement of the regulation of 2019 giving a set of detailed rules for the operation of UAS [17] and [28] in April 2021 the Commission has published the regulatory framework for U-space prepared by EASA, fulfilling in this way the objectives set in the 2016 Warsaw declaration.

The U-space creates and harmonises the conditions needed for manned and unmanned aircraft to operate safely, to prevent collisions between UA and other aircraft, and to mitigate the risks of UAS traffic on the ground. The regulatory package that consists of 3 documents ([23], [ [29] and [30]) which will enter into force on 22 April 2021 and will become applicable as of 26 January 2023.

In the following subsections a more detail summary of the main document [23] will be given. The other two are briefly described below.

Implementing Regulation (EU) 2021/665 [29] is a short amendment to IR 2017/373 [11]. This implementing rule is addressed to ATM. It adds 4 new definitions for U-space airspace, U-space service, common information service and dynamic airspace reconfiguration. It also lays down requirements for coordination with Air traffic services providers within U-space airspace and dynamic reconfiguration of the U-space airspace for air traffic control units.

Air traffic services providers shall:

1. Provide relevant traffic information regarding manned aircraft within U-space airspace
2. Establish coordination procedures and communication between air traffic service units and U-space service providers

Air traffic control units shall:

1. Ensure temporary limitations in U-space airspace depending on manned traffic demand
2. Ensure communication between U-space service providers and CIS providers about activation/de-activation of the designated U-space airspace

Implementing Regulation (EU) 2021/666 [30] is a short regulatory document addressed to manned aviation. It adds two new points to the current regulation EU2012/923 [32] to inform pilots about a new area of airspace named as 'U-space airspace', its definition and the relation with a new type of available services. In addition to this, it modifies the communication requirements established in SERA.6006 [13] which will include different means for Radio Mandatory Zones (RMZ), Transponder Mandatory Zones (TMZ) and 'U-space airspace'. Manned aircraft will be allowed to enter in a 'U-space airspace' if the two following conditions met:

1. No traffic control service is provisioned
2. Aircraft equipment includes a system to make the aircraft electronically conspicuous to the U-space service providers.

#### 3.2.1.1 Mandatory services

The commission implementing regulation 2021/664 [23] lists four mandatory services that must be provided in a U-space airspace and at least two other services that may be required by member state(s) for safety purpose:

**Article (18) the network identification service:**

A network identification service should provide the identity of UAS operators, and the location and flight vector of UAS during normal operations and in contingency situations and share relevant information with other U-space airspace users.

**Article (19) the geo-awareness service:**

A geo-awareness service should provide UAS operators with the information about the latest airspace constraints and defined UAS geographical zones information made available as part of the common information services. In accordance with Implementing Regulation (EU) 2019/947, the establishment of UAS geographical zones should take into account safety, security, privacy and environmental requirements.

**Article (20) the UAS flight authorisation service:**

A UAS flight authorisation service authorises UAS operations are free of intersection in space and time with any other authorised UAS flight within the same U-space airspace.

**Article (21) the traffic information service:**

A traffic information service should alert UAS operators about other air traffic that may be present in proximity to their UAS.

#### 3.2.1.2 Services that may be mandatory

Two other services in implementing regulation 2021/664 [23] may be deemed necessary by a member state in order to ensure safe operation in a given U-space airspace:

**Article (24) Weather information service:**

A weather information service should support UAS operators during the flight planning and execution phases, as well as improve the performances of other U-space services provided in the U-space airspace.

**Article (25) Conformance monitoring:**

A conformance monitoring service should provide real-time alerting of non-conformance with the granted flight authorisation and inform the UAS operators when deviating from it.

#### 3.2.1.3 Requirements

Implementing Regulation (EU) 2021/664 [23] provides a regulatory framework for the U-space.

Chapter I of EU2021/664 [23] provides principles, general requirements and definitions.

Chapter II of EU2021/664 [23] provides requirements on U-space airspace and common information services. Before a Member State designates a U-space airspace, an Airspace risk assessment has to be conducted. There will be an AMC/GM published for further guidance [31]. There are four mandatory U-space services:

- the network identification service
- the geo-awareness service
- the UAS flight authorisation service
- the traffic information service

An important part of U-space airspace is determination of UAS capabilities and performance requirements, U-space services performance requirements, applicable operational conditions and airspace constraints. All the above mentioned will be based on the performed airspace risk assessment.

For cross-border U-space airspace, states shall jointly decide on the designation, provision of U-space services as well as provision of the cross-border common information services. As for U-space airspace in a controlled airspace, the main objective is to keep UAS segregated and dynamic reconfiguration of the airspace ensures a link between the USSP and the ATC in the case of manned aircraft flights taking place in U-space airspace.

Chapter III of EU2021/664 [23] provides general requirements for UAS operators and U-space service providers.

UAS Operators have a list of requirements that they shall comply with such as the capabilities and performance requirements, applicable operational conditions and airspace constraints. U-space service providers themselves shall always be compliant to regulation 2019/947 [17] as well as comply with geographical zones limitations. UAS operator is expected to submit a UAS authorization request before each individual flight through the flight authorization service.

U-space service providers shall be certified and are responsible for providing the UAS operators with the U-space services. USSPs have to establish link with the air traffic services providers to ensure an adequate coordination and information exchange relevant for the safe provision of U-space services.

Chapter IV of EU2021/664 [23] provides the detailed description about data interchange of the four mandatory U-space services (network identification, geo-awareness, flight authorization and traffic information) plus the weather information and the conformance monitoring services.

Such service description includes a number of requirements. For instance, the data items that a flying UAS must make available to the network identification service shall include the altitude of the UAS and this shall be given twice: once as altitude above mean sea level and a second datum which can be either the height above the surface or above the take-off point. As a UAS is composed by the aerial vehicle and the ground station, both positions shall be reported. In case there is not a ground station, then the take-off point is used as such.

All transmission of data must always include a time stamp, and dynamic data shall be updated at the established (by national authorities) frequency.

Only conflict free UAS operations can be authorised, and, in case of conflict, the existing aeronautical prioritisation rules shall apply, including manned and unmanned, ATC and U-space controlled, and across different USSP. Alternative routes for a flight can be given as solution to non-authorised flights.

A flight authorisation will include some flexibility limits such as time delay or position deviations allowed. In case of traffic information, this shall include also manned aircraft.

Once on the air, the conformance monitoring service, not considered mandatory, shall provide alerts that help to keep safety levels high. These alerts must be communicated by informing to the originator flight of the non-conformance conditions, but also to the other close-by UAS.

Chapter V is about how USSP/CIS shall be certified.

Who certifies: the National CAA or EASA

How: see annex VI and VII

Conditions: service quality, economic viability (at least for 12 months), administrative and management processes according to UE 2017/373 [11], insurance and contingency plans for them and for end users.

- USSP can apply in conjunction with others under an agreement contract.
- Cease of activity when conditions are not met or after 6/12 months of non- activity.

Chapter VI - About the conditions for the CAA and EASA

- CAA/EASA shall: have qualified personnel, resources to audit USSP/CIS and online services for USSP/CIS,
- CAA/EASA will define traffic data exchange conditions (see annexes II and V), design of U-space airspace and its services, and assess safety.

Application of the regulation starts on 2023 (Jan 26th).

Content of the ANNEXES:

- ANNEX I - Criteria elements
- ANNEX II - Data access: online, fair, secure
- ANNEX III - Performance of data exchange
- ANNEX IV - Fields required for a flight permission: i.e., 4DT, emergency procedure, used technology for eID/COMM...
- ANNEX V - Data exchange between USSP, CIS and ATM
- ANNEX VI - Format of the USSP Certificate
- ANNEX VII - Format of the CIS Certificate

Content of the Appendix - Summary table for U-space services per Airspace class and Airspace user.

Conclusions from this summary table is proposed below:

- U-space is for UAS not flying under either IFR or VFR.
- Any A/C under ATC (i.e., all A/C in classes A-B-C-D, or IFR in class E) will never enter U-space. In case on necessity, the dynamic airspace configuration will first reduce the U-space area extension.
- Manned AC allowed to enter U-space are only those not under ATC control (i.e., VFR in class E or any A/C in class F/G).
- The conditions are that they will communicate position to U-space but will not get any information back. The USSP and the UAS shall give way to any entering manned aircraft.

### 3.2.1.4 Roles and responsibilities

While for most of the detailed services in EU2021/664 [23] the U-space service providers are responsible to provide data to the UAS operators (geo-awareness, flight authorisation, traffic information, weather information and conformance monitoring), in the case of the network identification service the responsibility of the data flow starts in the UAS and goes to the U-space. Still, this service is responsible to forward the relevant U-space data to the final users of the service, which can range from competent authorities to general public, including other U-space services and also other U-space service providers (USSP) or the ATC/CIS.

### 3.2.2 EASA implementing regulation on the rules and procedures for the operation of unmanned aircraft

EU Regulations 2019/947 [17] and 2019/945 [28] set the framework for the safe operation of UAS in European skies (EU and EASA Member States). They adopt a risk-based approach, and as such, do not distinguish between leisure or commercial activities. They take into account the weight and specifications of the UAS and the operation it is intended to undertake.

Implementing Regulation (EU) 2019/947 [17] sets the rules and procedures for the operation of unmanned aircraft by introducing three categories of UAS operations (open, specific and certified).

Delegated Regulation (EU) 2019/945 [28]on unmanned aircraft systems and on third-country operators of unmanned aircraft system. It provides requirements for the design and manufacture of unmanned aircraft systems.

Apart from the two UAS Regulations, EASA has also developed Acceptable Means of Compliance (AMC) and Guidance Material (GM) to the Regulation (EU) 2019/947 [18] in order to improve the harmonisation of operations with unmanned aircraft within the EU.

#### 3.2.2.1 Categories of operations and limitations

The Implementing Regulation (EU) 2019/947[17] establishes the rules and procedures applicable to the use of unmanned aircraft. Based on the risk level of the operations, three operational categories are established: ‘open category, ‘specific category’ and ‘certified category’.

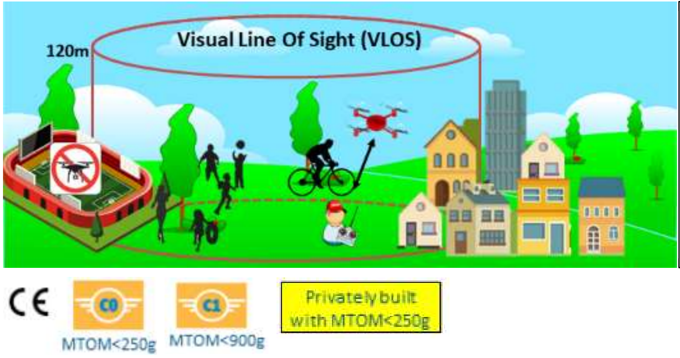

Figure 1 Categories of operations

The 'open' category is divided, in turn, into three subcategories: A1, A2 and A3.

- **Operational limitations:** presence of people not involved in the operation.
- **Requirements for the pilots:** theoretical and/or practical training.

- **Technical requirements for UAS:** classes, private construction and UAS prior to the entry into force of the standard.

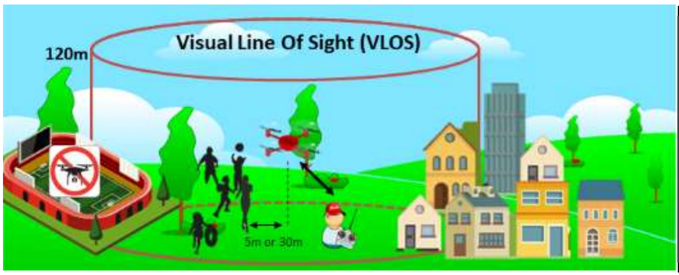
Open Category – Subcategory A1




- ➢ No fly over assembly people
- ➢ Reasonably expect that no uninvolved person is overflown. In case of unexpected overfly over uninvolved persons, the RPIC shall reduce as much as possible the time during which the UAS overflies those persons.

Figure 2 Subcategory A1 – https://www.easa.europa.eu/faq/116452europa.eu/faq/116452

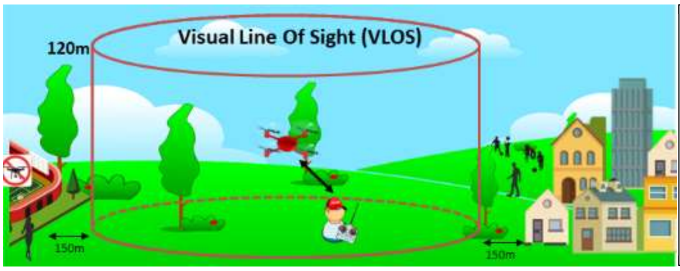
Open Category – Subcategory A2




- ➢ No fly over uninvolved people
- ➢ UAS at a horizontal distance of at least 30 metres from uninvolved persons, or up to 5 metres when low speed mode functions are activated


Figure 3 Subcategory A2 – from https://www.easa.europa.eu/faq/116452

Open Category – Subcategory A3




- ➢ No fly over uninvolved people
- ➢ Conducted in an area where the remote pilot reasonably expects that no uninvolved persons will be endangered within the range where the unmanned aircraft is flown during the entire time of the UAS operation


Figure 4 Subcategory A3 – from https://www.easa.europa.eu/faq/116452

The following table shows a full vision of requirements and limitations for the different open category and UAS label indicators after January 1, 2023.

Table 11 Open category of operations restrictions and requirements – from https://www.easa.europa.eu/faq/116452

| UAS | | Operation | | Drone Operator/Pilot | | |
|---|---|---|---|---|---|---|
| Class | MTOM | Subcategory | Operational restrictions | Drone Operator registration | Remote pilot competence | Remote pilot minimum age |
| Privately built | < 250 g | A1 (Can also fly in subcategory A3) | • May fly over uninvolved people (should be avoided when possible)<br>• No flying over assemblies of people | No, unless camera/sensor on board and a drone is not a toy | • No training needed | No minimum age |
| C0 | | | | | • Reader user manual | 16*, no minimum age if drone is a toy |
| C1 | < 900 g | | • No flying expected over uninvolved people (if it happens, should be minimised)<br>• No flying over assemblies of people | Yes | • Reader user manual<br>• Complete online training<br>• Pass online theoretical exam | 16* |
| C2 | < 4 Kg | A2 (Can also fly in subcategory A3) | • No fly over uninvolved people<br>• Keep horizontal distance of 30 m from uninvolved people (this can be reduced to 5 m if low speed function is activated) | Yes | • Read user manual<br>• Complete online training<br>• Pass online theoretical exam<br>• Conduct and declare a self-practical training<br>• Pass a written exam at the NAA (or recognized entity | 16* |
| C3 | < 25 Kg | A3 | • Do not fly near people<br>• Fly outside of urban areas | Yes | • Read user manual | 16* |
| C4 | | | | | | |
| Privately built | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | (150 m distance) | | • Complete online training<br>• Pass online theoretical exam | |

The 'specific' category comprises those UAS operations with a medium risk. Operations in the 'specific' category requires authorization from the competent authority before carrying out the intended operation, applying the mitigation measures identified in an operational risk assessment, except when the operation is performed under a standard scenario.

A Standard Scenario (STS) is a predefined operation, described in an appendix to EU regulation 2019/947. Two STSs have been published. STS 1 and STS 2 and they require use of a UAS with class identification label C5 or C6 respectively. In this case a declaration (responsible) on the part of the UAS operator will be sufficient.

However, if the operation is not covered by an STS and doesn't fall in the open category, then the UAS operator will need to have an operational authorisation before starting the operation. Two alternative approaches are provided for:

- ***An operational authorisation by conducting a risk assessment*** *using a methodology for the risk assessment; One method is:*
    - *SORA (specific operation risk assessment)**,** as proposed in EASA Acceptable Means of Compliance and Guidance Material [15]*

*Another method, proposed in CORUS ConOps:*

- *MEDUSA (MEthoDology for the U-Space Safety Assessment)*

- ***An operation authorisation through a predefined risk assessment' (PDRA)*** *as a simplification of the UAS operator conducting a risk assessment.*

Finally, a third option provided for the UAS operator is apply for a **light UAS operator certificate (LUC)** to the respective competent authority. A LUC which is an organisational approval certificate. This certificate grants powers and privileges to the UAS operator based on his degree of maturity, his knowledge of the sector and his good practices when operating. The privileges may be one or more of the following:

Conduct operations covered by standard scenarios without submitting the declaration.
Self-authorise operations conducted by themselves and covered by a PDRA without applying for an authorisation.
Self-authorise all operations conducted by themselves without applying for an authorisation.
To sum up, the following diagram, shows the three proposed options for a UAS operator to operate in 'specific' category.


Figure 5 Specific category of operations procedure

The 'certified' category encompasses those UAS operations with a high risk, carried out with UAS with which used on concentrations of people; designed and used to transport people; for the transport of dangerous goods that may put third parties at risk in the event of an accident or UAS operations in which the competent authority, based on the risk assessment, considers that the risk of the operation cannot be adequately mitigated without the certification of the UAS and the also the UAS operator and, where appropriate, without obtaining a license from the remote pilot.

Nowadays, but not yet in the regulation, three types of operation are proposed by EASA [19]:

- **Operations type #1:** International flight of certified cargo UAS conducted in instrumental flight rule (IFR) in airspace classes A-C and taking-off and landing at aerodromes under EASA's scope.
- **Operations type #2:** UAS operations in urban or rural environments using pre-defined routes in airspaces where U-space services are provided. This includes operations of unmanned UAS carrying passengers or cargo.
- **Operations type #3:** Operations as in type #2 but conducted with an aircraft with a pilot on board. Actually, this is expected to cover the first type of air taxi operations, where the pilot will be on board. In a second phase the aircraft will become remotely piloted (operations type 2).

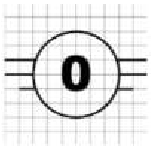
### 3.2.2.2 UAS equipment and characteristics requirements

This subsection aims to explain the European regulations on UAS to be sold to the general public; 2019/945 [28], it must be understood that there is a new classification of unmanned aircraft. Using a "class identification label" is intended to define the class of the UAS. Until now, the UAS had an identification plate with the operator and aircraft data. From now on they must carry a sticker indicating which class, or classes, they belong to, as well as the identification number that will be given to them once registered.

The aircraft class identification label shall be affixed in a visible, legible and indelible manner. In addition, all manufacturers must incorporate these labels on their UAS, with the commitment that the UAS meet the corresponding characteristics.

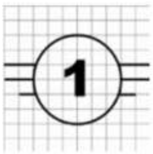
To belong to one class or another, unmanned aircraft must meet a series of technical requirements that are detailed below for each class of UAS.

UAS requirements described below belong to UAS which weight is less than 25kg; hence, they cannot carry huge payload such as passengers or heavy goods, but they could be used to carry light payload.



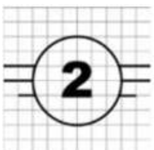

To belong to class 0, the aircraft must incorporate the image label and meet the following characteristics:

- Have an MTOW of less than 250 g
- Maximum speed in flight of 19 m/s
- Limit the maximum height from the take-off point to 120 m
- Be powered by electricity



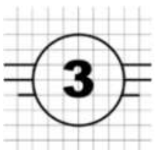

To belong to class 1, the aircraft must incorporate the image label and meet the following characteristics:

- MTOW less than 900 g
- Have a maximum speed in horizontal flight of 19 m/s.
- Limit the maximum height from the take-off point to 120 m
- Be powered by electricity
- Have a unique serial number
- Have a system for direct remote identification and network remote identification
- Be equipped with a geo-consciousness system
- Have equipped a low battery warning system for the drone and the control station (CS)



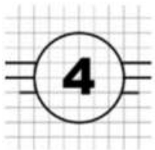

To belong to class 2, the aircraft must incorporate the image label and meet the following characteristics:

- Have an MTOW of less than 4 kg
- Limit the maximum height from the take-off point to 120 m
- Be powered by electricity
- Be equipped with a data link protected against unauthorized access to command and control functions (C2)
- Except if it is a fixed wing aircraft, be equipped with a selectable low speed mode that limits the speed to 3 m/s maximum
- Have a unique serial number
- Contain a system of direct distance identification and network remote identification
- Be equipped with a geo-consciousness system
- Have equipped a low battery warning system for the drone and the control station (CS)
- Equip lights for attitude control and night flight



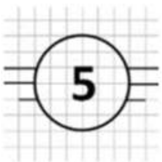

To belong to class 3, the aircraft must incorporate the image label and meet the following characteristics:

- MTOW less than 25 kg and a wingspan of less than 3 m
- Limit the maximum height from the take-off point to 120 m
- Be powered by electricity
- Have a unique serial number
- Have a system of direct distance identification and network remote identification.
- Have a geo-consciousness system equipped.
- Be equipped with a low battery warning system for the drone and the control station (CS)
- Equip lights for attitude control and night flight




To belong to class 4, the aircraft must incorporate the image label and meet the following characteristics:

- Have an MTOW of less than 25 kg, including payload.
- Not having automatic control modes, except for assistance with flight stabilization and for assistance in case of loss of link.
- Be safely controllable and manoeuvrable by a remote pilot following the manufacturer's instructions




To belong to class 5, the aircraft must incorporate the image label and meet the following characteristics:

- MTOW less than 25 kg.
- Not be a fixed wing aircraft, except if it is a captive UA.
- Have a system that provides the remote pilot clear and concise information about the height of the drone.
- Be equipped with a selectable slow speed mode that limits the speed to 5 m/s maximum.
- In the event of a loss of data link (C2), or in the event of a failure, have a method of recovering it or terminating the flight safely.
- Be equipped with a data link protected against unauthorized access to command and control functions (C2).
- Powered by electricity.
- Have a unique serial number.
- Contain a direct distance identification system.
- Have a geo-consciousness system equipped.
- Have equipped a low battery warning system for the drone and the control station (CS).
- Equip lights for attitude control and night flight.
- If the drone has a function to limit access to certain areas or volumes of airspace, it must be interoperable with the flight control system, and must inform the remote pilot when it prevents the UA from entering these areas or volumes of airspace.
- A C5-class drone may consist of a C3-class unmanned aircraft fitted with an accessory kit that converts it to C5-class.
- The accessory kit will not include changes to the C3-class drone software.

To belong to class 6, the aircraft must incorporate the image label and meet the following characteristics:

- Have an MTOW of less than 25 kg.
- Have a system that provides the remote pilot with clear and concise information about the height of the drone, providing means that prevent the aircraft from exceeding the horizontal and vertical limits of a programmable operational volume.
- Maximum ground speed in horizontal flight of 50 m/s.
- In the event of a loss of data link (C2), or in the event of a failure, have a method of recovering it or terminating the flight safely.
- Be equipped with a data link protected against unauthorized access to command and control functions (C2).
- Powered by electricity.
- Have a unique serial number.
- Have a direct remote identification system.
- Be equipped with a geo-consciousness system.
- Have equipped a low battery warning system for the drone and the control station (CS).

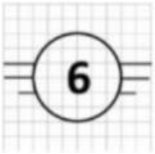



Figure 6 UAS classes requirements and characteristics

### 3.2.3 Examples of local regulations which may impact UAS operations in urban environment

In some countries, local authorities have the power to implement specific local regulations valid only in their areas of responsibilities. These regulations are usually adding constraints to the national one or may deal with an issue they are the only to face (e.g., protection of a natural area).

#### 3.2.3.1 France

For France, the city of Grenade, around 10 000 inhabitants, is taken as an example of local regulation which could impact UAS operations in urban environment.


This city has set rules restricting usage of machines during certain periods of the week and day to fight noise nuisance.

It is forbidden to use professional machines:

- between 20h and 7h
- on Sunday and bank holiday

And leisure machines (e.g., lawn mower, handiwork machine):

- On business day from 12h to 14h30 and after 19h30
- On Saturday from 12h to 15h and after 19h
- On Sunday and bank holiday from 12h to 16h and after 18h.

Figure 7 City of Grenade on VFR map

According to French rules of the air, this city cannot to overflown by a VFR flight below 3300 feet AGL.

These restrictions do not apply for urgent professional interventions (e.g., electricity, gas or water companies) or with the required authorization.

It is likely that these restrictions would apply also to UAS operations.

### 3.2.3.2 Spain, city of Barcelona

The Barcelona metropolitan area current local regulation are named Pla General Metropolità (PGM) [33] and Text Refós d'Ordenació Urbana [34]. Gathering a total of 27 municipalities the PGM regulates many of the day-to-day life in the metropolitan area, ranging from the Airport area (Articles 186-190), industrial areas (Art.124) or the future uses of land for communal equipment (Art.215). In some aspects, such as the environmental protection (Art.74) the PGM delegates to the municipalities the limits to approve new usage licenses.

Activities and edification to hold industrial activities rely in several elements to be declared. The power consumption is a key element to classify the activity, but also noise, emissions, water usage, residuals or safety aspects are used for the classification (Art.287-289). All articles related with noise give limits in decibels of type A (dBA). As an overall measure for environmental and human protection there is an absolute limit of 80 dBA, but further regulations, such as the added noise of an individual activity on the outside, stablished a maximum of 3 dBA over the background noise. This limit applies to external noise generated by industries. Regulation also sets a time schedule for external activity and noise that can be only from 8am to 9pm.

Nothing is reflected about privacy, vehicle emissions or power emissions of radio-frequency signals. These three aspects are found in the national regulations, which are mainly transposed from European regulations. For instance, the ground vehicle environmental categories. Nevertheless, the cities use this classification to declare areas of low emission, where vehicles within categories Euro3-Euro5 are not allowed to enter during week working daytime.

Both examples above show that it is likely that the regulatory framework in place in an area would be different to the one in place in others, even in the same country. Local authorities will implement additional (to the national/ European) regulations in accordance with local policy and in order to satisfy local electorate. This would have to be considered by UAS operators.

## 3.2.4 What in the Standard European Rules of the Air could affect urban UAS operations?

Aim of this section is to identify what in the SERA could affect urban air mobility UAS operations. From “Easy access Rules for SERA, December 2018” [13].

### 3.2.4.1 Regular minimum height

The minimum heights provided in the following sections are those published in the European Standardized European Rules of the Air. Some countries have increased or decreased some minimums in certain conditions.

Heights selected are those provided for flights over urban areas and outside, in order to take into account UAS operations linking two or several urban areas separated by non-urbanized zones.

Minimum heights are of utmost importance as they indicate where, in the vertical plan, a UAS is likely to encounter a manned aircraft.

### 3.2.4.2 The aircraft flies with Instrument Flight Rules

SERA 5015,(b),(2): except when necessary for take-off or landing, or except when specifically authorized by the competent authority, an IFR flight shall be flown at a level which is not below the minimum flight altitude established by the State whose territory is overflown, or, where no such minimum flight altitude has been established at a level which is at least 300 m (1 000 ft) above the highest obstacle located within 8 km of the estimated position of the aircraft.

Note: large unmanned aircraft (RPAS) flying in controlled airspace are considered as flying in IFR. These aircraft are usually (for the moment) state aircraft (mainly military) and their flight in civil controlled airspace requires early coordination between the operator (usually the military) and the air traffic control. Hence, as considered flying in IFR, IFR apply to these RPAS.

#### 3.2.4.3 The aircraft flies with Visual Flight Rules

##### 3.2.4.3.1 At night-time

SERA 5005 (5) ii: except when necessary for take-off or landing, or except when specifically authorized by the competent authority, a VFR flight at night shall be flown at a level which is not below the minimum flight altitude established by the State whose territory is overflown, or, where no such minimum flight altitude has been established, at a level which is at least 300 m above the highest obstacle located within 8 km of the estimated position of the aircraft.

##### 3.2.4.3.2 At daytime

SERA 5005(f), (1): except when necessary for take-off or landing, or except by permission from the appropriate authority, a VFR flight shall not be flown over the congested areas of cities, towns or settlements or over an open-air assembly of persons at a height less than 300 m (1 000 ft) above the highest obstacle within a radius of 600 m from the aircraft.

For inter-urban UAS operations, SERA 5005 (f) (2) will have to be considered, including AMC1 SERA 5005 (f) which states that “The competent authority should specify the conditions under which the permission is or may be granted, including the minimum heights above the terrain, water or the highest obstacle within a radius of 150 m (500 ft) from an aircraft practising forced landings, a balloon or an aircraft executing ridge or hill soaring.

SERA 5005, (f), (2): elsewhere than as specified in (1), at a height less than 150 m (500 ft) above the ground or water, or 150 m (500 ft) above the highest obstacle within a radius of 150 m (500 ft) from the aircraft.

#### 3.2.4.4 Flight plan

CORUS Concept of operations proposes to make mandatory the provision of UAS operation plan in U-space volume Y, Zu and Za. This UAS operation plan will probably not look like ICAO flight plan but contain some similar information. Common ideas are that the plan needs to convey who flies what where and when. Specific to the UAS operation plan are the quantification of all uncertainties in the planning and description of the trajectory as a series of one or more four dimensional volumes. The plan in essence indicates that the aircraft will be in each 3d volume during the specified time duration.

EU regulation 2021/664 [23] uses the term “flight authorisation request” in regard to the mandatory “flight authorisation request service,” see 3.2.1.1, and describes the format in Annex IV. Some further light is shone on the annex in the AMC/GM for 2021/664 [31]. Annex IV does not match the expectations of the plan described in the CORUS ConOps. This “flight authorisation request service” addresses only the authorisation of flight within the U-space airspace. There is no mention of coordination with ATC and absent from Annex IV is any way to indicate that a flight has permission to enter any airspace. Hence the “flight authorisation service” of 2021/664 cannot currently be used to authorise flights based in consideration of where they fly, nor to plan flights that exit U-space airspace.

The authorisation aspect of the “flight authorisation request service” of 2021/664 is limited to detecting conflicts between any new U-space flight request and any previously authorised U-space flight.

2021/664, 665 and 666 indicate that U-space airspace as described in the regulations, equivalent to Y volume, may be visited by manned aircraft which are electronically conspicuous, but which have not submitted a plan to U-space, which a will ineluctably prevent any strategic conflict resolution with unmanned traffic.

Nevertheless, as UAS operations shall be declared before flight in volume Y, Zu and Za, manned aircraft pilot may have access to a good situational awareness, provided they have access to information coming from the U-space Service Providers.

### 3.2.4.5 Collision avoidance

SERA 3201 General: “Nothing shall relieve the pilot-in-command of an aircraft from the responsibility of taking such action including collision avoidance manoeuvres based on resolution advisories provided by ACAS equipment, as will best avert collision”.

As mentioned, several times in the different literatures, this is quite hard for a pilot of a manned aircraft to see UAS in the sky due specifically to the small size of the UAS first, and to the fact that the pilot has to concentrate on its own operation while being close to the ground. These constraints in urban areas are exacerbated with the multiplicity of obstacles and contrasts coming from the ground.

Moreover, the number of UAS in urban environment may make impossible the detection by the pilot of all the UAS in its vicinity and likely to be dangerous.

Therefore, avoidance of collision between a manned aircraft and a UAS shall be the responsibility of the remote pilot when the UAS is flown VLOS. Nevertheless, the remote pilot flying a UAS in VLOS in dense traffic conditions may take advantage of services such as a traffic information to help avoid collision.

If the UAS is flown BVLOS, avoidance of collision will be provided by U-space services first, then by systems such as detect and avoid acting as safety nets.

### 3.2.4.6 Right of way

Right of way is generally based on the capacity to see the other aircraft, their type and behaviour. Details are provided in SERA 3210. This capacity does not exist for the remote pilot who is not on board the aircraft, and even for VLOS flight the view makes it very hard to know which UAS or aircraft is below, above, in front or behind the other.

This information may be provided by systems, to the UAS (and the remote pilot) directly if flying in autonomous mode, or to the remote pilot if the UAS is steered manually.

SERA describes right of way for the flight rules VFR, IFR and special VFR. There is no information in SERA on the right of way between manned and unmanned aircraft that are not following one of these flight rules. Implicit in the description of the traffic information service of EU regulation 2021/664 is a requirement that unmanned aircraft give priority to manned aircraft.

#### 3.2.4.7 VMC visibility and distance from cloud minima

In urban area and below 1000 feet, visual meteorological condition visibility and distance from cloud minima concern manned aircraft flying in VFR with special authorization or flying in the vicinity of an aerodrome for take-off, landing and aerodrome circuit.

Outside urban areas, these minima impact all the VFR flights.

Visibility and distance from cloud are clearly compatible with VLOS operations. They could be useful for a UAS pilot to see an aircraft, manned or unmanned (depending on the size) long in advance and early enough to take appropriate actions.

BVLOS operations should not be impacted by these parameters. The remote pilot would not take benefit of a good visibility for instance.

This is valid as long as the UAS does not carry sensors which performance do not depend at least on one of these parameters.

*** The VMC minima in Class A airspace are included for guidance to pilots and do not imply acceptance of VFR flights in Class A airspace.

| Altitude band | Airspace class | Flight visibility | Distance from cloud |
|---|---|---|---|
| At and below 900 m (3 000 ft) AMSL, or 300 m (1 000 ft) above terrain, whichever is the higher | A***B C D E | 5 km | 1 500 m horizontally<br>300 m (1 000 ft) vertically |
| | F G | 5 km | Clear of cloud and with the surface in sight |
| Below 3 050 m (10 000 ft) AMSL and above 900 m (3 000 ft) AMSL, or above 300 m (1 000 ft) above terrain, whichever is the higher | A***B C D E F G | 5 km | 1 500 m horizontally<br>300 m (1 000 ft) vertically |

Table 12: Meteorological conditions minima and distance from cloud for VFR flight – ICAO Annex 2 and SERA 5001

### 3.2.5 Identified gaps in the current regulation

Despite European regulation for UAS operations is quite advanced and still on-going, we can notice some gaps; below some elements missing in the regulation:

- The first gap identified is the lack of regulation for operations in the specific and certified categories related to the minimum distance between the UAS and the people or an assembly of people, and obstacle, whereas it is defined in the open category. Even if the operator, the UAS and the remote pilot are certified when operating above urban or populated environment, there should be minimum distances, vertical and horizontal, set between the UAS and obstacle, people and assembly of people.

- Regarding certified categories, for instance air taxis, current information (e.g., Doc. No: SC-VTOL-01, article 6 of EU 2019/947) we have in the regulation is not detailed enough whereas it is probably the kind of operations that will be performed soon.

- There is a need to establish prioritization rules considering type of vehicle and operations (manned aircraft, passengers-carrying UAS, cargo-carrying UAS) beyond the existing priority for safety-relevant flights.

- There is no clear definition of populated area. EU regulations, acceptable means of compliance and guidance material mention "populated area" but do not refer to a precise definition of the term:

EASA is pursuing to launch a study for a better measurement of population density in Europe, which include development of static and dynamic maps (EASA presentation of the 1st of October 2020 - "Operations in the medium risk of the Specific category").

- The SORA does not consider air risk due to other UAS flight, only with manned aircraft.

Nevertheless, JARUS WG 6 is already working to expand the scope of SORA to address the risk of collision when more UAS are flying in the same airspace (e.g., urban).

- No Standard scenario for operations specifically in urban environment in the Specific category has been proposed so far, especially for flight over uninvolved people. Provided the number of use cases of operations in urban environment which could not be performed in the open category (e.g., building inspection, photography, filming) nor in the certified category without dramatically increasing the cost, this would be relevant.

- No values for the separations (unmanned – unmanned and unmanned- manned) is provided. These could be an absolute distance or a function of performances (CNS and aircraft).

- It is also likely that the Standardised European Rules of the Air would have to be updated in order to describe the rules for operating in a U-space airspace.

The scope of EU regulations today is “Early U2”. Regulation 2019/947 [17] described minimal U1 implementation – registration, collection and dissemination of drone aeronautical information. Regulations 2021/664, 665 and 666 ( [23],[29],[30] & [31] ) describe some U2 services in a way that will only support low density operations. A number of situations are foreseeable in 2021/664 such as the arrival of a conspicuous manned aircraft in U-space airspace, or the dynamic redefinition (removal) of U-space that raise the question “and then what happens?”

To move forward, the EU regulations need to tackle higher density U2 by looking at traffic with frequent strategic conflicts and consider how to make efficient use of the available airspace, and then address U3; that is tactical separation and flight rules that would allow integration of manned an unmanned traffic.

## 3.3 System Performance

Performance characterisation is the structured way to describe the target outcome of a system and to monitor how close the outcome is to that target. In the specific case of Air Traffic Management, the ICAO Global Air Traffic Operational Concept, Doc 9854, [35] associates performance to the diverse demands of the system from diverse members of the ATM community. This ICAO ATM ConOps establishes the concept of ***Required ATM System Performance (RASP)[2]:***

> *"RASP is the set of criteria, expressed in the form of performance parameters and values of those parameters, that the ATM system needs to meet, with a given probability, in order to support the approved quality of service specified for a particular environment."*

In line with this conceptual framework, the role of performance characterisation for the U-space system in support of Urban Air Mobility is twofold:

- Set **expectations** about the system outcome.
- **Monitor** the external outcome of the system in a way that can be linked to the performance of internal functionalities, allowing for steering actions towards expectations.

### 3.3.1 Key Performance Areas

The first level of performance structuring is setting **Key Performance Areas**: those areas of performance considered critical for the system success in terms of outcomes, in line with the expectations of the relevant stakeholders. In the ICAO 9854 document [35], Appendix D, there is indeed a description of the **ICAO** 11 Key Performance Areas for ATM in terms of the expectations of the ATM community.

The other main source in European ATM providing additional definitions for the same KPAs and also proposing some amendments and additions is the SESAR Performance Framework and the **European ATM Master Plan** [36].SESAR PF is conceived for setting expectations and measuring benefits linked to solutions for manned air transport from a research and development point of view. To this aim, there are some ICAO KPAs left outside the list. Since the focus of the present document is the unmanned air traffic research and development, all ICAO areas are considered and analysed. In particular, three areas not included in SESAR PF were considered relevant additions to the CORUS-XUAM performance scheme by the attendees to the first CORUS-XUAM workshop (27th September to 1st October 2021, virtual event. 93% agreement through online poll): Access and equity, Participation and collaboration and Flexibility.

In the context of European drone traffic management, there has not been yet an attempt to define KPAs relevant for U-space. There are however a couple of references that add some light to the U-space performance scene:

- **U-space ConOps** from CORUS [4] addresses Social Acceptance as one key area to be considered linked to the expectations and perceived impact of various sectors of society.
- **SESAR JU guidance for U-space demonstrations** [37] puts the focus of the performance assessment for drone traffic management research and demonstration projects on certain KPAs (such as environment, safety, security, cost-efficiency and human performance). Besides,

[2] It must be noted that RASP accounts for the external performance (outcome of the system) to which corresponds the expectations. A different concept is the Required Total System Performance (RTSP), which is the internal performance related to the functionality of the ATM components as they contribute to deliver the external performance.

the document introduces specific questions for cost-efficiency and human performance, which can be read as further details of the scope of the related KPAs.

Outside the European scene, there are two main references to be observed, because of their advanced and structured contribution to setting a drone performance framework:

- The **Australian Urban ATM ConOps** [38], which builds on the same 11 KPAs of ICAO to set performance expectations/ benefits associated the effective functioning of main Urban ATM services:
    - Airspace and procedure design.
    - Information exchange.
    - Flight planning and authorisation.
    - Flow management.
    - Dynamic airspace management.
    - Conformance monitoring.
- The **UK Connected Places Catapult – Open Access UTM** programme [39] goes a step forward and introduces key principles (assailable to KPAs) tailored to the UTM, including the traditional safety, security or flexibility and also other innovative drone-specific areas such as transparency and scalability.

The following table summarises the definitions of each KPA in the mentioned references.

| KPA | ICAO | SESAR PF | SESAR JU guidance for U-space | Open Access UTM - UK Catapult |
|---|---|---|---|---|
| **Access and Equity** | A global ATM system should provide an operating environment that ensures that all airspace users have right of access to the ATM resources needed to meet their specific operational requirements and that the shared use of airspace by different users can be achieved safely. The global ATM system should ensure equity for all users that have access to a given airspace or service. Generally, the first aircraft ready to use the ATM resources will receive priority, except where significant overall safety or system operational efficiency would accrue or national defence considerations or interests dictate that priority be determined on a different basis. | | | |
| **Participation & Collaboration** | The ATM community should have a continuous involvement in the planning, implementation and operation of the system to ensure that the evolution of the global ATM system meets its expectations. | | | |
| **Capacity** | The global ATM system should exploit the inherent capacity to meet airspace user demands at peak times and locations while minimizing restrictions on traffic flow. The ATM system must be resilient to service disruption and the resulting temporary loss of capacity. | The ambition is to tackle capacity crunch, address the risk of unaccommodated traffic and increase the network traffic throughput in order to accommodate predicted demand with a sufficient margin. It also intends to provide sufficient | | |

| KPA | ICAO | SESAR PF | SESAR JU guidance for U-space | Open Access UTM - UK Catapult |
|---|---|---|---|---|
| | | scalability at key bottlenecks in the network to enable reductions in ATFCM delays and increase the potential for fuel-efficient trajectories. | | |
| **Cost Effectiveness/ Cost Efficiency**[3] | The ATM system should be cost-effective, while balancing the varied interests of the ATM community. The cost of service to airspace users should always be considered when evaluating any proposal to improve ATM service quality or performance. | The ambition is to provide necessary technical system changes, at reduced life cycle costs, while continuing to develop operational concepts to enhance the overall productivity of ANS provision. The performance ambitions are a reduction of costs per flight and gate-to-gate direct ANS cost per flight. | Cost Benefit Analysis (CBA) of deploying the U-space services (and required capabilities). | |
| **Efficiency** | Efficiency addresses the operational and economic cost-effectiveness of gate-to-gate flight operations from a single-flight perspective. In all phases of flight, airspace users want to depart and arrive at the times they select and fly the trajectory they determine to be optimum. | Efficiency and predictability together form "Operational Efficiency". Indirect economic benefits for flight operations, mainly through the reduction and better management of departure delays and more efficient flight paths, reducing both the additional fuel consumption | | |

[3] This KPA is conceptually the same for the two main references observed in this Operational Framework (ICAO and SESAR PF), although the exact term used in each one is different. ICAO uses “Cost Effectiveness” while SESAR PF talks about “Cost Efficiency”.

| KPA | ICAO | SESAR PF | SESAR JU guidance for U-space | Open Access UTM - UK Catapult |
|---|---|---|---|---|
| **Predictability** | Predictability refers to the ability of airspace users and ATM service providers to provide consistent and dependable levels of performance. Predictability is essential to airspace users as they develop and operate their schedules. | attributable to ATM and gate-to-gate flight time, and increasing predictability. For the military, operational efficiency is an enabler of mission effectiveness. This means the best possible adherence between the planning and the execution phase of the mission (e.g., in relation to fine-tuning of the transit time from/to the home base, real occupancy of the reserved airspace).<br>In addition to reducing departure delays, the aim is to increase the predictability of flight arrivals in accordance with commonly agreed reference business trajectories, prior to push-back. | | |
| **Environment** | The ATM system should contribute to the protection of the environment by considering noise, gaseous emissions and other environmental issues in the implementation and operation of the global ATM system. | The reduction in gate-to-gate $CO_2$ emissions is directly proportional to the average reduction in fuel burn per flight, and thus captured by the efficiency KPI.<br>In addition to its global impact due to $CO_2$ emissions, aviation has local impacts, in terms of noise and local emissions, that are specific to each airport and affected by airspace constraints, the traffic mix, local land use and local geography. | Considered but no definition provided. | |
| **Global Interoperability** | The ATM system should be based on global standards and uniform principles | Interoperability and global harmonisation rely on the | | |

| KPA | ICAO | SESAR PF | SESAR JU guidance for U-space | Open Access UTM - UK Catapult |
|---|---|---|---|---|
| | to ensure the technical and operational interoperability of ATM systems and facilitate homogeneous and non-discriminatory global and regional traffic flows. | synchronised application of standards and common principles, together with common technical and operational solutions for relevant aircraft and ATM systems. This includes civil-military interoperability. | | |
| **Safety** | Safety is the highest priority in aviation, and ATM plays an important part in ensuring overall aviation safety. Uniform safety standards and risk and safety management practices should be applied systematically to the ATM system. In implementing elements of the global aviation system, safety needs to be assessed against appropriate criteria and in accordance with appropriate and globally standardized safety management processes and practices. | Irrespective of traffic growth and taking into account that the ATM/ANS system must ensure gate-to-gate traffic safety (in flight as well as during surface movement, that is, during taxi and on the runway), the safety ambition is zero accidents as a consequence of ATM/ANS. Meeting this ambition will require a significant reduction in risk per individual flight. | Considered but no definition provided. | Cornerstone to enable increasingly complex drone operations – particularly in controlled airspace or urban settings, where mitigating risk to people, vehicles, property and other airspace users will remain challenging. |
| **Security** | Security refers to the protection against threats that stem from intentional acts (e.g., terrorism) or unintentional acts (e.g., human error, natural disaster) affecting aircraft, people or installations on the ground. Security risk management should balance the needs of the members of the ATM community that require access to the system, with the need to protect the ATM system. In the event of threats to aircraft or threats using aircraft, ATM shall provide the | The overall objective is to ensure that the airspace and the ATM system, including ATC and CNS infrastructure and airports, as well as ATM-related information, are adequately protected against security threats, meeting the expectations of European citizens and policymakers. | Considered but no definition provided. | Security refers to the protection of a person, item, service, etc. against threats i.e. the need to protect the UTM participants, drone operations, the public and the environment. Threats can be caused by external intentional acts (e.g., terrorism, spoofing attacks, cyberattacks), internal intentional acts (e.g., threats from disgruntled employees), and unintentional acts (e.g., human error, technical hardware or software error/failure). |

| KPA | ICAO | SESAR PF | SESAR JU guidance for U-space | Open Access UTM - UK Catapult |
|---|---|---|---|---|
| | authorities responsible with appropriate assistance and information. | | | |
| **Flexibility** | Flexibility addresses the ability of all airspace users to modify flight trajectories dynamically and adjust departure and arrival times, thereby permitting them to exploit operational opportunities as they occur. | | | Flexibility refers to the ability of the UTM architecture to evolve or adapt with respect to considerations relating to technological progress, risk and performance measures, policy and regulatory changes, and new business models. |
| **Transparency** | | | | Information sharing attribute of this UTM framework which will enable all stakeholders access to a common understanding of the airspace in terms of operations and services. As a result, UTM users will have the right of access to the airspace when they fulfil the operating requirements, but also a right to understand why access maybe denied. Considerations around transparency are important due to the potential impact on trust, security and safety in the system. There are other key considerations around transparency, particularly around the compromise between user privacy and security. |
| **Scalability** | | | | Scalability refers to the capacity for growth in the number of |

| KPA | ICAO | SESAR PF | SESAR JU guidance for U-space | Open Access UTM - UK Catapult |
|---|---|---|---|---|
| | | | | manageable drone operations, as well as the number (or density) of vehicles, or the number of actors, or services and messages that can reliably operate within the same UTM environment. |
| **Human Performance** | | Human Performance (HP) is used to denote the human capability to successfully accomplish tasks and meet job requirements. The capability of a human to successfully accomplish tasks depends on a number of variables that are usually investigated within the discipline of "Human Factors (HF)". These are procedure and task design, design of technical systems and tools, the physical work environment, individual competences and training background as well as recruitment and staffing. HP also depends on the way in which Social Factors and issues related to Change & Transition are managed. | Potential impact on ATCO in case of interface ATM/U-space, pilot, flight planning operators, etc. | |

Table 13: Definitions of KPAs applicable to ATM and U-space

To complete the summary provided in the table above, the U-space ConOps [4] provides the following description of Social Acceptance:

> *Drones bring high social and economic expectations. But social acceptance of drones is key for the full development of the economical expectations. To consider all aspect of social impact the acceptance is evaluated from three points of view: safety (perception), economic (accomplishment of economical expectations of the new emerging drone market) and political (any other social issue, which includes aspects such as the citizens' affectations from the drones' noise, the privacy potential compromise, the visual impact etc.)*

### 3.3.2 Performance Ambitions

As introduced at the beginning of this section 3.3, a main objective of the performance characterisation of a system is to drive outcomes in line with expectations. These are logically different for each stakeholder, depending on its business, technical and operational objectives. Besides, there can be regional and local differences in the specific objectives that each stakeholder has. The expectations analysed in this section does not account for these local specificities. They have been produced using expert judgement internal to the project and will be used as a framework to set the Performance Indicators to be measured in CORUS-XUAM demonstration.

The stakeholder list used is tailored to UAM:

- Service Provider:
    - U-space Service Provider (USSP)
    - One-service USSP[4];
    - Common Information Service Provider (CISP)
    - ANSP
    - Infrastructure SP
    - Supplemental Data Service Provider (SDSP).
- Safety Authority:
    - SA concerned with Drone Operators (Dos)
    - SA concerned with airspace and rules of the air
    - SA concerned with service providers.
- Regulator

[4] A USSP that provides one specialised service, which may or may not be regulated. The weather and data service providers are examples of these, but there could be others:
- Providing specific monitoring services: GNSS performance, Sunspot activity, Airborne dust…
- Using some proprietary algorithm to generate some "added value" service – input traffic demand, output perceived noise at ground level.

- Vertiport Operator
- Airport Operator
- UAS Operator
- Other airspace users:
    - Recreational & sport aviation
    - Aerial works
    - Private flights
    - Commercial air transport
    - Military, including state police.
- Society (in the sense of interests not already represented by other stakeholders)
- Local authorities with geographical scope:
    - Specific authorities (e.g., harbour authorities)
    - City/ Region/ State.
- Surface transport modes
- Value-added business.

The progress so far has been the production of expectations of service providers, airport operators and UAS operators.

| | Service Provider | | | | | |
|---|---|---|---|---|---|---|
| **KPA** | **USSP** | **One-service USSP** | **CISP** | **ANSP** | **Infrastructure SP** | **SDSP** |
| **Access and Equity**[5] | Fair access to airspace for its Drone Operators | | | No restrictions on ATM linked to UAM activity | | |
| **Capacity** | Accommodation of all operations managed by the USSP | | Capacity can meet the demand | | | |
| **Cost Effectiveness/ Efficiency** | Accomplishment of economical expectations of the new drone market | | Global costs and investment are covered by income | | | |
| **Efficiency** | Minimum delays and extra-distance flown for the operations managed | | Smooth management of resources | | | |

[5] Services in U-space are expected to be offered by commercially. All service providers expect equal business conditions and access to the market.

| | Service Provider | | | | | |
|---|---|---|---|---|---|---|
| **KPA** | **USSP** | **One-service USSP** | **CISP** | **ANSP** | **Infrastructure SP** | **SDSP** |
| **Flexibility** | Possibility to change trajectories of the operations managed to adapt to operational needs and/ or business opportunities | | | | | |
| **Participation & Collaboration** | Possibility to take part on discussions on the technical, regulatory and operational evolution of the U-space | Possibility to take part on discussions on the technical, regulatory and operational evolution of the U-space concerned service | Possibility to take part on discussions on the technical, regulatory and operational evolution of the U-space | Competence to take part on collaborative decisions impacting ATM operations | Possibility to take part on discussions on the standards and regulations impacting the provided infrastructure | Updated information on discussions on the technical, regulatory and standardisation aspects impacting the provision of the SDSP specific data |

| KPA | Service Provider | | | | | |
|---|---|---|---|---|---|---|
| | USSP | One-service USSP | CISP | ANSP | Infrastructure SP | SDSP |
| **Predictability** | Minimum changes due to network constraints in filed trajectories of the operations managed | Minimum changes due to network constraints in operations linked to the U-space concerned service | Maximum adherence to approved operation plans of flights in the managed airspace | Predictable drone operations so UTM-ATM knock-on delays are minimised | Maximum adherence to approved operation plans so that level of performance provided can be better planned and adjusted to demand | |
| **Safety** | Minimise risk of collision with other drones, infrastructure or manned aircraft of the operations managed | | Minimise risk of collision with other drones, infrastructure or manned aircraft of drones within the managed airspace | Safety level of UAM operations close to or within controlled airspace is high enough so there is not a subsequent decrease in safety level of ATM operations | Minimise risk of collision of drones with the managed infrastructure | |

| | Service Provider | | | | | |
|---|---|---|---|---|---|---|
| **KPA** | **USSP** | **One-service USSP** | **CISP** | **ANSP** | **Infrastructure SP** | **SDSP** |
| **Security** | Minimum security occurrences, and especially intentional rogue drones, in the airspace in which the USSP is operating or impacting the operations managed | Minimum security occurrences impacting the provision of the U-space concerned service | Minimum security occurrences, and especially intentional rogue drones, in the managed airspace | Security level of UAM operations close to or within controlled airspace is high enough so there is not a subsequent decrease in security level of ATM operations | Minimum security occurrences, and especially intentional rogue drones, in the vicinity of the managed infrastructure or impacting the CNS service provided | Minimum security occurrences impacting the provision of the concerned data service |
| **Transparency** | Visibility of operations and services in the area of service provision, as well as access to rationale for denied access or reduced priority | Visibility of operations and other services in the area of service provision | Visibility of manned operations from the ANSP (e.g., about TSAs, airspace closure, AIM, etc.) | Visibility of operations inside and close to controlled airspace | Visibility of operations and services in the vicinity of the managed infrastructure and/ or impacted by the CNS service provided | Visibility of operations and services impacted by the data service provided |

| | Service Provider | | | | | |
|---|---|---|---|---|---|---|
| **KPA** | **USSP** | **One-service USSP** | **CISP** | **ANSP** | **Infrastructure SP** | **SDSP** |
| **Scalability** | Possibility to growth in number of operations managed, unconstrained by technical limitations | Possibility to growth in number of operations served, unconstrained by technical limitations | Possibility to growth in number of operations managed, unconstrained by technical limitations | | | |
| **Social Acceptance** | Concurrence of number and typology of operations accepted by society with target operations managed | | Concurrence of number and typology of operations accepted by society with target operations managed | | Acceptance by society of new drone infrastructures and their service levels | |

| | Service Provider | | | | | |
|---|---|---|---|---|---|---|
| KPA | USSP | One-service USSP | CISP | ANSP | Infrastructure SP | SDSP |
| **Human Performance** | Clear and effective procedures and tasks design, and standards for design of technical systems and tools that support effectively human tasks within the USSP | Clear and effective procedures and tasks design, and standards for design of technical systems and tools that support effectively human tasks within the one-service USSP | Clear and effective procedures and tasks design, and standards for design of technical systems and tools that support effectively human tasks within the CISP | Clear procedures that allow smooth coordination ATM-UTM | Clear and effective procedures and tasks design, and standards for design of technical systems and tools that support effectively human tasks for the related infrastructure management | |

**Table 14: Stakeholders Expectations in terms of KPAs for Service Providers**

Table 15: Stakeholders Expectations in terms of KPAs for Service Providers

| KPA | Airport Operator | UAS Operator | Vertiport Operator |
|---|---|---|---|
| Access and Equity | No restrictions on airport management linked to UAM activity and assurance of access to drone performing airport-relevant operations | Free market<br><br>Fair and flexible accommodation of flights which cannot file authorization requests with great lead time, e.g., air taxis, ad-hoc delivery missions | Assurance of equitable access to a variety of UAS operators and USSPs from an operational perspective |
| Capacity | | Minimum delays and Minimum re-routing | Concept of operations that maximizes or at least not unduly restricts capacity for departing and arriving aircraft and VTOLs (e.g., through capacity-prohibitive contingency procedures) |
| Cost Effectiveness/ Cost Efficiency | | | Business case of each vertiport (may differ) need to be satisfied; overall ticket prize is partly shaped by the efficiency of the vertiport operation |
| Efficiency | | Optimal routes | Intermodality asks for an efficient UAS operation in order to meet transition times and affordable ticket prizes and social acceptance |
| Flexibility | | - Minimum time from request to acceptance<br>- Negotiation capabilities with other operators | Adequate handling of variation of demand patterns and densities is required. Tightly connected to capacity and operational resilience of a vertiport |
| Global Interoperability | | Standards for USSP API | Unified definition about a vertiport operator's role and responsibilities within U-space.<br><br>Standard procedures and communication protocols which describe the operation on a vertiport and are |

| KPA | Airport Operator | UAS Operator | Vertiport Operator |
| --- | --- | --- | --- |
| | | | distributed to all U-spacer users |
| Participation & Collaboration | Competence to take part on collaborative decisions impacting airport operations | Consultation on U-Space design | Competence to take part on collaborative decisions impacting vertiport operations<br><br>Active member of U-space and provider of U-space services (capacity, weather, workload/utilization, etc.) |
| Predictability | Predictable drone operations so airport operations and especially turn-around of other aircraft are not negatively impacted | Transparency of acceptance ratio and maximum response time | Predictable drone operations so vertiport processes can be efficiently planned and executed in support of a successful business case |
| Safety | Safety level of UAM operations close to or within the airport is high enough so there is not a subsequent decrease in safety level of airport operations | No drone's lose<br>Not high endurance<br><br>Minimize risk to third parties (since UAS operator may be liable for damage) | Primary concern which needs to be addressed on the airside air, airside ground and on the landside of a vertiport<br><br>Safety level of UAM operations close to or within the vertiport is high enough so there is not a subsequent decrease in safety level of vertiport operations |
| Security | Security level of UAM operations close to within airports is high enough so there is not a subsequent decrease in security level of airport operations. Rogue drones are avoided | Impossibility of hacking my drone | Security level of UAM operations close to or within vertiport is high enough so there is not a subsequent decrease in security level of vertiport operations. Rogue drones are avoided.<br><br>On-demand behaviour and short travel times asks for a modern and probably interoperable security check of passengers. Security of autonomous operations and |

| KPA | Airport Operator | UAS Operator | Vertiport Operator |
|---|---|---|---|
| | | | the provision of U-space services by the vertiport operator need to be ensured |
| Transparency | Visibility of operations in the vicinity of the airport | Clear rules for accessing the airspace and clear requirements for the approval of operations | Visibility of operations and services in the vicinity of the vertiport |
| Scalability | | Growth of business | Growth of business |
| Social Acceptance | | High rate of clients | Acceptance of operations and integration of vertiport services in the surrounding environment.<br><br>Main issue which will be faced by a vertiport operator and its facility. Integration into existing transportation networks and an active participation in U-space |
| Human Performance | | Minimal interaction | Minimal interaction (high degree of automation) is anticipated but responsibilities need to be clarified and the interaction with "modern" systems (propulsion, charging, passenger screening, operational procedures, monitoring etc.) need to be trained |

Table 16: Stakeholders Expectations in terms of KPAs for Airport and UAS Operators

RASP concept [27][35] has been also introduced as the set of performance requirements to be met by the system. It must be highlighted that "*RASP does not mean that the system performance can be expressed by a single figure or that performance figures have to be unique globally*". The implication of this is twofold:

- The required performance will be expressed in the form of a set of values for the correspondent set of indicators.

- The required performance can vary depending on the *environment.* The notion of environment impacts on the analysis of relevance of each KPA for each stakeholder. In plus of considerations of rural, suburban and urban areas, aspects such as type of airspace (possible examples – not yet discussed – are high performance layers, approach areas to vertiports, logistic hub surrounding airspace, environmentally sensitive areas) or level of complexity/ risk might influence in the level of relevance of each KPA.

### 3.3.3 Performance Indicators

The required level of performance in each KPA is measurable within a framework of **performance indicators**.

At the level of individual VLDs it is a way of covering the demonstration of success in reaching the VLD objectives (see Deliverable D35.). All in all, the global set of indicators shall be able to demonstrate achievement of global CORUS-XUAM objectives and also to mirror relevant results in a way compatible with dissemination of VLDs and global success to local boards/AB.

### 3.3.4 Key Performance Indicators

KPIs - *"Target" is understood to be the minimum that is required at a given point in time or at a given period and may also address the present.*

There are already some expectations included in the reference documents defining the KPAs in the Excel with KPAs-KPIs. ATM Master Plan 2020 establishes objectives for the deployment of full U-space services and UAM. A valuable output from the project, based on experiments, will be feedback on the need for updating the Master Plan proposals in terms of dates.

## 3.4 Stakeholders and use cases

System architects often need to describe how some 'system' is used. The system is some man-made thing that usually brings together different elements and requires particular operating procedures. Our system is U-space, the European implementation of UAS Traffic Management. Descriptions of uses of a system are often formulated as "use cases." Use cases are little stories explaining how some goal is achieved in terms of a sequence of system functions. They come as "nominal" and "non-nominal." Use cases are generally named for some tasks being achieved (e.g., "deliver pizza") and the nominal form is a story in which the goal is achieved. The non-nominal forms (and there are always many) are versions in which the goal is not achieved (the customer does not receive the pizza) or not achieved completely (the pizza arrives late and is cold) or not achieved in the intended way (the pizza is delivered by a guy on a motorbike, not by a UAS).

Use cases can be presented in different ways. As they are generally functioning as a means to get a group of people to agree or at least share a common understanding of how the system is being used, the presentation should be adapted to the audience as far as is possible - audience members often have particular concerns and interests.

System architects use different terms to describe the people in terms of the system. In the past a term that has been used is “actor” meaning a person who takes some action. (e.g., “press the green button”) But this idea of an actor is limiting in terms of explaining the person’s motivation. The approach used here is to use two terms.

Stakeholder
Role

The stakeholder is a group, corporate, organization, member, or system that affects or can be affected by an organization's actions. Stakeholders are typically identified by their properties or functions in society. (e.g., pizzeria manager, hungry person)

The role is a way to describe the function or position that someone has or is expected to have in an organization, in society, or in a relationship. Roles should not be defined in terms of the system. “Presser of the green button” is not a useful role name.

The mapping from stakeholder to role can be many to many as the situation determines.

### 3.4.1 General stakeholders

The stakeholders listed here are an expanded group building on the CORUS U-space ConOps volume 3, annex K. Following this list each is described in a subsection.

#### 3.4.1.1 UAM stakeholders in detail

##### 3.4.1.1.1 Air taxi booking service provider

An air taxi booking service is a service allowing the general public to book a journey in an air taxi. It offers mobility as a service (MaaS). This stakeholder may (or may not) be independent of any air taxi operator or any vertiport operator. An example of this stakeholder was Voom[6] which operated until the pandemic offering helicopter transport provided by multiple aircraft operators.

##### 3.4.1.1.2 Air delivery booking service provider

An air delivery booking service is a service allowing anyone who wants to, to book a delivery by air. This stakeholder may (or may not) be independent of any air delivery vehicle operator or any vertiport operator.

[6] https://acubed.airbus.com/projects/voom/

The nature of this stakeholder may not be immediately apparent if the business is focused on delivery of goods and does not draw attention to the means of delivery, for example Aha in Iceland[7].

#### 3.4.1.1.3 UAS operator

A UAM operator is the legal entity, performing one or more UAM operations and is accountable for those UAM operations. A UAM operation is an air transportation operation that carries passenger and/or goods. UAM is taken to include the terms delivery drone and Air Taxi, including what EASA describe as operations type 3[8]. The UAM operator may be a business or an individual or a non-commercial organization. The UAM operator can have several roles that involve it in different U-space use case, including but not limited to the planning of flights and their execution.

A UAM operation includes an operation conducted with an unmanned aircraft or with an aircraft with a pilot on board – the latter is expected to cover the first type of air taxi operations (**Operations type #3 according to EASA terminology**[9]**).**

#### 3.4.1.1.4 UAS command unit operator

As applicable, the organisation holding a Command Unit Operator Certificate (CUOC) and is responsible for ensuring that, at any time in its operating life, the Command Unit, including any installed component, conforms to approved design, specifications and performance, and is in a condition for safe operation of the certified Unmanned Aircraft. The UAS command unit operator can have several roles that involve it in different U-space use case.

#### 3.4.1.1.5 UAS manufacturer / type certificate holder

The UAS manufacturer / type certificate holder has an interest in vehicle and equipment certification processes. The UAS manufacturer or representative may have a role in U-space registration, for example as the provider of serial numbers.

#### 3.4.1.1.6 U-space Service Provider (USSP)

This stakeholder provides one or more of the U-space services.

Under EU regulation 2021/664 [23] U-space service providers providing services to UAS operators must offer a minimum set of services but may "resell" services provided by others. Hence USSP can supply services to each other as well as UAS operators and other aviators.

The CORUS ConOps provided a distinction of USSP into different classes based on a number of criteria. The EU regulation 2021/664 [23] is not really aligned with these so it is interesting to go over the scheme in the ConOps to understand what it contained.

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[7] https://www.aha.is/

[8] https://www.easa.europa.eu/domains/civil-drones-rpas/certified-category-civil-drones

[9] https://www.easa.europa.eu/domains/civil-drones-rpas/certified-category-civil-drones

| Name | Description | Key feature |
|---|---|---|
| Principal USSP | Service provider mandated by the state or a delegated authority to provide some specific services in a given geographic area. | Provides services that (any of)<br>[1] are not provided commercially<br>[2] require some delegated authority<br>[3] may need to be monopolistic |
| Operator USSP | Traffic management service provider whose customers are UAS operators.<br>Typically, Operator USSP provide a suite of services. | Provides traffic management services which are derived from and/or act on flight data and flights.<br>A commercial organisation which competes in the market. |
| USSP | Traffic management service provider. A USSP may specialise in providing particular service(s), either for resale or as an added value. | Provides one or more services to UAS/UAM operators and/or to other USSP. Specialised services may satisfy a niche market. |
| Supplemental data service provider (SDSP) | Provider of data used in UAS flight | Provides data that does not derive from flights, for example weather, terrain maps, population density |
| Infrastructure service provider | Provider of infrastructure such as communications, navigation or surveillance | |

Table 17 Different U-space Service Providers

The U-space regulation 2021/664 [23] takes a slightly different approach

The Principle USSP of CORUS combined unique services like provision of Aeronautical Information coming, together with activities that were inherently unprofitable like recording data to allow accident investigation. The regulation describes a Common Information Service which provides Aeronautical Information while recording data becomes an obligation on the commercial USSP as a cost of operating.

The EU regulation has the same distinction between Operator USSP and USSP but is not explicitly using these names. Within CORUS the distinction was made explicit. The revised CORUS XUAM ConOps should consider how the nomenclature can be harmonised and clarify the distinction between the USSPs providing services to end users (i.e., UAS/UAM operators) and those Service Providers that provide (partial) U-space services to USSP's for resale. A mechanism is required that allows certification of U-space Service Providers that only offer a subset of the services for the sole purpose resale.

The following table maps EU regulation 2021/664 terms to the CORUS ConOps

| CORUS name | 2021/664 name | Remarks |
|---|---|---|
| Principle USSP | Common Information Service Provider | 2021/664 specifies which services are provided.<br>Both foresee that each service has a unique provider and that this/these provider(s) are appointed by the competent authority. |
| Operator USSP | USSP | No distinction is made |
| USSP | | |
| Supplemental data service provider | Not mentioned | |
| Infrastructure service provider | Not mentioned | |

Table 18 U-space Service Providers

#### 3.4.1.1.7 Common Information Service Provider

In U-space, the CISP is concerned with the provision of the necessary information for the well-functioning of the ecosystem. Its objective is to ensure that the information comes from trusted sources and that it is of sufficient quality, integrity and accuracy as well as security so that the USSPs and other users such as ASNPs can use this information with full reliability when providing their services.

CISP are responsible for providing horizontal and vertical limits of the U-space airspace, the requirements for accessing such airspace, a list of available certified USSPs, any adjacent U-space airspaces, UAS geographical zones and static and dynamic airspace restrictions.

As the CISP is responsible for providing any U-space airspace restriction and requirements of such airspace, it makes sense to assume that CISP will also provide those airspace restrictions specific from UAM tailored U-space volumes, such as the activation and de-activation of vertiport corridors or protecting areas and gather any common information to be provided by USSPs managing UAM traffic, making it available to all UAM involved actors. Likewise, in the mid-term the provision of tactical conflict resolution service might be centralised by the CISP, enabling an early implementation of this service.

#### 3.4.1.1.8 Air Navigation Service Provider (ANSP)

An ANSP is a provider of services to manned aviation. ANSP operate today and the main point of interest is that U-space will change the way they work introducing new tasks and new tools.

ANSP in this work is a broad term to include all air traffic services and air traffic management. Notably ANSP includes the airport tower.

In the short term, ANSP’s main responsibility will be to ensure segregation of manned traffic in controlled U-space airspace from UAS. ANSPs will provide situational awareness information about surrounding traffic to the users operating in a specific airspace. The ANSP shall coordinate the interaction between UTM and ATM through the Collaborative Interface with ATC service providing instructions and clearances when needed.

ANSPs are responsible for triggering dynamic airspace restrictions and coordinating through the CIS with USSPs on potential contingencies and emergencies.

In the case of UAM, ANSPs might need to provide tailored traffic information services and set specific contingency and emergency protocols with HPVs given their different CNS and flight performance than those of SPV. Also, as described in Section 4, these vehicles are expected to fly higher, closer to controlled airspace below VLL, and also at airports.

Likewise, ANSPs will have to coordinate with the Competent Authority the establishment of the new U-space airspace volumes tailored for UAM, when such volumes are within the airspace under their responsibility.

| Flight Information Service Officer | Flight information service officers or FISO, provide a flight information service (FIS) to any air traffic that requests it, or requires it. FIS is provided together with ATC service in controlled airspace, but more and more ANSP's have dedicated units (FISO) that provide Flight Information to aircraft in uncontrolled airspace. |
|---|---|
| **TWR runway/Ground Control** | The Tower Runway Controller is responsible for the provision of Air Traffic Services to aircraft within the control zone, or otherwise operating in the vicinity of controlled aerodromes (unless transferred to Approach Control/ACC, or to the Tower Ground Controller), by issuing clearances, instructions and permission to aircraft, vehicles and persons as required for the safe and efficient flow of traffic. The Tower Runway Controller will be assisted by arrival, departure and surface management systems, where available.<br><br>The Tower Ground Controller is part of the controller team responsible for providing an Air Traffic Service at controlled aerodromes. His main task is the provision of ATS to aircraft and vehicles on the maneuvering area. He must also ensure that airport maintenance vehicles carrying out necessary improvements on an active maneuvering area do not interfere with the movement of aircraft. |

Table 19 ANSP roles

#### 3.4.1.1.9 Aeronautical Information Management Provider (AIMP)

The AIMP is likewise an existing actor in manned aviation whose tasks and tools will change slightly as U-space is introduced. Aeronautical Information Management is the task of producing the Aeronautical Information Publication, a collection of data describing the geography and procedures of for flying in a given country. UAS Aeronautical Information Management is the equivalent for U-space and overlaps with AIP with some features in common, though DAIM adds UAS specific information concerning very low level

#### 3.4.1.1.10 (Airfield/Airport) Aerodrome operator (civil, Military)

Aerodrome generalises any size of airfield or airport. The aerodrome operator is distinct from the ANSP and has business concerns and legal responsibilities which make them interested in / concerned by UAS flight and U-space procedures.

#### 3.4.1.1.11 Vertiport operator

A vertiport operator will provide services at a vertiport. Service provision might vary between vertiport for private use and public use. The vertiport operator will contribute to the development of rules regarding vertiport availability and priority given to specific fleet operators or mission type (e.g., scheduled operations).

Vertiport operators will be responsible for overseeing ground safety, security and boarding procedures and charging or refuelling, although this responsibility could sit with fleet operators or other third parties.

The vertiport operator will provide information regarding the operating status of their vertiport to various stakeholders through the CIS, including the availability of FATOs, stands (where applicable), personnel and charging (e.g., electricity).

#### 3.4.1.1.12 Cargo-hub operator

If Vertiports are considered to be passenger airports, then “cargo-hub” is an equivalent term for an aerodrome providing services to UAS flights carrying cargo. The operator of a cargo hub has the same responsibilities as a vertiport operator; operating the facility in a safe and efficient manner including the scheduling of arrivals and departures as well as supplying U-space with information about the aerodrome’s status and capacity to accommodate incoming aircraft.  Generic term to encompass national or local aviation authority.

#### 3.4.1.1.13 Competent authority

Generic term to encompass national or local civil aviation authority, or some entity delegated by them.

The competent authority expects that U-space ensures aviation law is followed, ensures safe and secure operation of all aircraft, promotes the minimisation of environmental impact and anticipates deployment challenges. The competent authority has a role in regulating U-space.

The Competent Authority will be responsible for certification of all elements that are considered to be safety related. They certify and oversee the USSPs and the CIS provider(s) with principal place of business in one of EASA Member States. The Competent Authority will have to certify UAM Operators and UAS operators (if requested)

Competent Authorities will be responsible for their certification and oversight, as well as, carrying out the necessary audits, assessments, investigations and inspections as established in their oversight programme.

#### 3.4.1.1.14 Authority for safety and security (police, fire brigade, search and rescue orgs)

Authorities involved in preparation and supervision of the operations of law enforcement such as police, security, military, homeland security that are responsible for law enforcement methods.

Publish danger areas in real time – relating to medical evacuation, police helicopter or similar

(Police only) Develop law enforcement methods related to illegal UAS use.

#### 3.4.1.1.15 Emergency Responders

Organisations involved in preparation and execution of emergency operations such as fire brigade, emergency, first aid, Search and Rescue (SAR).

May publish danger areas in real time – relating to medical evacuation, police helicopter or similar

#### 3.4.1.1.16 Local and specific authorities

Local authorities - city / region / prefecture / county / canton / state - support the definition of operating procedures and rules. They influence applications of U-space to urban needs – for example active measures limit noise "dose" in any one place, or coordination of transport by ground and air.

Responsibilities:

- Supports the definition of operating procedures and operational rules and limitation
- Explores applications of U-space to urban needs – for example active measures limit noise "dose" in any one place
- publishing VLL hazards as they arise – cranes, building work, etc.

Specific authorities – harbour / river or waterway / national park / prison / military / … have a similar role of ensuring U-space and UAS operations are in accordance with the particular activities and conditions in the region for which they are responsible.

Any authority expects U-space develops methods to support among the others:

Safety assurance
Security and privacy assurance
Enforcement of UAS regulations
publishing VLL hazards as they arise – cranes, building work, …
appropriate and optimal use of UAS in their domain
derive added value from data generated by routine UAS operations

#### 3.4.1.1.17 UAS delivery Clients

The clients of the delivery service have the goods that need to be delivered. They have a business arrangement with the UAS operator. They may host a UAM Aerodrome, and either be its operator or have a business arrangement with the operator of the landing site.

#### 3.4.1.1.18 UAS delivery Customers

The customers of UAS delivery receive goods. They benefit from the speed and efficiency of UAS delivery. They may host a Landing Site, and either be its operator or have a business arrangement with the operator of the landing site.

Their interaction with U-space will focus on landing-site setup and operation.

#### 3.4.1.1.19 Air-taxi passengers

The air-taxi passenger rides in an air taxi. Their interaction with U-space is generally indirect.

### 3.4.1.2 Roles

#### 3.4.1.2.1 remote pilot

Stakeholder: UAS Operator

The remote pilot is a natural person responsible for safely conducting the flight of one or several UAs in accordance with applicable rules and regulations and established procedures by operating the flight controls, either manually or, when the UA flies automatically, by monitoring its course and remaining able to intervene and change its course at any time.

The remote pilot is licensed and registered in the pilot registry, according to the typology of UAS used and the type of operation performed.

Remote Pilots make use of services provided immediately prior to and during flight:

- Traffic information service

In addition, additional services may be consumed:

- Tactical conflict resolution
- Emergency management
  - warnings of other flights in the vicinity which are out of conformance
  - warnings of changes of airspace availability – for example changes to accommodate manned aircraft in emergencies
  - assistance during emergencies
- Collaborative interface with ATC
- Weather information
- Monitoring of infrastructure
- Conformance monitoring

The remote pilot uses their own surveillance data and these tactical services to ensure safe and expeditious operation of the flight.

The state may require the remote pilot to be registered with U-space registration services. This registration may encompass their training level(s), experience, certification, insurance, and other personal data. Similarly, depending on the state and the details of the flight, the pilot's identity may be recorded in the operation plan. U-space may provide such pilots access to records of previous flight hours by means of the electronic logbook service.

The remote pilot is always a person working with a machine. The exact division of tasks between the person and the machine may vary. The whole is referred to as the "UAS pilot function" although responsibility remains with the human pilot - in general. In the most extreme case, all in flight information is processed directly by the machine and the human has an oversight function.

UAM vehicles are expected initially to be controlled by a pilot on board. In a next phase, some UAM vehicles will include a remote, ground-based pilot who is in command of a single or multiple UAM vehicles once the appropriate standards and certification criteria are defined. At some point, the term pilot may no longer be applicable and other terms such as monitoring pilot or supervisor may be used. Some UAM vehicles are expected to achieve full autonomy at a point in the future. The UAM environment will include a mix of piloting mechanism that include onboard pilot and autonomous operations.

Responsibilities:

- Responsible for the safe execution of the flight according to the U-space rules, whatever it is recreational or professional with one of the different license levels, according to the typology of the drone used.
- In charge to execute the drone flight through the Ground Control Station (GCS)

#### 3.4.1.2.2 UAS Crew

Stakeholder: UAS Operator

Under the term UAS Crew, the following roles are identified:

- Remote pilot is the person manipulating the controls of the UA and is in control of the flight path either directly or through controlling the on-board automation.
- A Visual Observer or UA Observer is a trained and competent person designated by the operator who, by visual observation of the unmanned aircraft, assists the remote pilot in the safe conduct of the flight

#### 3.4.1.2.3 UAS operator representative

Stakeholder: UAS Operator

A person representing a UAS Operator, the operator being registered in operator registry.

The UAS pilot (see above) works for the UAS operator and may be the same person as the UAS operator representative, but the two are described separately to aid understanding.

Interaction with U-space:

- Mission planning. The UAS operator representative is responsible for mission planning, which can be done manually or supported by automation, whereas the UAS pilot or crew executes it. This mission planning task includes all pre-flight activities such as SORA if required as well as obtaining any permits to enter zones or similar.
- Receiving tactical warnings that impact the flight and making tactical changes to the operation plan if needed
- Ensuring the flight complies with rules and regulations.
- Post flight activities – audits, inquests, etc

The UAS operator representative uses many U-space services in the pre-flight phase including but not limited to geo-awareness, operation plan preparation, the environmental services: weather, geospatial information, maps of population density, electromagnetic interference, communication coverage and navigation coverage.

#### 3.4.1.2.4 ATS Operator

Stakeholder: ANSP

ATS should have access to the air-situation generated from e-identification reports, with the usual controller-working-position tools to filter out those of no interest, give conflict alerts and so on. Main roles: Air Traffic Controller, Tower Supervisor, Tower Runway controller, Tower Ground controller, (A)FIS and RIS Operator.

How he/she interacts: User involved to achieve the interface with ATS.

### 3.4.1.2.5 Police or security agent

Stakeholder: Authority for safety and security

Security actors would be interested in the air situation, to identify operators and to apply relevant procedures.

Law enforcement Unit, responsible to develop law enforcement methods related to illegal UAS use.

How he/she interacts: User of registration, e-identification and interested in the situational awareness and monitoring alerts.

### 3.4.1.2.6 Pilot

Stakeholder: Airspace User

There are two type of pilot roles with regards to U-space:

This is about the pilot on board an aircraft, for a remote pilot, see 5.1.2.1 UAS remote Pilot.

The Pilot on-board is a natural person responsible for safely conducting the flight in accordance with applicable rules and regulation and established procedures by operating the flight controls, either manually or, when the aircraft flies automatically, by monitoring its course and remaining able to intervene and change its course at any time.

The pilot is licensed and registered in the pilot registry, according to the typology of aircraft used and the type of operation performed.

The rules and procedures under which pilots-on-board can operate in U-space and the way they will interact with U-space will need to be established.

### 3.4.1.2.7 Citizen

Stakeholder: The general public

Generic person who wants to be aware of UAS operation for any reason, for example because they believe UAS are impinging on their privacy.

How he/she interacts: a kind of authorised viewer of air situation and able to report about events.

### 3.4.1.2.8 Registrar

Stakeholder: Civil Aviation Authority, USSP, agent there-of

A registrar has a legal duty to operate a registry securely, reliably and adequately. The registrar will be a legal person, probably with staff.

How he/she interacts: they maintain the registry and may intervene in case of problems in the registration.

The registry is accessed by accredited registry updater and Accredited registry reader who respectively change or read the data.

#### 3.4.1.2.9 UAS Aeronautical Information Manager

Stakeholder: ANSP, AIMP

A body that may be independent of the Aeronautical Information Office and allows UAS specific aeronautical information to be registered, combines the information, assesses it, and then publishes the result.

#### 3.4.1.2.10 UAS specific aeronautical information originator

Stakeholder: Authority

The person or representative of the organisation that creates UAS specific aeronautical information. This actor is accredited and trained in the processes of creating, updating or deleting UAS specific aeronautical information.

This is reflecting the possibility to have a different originator of "constraints" for UAS.

#### 3.4.1.2.11 Authorised viewer of air situation

Stakeholder: The general public, Aviation User, Civil aviation Authority, UAS Operator, …

This groups actors like U-space operators, city authorities and some others such as researchers who can be trusted with the commercially sensitivities of the overall air-situation.

How he/she interacts: Who may be allowed to have a situational awareness according to privileges and privacy.

#### 3.4.1.2.12 USSP Supervisor

Stakeholder: USSP

Being the level of automation high, it is not envisaged the role of "Controller". Nevertheless, it has been envisaged a person who will arbitrate or impose a solution in some cases (in case of escalation required) who may intervene manually imposing ad-hoc solutions or taking over other USSP roles.

#### 3.4.1.2.13 Airspace access authorization Workflow Representative

Stakeholder: Civil Aviation Authority, Local Authority, ANSP, …

A person having the rights to participate in the authorization workflow (e.g., when local authority/USSP/NAA must express the approval or does not object).

#### 3.4.1.2.14 Capacity Authority

Stakeholder: ANSP, USSP, Civil Aviation Authority

A person receiving warning and alerts from the monitoring service

Responsible for setting the minimum safe operating conditions that determine the capacity of an airspace or an aerodrome due to safety

Responsible for setting noise level limits that limit capacity due to noise footprint and "dose"

#### 3.4.1.2.15 UAS Manufacturer Representative

Stakeholder: UAS Manufacturer / type certificate holder

It is responsible for UAS certification (if appropriate) and supplying registration information and using the system for all other obligations the UAS manufacturer must comply (e.g., UAS model/characteristics/performance publication).

#### 3.4.1.2.16 Airport Operator Representative

Stakeholder: Aerodrome Operator

The Airport Operator Representative is responsible for interacting with the system to protect airport perimeter (counter-UAS) and to contribute to the safe integration of UAS in the airport operations, including optimisation the use of resources, such as arrival and departure management.

The airport operator will be responsible to establish proper coordination with other relevant stakeholders.

#### 3.4.1.2.17 Vertiport operator representative

Stakeholder: Vertiport Operator

*This role has many of the same high-level interests as the aerodrome operator representative. However, the details of how these are achieved and the level to which they include U-space will vary.*

The vertiport Operator Representative is responsible for operating the vertiport in accordance with established rules and regulations and optimising those operations including arrival and departure management to make best use of limited resources like airspace, charging capacity and parking stands.

The vertiport operator will be responsible to establish proper coordination with other relevant stakeholders.

### 3.4.1.3 Airport shuttle, Type of aircraft involved

The following classes of aircraft are involved in UAM or operating in nearby airspace:

| Aircraft | EASA UAS ops type Classification | Pilot on board | Use of U-Space Services | Level of automation | Notes |
|---|---|---|---|---|---|
| **Manned VFR** | | Yes | No | None | GA, HEMS etc |
| **Manned VFR** | | Yes | Yes | None - low | Integrating manned aviation in U-space, advanced U-space operations |
| **Piloted UAM**[10] | Type #3 | Yes | Yes | None | Initial phase, like helicopter operations |
| **Piloted UAM** | Type #3 | Yes | Yes | Yes | Initial U-space operations for UAM |
| **Remote piloted UAM** | Type #2 | No | Yes | Remotely piloted, supported by automation<br><br>Some flight phases fully automated | Advances U-space operations for UAM |
| **Remote piloted UAS** | Type #2 | No | Yes | Remotely piloted, supported by automation | |
| | | | | | |

Table 20 Types of aircraft involved in UAM operations

For the definition of the EASA operation types, see section 3.2.2.1

### 3.4.2 Airspace stakeholders

[10] "Piloted UAM" shall be understood in the table below as "Piloted UAS performing a UAM operation".

*This section lists and defines stakeholders which have links with manned operations (e.g., airport, hospital, police) in the lower airspace that will be impacted by UAM operations. This should be limited to those operating at low altitude above urban areas, other than in those in the terminal areas of existing airports.*

- Helicopter Emergency Medical Services (possibly assisted by drone(s) in disaster recovery operation)
- Police
- Journalism, sports coverage
- Photography & filming
- Tourism, sight-seeing (depends on the definition of low altitude)
- Paragliding, hang-gliding, ultralight in some urban areas (e.g., Hármashatárhegyi repülőtér and Újlaki-hegy in Budapest).
- Special events, public spectacles military parades – 'Red Bull' air races, aerobatics, flypasts, displays
- VFR pilot

### 3.4.3 UAM Use cases

#### 3.4.3.1 Introduction

This section aims to propose an exhaustive list of the different use cases of operations in U-space which would potentially be conducted in urban environment. This is introduced over a generic description of the use case with the type of operation and short description, and a brief description of the U-space services usage through each phase of one operation, from the organization set up phase to the post-flight.

#### 3.4.3.2 Operation types overview

| Category | Description | Type | Description |
|---|---|---|---|
| **Passengers transportation** | *Optionally manned drones with the transportation of people as primary purpose* | Air Taxi | Providing point-to-point passenger transportation, possibly without fixed routes and/or schedule |
| | | Scheduled Shuttle | A shuttle service to transport passengers between vertiports over fixed routes.<br><br>Shuttle services to/from/between airports may involve interactions with other aviation. |
| | | Air Ambulance | Travel to/from the hospital for emergencies and potentially hospital visits |
| | | Sight seeing | Providing passengers with an aerial view. |
| | | Firefighter Vehicle | Quick response firefighting emergencies enabled by air mobility travel |

| Category | Description | Type | Description |
|---|---|---|---|
| | | Police Vehicle | Law enforcement individuals enabled by air support for daily routine tasks and emergencies management |
| **Movements of goods** | *Unmanned drones with the collection and delivery of physical objects as only purpose* | Goods delivery to the public | UAM aircraft and drones to deliver mail, food, and general goods in relatively low volumes to a range of destinations. |
| | | Goods delivery between business | Delivery of cargo between fixed points. These deliveries may take-off and land from and to UAS aerodrome facilities. |
| | | Medical/Urgent delivery | Delivery of urgently needed medical items and organs between hospitals |
| | | Aerial Warehousing | Using aerial craft to facilitate warehousing and logistics management |
| | | Intra-company goods delivery | Deliver legal/business documents, replacing inter office mail and traditional courier services |
| **Visual and data acquisition** | *Unmanned drones with the collection or streaming of data as only purpose* | Mapping | Mapping based on photogrammetry and classification of the imagery. |
| | | Survey | Photogrammetry to assess stocks of building materials stocked in heaps: sand, gravel, etc. |
| | | Archeology & Heritage mapping | Detection of & Diagnosis of the status of historical sites through acquisition of information via drones the aim is to create a digital map. |
| | | Infrastructure mapping and inspection | Inspection and 3D mapping of infrastructures (e.g., railway lines, oil & gas etc.) including detection of potential hazards. |
| | | Weather monitoring | Monitoring of atmospheric pressure and climate conditions to help weather forecasts |
| | | Inspections of structures | Periodical/recurrent monitoring of structures, for example bridges, towers, wind turbines, cranes. |

| Category | Description | Type | Description |
|---|---|---|---|
| | | Inspections of dangerous areas | Inspection of remote and dangerous areas reducing people involvement and costs |
| | | Search and rescue of missing people | Use drones to help in searching activities for missing people or fugitives |
| | | Land, sea and air traffic control | Monitor and control traffic situation on land, in harbors, on waterways, at sea and in the air |
| | | Security Patrolling | Substituting land patrolling activities with drones capable of patrolling wider areas with lower risks |
| | | Crowd events surveillance | Crowd monitoring during large events to detect or monitor emergency situations |
| | | Photos & Videos | Aerial filming and photography |
| | | Advertising tech | Data collection to support advertising activities (e.g., shopping windows, queue analysis) |
| | | Virtual Tourism | Exploration of touristic areas from home thanks to virtual reality |
| | | Journalism | use of drones for newsgathering purposes. Drone photos and videos allow journalists to make their reports more insightful and innovative. |
| **Aerial Work** | *Unmanned drones performing physical interactions with the world around them while in-flight* | First emergency support | Support emergency situations with medical and other professional tools (e.g., defibrillator) outside of the hospital perimeter |
| | | Anti-drone solutions | Use drones to monitor and intervene in case of unauthorized UAS activities |
| | | Remote medical visits | Reach remote areas to visit patients who can't move from their location |
| | | Harvesting | Reaching less accessible farmland for planting, harvesting, potable water |

| Category | Description | Type | Description |
|---|---|---|---|
| | | Crime fighting | Intervene in case of criminal activities with law-enforcement tools |
| | | Firefighting | Active support of firefighting activities using dedicated pumps (e.g., water spraying) |
| | | Landscaping/gardening | Assist gardening activities with drones to reach higher areas reducing risks for people |
| | | Trash collection | Replacement of trash trucks, hazardous waste disposal[11] |
| | | Cable installation | Installation of cables in difficult to reach areas |
| | | Anti-icing measures | Replacing winter snowplow and salt trucks |
| | | Pest control | Use drones for decontamination of areas from parasites and insects |
| | | Flying billboards | Use of drones as flying billboards for advertising |

Table 21 List of operation types in urban environment

#### 3.4.3.3 UAM Operation Lifecycle

**Pre-operational phase**: any general pre-operational activities related to the management of UAM and independently to the single flight: there are encompassing registration, publication of UAM corridor, operational of UAM.

Generic steps for the phase:

- Registering / obtaining approval as operator (UAM Operator, CAA)
- Registering aircraft
- Establish UAM Corridor if necessary (USSP, ANSP, UAM Operator, Cities, Vertiport operator, Civil Aviation Authority)
  - Including validation / approval by CAA
  - Publication of new airspace structure in AIP
  - Publication of Arrival/Departure/Holding procedures for each vertiport in AIP
- Establish contractual agreements between involved parties:
  - Including agreeing between USSP, ANSP, Vertiports.

[11] This use case requires carriage capability which is clearly not expected in short or mid terms

- Establishing agreements with the city, (public) transportation systems, citizens, etc.

- Establishing/offering booking access (App, Ticket store, etc.)

**Pre-flight**: Any activity related to the preparation of the individual flight prior to departure, including vehicle pre-flight checks, vehicle charging, flight planning, boarding passengers and/or cargo.

Generic steps for the phase:

- Flight planning
  - Obtain weather information
  - Submission of request
  - Conflict free check
  - Authorisation provision (if required)
  - Pre-Flight info (e.g., weather info, NOTAM)
  - Pre-flight briefing
  - Flight acceptance
  - Availability of the vertiports
- Preparing vehicle for flight (no U-Space services involved, unless flight is cancelled)
  - Vehicle Pre-flight check
  - Vehicle charging and / or fuelling
- Boarding passengers and/or cargo (no U-space services involved)
- Perform final Pre-flight checklist --> ready to fly

**Take-off**: the period in which the UAM vehicle physically departs from the location A (Vertiport, stand, runway, airfield, etc.) up to the point at which it reaches cruise altitude. Departure includes taxi, take-off and initial climb.

Generic steps for the phase:

- Obtain clearance to moving to take-off area (if needed)
- Obtain take-off clearance, when applicable
- Take-off from vertiport / operating site / airfield
- Enter the UAM corridor if one has been set or enter U-space airspace

**En-route**: The point at which the vehicle reaches cruise altitude up to the point at which it begins the approach to the destination location/point (Vertiport, stand, runway, airfield, etc.).

Generic steps for the phase:

- Fly according to the flight plan
- Execute conflict resolution instructions
- Obtain real time weather information
- Informing passengers about journey (e.g., weather, ETA, changes, delays) or customer waiting for a cargo delivery.

**Approach**: the period between the UAM vehicle aligning with the optimal track to the assigned destination and reaching the decision point (or decision altitude/flight). Descent is expected to occur within this phase. The UAM pilot will elect to either continue or land or climb to a safe manoeuvring altitude (executing a missed approach).

Generic steps for the phase:

- Confirm landing area is free from conflicts
- Execute approach procedures in case of uncontrolled airfield
- Request clearance in case of controlled airfield
- Execute conflict resolution instructions

**Landing**: the point at which the decision is made to continue to the destination from the decision point (or decision altitude/height) until the UAM vehicle lands.

Generic steps for the phase:

- Execute landing procedures,
- Execute conflict resolution instructions.

**Post flight**: the period after the UAM vehicle stops moving, the flight closes and securing the vehicle commence. Post flight activities typically includes de-boarding passengers and/or cargo and vehicle servicing activities.

Generic steps for the phase:

- Confirm landing
- Perform post-flight check list
- Disembarking passengers and/or cargo

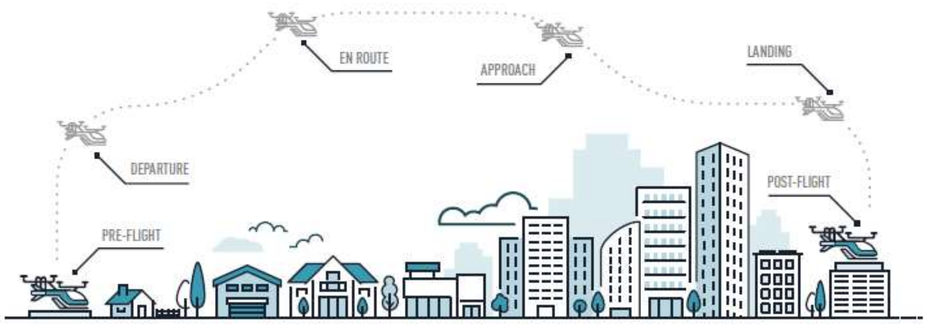


Figure 8 Flight phases representation [38]

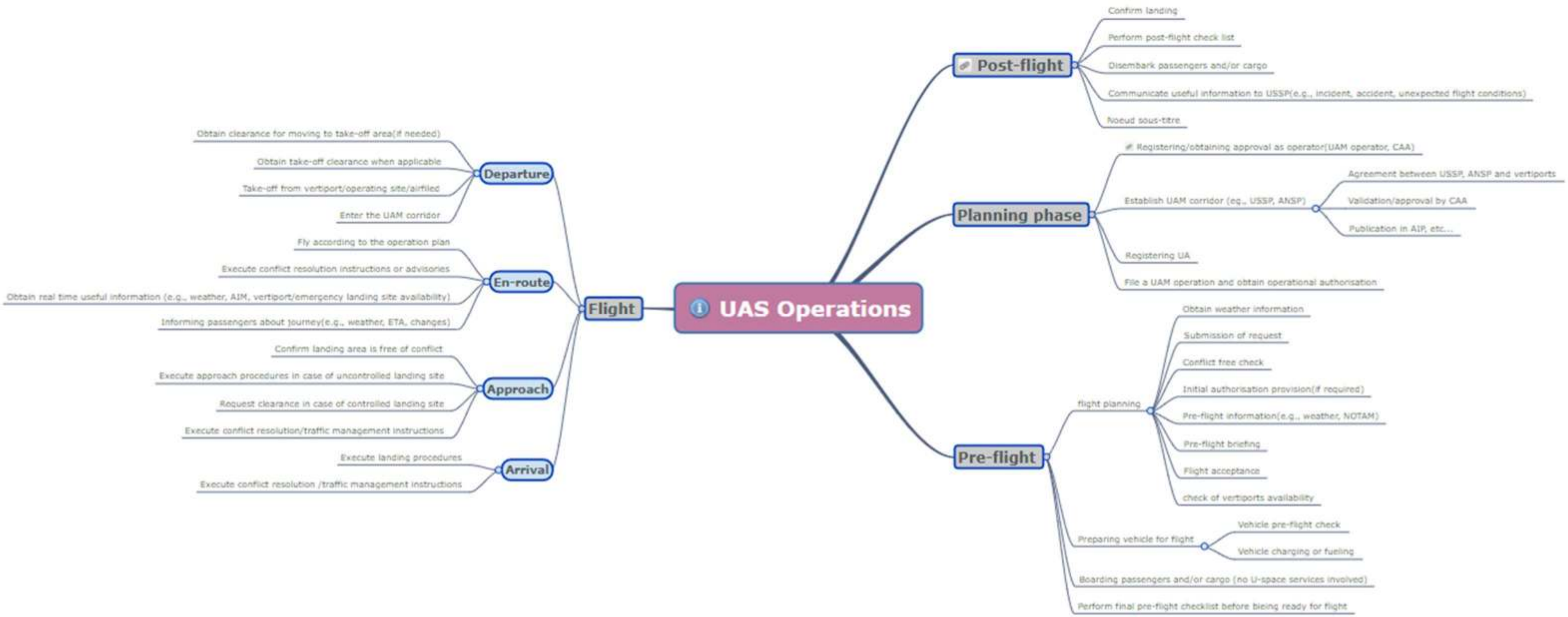


Figure 9: Overview of the UAS Operation lifecycle phases and associated activities

### 3.4.3.4 Use cases in nominal situation and linked U-space services

The table attached shows the use of the U-space services throughout the operation.

CORUS XUAM
U-space services.xls›

For graphical use case diagrams of the U-space services, see Appendix B.

## 3.5 Ground environment

The development and implementation of urban air mobility operations requires a holistic understanding of the ground environment. Introducing new mobility solutions into cities, offer many opportunities and benefits to citizens, but also brings challenges that need to be faced and addressed.

This chapter will first look into the aspects to be considered when entering the urban environment, and how UAM can not only be introduced, but also well integrated into the existing transport network and city landscape. Subsequently, the challenges – weather conditions, noise and privacy constraints - stemming from operations in urban zones will be elaborated upon. Later on, the ground infrastructure will be addressed; this is a critical element/enabler of UAM operations to be scaled-up. This chapter concentrates on take-off and landing segments, as the 'en-route' infrastructure is presented in chapter 3.9

### 3.5.1 General considerations and challenges

Urban Air Mobility imposes challenging conditions on the planning and the actual execution of the UAM operation itself when operated in an urban environment. A non-exhaustive overview of general considerations and challenges is provided in this chapter, including but not limited to the discussions about the lack of a definition of the term "urban" that distinctly describes the system boundary of UAM, urban obstacle scenery and weather peculiarities, as well as the overall integration of UAM into the city landscape, the existing public transport network, and into society in general considering noise and privacy issues.

#### 3.5.1.1 Definition of "urban"

Since the word "urban" (from the latin "urbs/urbis" – city) is part of the initialisation "UAM", understanding what a city is, which areas are urban and which are rural, what a commuting zone for a city is, etc. is crucial for the development of UAM operations. The French National Institute of Statistics and Economic Studies (INSEE) provides the following definition for urban areas [40]:

*A "[large] urban area" is a group of touching municipalities, without pockets of clear land, encompassing an urban centre (urban unit) providing at least 10,000 jobs, and by rural districts or an urban unit (urban periphery) among which at least 40% of [the] employed resident population works in the centre or in the municipalities [drawn to] this centre.*

*The 2010 zoning of urban areas distinguishes between:*

- *"Average[-sized] areas", a group of municipalities, without pockets of clear land, constituted by a centre [with] from 5,000 to 10,000 jobs, and by rural districts or urban units among which at least 40% of the [the] employed resident population works in the centre or in the municipalities which are [drawn to] this centre.*

- *"Small areas" [are] a group of municipalities, without pockets of clear land, constituted by a centre [with] from 1,500 to 5,000 jobs, and by rural districts or urban units among which at least 40% of the [the] employed resident population works in the centre or in the municipalities [drawn to] this centre.*

The Directorate-General for Regional and Urban Policy of the European Commission, together with the Organisation for Economic Co-operation and Development (OECD) gave definitions of "urban" and "rural" in a short 2012 paper [41]. A 2019 working paper [42] defined detailed algorithms for identifying many more typologies of functional urban areas, encompassing their economic and functional extent based on daily population movement patterns; a crucial input to UAM.

In 2014, the EU and the OECD issued a working paper [43], which went into force in March 2020 [44] et [45], defining new degrees of urbanisation. On a finer scale, cadastral maps record categories of all real estate, such as warehouse, trade, cultural, hospitality, industrial, sports, no-use, offices, historical, religious, shows, residential, and health. Similar to the functional urban areas, these categories help understand where people are located as a function of the time of the day. This is important in UAM for at least two reasons:

(1) defining transport demand and

(2) estimating the ground risk of urban flights (see below).

Cadastral maps are generally publicly available. However, they are usually only available in the national language and have different interfaces.

A consolidated definition needs to be defined within the U-space community.

### 3.5.2 Obstacle scenery

Terrain is a natural obstacle that any aircraft operation must consider. Planning a flight following a constant height above ground level (AGL) is a difficult task if there is a complicated terrain profile (see blue profile on the left of Figure 10). On the contrary, maintaining the same altitude above mean sea level (AMSL) may be impossible for the entire duration of the mission because of terrain relief (see red profile on the right of Figure 10). In the case of urban areas, a complex obstacle scenery will make the flight- planning task even more complex.

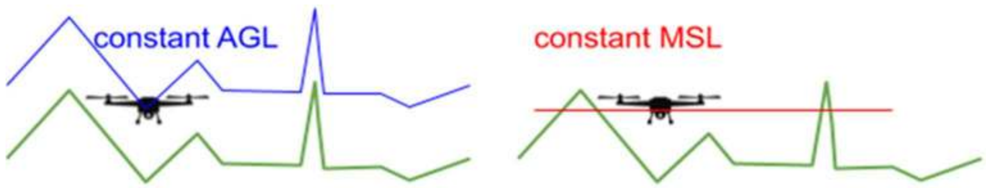


Figure 10 Neither AGL nor MSL alone will work everywhere [48]

Moreover, according to Commission Implementing Regulation (EU) 2019/947 [17] section UAS.OPEN.010, any unmanned aircraft operating within the open category "*shall be maintained within 120 metres of the closest point on the surface of the earth"*, except when flying within 50m from an artificial obstacle more than 105m tall, where it may fly up to 15m above the obstacle (if requested by the person/organisation responsible for the obstacle). The same maximum height of 120m is specified also for both STS's and 2 out of 4 PDRA's (see Tables 1 and 2 of GM1 to AMC1 Article 11 Rules for conducting an operational risk assessment). The Part A of the annex adds that *"the measurement of distances shall be adapted accordingly to the geographical characteristics of the terrain, such as plains, hills, mountains."* The obstacle scenery of UAM flights can change significantly if we compare different cities in different countries.

As presented in sections 5.1.3 and 5.3, the typical use cases (passenger transport, delivery and inspection work) flying under such height restrictions will need to face natural obstacles and terrain, especially in the case of UAM, with many artificial obstacles, as can be seen in any European city skyline. To reduce risk, the Commission Delegated Regulation (EU) 2019/945 [28] also mandates that the vehicles shall be "equipped with a geo-awareness system that provides an interface to load and update data containing information on airspace limitations related to UA position and altitude imposed by the geographical zones".

In consequence, the terrain profile is a vital piece of information for U-space. Care must be taken, however, to ensure coherent altitude measurement in different parts of the urban area, in which other airspace users may also be present. Below 5,000ft, manned aircraft traditionally use barometric height that provides an altitude based on the difference between the air pressure where the aircraft is compared with that measured at a reference point of known altitude on the ground, using a standard atmospheric model. UAS generally use a value provided by a satellite navigation related to the WGS84 ellipsoid, often translated so that the take-off point is considered to be zero height.

Digital terrain models (DTM) that provide altitudes for the bare ground, and digital surface models (DSM) that provide altitudes for the surface including buildings, vegetation etc., can be based on ETRS89, WGS84, using different geoid corrections or not, etc. Height itself can be defined by orthometric or ellipsoidal means. The difference between these comes from the reference system, which can be a geoid (which is based on the Earth's gravity) or an ellipsoid (a mathematical simplification of the geoid). Figure 11 shows an example of this and also includes the terrain, which can be above - this is the general case- or below the reference. Conventional aviation estimates their altitude from the orthometric height using atmospheric pressure, while UAs navigate using the WGS84 ellipsoid as the reference for their altitude.

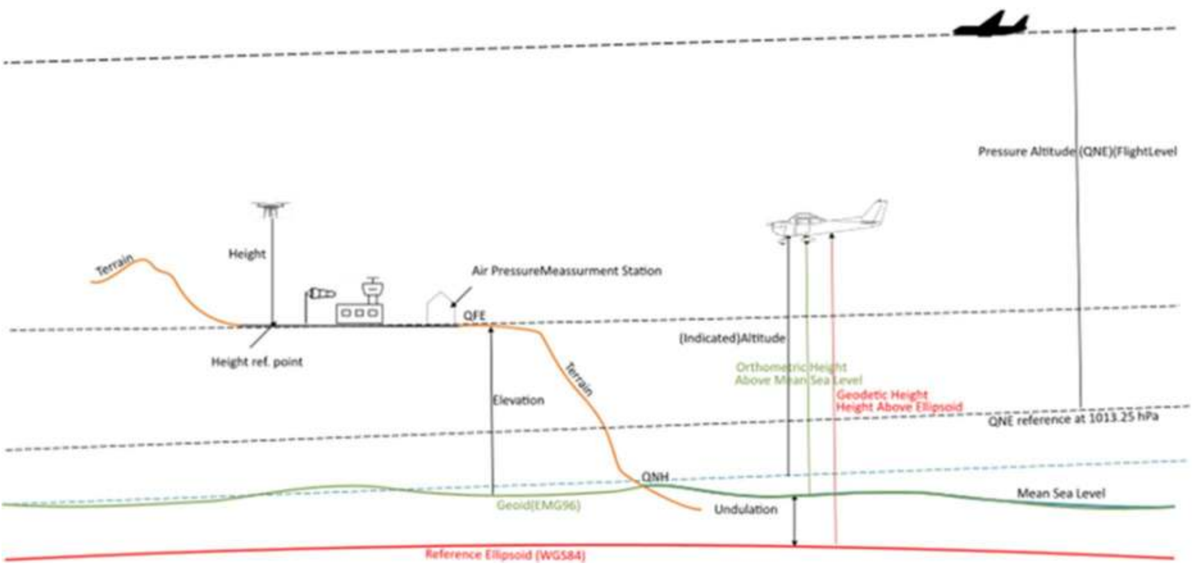

Figure 11 Height and altitude references (figures 2 of CORUS ConOps [4]))

There is obviously a need for a common frame of reference for height, and this issue was identified as early as the 1st CORUS Exploratory Workshop [46] . The EASA/EUROCONTROL discussion document [47] on defining a common altitude reference system (CARS) explored the different ways of measuring height and concluded that no on-board altimetry system was sufficiently accurate, therefore, U-space must step in to help define the altitude/height of flights. The preferred solution among the potential ones studied was that each airspace user should use the approved altimetry system best suited to the aircraft, airspace, or certification requirements, and that U-space functionalities should be used to translate these to a common reference. This is currently the subject of the ICARUS SESAR ER4 project. While some initial work on using U-space for CARS has been undertaken[48], the issue is far from being resolved and is also discussed in the "Airspace" section (see chapter 7).

In summary, since UAM ground infrastructure will mostly be placed within city boundaries with densely populated and built-up areas, the UAM operating environment will be small in space and great in complexity. UAM faces more complicated obstacle geometries more frequently than conventional fixed-wing aviation does due to proximity to the ground and smaller spatial scales. Firstly, the UAM operating environment is filled with various types of constraints: terrain and buildings, special flight rules areas and temporary flight restrictions, airport procedures, etc.[49] . Secondly, the impact on, and the rights of, inhabitants must be considered.

#### 3.5.2.1 Urban weather

Low altitudes over densely populated and built-up areas are complex operating environments for aircraft in terms of obstacles and corresponding regulations, but also face different weather phenomena compared with those usually experienced by aviation. The World Meteorological Organization (WMO) defines an urban climate as a "local climate that differs from its surrounding climate due to effect of buildings and emissions". […] The urban heat island is a typical feature of the urban climate. It is characterised by a difference in temperature between the hotter city and its cooler surrounding countryside and reaches its maximum in very sunny and low wind weather conditions. This difference can be as much as 10 Kelvin in large cities" [50].

According to[50], additional variations can be seen in air humidity, radiation, wind, noise emissions and air. The overall structure of the city including but not limited to the characteristics of the buildings (geometry, substance, facing), domestic heating, public/individual traffic and industry are main contributors to urban climate. Comparing an eVTOL e.g., a Volocopter 2X with a maximum take-off mass of 450 kg [52] with a helicopter e.g., an Airbus H160 with a maximum take-off mass of 6,050 kg [53], UAM eVTOL vehicles are not only much lighter, but are also at higher risk of being affected by the weather specifics caused by the urban environment. Rapidly changing weather conditions, potentially (hazardous) wind flow around buildings/vertiports and the appearance of micro-weather can challenge the feasibility of UAM operations at anytime. Furthermore, [VTOL_steiner] highlights regional and seasonal wind variations, gusts, and turbulences within and above cities as challenges for ground and air operations.

The extent to which specific and rapidly changing weather conditions degrade operating hours needs to be evaluated for every operating environment and the European UAM market in general The report 'An Assessment of the Potential Weather Barriers of Urban Air Mobility (UAM)' by [54] investigated the average number of weather-impacted hours for target American urban areasconsidering amongst others New York, Miami, Dallas, Denver and San Francisco. It concluded that an average of 6.1 hours/day during the winter, 7.3 hours/day in the spring, 2.9 hours/day in summer and 2.2 hours/day in the fall wereaffected by unsuitable weather conditions. Thus, the greatest number of hours per day affected by weather come during the winter and spring seasons [54].

To define operational limits and procedures on how to react to specific weather conditions, we first need to know in detail what we are going to face which requires comprehensive weather data collection in urban areas and at low altitudes. “It is recognised that the weather information for UAS operations may be different from the one provided by today’s meteorological service providers; in particular, as regards support of operations under the ‘open’ and ‘specific’ categories. UAS can fly near buildings and in areas where current aeronautical meteorological information is not always provided.” [55]

More information is needed regarding winds at ground level and above ground level (turbulent eddies, extreme and rapid changes in wind speed/ direction, micro-burst translation), temperature (heat island effect, effects on density altitudes), icing, turbulences and thermals [56].

The vertiport, an independent infrastructure component but an active part of U-space, can be one of the weather data collectors providing essential and continuous weather surveys of the vertiport and its vicinity to the U-space community. Additionally, each UAS (e.g., air taxi) can contribute to the data collection during its operation, which enhances the baseline for complex studies of urban weather phenomena. It is necessary to understand the operating environment of a UAS better, to always ensure safe operations and to improve the overall planning process by reducing uncertainties.

#### 3.5.2.2 UAM integration

UAM being introduced into metropolitan areas can either compete with or complement existing public transport modes and networks. The way of integrating a new mode of transport will influence and shape their future acceptance by the public. There is a difference between new transport modes connected to and harmonised with public transport modes such as metros, trams and busses, completing the existing network, extending the network’s range and offering greater public access, and an additional transport option that only serves selected customers at specific locations during specific and maybe personalised operating times.

EASA’s study on social acceptance of UAM [57] showed that an “insufficient integration into the existing transport ecosystem of the city (i.e., UAM just adding another layer of transport congestion)”, is one additional concern of the stakeholders interviewed. The survey concludes with the statement that “UAM services need to be integrated into the existing local mobility system. Visual impact of aircraft and infrastructure should be limited, and city landscapes preserved” [57].

Following the insights of EASA’s study [57] and the trend towards multi/intermodal city transport behaviour (e-scooters, bike, bus, tram, subway, underground, taxi, car-sharing, etc.) UAM operations and infrastructure need to support the European transport policy which aims for “a form of mobility that is sustainable, energy-efficient and respectful of the environment. These goals can be achieved by using multimodal transport that combines optimally the various modes of transport, exploiting each one’s strength and minimising the weaknesses. The European Commission hence pursues a policy of multimodality by ensuring better integration of the transport modes and establishing interoperability at all levels of the transport system.”[58]

Therefore, UAM operations need to be integrated rather than isolated and cover transport segments in need by decreasing travel time, offering additional transport capacity, etc.

UAM’s innovation potential may be easiest to exploit in cases where urban air travel provides significant time savings compared to the current ground-based journeys. One exemplary metric which could evaluate the adequacy of a mode of transport is the stretch factor which is introduced by [59].

According to [59], the stretch factor of a network is defined as:

$$stretch = f(s,t) = \frac{distance(s,t)}{|st|}$$

$$s = point\ of\ origin$$
$$t = point\ of\ destination$$
$$distance(s,t) = shortes\ distance\ between\ s\ and\ t\ along\ the\ network$$
$$|st| = Euclidean\ distance\ between\ s\ and\ t$$

$$(due\ to\ scale\ of\ our\ cities, earth's\ curvature\ can\ be\ neglected)$$

As an alternative to distance, travel time, fuel/energy cost, environmental impact etc. may be considered for both ground and air transport to define the stretch factor, e.g., the UAM path may be confined to the airspace available for UAM operations (see [59] and the "Airspace" chapter 7). UAM trips would be most competitive on origin-destination journeys having a high stretch factor by other means of transport.

Even though UAM describes a mode of transport that operates in the air, it needs supporting infrastructure on the ground to offer future customers access to UAM services in general. Therefore, ground infrastructure needs to be sized, designed, developed and placed with respect to the urban environment, the projected demand characteristic and the needs and expectations of the city and local residents.

The right design and placing of future UAM ground infrastructure is necessary on the one hand to provide convenient access and to blend into the urban scenery respecting public requirements, and on the other hand to live up to the requirements defined by the UAM operating procedures in the air and on the ground to provide an operation that is as safe but also as cost-efficient as possible.

A vertiport place on top of or next to existing transport network junctions (bus stations, train stations, etc.) would offer a secure and continuous demand stream, but often, these locations suffer already from noise, lack of parking spots, large numbers of busy people nearby, and in general increased traffic densities on the ground. The extent to which an additional UAM operation is going to add value to or instead amplifies the congestion of such a traffic junction needs to be analysed precisely for every vertiport use- case.

To "preserve city landscapes" [57], vertiports can make use of existing infrastructure (parking garages, train station buildings, rooftops, etc.) but can also function as a new attraction/ and highlight in the city landscape by developing a modern and sustainable design including e.g. entertainment opportunities, restaurants, stores, public meeting and relaxation areas etc. Both ways need for a vertiport design in harmony with the characteristics of the city that considers all the requirements of the surrounding neighbourhood.

From an operational point of view, the siting of the vertiport not only needs to offer a free operating environment to maintain safe operations on the ground and in air , but it does also needs to offer sufficient access to one or several energy sources (electricity, liquid natural gas, hydrogen, fuel, etc.) depending on the vehicle fleet operating and being charged/fuelled at the vertiport. Upgrading existing infrastructure with a vertiport, e.g., placing it on top, requires a detailed assessment of the refuelling/recharging capacity offered by the existing connection and the extent to which the city grid is capable of dealing with additional "UAM consumers". Furthermore, this needs to be compared to the projected demand for the given vertiport to assess the actual value of UAM at this location. If the building of new infrastructure is considered, the construction of new vertiport-site power plants, or an extension of the energy grid needs to be discussed as part of the vertiport planning process. How different energy sources will influence the cost/size of a vertiport and how refuelling/recharging of a

UAM vehicle can be guaranteed at a vertiport, was, for example, part of the research conducted in [60] .

A vertiport may feature several final approach and take-off areas (FATOs), gates, parking positions, taxiway systems, may be elevated and may even offer entertainment and shopping areas for passengers. Developing future vertiport designs and procedures also involve the evaluation of the surrounding area and its 3-D characteristic to make sure a vertiport respects take-off and landing slopes with acceptable safety margins;[61]

By providing the second publication of the MOC-SC-VTOL [83], EASA elaborated an approach in order to define the airspace volume required for take-off and landing operations of VTOL aircrafts at vertiports:

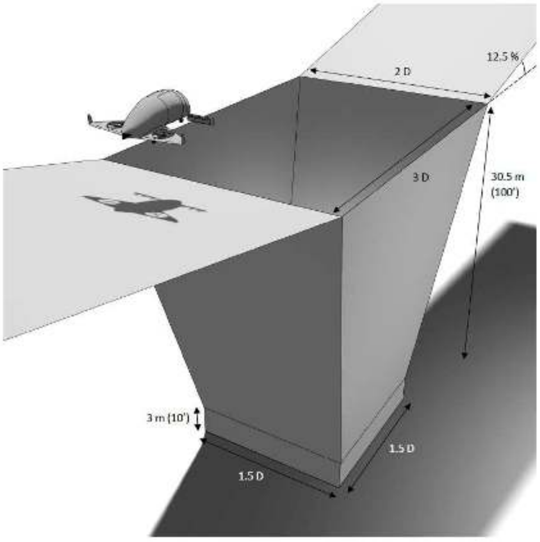


Figure 12 3D view of the VTOL take-off and landing volume based on reference volume [83]

Knowing the geometry and composition of rooves is also important to understanding which rooftops may support emergency landings. On the ground next to alternate vertiports, open water and unpopulated areas should also be identified for possible rerouting of dysfunctional unmanned aircraft. Information about the extent of these areas, as well as the vegetation present (grass, trees, flammable or not), is also essential.

In conclusion, the goal of the European Commission [58] which emphasises the importance of future transport modes to meet the concept of multimodality, should be the key driver during the planning and implementation phase for UAM operations in metropolitan areas and cities. Following this approach, UAM needs to be harmonised with existing public transport modes and networks, must be made interoperable (e.g., single ticketing) and UAM operations need to achieve a high degree of punctuality to offer a smooth transition to other modes. The coordination with exiting transport modes requires wise vertiport siting, including but not limited to the requirements of the city and its residents', a free and safe operating environment on the ground and in the air, sufficient access to energy, that offers convenient access for customers and is either retrofitted or a new public area that blends into the city landscape.

Details on various sizes of vertiports (ranging from 1-2 landing pads to >10 pads) are for instance discussed in the UAM ground infrastructure section in the recent EASA survey on public acceptance of UAM [57], where ease of access and connection to the electricity infrastructure are identified as important factors for vertiport location (see CURAM research at Georgia Tech for recharging schedule and electricity costs). EASA's RMT.0230 working group on vertiports is working on technical specifications for VFR vertiports.

### 3.5.2.3 Noise

The decibel (dB) is the unit of measurement for sound levels. It is used in the fields of communication, electronics and signals, but is mostly relevant for industries that have equipment that generate noise. Noise is very subjective, its perception changes from individual to individual, and also annoyance is also affected by the environment and the person's age. Since it covers the entire audible spectrum from around 20Hz to up to 20kHz, we apply filters to it when measuring it so that we only measure those parts of the spectrum that concern us. Typically, mid-range filter (measured in dBA) is used to provide objective values of noise.

In addition to the noise level, the exposure time and the area/population affected by noise are also important in an urban environment. Noise is therefore measured using different indicators: long-term average noise level (Leq), the percentage of time noise exceeded the background noise level n or any other specified n (Ln), the area affected by noise above ndB (An), the population affected by noise above ndB (Pn), etc.

Similarly, visual pollution from UAM may also be assessed, in particular due to security and privacy concerns that UAM may raise. The effect of both acoustic and non-acoustic factors may be represented using Community Tolerance Level (CTL) [62] (Fig. 14) which is in turn based on the seminal study of dose-response by Schultz [63]. For recent results see "Initial Investigation into the Psychoacoustic Properties of Small Unmanned Aerial System Noise" [64] by Andrew Christian and Randolph Cabel from NASA Langley Research Center which used NASA tools to show linear dependence between sound pressure and annoyance from drones, as well as that drones noise is perceived as systematically slightly more annoying than that of cars (the study was performed in NASA's room, where the subjects did not see where the sound came from).

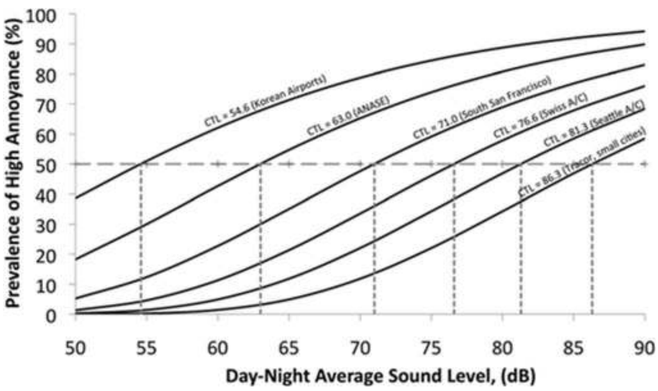


Figure 13 (Fig.2 in [62]: CTL value computed from the findings of six surveys of communities exposed to aircraft noise. Note that CTL values for the different communities shown vary over a range of 30 dB

### 3.5.2.4 Privacy

A person's privacy is a fundamental right according to European Union regulation (2000/C 364/01). Although privacy can have different interpretations and regulations in different countries, European Regulation 2016/679, known as GDPR, has helped to homogenize the understanding and treatment of private data across Europe. Personal data handling must carefully follow strict rules that define what personal data is, how to collect it, what to do with incidental data collection and how to use, store and disclose personal data.

Privacy was the major public concern in earlier surveys on social perception of unmanned aircraft. At that time most of the missions proposed were attached to surveillance, such as search, rescue or firefighting, agriculture aerial work, etc. The new urban applications for unmanned aircraft (UAM) are basically passenger transport and last-mile delivery. Although the ground environment of these applications is, of course, urban or suburban areas, characterised by the density of people and habitations, recent public surveys do not show privacy as being the main public concern anymore[57].

In addition to the new European regulation, the reasons for this evolution can be diverse. Firstly, the flight profiles for UAM (point-to-point direct routes) are very different from (non -UAM) surveillance flights, where long periods of hovering, or surveys that stayed in the same area for a long time, made the nearby inhabitants wary of the intrusion.

Secondly, in UAM the on-board payload are passengers and/or cargo, instead of the required camera of most aerial work. Of course, a camera can still be on board UAM vehicles for obstacle avoidance or for landing purposes. But most survey work is carried out by recording the ground, while UAM will use cameras only for live monitoring. This difference is well stated in the current privacy regulation that applies to video and images in which people appear. When recorded, the images must be stored in such a way that unauthorised access is prevented, explicit consent for data storage and usage is required from the persons being recorded and misuse apart from the announced primary function is subject to liability.

Finally, today's cities are full of cameras: at bank offices, in private buildings, in public transport, in many stores, on the street to observe road traffic, to fine cars not observing the rules, even in elevators. These cameras are mainly there for security reasons and citizens in high-density populations have learned to live surrounded by them, sometimes even requesting more coverage of some "dark areas". As said, the strong European GDPR legislation seems to be part of people's relaxation about privacy.

Along the same lines, the authorities point out that UAM and U-space must develop methods to ensure the privacy of citizens. U-space design, and services, such as geo-awareness, must, take into account safety, security, privacy and environmental requirements in accordance with Implementing Regulation (EU) 2019/947.

Of course, liability applies to any drone operator who violates privacy (e.g., a drone flying over houses with a camera, taking pictures or filming private gardens and buildings where people can be identifiable). The European "Drone Rules" project has published good practices for drones operations [65]. The recommendations are based on the belief that it is the drones industry that must be proactive and act to minimise these risks, while the institutions must make them aware of their responsibilities.

Not all information collected by a drone will qualify as personal information. Personal information is any information about a person who is or can be reasonably identified. Actions must be taken in advance (privacy by design, contacting and informing neighbours about the purpose of any filming, etc), during the flight (making the pilot visible and identifiable, filming in the contrary direction of habitations, etc...) and after flight (eliminating or blurring images with recognisable individuals [66] ).

### 3.5.3 UAM ground infrastructure

UAM ground infrastructure provides accessibility to UAM services and is the key supporting element of UAM for accommodating airside and landside operations and plays a mandatory part in the U-space framework. It defines what kinds of operations can be conducted (passenger transport, small/cargo

UAS), how many and what kinds of passenger/cargo can be processed and what kinds of vehicle are able to operate.

In this operational framework, a difference is understood between the following terms:

- **Vertiport** - take-off and landing site used by passenger carrying VTOLs or other VTOLs certified in accordance with Special Condition (SC) VTOL
  - Following the definition provided by EASA SC VTOL, vertiport means an area of land, water, or structure used or intended to be used for the landing and take-off of VTOL aircraft.
- Take-off and landing sites used by delivery UAS.

The reason behind distinguishing between take-off and landing sites for passenger carrying VTOLs and for delivery UAS, is that for the latter there are not yet any defined requirements on the landing sites to be used, and we can assume more flexible usage of pre-defined or ad-hoc Final Approach and Take-off areas (FATOs) for that purpose (e.g., in a garden, on a balcony, etc.). At the same time, as per SC VTOL, passenger carrying aircraft are required to use vertiports, on which EASA is currently working on defining design specifications.

### 3.5.3.1 Ground infrastructure for Cargo UAS (operating sites)

If we are considering a significant number of drone activities in metropolitan areas and cities including but not limited to parcel delivery, food delivery, transplant/ blood sample transport, “HEMS” and police surveillance etc., for most of the operations we need a suitable take-off and landing area which can probably vary between a high-traffic drone hub and a single landing area in someone’s garden. Most European city centres include high- rise buildings with several living quarters, where multiple households share a mutual entrance. In addition, not every household has a garden, private balcony, driveway or direct access to a private rooftop which makes it challenging to forecast how delivery drones will actually operate within an urban environment. One reasonable approach could be to implement take-off and landing sites for delivery UAS at points of interest within a neighbourhood, a district, or a city centre, which can be made accessible to everybody after registration. For postal services, DHL already provides this option with their “DHL Packstation”. Something similar could be possible for UAS deliveries, where it is no longer the postman , but UAS that safely delivers each parcel to the station (examples provided in Figure 146, Figure 157 and Figure 168.

Figure 14 Drone Station by DHL in collaboration with E-Hang [68]

Figure 15 Drone Delivery hub for hospitals **[69]**

Figure 16 Drone Delivery Station for Parcels **[70]**

Another approach to allow drones to deliver parcels in the city is to retrofit rooftops which then allows the tenant to directly receive the package in their apartment. Only tenants of the apartment unit right under the roof would qualify for this kind of parcel delivery. Changing weather conditions (rain, snow, etc.) need to be considered for this kind of operations. Examples are provided in Figure 17 and Figure 18.

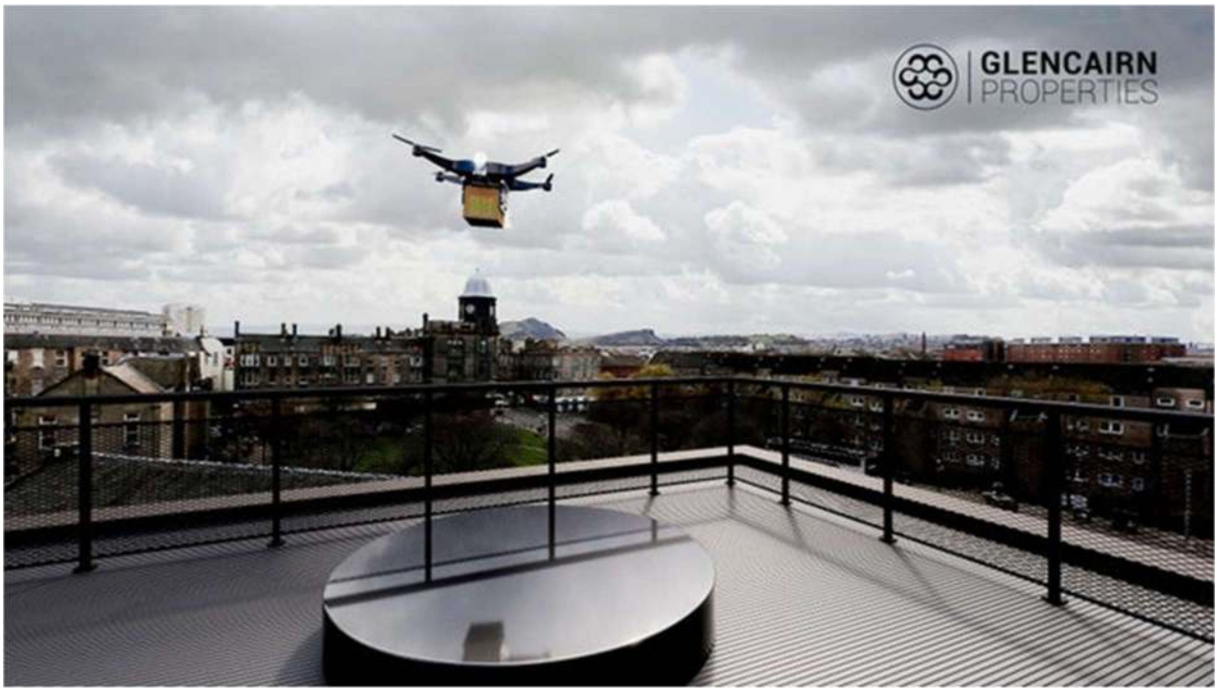


Figure 17 Roof Terrace for drone deliveries [71]

Figure 18 Roof Delivery [72]

If drone deliveries are scaled up and high-throughput operations are considered, the starting site, where delivery drones are equipped with the parcel and then take-off to the destination address/landing site may be pictured as delivery hubs.

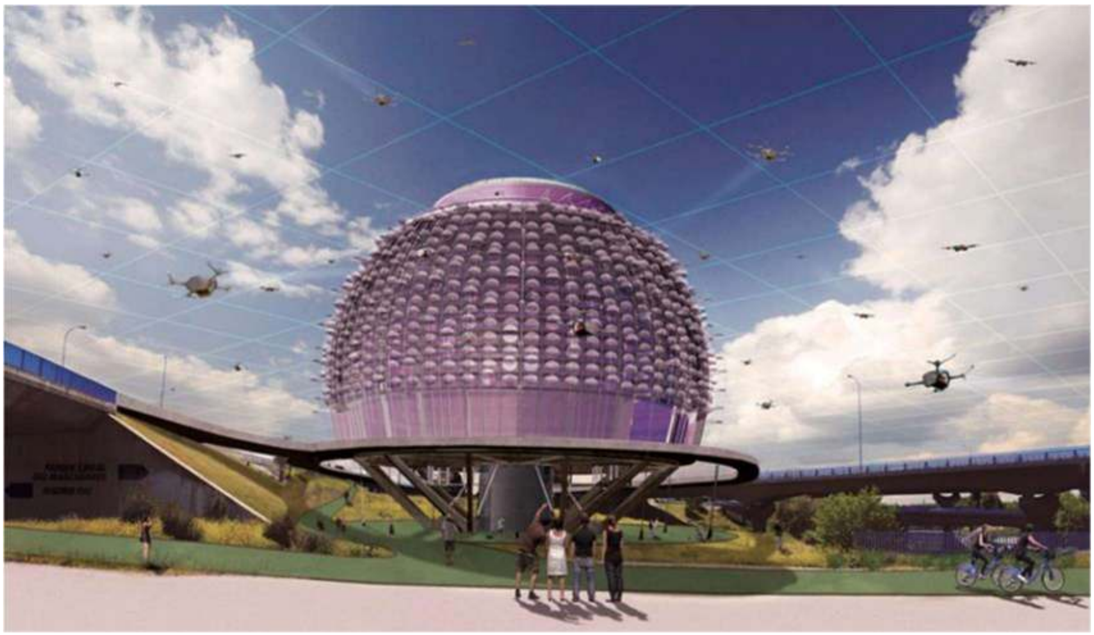

Figure 19Urban Drone port [73]

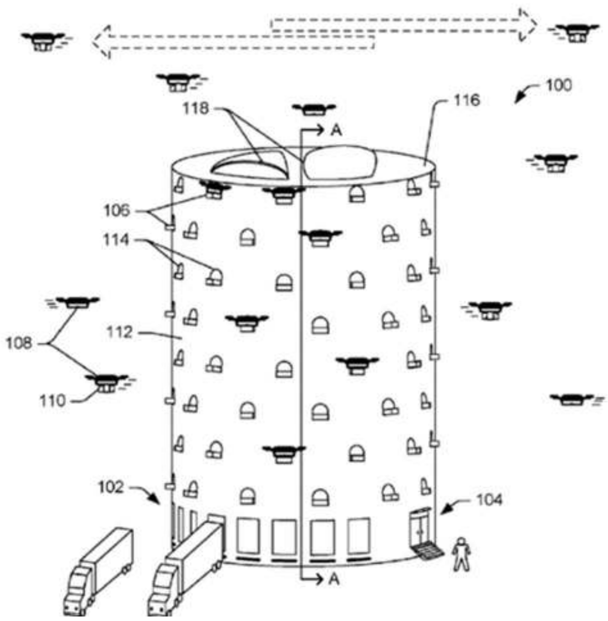


Figure 20 multi-level fulfilment centre [78]

#### 3.5.3.2 Ground infrastructure for passenger- carrying VTOLs

For passenger carrying VTOLs, either existing or new infrastructure could be used:

1) Existing infrastructure

Heliports - VTOL capable aircraft dimensions and performances meet the design characteristics of the heliport intended to be used.

Airports - where runways, ramps of hangars, or manoeuvring areas, terminal rooftops could be used.

2) New infrastructure:

Vertiports are specially designed to be used for the landing and take-off of passenger and cargo VTOL aircraft.

Before the distinction between different vertiports is presented, two categories of VTOLs are defined [76]:

1) Enhanced category: VTOL aircraft certified in this category would have to meet requirements for continued safe flight and landing and be able to continue to the original intended destination or a suitable alternate vertiport after a failure.

2) Basic category: For VTOL aircraft certified in this category, only controlled emergency landing requirements would have to be met, in a similar manner to a controlled glide or autorotation.

When considering vertiports for passenger VTOL aircraft operations, EASA distinguishes between different kinds of vertiports Figure 21[77].

As per EASA SC VTOL [76], VTOL aircraft certified in the **enhanced category**, need to satisfy the requirement of continued safe flight and landing (CSFL) and hence be able to continue to the original intended destination or a suitable alternate vertiport after a failure [76] This enhanced category of VTOLs covers those aircraft that carry passengers on board.

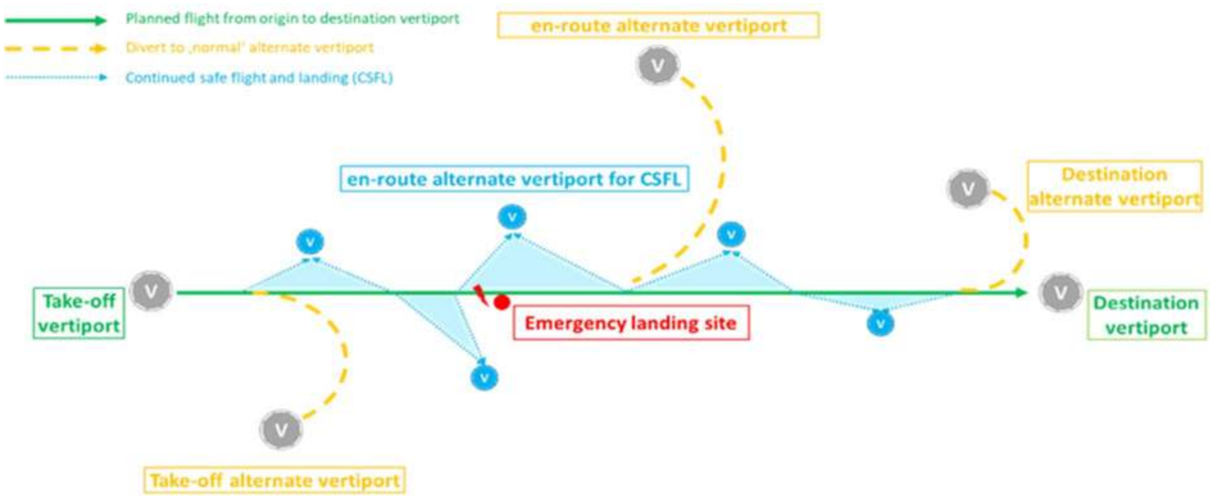


Figure 21 Vertiport classification from operations perspective [76]

The grey circles are normal aerodromes, heliports or vertiports, with the full range of facilities and services required for the operation, that the VTOL vehicle can take-off from. The blue circles are vertiports for CSFL, that only have a minimum set of facilities and services (to be specified), from which the VTOLs may not be able to take off. For cargo UAS and small UAS operations all operating sites can be used.

- **Take off and destination vertiport**: Each flight originates from a take-off vertiport and is planned and conducted to the destination vertiport.

- **Alternative vertiport**: An alternative vertiport is pre-planned and chosen in case it becomes either impossible or inadvisable to proceed to or to land at the intended destination vertiport. This can be either an alternative take-off vertiport, where the VTOL aircraft would be able to land should this become necessary shortly after take-off, or an alternative en-route vertiport, where the VTOL aircraft would be able to land if a diversion becomes necessary with normal aircraft performance while en-route, or an alternative destination vertiport, where the VTOL aircraft would be able to land should it become either impossible or inadvisable to land at the intended destination vertiport.

- **Alternative en-route vertiports for CSFL**: The alternative en-route vertiport for CSFL complies with the same minimum design requirements as the alternative en route vertiport. But it only has to fulfil a minimum set of services with respect to the aircraft and CSFL operations.

- **Emergency landing site** is excluded from these considerations as emergency landing may be carried out at any possible location, not necessarily at an aerodrome/operating site.

Take-off and destination vertiports could look like the one shown in figure 25 and figure 26:

Figure 22 VoloPort a top urban building with VoloCity and VoloConnect © Volocopter GmbH [74]

Figure 23 VoloPort Singapore outside © Volocopter GmbH, Raphael Oliver [75]

## 3.6 Airspace characterization in urban environment

### 3.6.1 Flight rules

ICAO Annex 2 [80] and SERA list VFR, IFR and SVFR (Special VFR). Flight rules standardise how aircraft behave, interact with each other during flight and how aircraft interact with air traffic control.

Remote flights, either operated as VLOS and BVLOS do not fit well into any the existing flight rule sets. We expect that at least one, perhaps several, new flight rules must be developed to integrate remote flights into the airspace.

A new set of flight rules for U-space, the so call U-space flight rules or UFR should be developed. UFR allows for but is not limited to BVLOS operation. It should also cater to the other types of operation, including VLOS and the operations currently performed under existing flight rules. The objective is to stay close to the existing rules, so that training requirements for pilots that want to fly in U-space are limited. The details of UFR are yet to be developed.

### 3.6.2 Pilot

Three general conditions are foreseen.

1. Human pilot on board the aircraft
2. Human pilot remote from the aircraft
3. Autonomous piloting software on board the aircraft, supervised remotely by a human.

These three are identified for the following reasons:

There is a significant distinction in terms of liability between involving (1,2) or not involving (3) a human pilot. There is a significant distinction in terms of latency, robustness and capabilities between an on-board (1,3) and off-board (2) pilot. U-space provides communications and other facilities that are optimised towards remote pilots or software piloting functions (2,3) and may be less optimal for human pilots on board (1)

Hybrid solutions between 2 and 3 where, for example, the UA will be piloted by software, augmented by piloting software on the ground and potentially supervised by a human operator are not explicitly discussed here. We note that the architecture of control systems should take the latency, achievable data rates and continuity of the remote-control link carefully into account.

In the early days some UAM operations will fly with a pilot on board. The project should anticipate all three options and also flights that transition from one to another.

UFR is expected to support 2 and 3 well.

### 3.6.3 On “controlled airspace" and U-space volumes

This section describes the structure of the airspace and links different terminologies.

#### 3.6.3.1 ICAO Airspace classes

ICAO Annex 11 [81] section 2.6 defines airspace classes A, B, C, D, E, F and G. Each is defined in terms of IFR and VFR flight and the services offered. From the current descriptions, UFR or any other ‘new’ flight rule is not permitted in any of the airspace classes defined by ICAO.

ICAO Annex 2 [80] section 3.1.10 defines restricted areas, and below that section is reproduced from Annex 2, Tenth Edition, July 2005:

*3.1.10 Prohibited areas and restricted areas*

***Aircraft shall not be flown in a prohibited area, or in a restricted area, the particulars of which have been duly published, except in accordance with the conditions of the restrictions or by permission of the State over whose territory the areas are established.***

Hence with today’s definitions:

- Any airspace classed from A to G can only accommodate UAS flights if they fly as IFR or VFR, including special VFR.
- Any airspace which accommodates aerial activity which is neither IFR nor VFR must be a prohibited or restricted area. Such activities are many and include UFR flight as well as rocket launches, skydiving, etc

#### 3.6.3.2 Controlled airspace

ICAO Annex 2 — Air Traffic Services [80] defines Controlled Airspace thus:

***Controlled airspace.*** *An airspace of defined dimensions within which air traffic control service is provided in accordance with the airspace classification.*

*Note. — Controlled airspace is a generic term which covers ATS airspace Classes A, B, C, D and E as described in Annex 11, 2.6.*

The list does not include F. Hence an advisory service is not sufficient for an airspace to be considered controlled.

Today many refer to “controlled airspace” meaning “airspace controlled by an air traffic controller.” This document stresses the precise meaning “airspace in which a tactical separation service is provided,” without stating by what means this service is provided.

#### 3.6.3.3 Geographic zones & U-space airspace

EU implementing regulation 2019/947, in Article 15 allows for the creation of Geographic Zones - see [17] and [18]. Geographic zones are created for the management of UAS traffic. Geographic zones may be restricted areas in the aeronautical information.

EU implementing regulations 2021/664, 665 and 666 [23], [29], [30] and [31] describe 'U-space airspace' which is a kind of Geographic Zone in which U-space services are provided. This may be is a restricted area in the sense that any aircraft not engaged in U-space network identification, nor visible to ATC (equipped with a transponder, etc) must be electronic conspicuous to U-space. [30]

#### 3.6.3.4 U-space volume types

Note: *The proposal in the sections below is still under discussion within the CORUS X UAM project* and will refined in the CORUS X UAM ConOps.

The U-space ConOps of CORUS [4] describes three Volumes distinguished primarily by the conflict resolution service offered by U-space. X has none, Y has strategic (i.e., plans do not conflict) and Z has tactical conflict resolution. Z has been identified as coming in two types: Za and Zu. In Za the tactical conflict resolution is by ATC, with the support of U-space tools for surveillance, communications, etc. In Zu, the conflict resolution is by U-space service alone. The CORUS ConOps identifies a question. Is Z **controlled** airspace or **uncontrolled**. The current ConOps [4] allows either.

When Z is controlled airspace the conflict resolution service gives instructions. The conflict resolution service is responsible for maintaining separation.

A form of Z in which the conflict resolution service gives advice. The pilot is responsible for maintaining separation. Like ICAO Class F, this is not considered to be controlled airspace. See 3.6.3.2

Each option has implications in terms of performance, capacity, cost, …

The CORUS project and the U-space ConOps grappled with the difficulty of classifying Z as controlled and allowed for it to be either controlled or uncontrolled. This compromise is problematic and confusing. Hence this document introduces two distinct names and uses them from now on.

Z volumes are airspace in which separation instructions are sent by a U-space service provider: **Zu** (Z U-space control)

Z volumes are airspace in which separation advice is sent by a U-space service provider: **Zz** (Z, zero control)

Z volumes are airspace in which separation instructions are sent by ATC: Za (Z, ATC control)

Z volumes are airspace in which separation advice is sent by a FIS (Zf, zero control)

Hence Zu and Za are both controlled airspaces. Zz is not.

#### 3.6.3.5 Relationship between ICAO classes and U-space volume types

As mentioned in 3.6.3.1, under current definitions volumes XYZ could only be parts of existing ICAO classes of airspace if (and only if) all traffic within them followed VFR or IFR. The difficulty for UAS to follow IFR is not the navigation or deconfliction aspects so much as the equipage requirements.

| # | ICAO | 2019/947 Geo Zone | 2021/664 U-space airspace | CORUS-XUAM | Flight rules | Remarks |
|---|---|---|---|---|---|---|
| α | G above VLL,<br>ABCDEF | No | No | Not U-space | IFR ** & VFR *** | For U-space users such airspace would probably be marked a Y volume and any U-space operation plan penetrating this airspace will either not be approved or will be subject to conditions or warnings. |
| β | ABCDE | No | No | Za | IFR **<br>& VFR | Za if and only if the flight's entry into the airspace is enabled by a U-space planning process that includes ATC approval. |
| γ | G VLL | No | No | X | VFR & IFR *** | UAS fly below VFR limits but in effect conform to VFR flight rules |
| δ | G VLL | Yes | No | X | VFR & IFR *** | Conditions apply<br>UAS fly below VFR limits but in effect conform to VFR flight rules |
| ε | Restricted Area | Yes | No | X | VFR | Restrictions may apply:<br>Geo-zones can exist to manage which UAS flights are allowed |
| ζ | Restricted Area | Yes | No | Y | Dependent on the restriction | Potentially a no fly zone for UAS |
| η | Restricted Area | Yes | Yes | Y | See 1 & 2, below | No tactical separation service supplied by U-space |
| θ | Restricted Area | Yes | Yes * | Zu | UFR<br>See 1, below | Tactical separation service supplied by U-space. |
| λ | Restricted Area | Yes | Yes * | Zz | See 1 & 3, below | Tactical separation **advice** supplied by U-space |

Table 22 airspace structure summary

* 2021/664 describes something approximating Y. Zu and Zz are considered as extending Y

** IFR only in A.

*** IFR unlikely in G

1) UFR is defined as how to fly in Zu. In Zu there is U-space tactical conflict resolution, hence UFR includes obeying U-space tactical conflict resolution. As mentioned in section 3.6.1, UFR is not fully defined in this document. It is expected that Zu only supports UFR and all aircraft in Zu must follow UFR.

2) An airspace which is a U-space airspace according to 2021/664 [23] & [31], most closely matching the CORUS volume Y, is one aimed at supporting BVLOS operations by means of strategic conflict resolution. Hence flights in the airspace do not follow UFR as flown in Zu, as tactical support is limited to traffic information. 2021/664 foresees entry of VFR or IFR traffic into U-space airspace as being an emergency procedure in which U-space traffic "take

appropriate measures." Hence it should be noted IFR and VFR traffic are not catered for in Y volumes.

3) The flight rule in Zz is not UFR as flown in Zu.

#### 3.6.3.6 Around airports

The other problem we need to tackle is that today around airports, the airspace (the CTR) is often classified as controlled down to ground level for significant distances – several km. This results in many urban areas being in controlled airspace. As urban UAS operations begin, it is likely that these regions will not be offered separation services to small UAS by ATC at the airport who that lack the surveillance, procedures and manpower to provide them. Instead of being Za, such regions may be reclassified as Y or Zu or Zz, and notably neither Y nor Zz are controlled airspace.

#### 3.6.3.7 Summary

In summary, the following are all controlled airspace:

- Airspace classes A, B, C, D, E
- U-space Zu volumes inside restricted areas,
- U-space Za volumes inside ICAO classes A, B, C, D, E

ICAO controlled airspace is described to the UAS community as Za for two reasons: 1) to aid UAS community comprehension and 2) to allow the U-space ConOps to describe how UAS flights and operators should act to fly within such airspaces. Not all controlled airspaces are Za volumes – only those for which the U-space Za procedures can be used.

All flights in Zu fly UFR.

The following are all uncontrolled:

- Airspace classes F, G
- U-space volumes X, Y and Zz created inside restricted areas.

UAS Flights in X in uncontrolled airspace must fly in accordance with VFR or IFR.

Y volumes may exist simply to exclude UAS traffic. Such Y volumes may be created in any airspace.

### 3.6.4 Operations

The following operations flight phases are foreseen:

- Taxi
- Take off from (from airport, vertiport or any facilities or areas where take-off is possible and allowed)
- Climb / departure
- Exit terminal area and join en-route phase
- Cruise in low, medium or high-density environment
- Descent approach
- Join the arrival sequence
- Final approach
- Land at Airport
- Land at Vertiport
- Land at TOLA
- Missed approach

### 3.6.5 Discussion of flight rules for different operations

In general, four modes are foreseen as appropriate to the conditions:

1. As manned operations – IFR or VFR
2. In Za volume. ATC control the flight, either using U-space ATC tools (UFR) or as now IFR or VFR
3. In Y or Zz volumes the flight is uncontrolled but receives traffic information (Y) and advisory service (Zz) from U-space. This is close to VFR or SVFR.
4. In a Zu volume. The flight is under U-space – UFR.

A quick examination of UFR follows. The key features of aircraft operating under UFR are:

High density BVLOS UAS remote flight operations are supported by means of U-space.
All operations are planned and known to U-space.
Tactical separation instructions are sent from U-space by means of data communications, not voice.
Vehicles use a detect and avoid feature as a safety net, it is not the primary means of achieving tactical separation.
Separation minima depend on the prevailing conditions for each pair of aircraft.
Each airspace has a set of operational performance minima with corresponding separations and capacity.
Messages sent by means of U-space community may be received by and acted on by the vehicle without human consideration and judgement. The pilot would have a monitoring role. The rapid reactions this would allow would be considered in any pairwise separation minima calculation. The number (frequency) and types of instructions will probably change significantly from current operations. *It may be that this way of working becomes mandatory in some airspaces to ensure consistently rapid reactions and subtlety of control that enable high capacities.*

Significant difficulties of integrating manned aircraft into this environment would be

Translating communications to and from U-space into a form convenient for a human pilot.
Allowing for the reaction time and unpredictability of a human pilot.
Training the pilot to new rules, even if the maximum is done so that UFR are close to IFR.

### 3.6.6 Operations in Airport & CTR, class A, B, C, D

#### 3.6.6.1 Areas of active control:

It is expected that operations of UAM would resemble existing helicopter operations with dedicated arrival & departure routes, taxiing areas and similar.

This is not a requirement however and on-board piloted UAM vehicles may operate as U-space flights, as will vehicles without a human pilot on board. Such U-space flights are expected to operate in airports in either in Za with ATS in control the flight through U-space, or in U-space volumes Y, Zz, Zu as defined. Za volumes are of most interest if the flight has to be “routed” or managed tactically with manned traffic.

Hence the Airport would be Za with aircraft operating as manned (IFR/VFR) or unmanned (UFR) on a case-by-case basis. Achieving efficient and safe operations in these mixed modes will be challenging. Effects on controller workload and airport capacity need to be carefully considered.

#### 3.6.6.2 Areas further from the airport:

Establishment of Zu or Zz in classes A, B,C, and D has not been discussed in the CORUS ConOps but seems to be valuable. CTR may be defined down to ground level at a distance from the airport at which ATC are neither interested nor willing to offer a control service to a new and numerous collections of traffic. Hence such volumes may be defined as Zu (or Zz or Y). The choice of whether such a Z airspace is operating as Zu (U-space controlled) or Zz (uncontrolled) should be made on the basis of traffic safety rather than an automatic inheritance of this status. Conversion of such CTR areas to in effect class G, combined with a "*U-Space Avionics Mandatory Zone*", may be achieved by creation of restricted areas in the short term.

### 3.6.7 Class G above an urban, suburban or other area

The expectation of the team is that Zu is the normal designation of the airspace, with Zz and Y in areas of low to very low demand. UAM would operate as "UFR" whether or not there was a pilot on board.

Work should be done to define what UFR is and once that is established how IFR and/or VFR flights differ. Once that is done study is needed to establish how non-UFR traffic can safely enter Zu, Zz and Y.

### 3.6.8 Other considerations

Airspace volumes will have minimum navigational or technical performance criteria attached to them. These will be set as needed by the target level of safety, the expected traffic demand and so on.

Transition from current operations to the intended goal will be a slow process in which a lot is learned on the way. The goal should be defined to an appropriate level of detail.

### 3.6.9 Intermediate Conclusion:

- Most UAM operations are predicted to occur in Zu airspace where separation services are provided.
- Where interaction with ATC is needed, U-Space shall be considered Za. shall be used.
- Where Y and or Zz should work are not able to provide sufficient airspace capacity, hence Zu is preferred in areas with high capacity demand and safety requirements.
- We may create Zu, Zz and Y in airspaces on any current ATM airspace.

### 3.6.10 Acceptable Means of Separation

This section compares different means of separation in different airspace. Each case considers two aircraft, proposes a means of separation and comments on this. Note that the table below mixes flight rules and UAS modes of operation. Note that the tables below consider VLOS and BVLOS as distinct from IFR - it is possible to operate UAS as IFR but in this case they appear in the table as IFR.

#### 3.6.10.1 U-space Uncontrolled Airspace, Y, Zz:

| volume | Flight | | Tactical Separation | Remarks |
|---|---|---|---|---|
| Y | VLOS | VLOS | See & Avoid assisted by U-space Traffic Information when available | If both take action, then the risk neither does is reduced. That reaction also helps the VLOS/BVLOS case. |

| volume | Flight | | Tactical Separation | Remarks |
|---|---|---|---|---|
| Y | VLOS | BVLOS | VLOS: See & Avoid assisted by U-space Traffic Information when available | BVLOS must be slow moving and visible.<br>VLOS pilot must be aware that he/she is responsible to avoid the other aircraft, either operating BVLOS or VLOS.<br>The BVLOS has priority. |
| Y | BVLOS | BVLOS or VLOS | U-space Traffic Information when available<br>Detect and Avoid[12] when available | |
| Zz | Any | Any | U-space tactical conflict resolution advice | Safety net is Detect and Avoid, when available or see and avoid, when available |
| Y | VLOS | VFR or IFR | U-space Traffic Information when available<br>VLOS: See & Avoid | VLOS limited to an altitude of 500ft AGL (or lower, 400ft), to reduce risk of encounter.<br>Additional rules when operating near airfields (e.g., requirement to inform airport)<br>Manned aircraft has priority. |
| Y | BVLOS | VFR or IFR | U-space Traffic Information when available<br>BVLOS: Detect and Avoid | Detect & Avoid should work to high level of reliability. |

Table 23 Tactical Separation methods in uncontrolled airspace

At the level of airspace class definition, no decision needs to be made regarding the technical solution for detect and avoid or conspicuity; the airspace class describes the responsibilities for aircraft operating under various Flight Rules.

A cooperative D&A solution could be based on e-conspicuity. This would require all air traffic to be suitably equipped with a transponding and/or broadcasting device[13].

Non-cooperative D&A (aka S&A) may also be used, based on vision, sound[14], radar, lidar, etc.

The technical solution needs to be addressed at airspace management level. Like Transponder Mandatory Zones that exist today, an e-Conspicuity Mandatory Zone would be required for the e-Conspicuity based D&A type, limiting access to that airspace to aircraft that are equipped with e-Conspicuity. Similarly, an “Non-cooperative D&A Mandatory Zone” would require UA to be suitably

[12] Detect and Avoid is sometimes used to mean a cooperative scheme where aircraft take measures to be detectable by other aircraft, in which case Sense and avoid is used to mean as scheme that can sense any other aircraft, cooperative or not. Here Detect & Avoid covers both.

[13] Research has shown that this may be feasible at low cost. The PERCEVITE project proposed a scheme based on WiFi. ASTM F3411-19 proposes WiFi and Bluetooth.

[14] Percevite project – hear and avoid. Manned aircraft are often quite noisy.

equipped with non-cooperative D&A means, but it would not put additional equipment requirements on manned aviation.

The performance requirements for D&A equipment would need to be addressed in a Standardisation process. The performance level of the D&A will directly affect the residual risk and therefore impact the maximum airspace capacity.

See & Avoid and Detect & Avoid are safety barriers that lower the probability of mid-air collisions, but they are not infallible:

- ➔ Not seeing / detecting in time, or at all (studies have shown failure to see is common)
- ➔ Not properly executing avoidance manoeuvres

The introduction of UAS corridors, well-known to GA traffic, could help to organise smooth traffic flows as well as reducing the risk associated to S&A/D&A because GA will tend to avoid those corridors.

At increasing traffic levels, S&A/D&A errors will increasingly lead to near misses and mid-air collisions. To enhance the effectiveness of S&A, a Traffic Information Service can be introduced, which is an Information Service that advises pilots about other traffic in the vicinity.

#### 3.6.10.2 U-space Controlled Airspace, Zu/Za:

| Flight | | Separation | Remarks |
|---|---|---|---|
| BVLOS<br>or<br>VLOS | BVLOS<br>or<br>VLOS | U-space<br>Tactical conflict resolution | D&A – if present – is a safety-net[15]. |
| BVLOS<br>or<br>VLOS | VFR<br>or<br>IFR | UAS:<br>Tactical conflict resolution<br>Replanning due to airspace restriction<br>& Emergency Management (alerts) | |

Table 24 Separation methods in controlled airspace

Controlled airspace is about predictability.

## 3.7 Systems in support of UAM

### 3.7.1 Collaborative systems for UAM

When considering tools for solutions, we will always find the combination of systems, procedures, and qualified people with specific roles at the core of solutions.

Procedures and airspaces structures are already addressed in their specific chapter, as well as legislative aspects.

Also, people or stakeholders and their specific roles are addressed in specific chapters.

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[15] When UAS and GA traffic are segregated, under what circumstances is Sense & Avoid (or Detect & Avoid) needed as a safety net? What would the decision depend on? Ground risk – meaning the effect of a collision? Or only air risk – meaning the probability of a collision?

So, in this chapter we have to deal with the systems that will be involved in providing the necessary services for UAM. The paradigm here is that the cooperation of various systems is the way forward, since the complexity of the total task can probably not be solved by just one system.

Several the envisaged and involved systems are already existing today, but eventually they must be modified or extended, and another number of systems will have to be developed yet.

We furthermore assume that for these systems interconnectivity exists (VPN over internet), including mobile communication via the telecommunication network. With this assumption we may add mobile devices to the whole network. Mobile telecommunication today is yet limited in altitude. Investigations have shown that usually there is a coverage up to 150 meters, at some spots even up to 1000 m, but the latter cannot be assumed everywhere. The mobile telecom service providers, however, are beginning to elaborate this market, and for simplification we may presume that a mobile coverage up to 10 km altitude will exist soon.

All actors/stakeholders in UAM will make use of specific systems providing specific functions and services. As a starting point we list the relevant systems, their role and functionality today, seen at a national scope:

| System | Actor/ Stakeholder | Function | Role in UAM | Status |
|---|---|---|---|---|
| **UAS/UAM registration database** | CAA | DB of all UAS<br>Proxy to foreign registration DBs | Central registry with unique operator and vehicle ids, and related data | Under construction |
| **ATM Multi Sensor Data Fusion (MSDF) Tracker** | ANSP | Tracking and fusion of all kinds of surveillance data | Computation of the overall situational traffic (=sum of all tracks, manned and unmanned) | Many variants existing, a few only with the capability to fuse manned and unmanned traffic |
| **ATM Situation Display / Controller Working Position (CWP)** | ANSP | Air traffic situation display and working position for air traffic controllers | Situational awareness means incl. traffic and geodata on ATC side | Many variants existing |
| **ATM Flight Data Processing System (FDPS) and flight plan displays** | ANSP | Display of flight plans, management of flight plan workflow | Flight Planning coordination means on ATC side | Many variants existing, some of them integrated with the CWP |
| **ATM Safety net Functions** | ANSP | Conflict Detection on Area intrusion, minimum altitudes, and Short Term Conflict Alerting (STCA) | Conflict detection for manned aviation | Many variants existing, but no consideration of UAS |

| System | Actor/ Stakeholder | Function | Role in UAM | Status |
|---|---|---|---|---|
| **CIS Traffic information data provision** | CISP | Traffic service (e.g., tracks) provision to U-Space, either ATM tracks only, or a fused situation with integrated UAS tracks | Provision of situational awareness to (all?) U-Space stakeholders | In development, prototypes existing |
| **CIS geodata information provision** | CISP | Compilation, quality assurance, and data service provision of geodata both from ATC and for U-Space purposes | Foundation of geodata services to (all?) U-Space stakeholders | In development, prototypes existing |
| **UTM** | USSP | UAS Traffic Management provision by one or many USSPs<br>Uses track data and geodata to provide comprehensive air situation picture<br>Computes conflicts for UAS and UAM, also with manned aviation<br>Computes conflict resolutions for UAS and UAM<br>Processes flight requests and permissions, validates against geo-zones and regulations<br>Coordinates flight-plan status with ATM | Coordination platform for the interaction of all stakeholders in a U-Space, exchange of traffic information, geodata, flight plans, permissions<br>Clients of UTM:<br>At the USSP to grant standard permissions and provide situational awareness might exist<br>at authorities to grant special permissions,<br>at cities to allow the definition of temporary NFZs<br>at police to support law enforcement<br>at UAS/UAM operators to provide situational awareness<br>at UAS pilots in the field to provide situational awareness<br>at VFR pilots to provide situational awareness | In development, prototypes existing |

| System | Actor/ Stakeholder | Function | Role in UAM | Status |
|---|---|---|---|---|
| **UTM clients for USSP** | USSP | Situation awareness in AoR<br>Permission granting | Situation awareness<br>Geo-awareness and geodata modifications in AoR<br>Permissions in scope of USSP | In development, prototypes existing |
| **UTM clients for authorities** | authorities | Situation awareness in AoR<br>Permission granting | Situation awareness<br>Permissions beyond scope of USSP<br>Geo-awareness and geodata modifications in AoR | In development, prototypes existing |
| **UTM clients for cities** | City | Situation awareness in AoR | Situation awareness<br>Geo-awareness and geodata modifications in AoR (temp. NFZ) | In development, prototypes existing |
| **UTM clients for police** | Police | Situation awareness in AoR<br>Search and identification | Situation awareness<br>Law enforcement activities<br>Geo-awareness and geodata modifications in AoR (temp. NFZ) | In development, prototypes existing |
| **UTM clients for operators** | UAS or UAM operator | Situation awareness in AoR<br>Flight planning and validation | Situation awareness | In development, prototypes existing |
| **UTM clients for pilots in the field** | UAS pilots | Situation awareness in AoR<br>Flight planning and validation | Situation awareness, including mobile versions | In development, prototypes existing |
| **UTM clients for VFR pilots** | VFR pilots | Situation awareness in AoR<br>Flight planning and validation | Situation awareness, including mobile versions | In development, prototypes existing |

| System | Actor/ Stakeholder | Function | Role in UAM | Status |
|---|---|---|---|---|
| **Operator fleet management system** | UAM operator | Fleet asset management, fleet workflow management, fleet monitoring, UAS resource planning, central DB for bookings | Source of UAM flight plans, Interacts with UTM | In development |
| **UAM booking system** | UAM operator resp. passenger | Booking app for calling an air-taxi, interfaces with the central operator fleet management | Tool for passengers or customers to call an UAS or UAM service | In early concept phase |
| **UAS ground control system or RPS** | UAM operator and/or pilot in the field | Controls the UAS or UAM (manually, semi-manually, per uploaded/activated flight path) | Tool for the execution and control of the UAS or UAM flight,<br>May integrate with UTM client | Many variants for UAS exist, for UAM systems are in development |
| **UAS on board flight management system** | UAS or UAM itself | Flies the UAS or UAM, evtl. receives commands (flight path, controls), provides UAS or UAM position via LTE<br>Might use extra devices for that purpose (HOD, ADS-B, FLARM, R-Id) | The flight system of the UAS or UAM, position data provision | Many variants exist in various stages |
| **Vertiport management system** | Vertiport manager | Monitors and manages a vertiport or many vertiports and its resources | Provides vertiport data and status to UTM | In early concept phase |
| **U-space surveillance means** | USSPs and/or ANSP | Surveillance of UAS with: ADS-B, FLARM, HOD, LTE, RID, DDS/C-UAS | UAS identification and surveillance infrastructure to observe UAS or UAM flights | Solutions for ADS-B, FLARM, LTE, HOD exist.<br>Solutions for RID are upcoming.<br>DDS/C-UAS are evolving, some solutions for smaller AoRs exist, a few for larger AoRs and airports |

Table 25 U-space related systems

A diagram of these systems connected to the internet & mobile communication infrastructure is added below. This diagram may consecutively be used to illustrate the various communications between the systems.

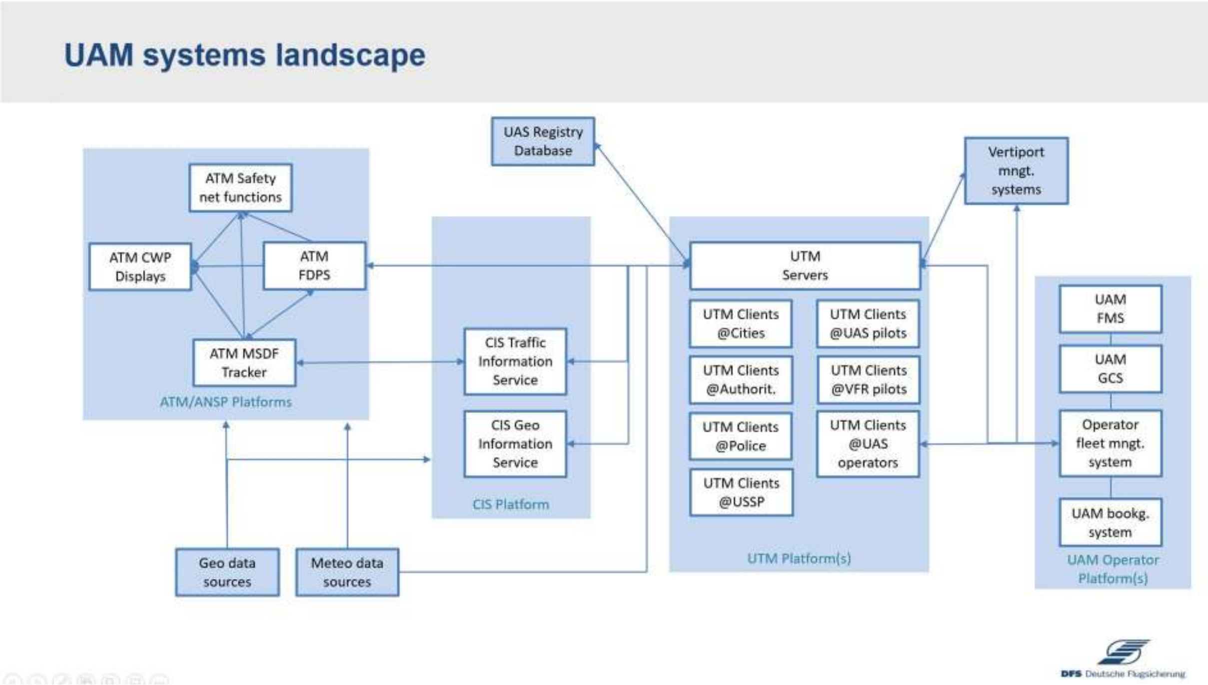


Figure 24 UAM systems landscape

Platforms here do not imply a specific technology, they could be LANs, Cloud based environments, or simply a set of coexisting systems in the same organisation.

We assume that there will be at least 4 types of such platforms for UAM, resp. in the aviation area of the future:

- ATM/ANSP platforms
- CIS platforms
- UTM platforms
- UAM operator platforms
- Furthermore, at least 4 additional instances of specific systems will be required for UAM:
- The national UAS registry database, also acting as a proxy to foreign registries
- The national set of geodata sources (evtl. unified in one QS-controlled database)
- The METEO data sources (by METEO service)
- A series of local vertiport management systems

**Neighbour systems for UAM**

| Neighbour systems | Explanation | Owner | Remark |
|---|---|---|---|
| **METEO data sources** | Provision of aviation weather<br><br>Provision of UAS operations weather | METEO service | Could be provided through CIS |
| **Geo data sources** | Cataster<br><br>DLM<br><br>Geodatabases of the authorities | mapping service,<br><br>geodata service<br><br>aeronautical geodata service (usually with ANSPs) | Will probably be provided through CIS |
| **UAS manufacturer data** | Permission-relevant, performance-relevant, and safety-relevant UAS data | manufacturers | Parameters have to be considered in permissions, airspace usage, mission permissions |

Table 26 Neighbour systems for UAM

### 3.7.2 Registration database

**Actor/stakeholder and its variants:**

The registration database belongs to the tasks delegated to the member state, and it is up to the member state to decide about its implementation. Foreseeable implementation variants are:

Registration database at the CAA

Registration database at the combined CAA/ANSP

Registration database at a mandated suborganisation

The ministry of transport in a member state will probably be the instance, where the allocation is decided. The decision will be influenced by the already existing structure of aviation-related authorities, depending on its either centralised or federated structure. In countries like Austria, it seems to be more centralised and thus will more probably be allocated to the combined instance of CAA and ANSP at AUSTROCONTROL, in other countries with a split between CAA and ANSP this task might be allocated to either the CAA or the ANSP (see e.g., Italy), or – in an even more federated context – it might be delegated to a specific authority below the CAA level, like to the Luftfahrtbundesamt (LBA) in Germany.

**Function in more detail, differentiating also the status today and the needed extensions in future:**

| Functions, in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Central registry with unique operator and vehicle ids, and related data storage:**<br>**Registry of operators, registry of UAS,**<br>**Registry of LUC?**<br>**Data search functionality**<br>**Data maintenance functions**<br>**Data versioning and history** | Descriptive data for operators (name address, id, email, etc)<br>Descriptive data for UAS (id, brand, type, serial nr., equipage, etc.)<br>Data for Light UAS certificate management<br>Functions to search manually by an operator or remotely by a system to retrieve data on an operator and/or an UAS<br>Data from the past may not go lost by modification but need to be stored as valid for a certain timeslot in the past. A versioning therefore is required. When searching, the time dimension has to be considered as well. | Registry is under construction; provision of unique ids is granted | Accessibility for UTM systems, including for the tracking and MSDF fusion component in UTM to use the unique ids for UAS track identification |
| **Transnational data provision and exchange**<br>**Retrieval of foreign data on operators and UAS**<br>**Evtl. remote update of certain data for UAS and operators (in case of accidents, termination of operations etc.)** | Data from registries abroad shall be accessible to allow identification and flight planning in a foreign country inside Europe.<br>By default, data access for modifications is assumed to be with the assigned authority, but there might be emergency or contingency cases, where severe events need a remote access for modifications. | Data exchange not yet existing; work is max. in conceptual phase | Transnational interoperability with foreign UAS registry databases to exchange ids and related operator and vehicle data for UAS operations abroad |

Table 27 Registration database functions in more detail

**Communicating partner systems and data exchange**

| Partner system | Exchange purpose | Data in/out | Remarks |
|---|---|---|---|
| **A UTM system (one at an USSP or the national one)**<br>**Either from within the member state, or from a foreign state in Europe** | Retrieval of identification data for an operator or an UAS | UAS track properties for search in, full identification data out<br>Operator properties for search in, full operator identification data out | Data privacy issues yet to be considered |
| **A foreign UAS/UAM registration database** | Retrieval of identification data for an operator or an UAS<br><br>Data update provision due to specific events or knowledge | UAS track properties for search in, full identification data out<br>Operator properties for search in, full operator identification data out<br><br>UAS or operator matching criteria in,<br>Updated of related data in<br>Confirmation or rejection of update out | Data privacy issues yet to be considered |

Table 28 Registration database communicating partner systems and data exchange

**Role today and in future in UAM**

The registry provides the authorised identification of an UAS and an operator, with all relevant attached data that are necessary to be participant in U-Space. Some UTM implementations today already have included database functions for UAS and operator registry. It needs to be decided, whether registry and UTM shall remain separate systems und functionalities, or whether they will be rejoined again. In any case, bilateral – or even multilateral - data access is required. If there will be several UTM systems – as USSPs – per country, it is more likely that registry and UTM remains separated.

### 3.7.3 ATM MSDF Tracker

**Actor/stakeholder and its variants**

ATM MSDF trackers use radar and other certified surveillance data in ATM to collect position data of moving aircraft and compute a statistically optimal track update for all detected aircraft. The track of an aircraft contains a 4D position, identification, and kinematic parameters of the aircraft such as ground speed, heading, manoeuvre state, rate of climb or descend, and other current status parameters. Trackers perform also some monitoring of surveillance sensor status and use that assessment information in the computation of the statistical estimation. Track updates are computed permanently on a cyclic or event-basis and distributed to a series of consumer systems, such as ATC controller working positions (CWPs), flight plan data processing systems (FDPS), conflict detection systems like STCA, MTCD, Aera intrusion alert or terrain proximity warning systems, and other traffic management assistance systems in ATM. ATM MSDF trackers are the primary source of up-to-data manned aircraft position data, also for U-Space systems as additional future consumer systems. ATM MSDF tracking systems are allocated to stakeholders within the ANSP organisation at various levels:

ATM MSDF tracker per control zone around an airport (tower context)

ATM MSDF tracker per area control center (ACC or UAC context)
ATM MSDF tracker per ACC and its associated towers (combined context)
ATM MSDF tracker per country

UTM systems might consume track data of the neighbouring ATM MSDF trackers or use the services of a CIS provider. A CIS provider will need to use ATM MSDF capabilities in the scope of its area of responsibility. If a nationwide ATM MSDF tracker is available, it will reduce complexity of communication a lot and also minimise the risks of ambiguities, however, a national ATM MSDF tracking capability is demanding, and only available in a subset of the European countries (at least in Austria, Belgium, Denmark, Germany, Luxembourg, Netherlands, Portugal, Switzerland).

**Function in more detail, also differentiating the status today and the needed extensions in future.**

| Functions in more detail | Status today | Needs in future |
|---|---|---|
| **Integration of position data from radars (Primary, SSR, Mode S), Multilateration systems (MLAT), evtl. ADS-B** | Existing in all European countries, with various levels of integration (see above) | Might need an integration at national level to reduce communication complexity<br>Might need the integration of position data sources of unmanned traffic, like ADS-B, FLARM, 5G mobile comm. to compute a common air situation picture |
| **Statistically optimal estimation of current track states of aircraft** | Existing in all European countries, with various levels of integration (see above) | More complex motion models in statistical filters to integrate also UAS manoeuvres |
| **Track distribution to consumer systems** | Existing in all European countries, with various levels of integration (see above) | Track distribution also to new consumer systems like CIS platforms, UTM-systems |
| **Assessment of sensor data, status, quality, and control feed back into the estimation process** | Existing in all European countries, with various levels of integration (see above) | Extensions for new types of sensors and position data sources like FLARM, and 5G. |

Table 29 ATM Multi-Sensor-Data-Fusion Tracker functions

**Communicating partner systems and data exchange**

| Partner system | Exchange purpose | Data in/out | Remarks |
|---|---|---|---|
| **ATM situation displays** | Track provision for air situation picture | Tracks out | |
| **ATM FDPS and flight plan displays** | Track provision for flight plan correlation | Tracks out | |

| Partner system | Exchange purpose | Data in/out | Remarks |
|---|---|---|---|
| **ATM safety net functions** | Track provision for conflict detection: short term conflict alert (STCA), medium term conflict alert (MTCD), Area intrusion alert (AIA), Terrain proximity warning and minimum altitude (MRVA) | Tracks out | |
| **CIS traffic information data provision** | Track provision for servicing UTM consumer systems at USSPs | (a) ATM Tracks out<br>(b) UAS plots in, combined ATM and UAS tracks out | May be designed in two ways:<br>(a) ATM tracks out to U-Space only<br>(b) UAS position data are fed from UTM resp. U-Space sensors at USSPs to the central MSDF tracking as well, combined manned and unmanned track situation is computed and redistributed to USSPs |

Table 30 ATM Multi-Sensor-Data-Fusion Tracker partner systems and data exchanges

#### Role today and in future in UAM

ATM MSDF trackers are the functional core of ATM systems and the computation of the current air situation picture, where controllers act on and ensure the safety of the ATM system.

Manned aviation and UAS will get together. The less segregation, the higher capacity of given airspace is available for all participants. Non-segregated airspace needs a commonly sensored, computed, and distributed air situation picture. Even in segregated airspace structures, common awareness helps for the coordination close to the borders of both airspaces or in emergency and contingency cases ("reconfiguration of airspace").

At a first level of collaboration ATM MSDF tracker data will need to be provided to U-Space via the CIS function. A second integration step might allow a two-way communication to use the existing MSDF tracking capabilities for feeding UAS data in and getting a combined manned and unmanned traffic situation out. Expensive investments in own tracking technologies at USSPs could be avoided this way.

### 3.7.4 ATM situation display (CWP)

#### Actor/stakeholder and its variants

Basically, CWPs are available for 4 stakeholder groups inside an ANSP, for the work of the controllers:

- SMGCS/A-SMGCS CWP for apron and taxi controllers at airports, with regionally varying models of workshare between ANSPs and airport
- Tower CWP for tower controllers managing approaching/landing and starting/departing aircraft at airports
- Centre CWPs for area control centres, evtl. with variants for dedicated approach controllers (approach sequencing), departure controllers, area controllers, and upper airspace controllers
- FIS CWPs for controllers supporting general aviation with flight information services and navigation support

**Function in more detail, differentiating also the status today and the needed extensions in future.**

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Air traffic situation display** | Display of ATM tracks over configurable map background | Existing in all European countries, with various levels of integration | Might include UAS tracks in controlled airspace in the future (unmanned cargo systems)<br>Might include relevant subpart of UAS traffic in VLL (FIS CWPs, SMGCS CWPs, TWR CWPs) |
| **Combined display of tracks and flight plan information** | Tracks and flight plans are correlated. Flight plan information is available for correlated tracks | Existing in all European countries, with various levels of integration | Might include UAS tracks in controlled airspace in the future (unmanned cargo systems)<br>Might include relevant subpart of UAS traffic in VLL |
| **Weather information display** | Aviation weather data today only | Existing in all European countries, with various levels of integration | UAS will need specific weather in VLL with a refined grid resolution and additional other elements, but possibly not relevant to the ATM controller |
| **Conflict alarm display** | Display of conflict detection between aircraft or between aircraft and environment: short term conflict alert (STCA), medium term conflict alert (MTCA), Area intrusion alert (AIA), Terrain proximity warning and minimum altitude (MRVA), conformance monitoring with flight plan | Existing in all European countries, with various levels of integration | UAS in controlled airspace probably will be treated like aircraft with limited features, conflict detection will work like for aircraft, possibly conformance monitoring will have differences in detail<br>UAS in uncontrolled airspace will not be relevant for ATM controllers, but possibly for FIS, SMGCS, and Tower CWPs |
| **Conflict resolution support** | Assignment of new flight levels<br>Assignment of new route elements<br>Provision of situational awareness and navigational information | Existing in all European countries, with various levels of integration | FIS might support VFR with UAS-related traffic information and warnings |
| **Sector transition coordination support** | Handover between sectors in ACCs and UACs<br>Handover between Tower and ACC<br>Handover between Tower and SMGCS | Existing in all European countries, with various levels of integration | |
| **Contingency and emergency support** | Display of aircraft specific alarms and conditions<br>Provision of support information to pilots | Existing in all European countries, with various levels of integration | |

Table 31 ATM situation display functions

**Communicating partner systems and data exchange**

| Partner system | Exchange purpose | Data in/out |
|---|---|---|
| **ATM MSDF tracker** | Situation picture | Tracks in |
| **ATM FDPS** | Flight plan information | Flight plans and correlated flight plan in conformance monitoring status in |
| **ATM SNF** | Safety net functions results shown in CWP | Warnings and alerts in |

Table 32 ATM situation display partner systems and data exchanges

**Role today and in future in UAM**

CWPs are dedicated to manned air traffic solely today. UAS in controlled airspace will join in in the future, with specific attributes and display elements, and possibly slightly modified parameters in monitoring and warning (different dynamics, flight envelope, degrees of freedom, etc.).

FIS CWPs might get a specific role in providing UAS activity awareness to VFR traffic.

SMGCS and tower CWPs will be interested in the future in UAS traffic, in case there are regular or irregular UAS activities at an airport.

### 3.7.5 ATM FDPS and flight plan displays

**Actor/stakeholder and its variants**

FDPS variants are used by 2 stakeholders inside ANSPs:

- Tower Control uses Tower FDPS, or short TFDPS to define new (individual) flight plans, or modify flight plans that are received from ACCs or the European ATM Network Manager (former CFMU), where European repetitive flight plans are collected for a season or a year
- ACCs or UACs use and modify flight plans that are received from ACCs or the European ATM Network Manager (former CFMU), where European repetitive flight plans are collected for a season or a year

FDPS are in essence flight plan workflow management systems, where flight plan data are forwarded along the path of the flight execution from start through all sectors (in ACCs and UACs) to the landing destination at an airport. So, all flight plan workflows start and end at an airport (tower control).

There is a server functionality that performs the computations, and there are display clients that interact with the server. Display clients are part of the CWP setup, either in an integrated manner with the traffic situation displays, or in a separate setup, with its own application.

**Function in more detail, differentiating also the status today and the needed extensions in future.**

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Display of flight plans** | Display in strip-like tables in extra display applications or integrated in the CWP display<br><br>May include sequenced displays of flight plans based on time, priority, optimisation | Static and dynamic displays, differentiated for ATC tower and ATC centre applications<br><br>Operational at all tower control and ACC/UAC units in Europe | May have to include UAS flight plans in controlled airspace<br>May have to include UAS flight plans from adjacent airspaces (U-Space, VLL) for situation awareness and ease of coordination |
| **Management of flight plan workflow** | Managements of requests and clearances, change of status of flights, modified routings, pre-information and coordination along the flight plan path | Operational at all tower control and ACC/UAC units in Europe | Flight plan coordination with UAS and UTM might be handled in TFDPS, if controlled airspace is affected. |
| **Modification of flight plans** | Modification of routings, timings (ETD, ATD, ETA, ATA, etc.), and coordinated flight levels for hand-over | Operational at all tower control and ACC/UAC units in Europe | Flight plan coordination with UAS and UTM might be handled in TFDPS, if controlled airspace is affected. |
| **Coordination on flight plan basis** | Flight plan conflicts, either detected by MTCA functions or considerations of ATC controllers, might lead to modifications for conflict resolution | Operational at all tower control and ACC/UAC units in Europe<br>MTCD operational at some ACC/UAC units in Europe, currently rollout and update in progress | MTCA in controlled airspace will possibly have to handle also UAS flight envelopes in the future (limited performance of manoeuvrability) |

Table 33 ATM FDPS and flight plan display functions

**Communicating partner systems and data exchange**

| Partner system | Exchange purpose | Data in/out | Remarks |
|---|---|---|---|
| **ATM CWP Display** | Integrated or extra display<br>Tower version of CWP<br>ACC/UAC version<br>Eventually also, FIS version | Flight plan modifications, new flight plans, flight plan deletions in<br>Flight plan data out | |
| **ATM MSDF tracker** | Correlation,<br>Flight plan update for actual positions and time computation | Flight plans out<br>Tracks in | |
| **ATM Safety net functions** | Usage of flight plan data for conflict detection and conformance monitoring | Flight plans out<br>Warnings and alerts in | |

| Partner system | Exchange purpose | Data in/out | Remarks |
|---|---|---|---|
| **UTM** | UAS flight plan preannouncement<br>UAS preannouncement clearance<br>UAS flight coordination | UAS flight plans in<br>Clearances out<br>Flight plan modifications out | Might be an additional direct connection to coordinate UAS flight plans that affect controlled airspace<br>(Modification in the platform diagram) |

Table 34 ATM FDPS and flight plan display communicating systems and data exchanges

**Role today and in future in UAM**

Today there is no function or communication with respect to UAS and UTM. Military drone operations might have a regular flight plan (or be completely invisible), such operations are treated like usual controlled flights, with (manual) consideration of the limited degree of freedom in manoeuvring.

There might be in future an additional direct connection to coordinate UAS flight plans that affect controlled airspace

### 3.7.6 ATM Safety net server

**Actor/stakeholder and its variants**

ATM safety net servers are usually allocated to ACCs and UACs, and to a much lesser degree to tower applications.

Safety net servers compute:

- Short-term conflict alert between aircraft
- Area intrusion alert
- Minimum radar vectoring altitude violations and ground approximations
- Some of them also medium-term conflict alerts (MTCA) between aircraft, with a longer horizon of look-ahead time (10 min +), and therefore taking flight plan data into consideration
- Conformance monitoring (to flight plan, including monitoring of coordinated altitudes)

In the tower context safety net functions might be more easily found in the context of SMGCS with runway incursion monitoring, and conflicts between taxiing aircraft, and also vehicles.

**Function in more detail, differentiating also the status today and the needed extensions in future.**

| Functions in more detail | Status today | Needs in future |
|---|---|---|
| **Short-term conflict alert** | Operational in most ACCs and UACs in Europe | Systems as such are not expected to interface with UAS and UAM, but algorithmic knowhow may be an important source to UTM |
| **Area intrusion alert** | Operational in most ACCs and UACs in Europe | Systems as such are not expected to interface with UAS and UAM, but algorithmic knowhow may be an important source to UTM |

| Functions in more detail | Status today | Needs in future |
|---|---|---|
| **Minimum radar vectoring altitude violations and ground approximations** | Operational in most ACCs and UACs in Europe | Systems as such are not expected to interface with UAS and UAM, but algorithmic knowhow may be an important source to UTM |
| **Medium-term conflict alerts (MTCA) between aircraft** | Operational in most ACCs and UACs in Europe | Systems as such are not expected to interface with UAS and UAM, but algorithmic knowhow may be an important source to UTM |
| **Conformance monitoring** | Operational in most ACCs and UACs in Europe | Systems as such are not expected to interface with UAS and UAM, but algorithmic knowhow may be an important source to UTM |

Table 35 ATM Safety net server functions

**Communicating partner systems and data exchange**

| Partner system | Exchange purpose | Data in/out | Remarks |
|---|---|---|---|
| **ATM MSDF tracker** | Track provision for conflict detection: short term conflict alert (STCA), medium term conflict alert (MTCA), Area intrusion alert (AIA), Terrain proximity warning and minimum altitude (MRVA) | Tracks in | |
| **ATM FDPS** | Usage of flight plan data for conflict detection and conformance monitoring | Flight plans in<br>Alerts and warnings out | Might evolve to conflict resolution and assistance tools (already ongoing research work, and also part of advanced controller support functions |
| **ATM CWP** | Safety net functions results shown in CWP | Warnings and alerts out | |

Table 36 ATM Safety net server communicating partner systems and data exchange

**Role today and in future in UAM**

Safety net systems in ATM as such are not expected to interface with UAS and UAM, but algorithmic knowhow may be an important source to UTM.

### 3.7.7 CIS traffic information data provision system

**Actor/stakeholder and its variants**

Common information services provide information on U-spaces, adjacent U-Spaces, geodata, traffic information data, and similar "foundation data" of airspace management. The provision of ATM traffic data and ATM geodata is considered as part of the CIS in many national ConOps drafts in Europe.

The CIS platform is discussed in 2 variants:

- A central, single CIS platform and provider (S-CISP)
- A federated approach with multiple CIS platforms and providers, possibly one per USSP (N-CISP)

S-CISP would reduce the complexity of data versions and communications, but as such it would not be a competitive task. A N-CISP approach seems to fit to a competitive market-oriented approach. The question is whether CISP really needs market competition, or whether it is better to have single sources of truth for traffic data and geodata as a foundation for the competitive USSP services that build upon these data. Multiple sources of foundation data – e.g., map data and traffic positions - inherit the risks of ambiguities, which might be critical in emergency or contingency situations. Ambiguities were also involved in most of the aviation accidents in history, therefore it might be considered as a serious risk.

On the other hand, a competitive approach offers the chance to find best services and market prices for the CIS services (if there is really competition instead of a hidden monopoly), however, there will then be no guarantee.

Most ANSPs seem to be in favour of a S-CISP solution, while some USSP candidates seem to prefer a N-CISP approach. Either approach will affect the architecture of the U-Space system landscape and the structure of communication fundamentally.

**Function in more detail, differentiating also the status today and the needed extensions in future.**

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Provision of traffic data** | ATM tracks | Prototypic systems existing in some countries, development ongoing | |
| **Provision of traffic data** | Also manned aviation tracks in VLL | Largely not covered in ATM systems, since no coverage | VLL traffic like VFR, HEMS, SAR need to become visible as well<br>Possibly plot data feed via CISP into central MSDF, to get back a complete fused air situation |
| **Provision of traffic data** | Possibly also, UAS tracks | Not covered in ATM systems, and very expensive for UTM systems | UTM systems with attached U-Space surveillance means might collect UAS plot data and forward it to central MSDF, and get back a fused situation of manned and unmanned aviation |

Table 37 CIS traffic information data provision system functions

**Communicating partner systems and data exchange**

| Partner system | Exchange purpose | Data in/out | Remarks |
|---|---|---|---|
| **ATM MSDF tracker** | Track service | U-Space plots out<br>Tracks in | |
| **UTM systems** | Track Service | Tracks out<br>U-Space plots in | |

| Partner system | Exchange purpose | Data in/out | Remarks |
|---|---|---|---|
| **Optional: pass thru of UAS mission data and clearances** | Tbd. | Tbd. | Might need an update of the diagram, interface to FDPS? |

Table 38 CIS traffic information data provision system communicating partner systems and data exchanges

**Role today and in future in UAM**

There is no existing role today, as such systems really are not yet existing. CISP will be fundamental for the system design of U-Space.

### 3.7.8 CIS geodata information provision system

**Actor/stakeholder and its variants**

Similar consideration as in chapter 7.7.

**Function in more detail, differentiating also the status today and the needed extensions in future.**

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Provision of geodata** | Provision of aeronautical geodata<br>Provision of NFZ geodata<br>Provision of land use data | Prototypic systems existing in some countries, development ongoing | Operational system(s) needed |
| **Consolidation of geodata** | Merge and QS of geodata from variety of sources, if no central agency is available | | |
| **Provision of U-space geometry data and adjacent U-Spaces** | U-Space limits<br>Adjacent airspaces | Prototypic systems existing in some countries, development ongoing | Operational system(s) needed |
| **List of certified USSPs** | Database of certified USSPs with central repository, and shared viewing and modification capabilities | Prototypic systems existing in some countries, development ongoing | Operational system(s) needed |
| **USSPs terms and conditions database** | Database of terms and conditions with central repository, and shared viewing and modification capabilities | Prototypic systems existing in some countries, development ongoing | Operational system(s) needed |
| **UAS capabilities and performance requirements** | Database of requirements with central repository, and shared viewing and modification capabilities | Prototypic systems existing in some countries, development ongoing | Operational system(s) needed |

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **UAS geo-zones and static restrictions** | Database of zones and restrictions with central repository, and shared viewing and modification capabilities | Prototypic systems existing in some countries, development ongoing | Operational system(s) needed |
| **Repository of dynamic restrictions** | Database of dynamic restrictions with central repository, and shared viewing and modification capabilities | Prototypic systems existing in some countries, development ongoing | Operational system(s) needed |
| **Dynamic airspace reconfigurations** | Highly dynamic database and messaging system of dynamic reconfigurations with central repository, and shared viewing and modification capabilities | Prototypic systems existing in some countries, development ongoing | Operational system(s) needed |

Table 39 CIS geodata information provision system functions

**Communicating partner systems and data exchange**

| Partner system | Exchange purpose | Data in/out | Remarks |
|---|---|---|---|
| **Geodata source** | Geodata compilation, merging, quality assurance, versioning, distribution | Geodata in | |
| **UTM servers** | Geodata provision as a common reference | Merged geodata out | |

Table 40 CIS geodata information provision system communicating partner systems and data exchanges

**Role today and in future in UAM**

Today there is no such function existing yet, will fundamentally form the structure of systems and communications in U-Space.

## 3.7.9 UTM

**Actor/stakeholder and its variants**

USSPs will use UTM systems for USSP service provision such as:

- Traffic information service
- Geo-awareness service
- UAS flight authorisation service
- Network remote identification service
- Conformance monitoring
- Weather service
- Provision and reception of dynamic restrictions
- Sharing of USSPs terms and conditions

UTM systems and services are at the core of U-Space and serve as building blocks for it in a market that is expected to be competitive.

In some countries CIS and UTM are merged into a single system (PANSA Poland?), in most others CIS and UTM are seen as separate systems. While CIS are considered in majority to be central and single instance, UTMs are regarded as systems with several USSPs in competition, and therefore with a number of instances in U-Space.

**Function in more detail, differentiating also the status today and the needed extensions in future.**

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Traffic information service** | Provision of track information for manned and unmanned traffic<br>Provision of flight plan information for UAS<br>Provision of conflict warnings and alarms | Prototypes existing, very few systems operational<br>Provided situation awareness is limited | Needs to provide full and complete situation awareness |
| **Geo-awareness service** | Provision of geodata, maps,<br>and geodata related alarms | Prototypes existing, very few systems operational | Needs to provide full and complete geodata |
| **UAS flight authorisation service** | Flight authorisation within the scope of the USSP<br>Flight authorisation in coordination with other authorities | Prototypes existing, but very few systems are operational. An open standards software development initiative is going under the name "interUSS project" (Home-InterUSS (interussplatform.org)) | Needs to provide full service for all UAS classes of UAS, and all types of missions |
| **Network remote identification service** | Provision of a unique identifier for a flight object in U-space | Prototypes existing, very few systems operational | Needs to provide full service for all UAS classes of UAS, and all types of missions |
| **Conformance monitoring** | Monitoring of track accordance with flight plan limits, generation of warnings and alerts | Prototypes existing, very few systems operational | Needs to provide full service for all UAS classes of UAS, and all types of missions |
| **Weather service** | Provision of aviation weather plus U-Space weather<br>Provision of weather-related restrictions, warnings and alarms | Prototypes existing, very few systems operational | Needs to provide full service for all UAS classes of UAS, and all types of missions |
| **Provision and reception of dynamic restrictions** | Exchange of dynamic restrictions with other UTM and with ATM | Prototypes existing, very few systems operational | Needs to provide full service for all UAS classes of UAS, and all types of missions |

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Sharing of USSPs terms and conditions** | Communication of T&C with other USSPs | Prototypes existing, very few systems operational | To be completed |
| **Future services** | To be defined | To be defined | The set of U-Space services is expanding as U-Space evolves over time. Special attention is needed for scalability, security and interoperability between USSPs |

Table 41 UTM functions

**Communicating partner systems and data exchange**

| Partner system | Exchange purpose | Data in/out |
|---|---|---|
| **UAS registry database** | Registry data retrieval | UAS/operator search criteria in<br>Registry data out |
| **CIS traffic information service** | Traffic information retrieval | Track data in<br>Flight plan data out? |
| **CIS geoinformation service** | Geodata information retrieval | Geodata in |
| **Meteo data sources** | Meteo data retrieval | Meteo-data in |
| **All types of UTM clients** | Client service provision | Specific client service data exchange |
| **Operator fleet management systems** | UTM to operator's fleet management. coordination | Traffic information out<br>UAS flight plans in |

Table 41 UTM communicating partner systems and data exchanges

**Role today and in future in UAM**

UTM systems will be the building blocks of the U-Space system landscape, together with UAS, UAS surveillance means, and possibly operators' fleet management systems.

#### 3.7.9.1 UTM client system for authorities

The UTM client system for authorities provides the authorities with the means of accessing data in the UTM servers as well as the CIS data. The functionality used by various authorities can be roughly divided into three categories:

1) Providing geographic information
2) Approving (special) operation plans

3) Planning and executing UAS operations on behalf of the authorities

**Function in more detail, differentiating also the status today and the needed extensions in future.**

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Providing access to geographic information** | Authorities need access to geographics data in support of, for example, U-Space operation authorisation processes | Under development, first systems are operational. | |
| **Workflow support for assessing flight operation authorisation request** | The appropriate authorities need means to assess the acceptability requests for operation authorisation. This typically requires data from various sources and natures (geographic information, legal, technical information about equipment etc) | Initial systems are operational, however further automation is desirable. | As traffic increases, there is a need for extensive automation of the approval process in order to keep the response times to requests reasonable. |
| **Flight planning in support of emergency and law-enforcement flights** | The flight planning in support of emergency and law-enforcement is similar to that of regular UAS operations but has a different set of operational limitations. The UTM Client System for Authorities should provide the capability to plan flights with higher priorities and other restriction than those that apply to regular users. Functionality may include management of temporary restricted airspace to e.g., to protect SAR operations from conflicting traffic. | Initial systems have been developed for demonstrator projects; further development is needed. | |

Table 42: Functions today's status and needed extensions in the future

**Communicating partner systems and data exchange**

| Partner system | Exchange purpose | Data in/out | Remarks |
|---|---|---|---|
| **UTM system** | The client obtains its main data from the UTM system | Geo-zones in / out<br>Flight plan in / out<br>Flight plan approval out<br>Registration / Operator information in | |
| **Authority-specific systems** | Synchronise authority-specific data with the UTM system (e.g., geographic information) | | |

Table 43 UTM client systems for authorities communicating partner systems and data exchanges

### 3.7.9.2 UTM client system for cities

The UTM client system for cities allows local authorities to interact with the UTM system. It should provide the city authorities with means of establishing and distributing rules on UAM operations (e.g., noise limitations) and local obstacle data (e.g., tower cranes) Function **in more detail, differentiating also the status today and the needed extensions in future**

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Manage local airspace restrictions, obstacles etc.** | The city authorities have the best knowledge of local (temporary) obstacles. | Management of airspace and obstacle database is under development stage in current UTM systems. | The functionality needs further expansion, especially the delegation of management functionality to lower authorities. |
| **Generate statistics for airspace usage, social impact reporting etc.** | The local authorities will need information from the UTM system in support of mobility policy development. | | |

Table 44 functions of UTM client system for cities

**Communicating partner systems and data exchange**

| Partner system | Exchange purpose | Data in/out | Remarks |
|---|---|---|---|
| **UTM Server system** | The UTM Server system is the interface to the CIS, which holds the airspace and obstacle information. | | |

Table 45 communications of UTM client system for cities

### 3.7.9.3 UTM client system for police

The UTM client system for police shall combine function of the client system for authorities (e.g., in support of creation of pop-up no fly zones) as well as function of operators (e.g., in planning flights for policing purposes). Flights managed through the police client shall have the option of being marked as priority flight, giving it the priority over other flights when it comes to deconfliction.

### 3.7.9.4 UTM client system for operators

The UTM Client system for operators gives access to those services in the UTM systems that are of importance to UAS operators.

**Function in more detail, differentiating also the status today and the needed extensions in future.**

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Provide access the U-Space services in support of flight operations** | This is the general interface that provides the operation access to functions offered by the USSP | Prototypes existing, very few systems operational | |
| **Traffic information** | Provides real time information to the traffic situation. | Functionality is available as an evolution from ATM systems | Needs to be expanded with U-Space relevant information on the traffic (e.g., in support of priority rules, right of way, etc) |
| **Operation planning** | Allowing for the submission and modification of operation plans. | Prototypes existing, very few systems operational | |
| **Visualisation of Geo-information** | in support of flight planning | Prototypes existing, very few systems operational | |
| **Obtaining weather information** | in support of flight planning | Prototypes existing, very few systems operational | |

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Access to UTM-ATM interface** | For obtaining clearance from ATC when exiting U-Space, or for coordination in mixed traffic environments | To be developed | |

Table 46 UTM client system for UAS operators

### 3.7.9.5 UTM client system for pilots in the field

The UTM client system for pilots in the fields provides the pilot with accurate up-to-date information in support of the execution of the flight. This includes traffic information, weather information, non-conformance monitoring alerts of own flight and nearby aircraft as well as access to the UTM – ATM interface in support of obtaining clearances from ATC.

**Function in more detail, differentiating also the status today and the needed extensions in future.**

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Traffic information** | Provides real time information to the traffic situation. | Functionality is available as an evolution from ATM systems | Needs to be expanded with U-Space relevant information on the traffic (e.g., in support of priority rules, right of way, etc) |
| **Provision of geo-zone information** | Provides real time information about the position of the aircraft with respect to geo-zones. | Prototypes existing, very few systems operational | |
| **Obtaining weather information** | in support of flight execution | To be developed | |
| **Conformance monitoring** | This function is to warn about deviations from the deconflicted flight plan of either own aircraft or other (nearby) traffic | To be developed | |
| **Access to UTM-ATM interface** | For obtaining clearance from ATC when exiting U-Space, or for coordination in mixed traffic environments | To be developed | |

Table 47 functions of UTM client system for pilots in the field

### 3.7.9.6 UTM client system for VFR pilots

The UTM client system for VFR pilots brings the U-space functions to the cockpit of manned aviation.

**Function in more detail, differentiating also the status today and the needed extensions in future**.

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Traffic information** | Provides real time information to the traffic situation. This could be augmented with traffic alerting function that warn for nearby traffic. | The data link to manned aircraft is not yet available, nor the avionics or handheld applications to display the traffic. Similar functionality exists in the form of FLARM and ADSB based traffic information | Needs to be expanded with U-Space relevant information on the traffic (e.g., in support of priority rules, right of way, etc) |
| **Provision of geo-zone information** | See section above | | |
| **Obtaining weather information** | See section above | | |
| **Conformance monitoring** | See section above | | |
| **Access to UTM-ATM interface** | See section above | | |

Table 48 functions of UTM client system for VFR pilots

### 3.7.10 Operator fleet management system

The operator fleet management system is at heart of the UAM operator's operation. It is responsible for planning the utilisation of the fleet, assigning transport requests to individual aircraft, planning and monitoring flights for those aircraft as well as planning battery usage and charging. Whilst the implementation details of fleet management systems is out of scope of CORUS-XUAM, the development of U-Space solutions needs to recognise the need for interoperability with such systems.

**Function in more detail, differentiating also the status today and the needed extensions in future.**

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Receive and process transport requests from customer** | | Prototypes are under development | |
| **Assign aircraft to fulfil transport request** | | Prototypes are under development | |
| **Prepare and submit flight plans** | | Prototypes are under development | |

Table 49 functions of operator fleet management system

**Communicating partner systems and data exchange**

| Partner system | Exchange purpose | Data in/out | Remarks |
|---|---|---|---|
| **UTM** | Flight planning<br>Traffic information | Out: Flight plan submission<br>In: flight plan approval/denial<br>In: Flight plan modification request | |
| **UAM booking system** | Customer transport request | In: transport request<br>Out: Booking confirmation/denial | |
| **UAM GCS** | Flight plan exchange<br>Vehicle status information | Out: Flight plan<br>In: vehicles status information | |

Table 50 Communicating partner systems and data exchanges of operator fleet management system

## 3.7.11 UAM/UAS ground control system or RPS

Whilst the implementation details of ground control systems are out of scope of CORUS-XUAM, the development of U-Space solutions needs to recognise the need for integration of UTM functionality within such systems. The UTM system will have to provide appropriate interfaces to enable tight integration of UTM functions in, and provision of data to ground control systems.

**Function in more detail, differentiating also the status today and the needed extensions in future.**

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Pilot functions** | (see section on UTM client for pilots in the field) | | |
| **Receive orders and communicate status with Fleet management system** | | Prototypes are under development | |

Table 51 functions of UAM/UAS ground control system or RPS

## 3.7.12UAM/UAV onboard flight management system

The flight management system is an onboard system of a UAV that is responsible for providing a reference path which will be followed by the flight control system. As such, the FMS is holds and updates in the intended flight path of the UAV for both nominal and abnormal situations. The intended flight path may be updated based on inputs the Ground Control System or autonomously based on inputs from on-board sensors.

In case the connection to the GCS is lost, the FMS shall keep the UAV on a safe path, potentially all the way to the landing, which may be at an alternative landing site.

The intended flight path may be shared with the UTM system for purposes of conflict detection and avoidance. In that case, the accuracy of the definition of the flight path combined with the ability of the flight control computer and the navigation system to accurately fly that path will be one of the factors driving the required size of safety buffer between passing aircraft.

When separation between aircraft is based on shared flight path intent data, the FMS may also function as a route conformance monitoring subsystem to detect path deviations by approaching aircraft. This can enable early detection of collision risk which can then be reduce by the FMS by altering its own intended flight path.

The more autonomous the UAV is, the more critical the role of the FMS in keeping the flight safe.

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Managing the flight path in agreement with the deconflicted flight plan.** | | | |
| **Providing a reference path to Flight control system** | | | |
| **Managing contingencies flight paths in case of failures in links or on-board systems** | | | |

Table 52 functions of UAM/UAS onboard flight management system

**Communicating partner systems and data exchange**

| Partner system | Exchange purpose | Data in/out | Remarks |
|---|---|---|---|
| **UAS Ground Control System** | All control information will come through the UAS Ground Control System | | |

Table 53 communications of UAM/UAS onboard flight management system

## 3.7.13Vertiport management system

A Vertiport management systems is responsible for coordinating local traffic movement on surface of the vertiport as well as maintaining vertiport planning and status information up-to-date and distributing this information to various stakeholders.

Maintaining a plan of FATO utilisation in support of Demand / Capacity balancing
Assigning FATO's to approaching / departing vehicles
Orchestrating surface movement at the vertiport (if applicable)

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Maintaining a plan of FATO utilisation in support of Demand / Capacity balancing and air taxi operations planning** | | Not developed yet, baseline may get inspiration from airport operation planning systems / SWIM | |
| **Assigning FATO's to approaching / departing vehicles.** | | Not developed yet | |

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Orchestrating surface movement at the vertiport (if applicable)** | | Not developed yet, baseline may get inspiration from ASMGCS | |

Table 54 functions of vertiport management system

**Communicating partner systems and data exchange**

| Partner system | Exchange purpose | Data in/out | Remarks |
|---|---|---|---|
| **UTM flight planning system** | Demand / Capacity balancing | FATO availability. Slot reservation & confirmation. | |
| **Fleet management system** | Exchanging passenger information to guide passengers to the right stand. Assigning stands to air taxis. | | |
| **UAS** | Surface movement guidance | Taxi route (if applicable) | |

Table 55 communications of vertiport management system

### 3.7.14U-Space surveillance means

A wide variety of surveillance technologies will be used in U-Space. Especially in the near term, traditional surveillance means used in manned aviation such as secondary radar, 1090 Mhz multilateration, ADS-B and potentially FLARM will be used to locate manned aviation, as is done currently. Some of these technologies may also be applicable to a number of unmanned aircraft, however it is foreseen that aircraft will be connected to the UTM system (either directly or via the GCS) over an IP-based communication link. This link will be used to provide the UTM system with position and velocity data, either from the aircraft's navigation system, or from a dedicated GNNS receiver (e.g., Hook-on-Device). At the same time this link can be used to provide real time trajectory forecast from the UAV to the UTM system. This enables better conflict prediction and resolution.

In addition to a UTM System based centralised surveillance, air-to-air surveillance may play a role in collision avoidance. The benefit of air-to-air surveillance is that it does not rely on connectivity to the UTM system, which may face continuity issues in areas of poor communication system coverage. Air-to-air surveillance is also likely to have a lower latency than a centralised surveillance solution. A downside of air-to-air surveillance is the difficulty to innovate whilst maintaining interoperability between aircraft. Where a UTM system could act as a translation layer between various technologies, air-to-air surveillance systems must be interoperable with each other. Introduction of new air-to-air surveillance technologies can only be successful if backwards compatibility with existing technologies is guaranteed, or the whole fleet is upgrading to the new technology at the same time.

Therefore, a U-Space air-to-air surveillance system should be focussed on enabling robust last resort collision avoidance a strong safety barrier, whilst the centralised surveillance should be focussed on enabling efficient tactical routing in order to achieve high operational performance within U-Space while avoiding conflict situations.

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **Mode S SSR** | Mode- S Secondary Surveillance Radar. | Used by most ANSPs for the surveillance of aircraft in controlled airspace | Due to the limited Mode-S address range (16 million unique addresses worldwide) and 1090 Mhz frequency overload, Mode-S cannot facilitate many additional users. Use in U-Space is mostly limited to existing (manned aviation) users. |
| **ADS-B** | Automatic Dependent Surveillance -Broadcast. A technology that uses Mode-S transponders to broadcast e.g., position, velocity and identity information. | Implemented on aircraft with a MTOM exceeding 5700kg and/or maximum cruising airspeed greater than KTAS :250kts | Due to the limited Mode-S address range (16 million unique addresses worldwide) and 1090 Mhz frequency overload in a number of geographic areas, ADS-B cannot facilitate many additional users. Use in U-Space is mostly limited to existing (manned aviation) users.<br>Since ADS-B uses an unencrypted link without means to authenticate the transmitter (like all Mode-S based communication), there are security concerns mainly related to spoofing. A secured form of ADS-B that address this issue would be welcomed. |
| **Wide Area Multilateration (WAM)** | Wide area multilateration is a technology that determines the position of aircraft by measuring the difference in time of arrival of a signal transmitted from the aircraft's transponder. | Used by various ANSPs for the surveillance of aircraft in controlled airspace | WAM works with signals from the Mode-S transponder on aircraft. Due to the limited Mode-S address range (16 million unique addresses worldwide) and 1090 Mhz frequency overload in a number of geographic areas, Mode-S cannot facilitate many additional users. Use in U-Space is mostly limited to existing (manned aviation) users. |
| **FLARM** | FLARM is a traffic awareness and warning system for General Aviation. It provides increased situation awareness by actively warning the pilots of potential traffic conflicts. | Mature, proprietary, technology Used mainly in gliders, light single engine propeller aircraft and HEMS. | |

| Functions in more detail | Explanation | Status today | Needs in future |
|---|---|---|---|
| **IP based Dependent Surveillance** | This technology uses an IP based communication system to transmit position, velocity and identity information to a central traffic tracking system. Conceptually, additional information such as intended flight path can be added to the submitted dataset. | In development, various implementations are emerging (e.g., Droniq Hook-on-Device) | Standardised interfaces have to emerge from the current implementations so that the systems work in all U-Space implementations. |
| **Air-to-Air surveillance** | | In development (e.g., ACAS Xu, ACAS sXu) | |

Table 56 functions of U-Space surveillance means

## 3.8 Operational procedures

The safety and performance of the system enabling UAM is the result of the interaction of the three constituents of the UAM system: people, procedures and equipment.

Procedures prescribe the interactions between people, between people and equipment and between equipment. They consist of a predictable sequence of events, ensuring consistent outcomes, enabling the UAM system to perform according to expectations in a safe manner.

Therefore, procedures in UAM should cater for nominal as well as non-nominal situations.

This chapter breaks down the need for operational procedures for UAM in various phases of the flight. It focusses on procedures that are relevant of the U-Space implementation, and specifically on those procedures that are specific to UAM.

### 3.8.1 Procedures in the pre-operational phase

The organisation phase, which addresses the pre-operational activities see the following procedures:

#### 3.8.1.1 Procedures for establishing the UAM operator:

Registering as operator with the CAA and obtaining permission to operate

This establishes the conditions under which the operation is permitted

Registering the aircraft used for the UAM operation

#### 3.8.1.2 Procedures for establishing the U-Space

This is an Airspace change process, involving ANSPs, USSPs, local authorities, CAA, vertiport operators, UAM operator and other airspace users.

Including validation / approval by CAA

Publication in AIP etc.

#### 3.8.1.3 Contractual agreement processes

Including agreements between the UAM operator, USSP, ANSP and Vertiports.

### 3.8.2 Procedures in the pre-flight phase

The pre-flight phase is addressing all activities associated to a flight, before the flight takes place.

#### 3.8.2.1 Procedures for planning a flight

The flight planning procedures are to ensure that the planned flight is not conflicting with other planned flights and does not exceed vertiport or airspace capacity so that, with a high level of confidence, the flight can be executed as planned. The planning process will be initiated by the UAM operator. Additionally, the vertiports, USSP and optionally ANSP and other UAM operators are involved.

#### 3.8.2.2 Procedures for changing of flight plan prior to flight

It is to be expected that not every flight will be executed as planned. In some cases, prior to departure a change of the plan is needed. Procedures for changing a flight plan prior to flight will need to be established. These procedures must at least address the following cases

- Change of timing (early / late departure and/or arrival)
- Change of routing
- Change of destination
- Change of vehicle
- Change of uncertainty – refinement of a plan to reduce the uncertainty, particularly take off time uncertainty.

They should describe the actions taken by the operator as well as by the USSP and vertiport operators to ensure the flight plan is not conflicting with other plans.

#### 3.8.2.3 Procedures for deconfliction of flight plans

In case a flight plan is filed, or a change is to a plan is requested that is conflicting with pre-existing flight plans, there is a need for a procedure to deconflict these plans. In the simplest case, the new plan or the requested change which creates a new conflict is denied, however it seems that for operational efficiency a more sophisticated procedure is desirable. Such a procedure could involve proposing a similar, deconflicted plan optionally optimising the use of airspace by proposing modifications to other plans as well. This procedure should not be limited to the pre-flight phase, it should also cater for changes of flight plans of flights that are already active. Priorities might be introduced to consider repetitive flights plans allowing planning certainty as well as classification of goods, such as passenger flights. The deconfliction procedure needs to take in to account the priority status of flights, for example for law-enforcement, medical or search and rescue operations.

CORUS' ConOps [4] described a concept "Required time to act" which in essence carries over some lessons from manned aviation. In manned aviation, strategic conflict resolution is usually considered infeasible, but demand capacity balancing is analogous. Specifically in manned IFR flight in Europe today:

changes to plans are extremely common
the uncertainties in those plans are large
plans are filed at a range of different times before flight
problems that need rectification are typically only visible when almost all plans are filed.

Drawing on this experience, Required Time to Act was put forward as a mechanism to resolve what would otherwise be a systematic unfairness between different business models if "first to file" was taken as the prioritisation scheme. RTTA proposes that strategic conflict resolution consider the plans in three groups. Required time to act is a time offset from the start time of the flight; in manned aviation terms the estimated "off block" time.

Plans which have not yet reached RTTA are ignored
Plans which have passed RTTA are considered as immutable
Plans which are at RTTA are deconflicted with the immutable flights and then each other

Yet to be worked out are what is RTTA, suggestions include 5 minutes, and how broad a time window is considered as being “at RTTA”, for example 1 minute. Both of these choices and even the utility of RTTA are highly dependent on the exact nature of UAS operation plans, in particular the extent to which they are likely to conflict and likely change.

European regulation 2021/664 [23] views strategic conflict resolution as being the task of the U-space service providers and that there may be multiple USSP active in any airspace. The acceptable means of compliance and guidance material [31] for 2021/664 [23] proposes that the conflict detection across multiple USSP can occur following ASTM standard F3548-21 [88], that is making use of the Inter-USS [89]. 2021/664 [23] requires that strategic conflict resolution prioritise earlier filing time, as noted CORUS [4] explained that this was inherently unfair.

### 3.8.3 Procedures during the flight

#### 3.8.3.1 Movement on the surface of a vertiport

Especially on busier vertiports, ground movements need to be carefully orchestrated to optimise the utilisation of FATOs/ stands and avoid deadlocks on taxiways. For efficient vertiport operations, it is crucial that aircraft do not occupy the FATO’s longer than necessary. It should be avoided that aircraft on the FATO are waiting for permission to move onwards while they are preventing other flights from landing. For departing flights, this mean that they should not move onto the FATO area if they have no clearance (explicit or implicit) to take-off. Landing aircraft should vacate FATOs as soon as practical. Procedures for ground traffic management will need to be developed.

On less busy vertiports, the ground movement does not require much orchestration. It such cases the traffic could be self-organised. Procedures for self-organising ground traffic need to be developed.

#### 3.8.3.2 Procedures for departing a vertiport

To depart from a vertiport procedures are needed to verify

1) The aircraft is fit to fly (final checks) (it is better to be on the ground and wish to be up in the air, than to be up in the air wishing to be back on the ground)
2) The flight plan is conflict free and the destination vertiport is available (as well as the alternates)
3) The weather is permitting the flight

In case the vertiport is in controlled airspace, a clearance from ATC may be required as well unless agreed otherwise in a Letter of Agreement (LoA).

Two flavours of the departure procedure will exist:

Departing from vertiports in controlled airspace/U-space airspace
Departing from vertiports outside controlled airspace / U-space airspace

#### 3.8.3.3 Procedures for approaching and landing at vertiports.

Procedures are needed for approaching and landing at vertiport. At busy vertiport, orchestration of airborne and surface traffic may be required to achieve safe operations at high throughput. At quieter vertiports, self-organising procedures can be used to achieve safe and efficient operations.

Approaching and landing at vertiports inside controlled airspace / U-space airspace
Approaching and landing at vertiports outside controlled airspace / U-space airspace

#### 3.8.3.4 Procedures to transit from one airspace to another

Procedures for leaving and entering areas of responsibility of ANSP / USSP must be agreed. The following cases have been identified

Leaving U-Space airspace and entering controlled airspace
Leaving controlled airspace and entering U-Space airspace
Leaving uncontrolled airspace and entering U-Space airspace
Leaving uncontrolled airspace and entering controlled airspace
Leaving controlled airspace and entering uncontrolled airspace
Leaving U-Space airspace and entering uncontrolled airspace

#### 3.8.3.5 Procedure for changing of flight plan during flight

In some use cases, the flight plan may need to be changed during flight on initiative of the operator or commander of the aircraft.
These procedures to change the flight plan during the flight can be initiated by the commander /operator of the aircraft.
Change of timing (early / late)
Change of routing
Change of destination
In all cases the UTM system will have to revalidate the plan which involves checking it against geo-zones, conflicts with other traffic and capacity at the vertiport of destination. Upon agreement by the UTM system, the proposed change becomes accepted in the active flight plan.

In other cases, the initiative to change the flight plan comes from the UTM system, e.g., when a conflicting flight plan is submitted with higher priority, or when airspace is dynamically reconfigured. The change is proposed to the commander and after accepting the change, the proposed change is incorporated in the active flight plan.

#### 3.8.3.6 Procedures for dynamic reconfiguration of airspace

Procedures applied by ATC
Procedures applied by actors involved in UAM operations

### 3.8.4 Emergency and Contingency procedures

#### 3.8.4.1 Emergency procedures

Procedures will need to be developed for the following emergency cases: (initial list)

Aircraft low energy state (land as soon as possible)
Aircraft degraded technical state (land as soon as possible)
Aircraft degraded technical state (land at nearest suitable)
Medical situation of a passenger (land at nearest suitable)

#### 3.8.4.2 Contingency procedures

Procedures will need to be developed for the following contingency cases: (initial list)

Intermittent loss of communication (single aircraft)

Loss of communication (single aircraft)
Loss of communication (multiple aircraft in same area)
Loss of communication (all aircraft in an area)
Mass deviation due to blocked vertiport
Mass deviation due to unexpected deteriorating weather
Diversion due to insufficient energy to reach destination (but not yet in low energy state)

## 3.9 CNS characteristics in urban environment

This section has three main objectives:

Identify the current CNS technologies (What is used?).
Identify the associated architecture required to support VLL and above VLL operations and answer how to fit/integrate CNS in U-space.
(Most importantly) Bring to the industry and all the stakeholders a high-level performance-based environment guide referring to CNS in U-space.

The used and followed concepts and methodology to develop this high-level performance-based urban environment guide is focus on the concept of required total system performance (RTSP). When looking at the ATM industry, we find the required ATM services and performance (RASP) which is the criteria expressed as performance parameters and the values of these parameters to be met by the ATM system, with a determined probability, to provide support to the approved service quality specified for a particular environment. So, why don't extrapolate these criteria but expressed as operational and technology performance parameters to be met by the U-space industry in order to provide approved safety and quality CNS performance for the particular urban environment.

This guide aim is to pave the path and propose a user's guide to specify performance requirements and make them achievable and measurable along all the flight phases of an operation as well as frame this concept under the umbrella of service level agreement's point of view supporting this operational framework.

A small example to contextualize the latter. While pretending to perform an operation, the UAS operator might have very good communications performances indicators in the area. However, the area where operating has poor navigation and surveillance coverage or not even that. Having high performance over a single CNS system it doesn't bring anything. If the UAS has a very high accuracy but very high latency there's nothing to do with that high accuracy. So, a balance between all the performance requirements across all CNS systems have to be managed and determined along all the flight plan phases and the UAS operator must be aware of them.

The performance requirements and key indicators which will be analysed in order to be the spine of this performance-based guide are:

- Integrity
- Continuity
- Functionality
- Availability
- Accuracy
- Latency

In order to achieve those objectives, 3 main tasks have been addressed:

- Describe how a service and its performance model works in U-space in CNS environment.
- Look at technologies and its limitations in U-space.
- Describe the relations, interoperability, and performance between CNS systems.

To sum up, at the end of this sections, this operational framework CNS guide in urban environment operations for UAS wants to let the UAS operators, USSPs and other stakeholders to derive and their practical experience in operations, operational needs analysis and technical or technological needs.

**State of the art**

When we talk about operating in an urban environment, we find limitations due to the very low level where the UAS have to operate. Houses, skyscrapers, various infrastructures attenuate, block and reduce the signal-to-noise-ratio of radio signals that must interact with the UAS. These infrastructures block the Global Navigation Satellite System (GNSS) signals that must be used by the UAS to navigate. In addition, the Automatic Dependent Surveillance Broadcast that operate in the 1090 MHz band are already beginning to be or almost reach saturation due to the large number of aircrafts.

By definition, "communications, navigation and surveillance are essential technological systems, procedures and programs for pilots in the air and air traffic controllers on the ground. They facilitate the process of establishing where the aircraft is and when and how it plans to arrive at its destination".

So, with the coming increasing of commercial and non-commercial operations in urban environment (EASA and NO EASA) CNS systems will play a fundamental and determining role to host the forecasts of operations in a medium-long term time horizon.

### 3.9.1 Communication

This section discusses data communications. We cannot be technologically agnostic because the objective of this chapter dedicated to CNS in urban environments is not to analyse all the available technologies and choose which are the most appropriate or the best. The objective is to design a performance-based guide that provides an analysis methodology so that the operator himself can choose the technological solution that best suits the operational environment where he is going to develop his operations.

Communications in an urban environment will be used by all kinds of vehicles and its function is to provide the flight status of the operator's aircraft, their positions, speeds, directions, etc. and any other relevant and useful information to share with the competent authorities such as weather information for example.

As previously mentioned, due to the shielding, weakness and loss of the signals in these environments, the first assumption is made. Since it will operate in physically unfriendly environments and the trend of the electromagnetic spectrum is to become congested over time, communications will have to be digital.

In the short term, communications will still be carried out through legacy systems such as voice communications. But these have great drawbacks and disadvantages which have been aggravated with the increase in air traffic. This happens because the aircraft that are in charge under the same controller are tuned to the same frequency. With increasing operations, the likelihood of a pilot accidentally accepting orders sent to another pilot is considerable.

To mitigate such an error, communications protocols have been implemented, but these slowed down communications by having to repeat and duplicate the information sent. In addition, it requires a large amount of time since first it is necessary to have the attention of the pilot or the controller and secondly to give the order or send the request. And finally, thirdly, you will wait to receive the required confirmation or information.

Traditionally, this problem has been mitigated by partitioning the radioelectric spectrum of saturated air traffic control into smaller sectors. And each of these chunks is given to its own controller and so each uses a different voice communication channel. However, this solution has two problems. The first one is due to the increasing the number of frequencies we are increasing the amount of traffic transfer operations between controllers. That increases the workload. This overload occurs when the flights are transferred from one controller to another, which requires coordination between the controllers themselves and a voice communication between the pilot. The second problem is that the number of voice channels available is finite. And if we look at high-density airspaces such as large cities and airport hubs in Europe, there may not be channels available within a certain period of time to accommodate all drone operations in those environments.

In short, in some cases it will not be possible or feasible to increase the cuts and sectorization of the radioelectric spectrum for voice communications. A new strategy is needed to cope with increased demand. The solution is to base communications on data links adapted on the aviation and the UAM need. These offer a better strategy and furnish the effective capacity of digital communications.

It is well known that the number of drones in our airspace is increasing and also that BVLOS operations are very attractive for their business opportunities and use cases.

This requires a reliable command and control link (C2 Link). This link must have a wide coverage that covers a large region and also be highly reliable to guarantee the safety of operations, the integrity of the aircraft and the infrastructures and people on the ground. The technology chosen and previously introduced, capable of meeting this need, is mobile networks. Mobile networks already offer practically total coverage. They also offer excellent security levels.

Despite the fact that the solution in betting on digital communications using the current telecommunications networks of mobile telephony has certain limitations due to its current layout and design architecture.

Mobile phone antennas are designed to provide coverage to users with a mobile phone. And these, it is at ground level. With which the antennas are oriented towards the ground. Here we detect the first problem. There is a vast network coverage at ground level, however, UAS fly at a certain height.

Although we call the environment operations VLL, for reasons of performance and type of operation, the UAS fly to certain levels of the ground where the coverage and quality of the signal is not good enough to reach the levels of integrity, continuity, functionality, and availability.

Mobile phone companies and operators should make an investment in doubling the infrastructure to reorient the antennas towards the sky. But it is evident that such investment, with the current standards of the number of operations that are being carried out, cannot cover the costs of this type of deployment.

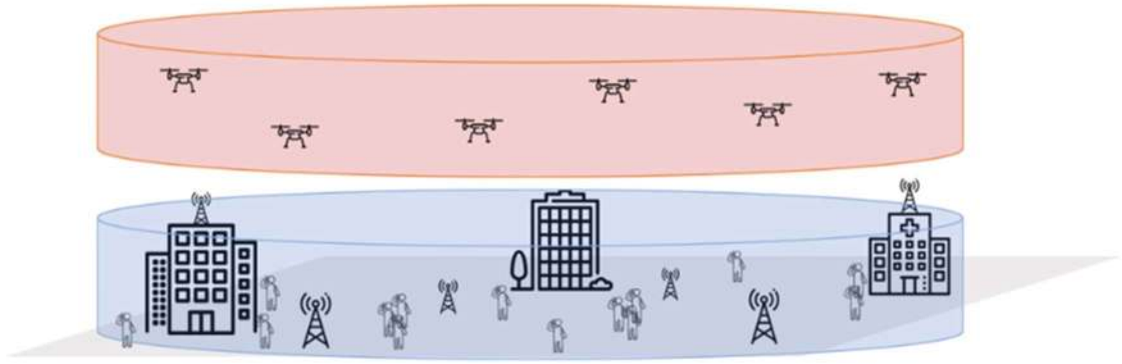

Figure 25 Current Mobile Network Coverage

The urban environment has insufficient users to cover the current cost. During the coming years when increasing the urban environment operations, mobile company operators will be more interesting and more affordable talking in a cost-effective way.

The proposal presented below is an iteration of the current connectivity between an aircraft and the ground control station through the conventional command and control link (C2 Link) that we already know is limited by signal obstructions in the urban environment. To increase said connectivity and number of operations while maintaining and ensuring the key indicators that are working on in this section of the operational framework (integrity, continuity, functionality and availability). To do this, focus should be on the next evolutionary leap in communications and have connectivity from the GCS to mobile phone stations that provide access to U-space services and feed the aircraft with important information.

Finally, and more interesting and relevant is to deploy a real and effective coverage of mobile communications both, GCS and UAS.

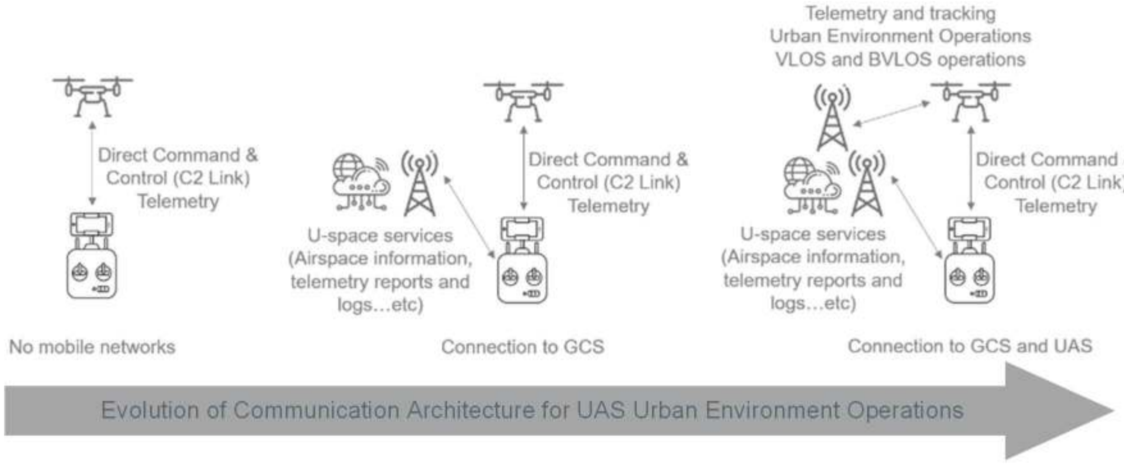


Figure 26 Roadmap to implement Mobile Network Communication Architecture

### 3.9.2 Navigation

Next, we are going to address the aspect of air navigation. Generally, navigating through the air is almost the same as navigating on land or sea. This includes planning the route, controlling the movement and the movement of the vehicle from a starting point to an end point. But navigating through the air has certain differences to be aware of. That make it more difficult to successfully navigate. And it is even more complicated if these flights take place in urban environments densely occupied by tall buildings and complex infrastructures. The Global Navigation Satellite System (GNSS) is prone to data degradation or complete signal loss due to multipath effects, interference, or antenna dimming. Added to this, there are other problems and risks that must be taken into account and be mitigated. An example of this is illegal interference such as jamming and spoofing. Low-cost technology solutions and systems for a civilian public and commercial sector are even more vulnerable to these attacks.

The first important aspect is speed. Aircraft flies at relatively higher speeds than vehicles that travel on the earth's surface. This first consideration reduces the time you have to calculate your position during the flight. Also, depending on the type of aircraft (fixed wings, rotary wings, VTOLs) they cannot be stopped in the air. Another related consideration is the issue of fuel and / or its power sources. When planning a mission or flight plan, among the dozens or hundreds of parameters to study and define one of the most important is fuel / energy. How much energy will we need to go from point A to point B at a certain speed, height, direction, turns, the different changes that we will have to make to maintain correct navigation and as accurate as possible.

Finally, navigation accuracy is a central point in the collision prevention. An event, incident or accident in air terms usually has fatal consequences and outcomes, either accounting for material damage or human damage. Well, constant knowledge of the position is extremely fundamental.

The navigation techniques and flight procedures for the air navigation are subject to whether the aircraft is operating under visual or instrument flight rules.

Once we have introduced and defined the art of navigating through the air, we are going to land navigation in the context that concerns us. What is to analyse what technologies are currently assisting UAS and their limitations in urban environments and how to provide a better navigation technology to assist operations in urban environments, thus being able to reduce safety distances, further strengthening safety of the aircraft, their payloads, the people and infrastructures that are on the ground. And finally, in operational terms, to be able to host more operations in the same airspace structure thanks to reducing said separation distances between aircraft. Increased capacity, and consequently the demand of the industry.

**State of the art of navigation**

The conventional navigation that we are used to with Ground-based radio-navigation systems (NDB, VOR, DME, ILS…) does not apply in the environment we are working in or with the type of aircraft that operate in it. For reasons such as that the receivers have not and never will be miniaturized to be on-boarded in UAS. And the most relevant reason is that the accuracy is too low for the intended purposes.

So, we have to look at other technologies and solutions and mix some of them to enhance the operational and technical performance requirements. Some technologies are still in an early stage of development and testing and have not been implemented in large environments to validate them.

However, what is intended to be enhanced and promoted is that the operator must seek and implement the best solution for navigation and positioning of their aircrafts. As it has been doing in recent years, it will be a mix and match of these technologies. This leads to better performance in addition to the fact that when different solutions are combined and implemented, greater redundancy is achieved. Something vital and basic in the aeronautical sector.

The main used and tested current technologies for positioning and navigation for UAS that we can find and work with are based on GNSS:

- GNSS: The Global Navigation Satellite System involves a constellation of satellites orbiting at about twenty thousand kilometres altitude over the earth surface, continuously transmitting signals that enable users to determine their position with global coverage. This solution is the most basic and cheapest. There are 6 constellations available (2 of them are in their final phase of deployment). It has drawbacks such as the need for a minimum of satellites arranged in line of sight. The waves cannot pass through obstacles such as buildings and mountains.

- Galileo: Galileo is Europe’s own global navigation satellite system, providing a highly accurate, guaranteed global positioning service under civilian control. It is inter-operable with GPS and GLONASS. Galileo receivers compute their position in the Galileo Reference System using satellite technology and based on triangulation principles.

- GPS: The GPS is a space-based global navigation satellite system (GNSS) that provides reliable positioning, navigation, and timing services to civilian and military users on a continuous worldwide basis freely available to all. It is maintained by the United States government and is freely accessible by anyone with a GPS receiver.

- GLONASS: Is a radio-based satellite navigation system operated for the Russian government by the Russian Space Forces. It is an alternative and complementary to the United States' GPS, the Chinese Compass navigation system, and the planned Galileo positioning system of the European Union.

- Beidou: The BeiDou Navigation Satellite System (BDS), also known as Beidou-2, is a project by China to develop an independent global satellite navigation system. BeiDou System is not an extension to the previously deployed Beidou-1, but a new GNSS similar in principle to GPS and Galileo.

- QZSS: QZSS is a Radio Navigation Satellite System. It will enable a better reception in urban areas, in particular in Japan, by increasing accuracy and continuity, essentially for position-based application.
- IRNSS: Indian Regional Navigation Satellite System. This constellation is clearly focused to be useful for Indian users and those operating at a range of 1500 to 2000 km of India boundaries.

However, using stand-alone GNSS is inadequately precise for UAS navigation in urban environment, due to the performance it delivers. Let's have a look on how it works. A GPS receiver listens to satellites to measure its distance to each sat, at a given time, and thus its location by simple geometry calculation. The distance to a sat is measure by the time it takes for this sat's GPS signal to travel to the GPS receiver. To do that, each sat emits a unique Pseudo Random Noise signal (PRN), or C/A code, repeated at a frequency of 1,023 MHz. The PRN period length is 1 ms or, due to the speed of light of 300.000.000 m/sec, about 290 meters. The distance measurement precision is about 1% of the measured signal wavelength. This result in a standard GPS precision is about more or less 3 meters.

3 meters uncertainty is not good enough for urban UAS navigation. To improve this precision, we can do two main things:

Measure a higher frequency signal (smaller wavelength than the PRN)
Correct measurements errors by subtracting them with differential trick or model errors, when possible, to supress them.

Along the first option, the use of a higher frequency signal, luckily, GNSS standards use two high frequency carrier signals. (L1: 1575 MHz, L2: 1227 MHz) on which the PRN is transmitted.

By measuring the L1 carrier signal phase, at 1575 MHz, instead of the PRN at 1 MHz, we can measure a signal with a wavelength of 19 cm. And thus, a theoretical distance precision of more or less 2mm.

However, such 2mm precision is not reached because of signal/time measurements errors due to:

Satellites internal clocks errors
Satellites orbit errors
Ionospheric/tropospheric signal propagation delays
Receiver noise
Signal travel distance errors due to multipath reflections.

In order to correct or even supress these errors we can feed the GPS receiver with correction data. On this statement, there are different approaches. Some of them with the more interest for UAS operations in urban environment are

Satellite Based Augmentation System (SBAS)
Differential GPS approach (DGNSS)
Real Time Kinematics (RTK)
Precise Point Positioning (PPP)

Augmentation of GNSS means improving the navigation system's attributes, such as accuracy, reliability, and availability, through the integration of external information into the calculation process. There are many such systems in place, and they are generally named or described based on how the GNSS sensor receives the external information.

A Satellite-based Augmentation System (SBAS) is a civil aviation safety-critical system that supports wide-area or regional augmentation – even continental scale - through the use of geostationary satellites which broadcast the augmentation information. A SBAS augments primary GNSS constellations by providing geostationary ranging, integrity and correction information. While the main goal of SBAS is to provide integrity assurance, it also increases the accuracy with position errors below 1 meter. With SBAS we can achieve better accuracy when compared to using only GNSS.

SBAS but has certain limitations such as that it is necessary to be in line of sight. We can automatically determine that for applications in the environments we are dealing with, where there are obstacles, this is an impediment.

Next, we will highlight the SBAS systems currently available operationally. Each of them covers a different region of the planet. In the United States we find the WAAS. In Japan there is MSAS, GAGAN for India and SDCM in Russia.  And finally, but not least, indeed is the one that with more relevancy in this discussion is EGNOS.

The European Geostationary Navigation Overlay Service (EGNOS) is Europe's regional satellite-based augmentation system (SBAS) that is used to improve the performance of global navigation satellite systems (GNSSs), such as GPS and Galileo. EGNOS uses GNSS measurements taken by accurately located reference stations deployed across Europe.

All measured GNSS errors are transferred to a central computing centre, where differential corrections and integrity messages are calculated. These calculations are then broadcast over the covered area using geostationary satellites that serve as an augmentation, or overlay, to the original GNSS message.

As a result, EGNOS improves the accuracy and reliability of GNSS positioning information, while also providing a crucial integrity message regarding the continuity and availability of a signal. In addition, EGNOS also transmits an extremely accurate universal time signal.

Differential GNSS (DGNSS) is a kind of GNSS augmentation system based on an enhancement to primary GNSS constellations information by the use of a network of ground-based reference stations which enable the broadcasting of differential information to the user to improve the accuracy of his position, but the integrity is not assured.

PPP is a positioning technique that removes or models GNSS system errors to provide a high level of position accuracy from a single receiver. A PPP solution depends on GNSS satellite clock and orbit corrections, generated from a network of global reference stations. Once the corrections are calculated, they are delivered to the end user via satellite or over the Internet. These corrections are used by the receiver, resulting in decimetre-level or better positioning with no base station required.

PPP delivers accuracy up to 3 centimetres. A typical PPP solution requires a period of time to converge to decimetre accuracy in order to resolve any local biases such as the atmospheric conditions, multipath environment and satellite geometry. The actual accuracy achieved, and the convergence time required is dependent on the quality of the corrections and how they are applied in the receiver.

Similar in structure to an SBAS system, a PPP system provides corrections to a receiver to increase position accuracy. However, PPP systems typically provide a greater level of accuracy and charge a fee to access the corrections. PPP systems also allow a single correction stream to be used worldwide, while SBAS systems are regional.

RTK stands for Real-Time Kinematic and is a technique that uses carrier-based ranging and provides ranges and therefore positions that are orders of magnitude more precise than those available through code-based positioning. RTK techniques are complicated. The basic concept is to reduce and remove errors common to a base station and rover pair.

RTK is used for applications that require higher accuracies, such as centimetre-level positioning, up to 1 cm + 1 ppm accuracy.

The UAS determine their position using algorithms that incorporate ambiguity resolution and differential correction. Corrections are as accurate as the known location of the base station and the quality of the base station’s satellite observations. The location of the base antenna selection is important for minimizing environmental effects such as interference and multipath, as is the quality of the base station and UAS receivers and antennas.

### System comparison

DGNSS & RTK

- Both require a precisely known position of the base station.
- Both require a transmission link between the base and UAS.
- The maximum distance between the base and the UAS can be much greater for DGNSS.
- RTK (carrier phase use), is a way more accurate than DGNSS (PRN use)

SBAS & PPP

- Both have the same working architecture.
- PPP use carrier phase while SBAS using PRN
- PPP gets more accurate corrections and is overall more accurate.
- SBAS is free where PPP isn't.
- SBAS works instantly whereas long convergence time of PPP (EKF).
- SBAS is regional and PPP is global.

DGNSS & SBAS

- Same range of accuracy (i.e., lower than other methods).
- DGNSS require a base station, SBAS doesn't.
- DGNSS requires a link with UAS, SBAS doesn't.
- DGNSS HW and setup is more complex than SBAS.

RTK & PPP

- Same range of accuracy (i.e., best of all methods)
- RTK requires a base station, PPP doesn't.
- RTK requires a link with UAS, PPP doesn't.
- RTK WH and setup is more complex than PPP.
- RTK is free, PPP isn't.
- RTK works at a maximum 10 Km from base, PPP works globally (no base needed).

## 3.9.3 Surveillance

When we approach the aspect of surveillance of the air traffic that circulates daily in our skies, it's one of the most basic and main functions of air traffic management (ATM). In the current operational framework, such surveillance is mainly achieved through what we call Secondary Surveillance Radars (SSR) and Automatic Dependence Surveillance (ADS).

This data is displayed on the screens that air traffic controllers use to solve potential conflicts that may arise in both strategic and tactical phases. To avoid work overload, the airspace is divided into sectors and each sector is assigned to a team of controllers.

But when we try to apply these solutions in the urban environment, these technologies are not valid for reasons that we have repeated several times. In the first place, normally the UAS that operate in these environments tend to be of reduced dimensions, and the speeds to operate safely between buildings, on people cannot be very fast. That is, compared to manned aviation, the speed is very low.

Therefore, due to their size and speed, they are easy to confuse with birds. Second, there are no easy methods for ordering the screen when the radar is aimed at urban environments with many moving objects that need to be filtered, such as cars, pedestrians, etc.

There are specialized systems for UAS detection, such as electrooptically coupled X-band radars that can detect typical UAS within a range of 1 km.

The use of the X-band, the high bandwidth and the low power consumption are some of its most outstanding characteristics compared to other technologies. Signal and data processing is fully programmable using the latest high-resolution auto-tracking and target detection techniques to meet surveillance requirements

However, we again run into the problem of line of sight. These types of solutions are not compatible in urban environments due to line-of-sight requirements. These systems can be used to protect airports, power plants, or other critical infrastructure. So, we have to go for other approaches based on the detection of radio frequency (RF) emissions. Those systems shall detect UAS based on commonly used frequencies such as 35MHz, 430MHz, 460MHz, 2.4GHz, or 5.8GHz, all commonly used for communication with UAS.

The way to tackle this surveillance architecture and accomplish and accommodate those performance-based requirements lays on a surveillance architecture based on a mix of ground and air surveillance technologies.

In order to detect, identify and monitor UAS the industry has to deploy this mix of ground and air systems with some of the following crucial capabilities

- Capacity to monitor and detect any drone at any frequency in real-time.
- Cover a wide range of surface.
- Capacity to cover full dome (360º & 90º) with tracking accuracy.
- Scalability for huge sites.
- Compatible to detect and track 3G, 4G and 5G in mobile network connectivity environment.
- Locate UAS and its operators and identify the UAS model and brand.
- Wide frequency range of detection (9KHz to 20 GHz).

Finally, and as the main objective of CORUS-XUAM and the development of U-space and its services, we have to talk about the services that should be part of the solution architecture to provide surveillance in operations with UAS in urban environments. Since cities will be the first hubs and points of interest where U-space services will be tested through service providers.

Services such as Network Identification, Traffic Information and Tracking will be essential to provide these levels of surveillance thanks to the technologies of mobile phone providers among others.

Through the network identification service within U-space airspace operationally supports traffic safety and the traceability of the unmanned aircraft during its flight. Indeed, based on this information, the USSPs can share UAS traffic information between themselves and therefore provide traffic information to UAS operations.  In order to obtain this information on other traffic there are ground station systems with the capabilities described before. Other sources that make this information available is through the network identification system or through other technical means (e.g., from manned aircraft ADS-B, transponders, FLARM…etc).

### 3.9.4 Conclusions

After the previous analysis of communication, navigation and surveillance technologies and methodologies, we reached the point of discussing and proposing a way to insert operations in the urban environment and leaving the framework open for the industry itself, service providers and operators to take base this proposal, mature, expand and work with the advancement, development, and own maturation of existing technologies as well as those to come. In the same way as the approval of regulations.

But first of all, it is important to address some questions to consider that will help guide the strategy of defining operations, as well as their performance in the urban environment. These questions to consider are those that an operator must consider when defining, designing, and choosing the technologies and methodologies that are not only the most appropriate to achieve their objectives but also to achieve the performance parameters and the values of these parameters to be met and agreed by all the stakeholders.

- What level of position is required for my operation to be successful?
- What level of communication is required for my operation to be successful?
- What level of surveillance I have to face-off and be electronically conspicuous and collaborative?
- Is it practical to set up the newest and expensive equipment?
- Do I have a reliable communication link?
- Where do I need my operations and core business to work?
- What is the geographical environment like?
- How congested is the environment?

So, the general description of the approach is a trade-off between the U-space service providers (USSPs) and the UAS operators that requests to operate in an urban environment. On the one hand, regulation, standards, agencies and various administrations, service providers must define minimum requirements to be able to operate in an urban environment such as a city, near an airport, on top of crowds of people at mass events. …etc. They must propose the minimum requirements of required communication, required navigation, and required surveillance performances to accomplish.

On the other hand, the UAS operators shall analyse those minimum performance CNS requirements to reach and manage to combine whatever technologies needed to be able to fit in a high demand and capacity environment such as the urban where the operational stress and workload is considerable.

The minimum performance CNS requirements that suit a specific urban area are not necessarily the same as those of another urban area that may have different traffic density, traffic patterns, geographical characteristics, better CNS technologies coverage…etc. However, the process to guide and approve the safe and secure development of those operations will be the same.

The UAS operators requests to their respective member state authority, U-space service provider or the current authority responsible to accommodate and authorize to operate in an urban environment.

The UAS operator will be replied with the minimum performance-based requirements of CNS for this particular area that has to reach and demonstrates the operational and technological capabilities to achieve.

Note: The numeric values for the parameters (Integrity, Continuity, Functionality, Availability, Accuracy and Latency) are randomly assigned. It’s just for graphical purposes.

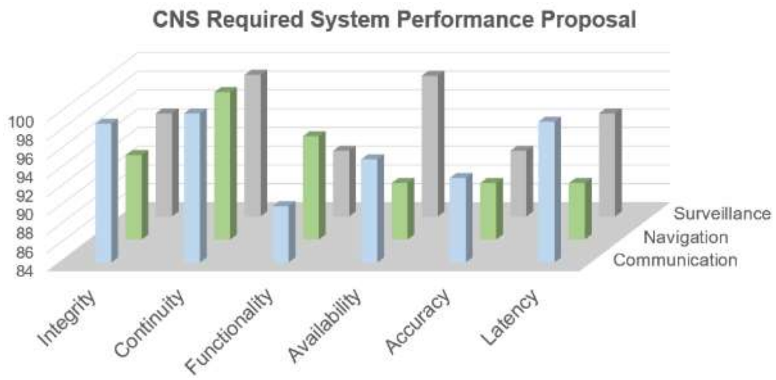


Figure 27 CNS Required System Performance Proposal

The UAS operator has the due and responsibility to make sure their operation will achieve this minimum performance levels. While better and greater are the levels of assurance the better, faster, and easier will be served and accommodated in the urban environment to start its operations.


Figure 28 CNS Required System Performance Achievements

After the analysis of the environment, the density will be operating, the mobile network coverage, the weather conditions, the geographical distribution of the terrain, the access to GNSS…among many topics, the UAS operator will be able to detect the performance gaps and apply the corrective measures as better equip the aircrafts, the ground control station…etc

What is essential and fundamental is the performance-based approach. That is, let it to the industry to set goals and measure in an objective way. In this way, we can establish and determine that the metrics that will later qualify the requirements for access to the urban environment should have a SMART (Specific – Measurable – Accurate – Relevant – Timely) focus.

## 3.10 Risk assessment classes

This section aims at proposing a framework to classify the risks of Urban Air Mobility operations, by unmanned aircraft but also encompassing Urban Air Mobility by manned operations.

Air and ground risks are taken into account for operations inside the city (inner-city operations) and operations linking two or several urbanized areas (inter-cities operations).

### 3.10.1 Air risk classification

The air risk must be assessed considering different combinations of aircraft encounters, whether the aircraft is manned or unmanned, or having people on-board or not.

The likelihood to have encounters between any type of UAV and manned aircraft differs whether the operations occur in an environment close to airport, aerodrome or heliport, or above the countryside.

The possibility to mitigate this risk will depend on the type of U-space and ATM services provided and aircraft equipage. Some dedicated airspace structures may also play a role by clearly segregating operations of any kind: manned- unmanned, unmanned parcel transportation – unmanned passenger transportation, etc…

Then the following pairs are to be taken into account:

- Separation between UAVs without people on-board (neither passengers nor human flight supervisor
- Separation between UAVs and manned aircraft
- Separation between UAVs and UAVs with people on-board.
- Separation between UAV carrying people and manned aircraft.
- Separation between two UAV carrying people.

Inside UAV without people on-board, a distinction between those carrying nothing or non-critical goods and the other could be introduced. For the latter, the air risk is limited but would dramatically increase the ground risk, by directly impacting a person's life (e.g., if the UAV carries blood or an organ), or by polluting water for instance (e.g., UAV carries dangerous goods).

### 3.10.2 Ground risk classification

The ground risk classification is divided into two specific operational environments. On one hand, there are the inner-city UAV operations, whereas on the other hand the inter-cities UAV operations.

In the first case, the whole flight will mainly cover urbanized areas with infrastructures dedicated to citizens way of life, including facilities for UAV operations such as vertiports or parcels hubs. Density of people in these areas may be very high.

In the second case the flight will be performed above urbanized areas and the other part will be mostly above sparsely or non-populated areas. Density of population should be low.

In that case the same ground risks as in the first case have to be encompassed but an extended (compared to the inner-city one) ground environmental risk may be added. Probably the specificities of the mapping around and between the cities will also impact the ground risk negatively.

### 3.10.3Transportation of people in U-Space

Transportation of people in U-space, whether they are by unmanned aircraft or by manned aircraft is one of the main drivers of the risk assessment classes in U-space.

At the early stage of U-space implementation, manned and unmanned operations will be segregated, and this will require a minimum coordination between ATCO and USSP in airspace class A to E.

In class G, the aeronautical information will be the key.

The question is whether UAV carrying passengers could be consider as "manned aircraft «when having a pilot on-board, or not. Will the pilot have a role to steer the aircraft or just supervise the flight?

Once segregation concept will be removed and UAV operations well integrated, the risk will be mitigated by services and aircraft equipage. At this stage of U-space, UAV carrying passengers will no longer have a pilot on-board, and we can suppose that services and equipage will provide a sufficient level of safety.

### 3.10.4 Transportation of goods in U-space

The transportation of goods in U-space, whether it is considered inner-city or inter-city, mainly impacts the ground risk.

On a ground risk point of view, we could divide the risk into two different classes:

- The risk impacts people, animals and nature.
- The risk impacts only structures such as buildings.

Goods collision with the ground may directly or indirectly impacts people, animals or nature.
By falling directly onto one of those, by spreading dangerous substances on the ground or in the water or if the goods transported are medicals (e.g., bloods, organs), by indirectly impacting people or animals to whom the goods were intended.

In case of collision only with structures, without reaching people, animals or nature, the risk is only material.

To introduce distinction in the goods, we can propose a goods classification by risk consequences:

| Impacted elements / Type of goods | People | Animals | Nature | Structures |
|---|---|---|---|---|
| **Dangerous goods** | High risk | High risk | High risk | Medium risk |
| **Medicals** | High Risk | High risk | None | None |
| **Big and/or heavy parcel** | High risk | High risk | High risk | High risk |
| **Small parcel with dangerous shape** | Medium to high risk | Medium to high risk | Low risk | Low risk |
| **Small and/or light parcel** | Low to medium risk | Low to medium risk | Low risk | Low risk |

Table 57 Goods classification by risk consequences

# 4 Operational Performance of UAM

## 4.1 Introduction

The operational performance of Urban Air Mobility (UAM) systems is critical for the safe and effective integration of these systems into urban airspace. In this chapter, we will explore the various factors that impact the operational performance of UAM, including the environment in which they will operate, the assumptions made about their capabilities and limitations, and the performance and operational requirements that must be met. The section on Performance and Operational Requirements is particularly important as it presents the results of the analysis and demonstrates how UAM systems meet the necessary performance and operational requirements.

The chapter is the output of CORUS-XUAM Task 3.2, which is part of CORUS-XUAM work package 3. It builds upon the use cases stated in the Definition of the Operational Framework section analysing the nominal use cases regarding performance and operational perspective incorporating the input from various Very Large Demonstrations (VLDs) through WP5 coordination.

The later chapters, addressing Tasks 3.3 and 3.4, will further modify and extend these use cases, and WP4 will analyse how U-space services meet the needs of these use cases, describing in detail the sequences and information flows of the services.

## 4.2 Environment Description

This section describes the context on which Urban Air Mobility (UAM) Operations are expected to happen, and under which conditions the project CORUS-XUAM foresee the nominal Use Cases (UCs) to occur.

According to EASA [107], UAM is a new safe, secure and more sustainable air transportation system for passengers and cargo intended for, but not exclusively bound to, urban environments, enabled by new technologies and integrated into multimodal transportation systems. The transportation is performed by electric aircraft taking off and landing vertically, remotely piloted or with a pilot on board

These conditions include different elements, including the capabilities horizons, the traffic prognosis of this operations and other concepts surrounding these operations, like the vertiport environment, the airspace type and structure, new flight rules to accommodate this operations, different type of vehicles, the rules of separation, and the different phases that comprises a single operation.

The selection of specific condition within the environment section describes the different scenarios, a list of the different scenarios used to describe the UCs are described in section 4.4

### 4.2.1 Maturity Levels

This section describes the progression of UAM implementation in a sequence of maturity levels. Rather than describing a timeline, we describe the progression in terms of capabilities of the U-space system and its constituents.

The levels presented in this section are inspired by NASA's Urban Air Maturity Level scale. Whilst the levels presented are similar, they are not the same due to a slightly different approach in Europe's U-space regulation. For a description of the NASA UML see Kenneth H. Goodrich & Colin R. Theodore (2021): Description of the NASA Urban Air Mobility Maturity Level (UML) Scale.

Although this work is mainly focussed on the development of Urban Air Mobility, interoperability with other types of operations occurring within the same airspace need to be considered as well. UAM operations will be typically flying in the lower airspace but are not restricted to Very Low Level (VLL).

The type of operations in U-space:

- Urban Air Mobility
  - Passenger transport operations
  - Transportation of goods
- Aerial work, such as operations for
  - agriculture, construction, photography, surveying, observation and patrol, aerial advertisement
- Government / State operations
  - Law Enforcement
  - Search and Rescue
  - Helicopter Emergency Medical Services

#### 4.2.1.1 Maturity Level 1: Pre-operational trials and validation

The first phase, which is the phase we are entering now, covers qualification, certification, and operational demonstrations in temporary reserved environments.

In this phase, most vehicles involved will be pre-operational prototypes that are nearing the completion of the type certification process. Initially, Aircraft Certification regulation will likely require that UAM passenger transport operations will be conducted with a pilot on board, as certification baselines for remote-controlled or autonomous flying aircraft with passengers on board are not yet established. Early good transport operations, aerial work and government / state operations may be flying without a pilot on-board.

For trials with unmanned passenger carrying aircraft, as well as larger scale transport drones, the airspace in this phase is characterised as a restricted sandbox environment, limited to traffic involved in the trials. Temporary Reserved Airspaces are likely often used in this phase, to ensure that other, non-involved aircraft will not intervene and pose risk to the trials.

When the trials focus on UAM aircraft operating with a pilot on-board, standard flight rules may be applied and direct VHF voice communications with ATC can be facilitate the integration of the trial existing airspace structure be without restricting other operations in the vicinity.

Other trials and validations may focus on assessing the viability of supporting U-space / UTM implementations. This includes testing of communication, navigation and surveillance technologies as well as higher level functions of the UTM system.

Early BVLOS operations outside U-Space trial areas can be accommodates if they are segregated from other air traffic. BLVOS operations pose a challenge to existing airspace users, especially since the UA will be difficult to see by VFR pilot and the UA will not have Detect (and Avoid) technology that can warn the remote pilot or otherwise prevent collision hazard with all types of possibly conflicting traffic.

To avoid airspace conflicts and related collision hazards, the BVLOS flights can be accommodated in a restricted area, danger area, (temporarily) reserved airspace or by other means.

Whilst such approach enables safe operation of BVLOS alongside manned traffic in segregated airspace volumes, it leads to inefficient use of airspace. Since existing airspace users, especially those in uncontrolled airspace, cannot be notified on short notice about activation of temporarily reserved airspace, BVLOS flights requiring segregation need to be planned well in advance. The conventional mechanism of notifying other airspace users by NOTAMs limits the flexibility and efficiency of reconfiguring airspace to accommodate BVLOS operations.

#### 4.2.1.2 Maturity Level 2: Early commercial operations

Early commercial UAM operations will take place in a Maturity Level 2 environment.

The environment is characterised by low traffic levels, as there are only a few vertiports and UAM routes in the urban environment, and operations will not occur on large scales.

Initial Aircraft Certification rules will require that UAM passenger transport operations are be conducted with a pilot on board. This allows for UAM to be conducted under current air traffic management practices, especially with respect to flight rules. However, in parallel, early U-space implementations will emerge where the Traffic Services are provided by U-space Service Providers.

Within these early U-spaces, the unmanned traffic will have to be segregated from pilot-on-board operations that fly under IFR/VFR flight rules as there are no regulations existing that support mixed manned / unmanned traffic. Pilot-on-board UAM operations in U-space may fly under alternative flight rules that allow the integration of manned & unmanned U-space traffic in the same airspace.

Initial U-space services are provided (2021/664, network identification service, geo-awareness service, UAS flight authorisation service and traffic information service), by a singular or multiple USSPs and a single CISP.

#### 4.2.1.3 Maturity Level 3: Increasing automation level

Maturity level 3 is a transitional phase, still seeing low density of operations, but with increasing capability of both the aircraft as well as the U-space systems.

In UML 3 the integration between U-space operations and the ground infrastructure is increased. Vertiports will connect to the UTM system in support of DCB and contingency planning and conflict resolution services are expanded, covering both the pre-flight as the in-flight phase.

Services to support both VFR and IFR flights in U-space are introduced, allowing integration of existing manned aviation in U-space. This requires technologies to augment or replace the See and Avoid procedures used for VFR.

The CNS infrastructure to support these U-space service will be gradually rolled out. The surveillance becomes sufficiently good that U-space can provide tactical separation. The communication becomes reliable enough to reduce separation distances. This will enable the increase of traffic density and complexity for the next UML step.

The integration between ATM and UTM will allow transfer of aircraft between U-space and other airspace and facilitate dynamic reconfiguration of airspace to facilitate traffic that is not compatible to U-space.

U-space service providers are demonstrating operational maturity in support of certification for denser traffic operations that include remote controlled passenger carrying flights.

#### 4.2.1.4 Maturity Level 4: Large scale operations

UAM Maturity level 4 will see increasing levels of traffic density. In the U-spaces with medium traffic densities, the operations are relying on the UTM system including for both pre-flight and in-flight (tactical) separation. This level sees a high level of automation and the possibility of autonomous operations in specific phases of flight, e.g., to deal with loss-of-link situation.

UML 4 is the first level with remotely piloted operations of passenger flights (single pilot per vehicle).

UAM Maturity level 4 is assumed for larger scale vertiports operations.

#### 4.2.1.5 Further evolution

Long term evolution of the U-space environment will see increasing traffic densities and complexities. Reliance on the supporting UTM systems for operational performance and operational safety will increase.

- Integration of GA, need for retraining of users
- Hight density & complexity
- Medium/High risk level
- More Autonomous operations
- Services more focused on tactical capabilities (Tactical De-confliction)

### 4.2.2 Traffic Prognosis

- Low density traffic with segregation from manned aviation, where this traffic is assumed to be low enough to be manageable by strategic conflict resolution alone.

- High density urban operations with no segregation.

### 4.2.3 Types of environments

The SESAR JU defines U-space[16] as “an enabling framework designed to facilitate any kind of routine mission, in all classes of airspace and ***all types of environments*** - even the most congested -...” This encompasses Urban Air Mobility, which is indeed the target of CORUS-XUAM. The notion of environment, as a subset of urban scope, is relevant for the deployment of U-space in support of UAM, influencing aspects such as functionalities of the services, level of required performance, types of operations supported or airspace structuring. Requirements resulting from the execution of demonstrations in each (sub) environment might be different.

In this sense, and with a view of better addressing the diverse use cases, CORUS-XUAM VLD addresses the following UAM environments which are defined in the CORUS-XUAM Demonstration Plan (D5.1) [91], also depicted in Figure 29 below:

- **Urban environment**, defined as an area either within the urban centre or a dense urban cluster of a city [92];

[16] https://www.sesarju.eu/U-space

- **Sub-urban (residential) environment**, defined as an area within a semi-dense urban cluster or a peri-urban cell [92] used mainly for residential purposes;
- **Sub-urban (industrial) environment**, defined as an area within a semi-dense urban cluster or a peri-urban cell [92] used mainly for industrial activities;
- **Sub-urban (intercity) environment**, defined as a succession of semi-dense urban clusters and peri-urban cells linking two close cities.

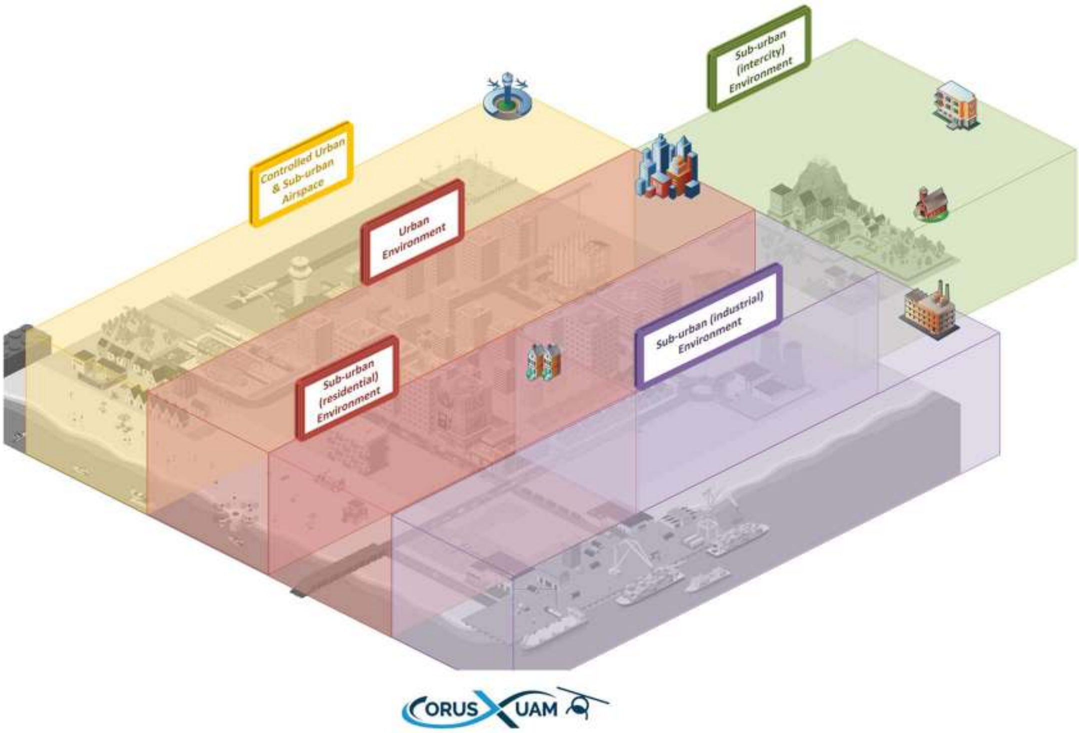


**Figure 29:** CORUS-XUAM Operational Environments

In addition to the defined environments, **controlled airspace** within urban and sub-urban areas corresponds to areas belonging to any of the above environments within airspace managed by ATC.

From the point of view of operational environments, the scope of CORUS-XUAM is:

- Mixed operations/missions in urban and suburban environments and in an airport environment, including at least:
  - Seamless door-to-door transport of people, including UAM flight between different cities (inter-city scenario);
  - Seamless door-to-door transport of goods (logistics services);
  - Depot-to-depot transport of goods (logistics services);
  - Visual and data acquisition and aerial works, and in particular:
    - UAM for emergency operations;
    - Surveillance of people traffics flows and infrastructure.
- Involvement of a dedicated vertiport placed in a city.

Moreover, CORUS-XUAM VLD targets the following operational and technical aspects:

- Seamless transition between different UTM systems;
- Seamless coexistence of different USSP;
- Automated flight and flight planning management;
- Ad-hoc weather information provision;

- Mission planning management;
- Collaboration and interface between ATM/ATC and USSP/U-space;
- Use of eVTOL and fixed-wing UAM solutions;
- Use of UAM of different performances and power supplies (electric/fuel);
- Involvement of small drones for specific missions in a mixed environment.

### 4.2.4 Vertiport Environment

As part of future Urban Air Mobility (UAM) 'vertiports' will serve as landing and take-off sites for air taxis, i.e., passenger carrying VTOLs. Vertiports will be equipped with a number of facilities, including charging facilities for electrically operated vertical take-off and landing (eVTOL) vehicles as well as passenger boarding, de-boarding, and waiting areas. Vertiports with different scales changing to the demand and environment constraints serve for public usage and each one has the role of vertiport operator.

Their locations need to be depicted in the VFR map and all vertiports will be compliant with local and regional rules. In the absence of clear standards, the concept of vertiports is largely inspired by heliports, including the Touchdown and Lift-off (TLOF) area, the Final Approach and Take-off (FATO) area, the Safety Area around the FATO and stands as applicable. Vertiports may be located in any area, but realistically predominantly in urban areas and close to airports, permitting air taxi operations within cities and between cities and airports.

Additionally, while the aircraft is moved between TLOF and stand without depending on its power and wheels, Ground Movement Equipment (GME) or alternative means need to be accommodated in the vertiports. GME serves as towing equipment in the form of a wheeled vehicle to move the aircraft horizontally on the vertiport surface, which can be either manually operated or remotely controlled or supervised by a member of the technical ground crew. Other possibilities are also envisaged without the use of GME for moving between TLOF and stand, e.g., landing gear. In U-space airspace landing and departure operations at Vertiports will be managed through U-space, a largely automatic system that will perform the necessary control tasks (sequence building, landing clearances, hold instructions, taxi clearances, etc.).

The following sections detail assumptions for initial operations of a vertiport as considered in CORUS-XUAM which means that some simplifications are made, and some constraints are introduced. Future iterations may introduce additional features and hence complexity.

#### 4.2.4.1 Vehicles

Whilst a number of vehicle types will undoubtedly be used in urban air mobility, we make the assumption that urban vertiports will be used mainly by eVTOL and hybrid VTOL aircraft. The main reasons for this are

- We assume that in urban areas not enough space for landing and take-off strips for short-Take-Off and Landing (STOL) vehicles will be available; VTOLs require significantly less space for take-off and landing.

- Electrically powered vehicles have clear advantages in terms of noise and pollutant emissions which is a relevant criterion in urban areas.

- In terms of endurance, hybrid propulsion systems used by VTOL aircraft are still less noisy than commercial helicopter operations but provide higher endurances compared to purely electric ones. When noise is not a relevant operational constraint, VTOL aircraft with combustion engines, e.g., small helicopters, can be served since they require the same facilities as eVTOL aircraft minus the charging facilities.

The vehicles must be compliant with the vertiport's operating licence, which may specify maximum weight, noise, fire risk, technical equipment, times of operation, etc.

We assume passenger-carrying flight (air taxi operations) either with a pilot on board (ML2, ML3) or with a remote pilot operating beyond BVLOS – Beyond Visual Line Of Sight (ML4).

#### 4.2.4.2 Vertiport facilities

The present design concept of vertiports, which is based on the EASA Guidance Material for Design of VFR vertiports [108] and largely inspired by current standards and recommendations for heliport design (e.g., ICAO Annex 14, Volume 2), provides the following facilities:

- Touchdown and Lift-off (TLOF) area(s);
- Final Approach and Take-off (FATO) area(s);
- Safety Area(s) around the FATO(s);
- Stands
- Facilities for re-energizing of aircraft batteries;
- Areas for taxiing (under own power) and ground movement (not under own power) of VTOL aircraft between the FATO and TLOF; and
- Passenger embarking, disembarking, and waiting areas.


**Figure 1: Example on TLOF, FATO and Safety Area**

FATO and safety area are always placed together within vertiport environment, but TLOF and Stand can be placed elsewhere. Different options are expressed in Figure 30 for:

– Air taxiing, with TLOF being at the same place as the stand, where vehicle moves hovering over the vertiport surface on its own power. Vehicle does not lift-off or touch down at the FATO.

– Ground movement, where TLOF and FATO being at the same point and the stand in a different place, where ground movement of the vehicle is needed (e.g., for longer distances), vehicle can be moved under own power or vertiport movement system.

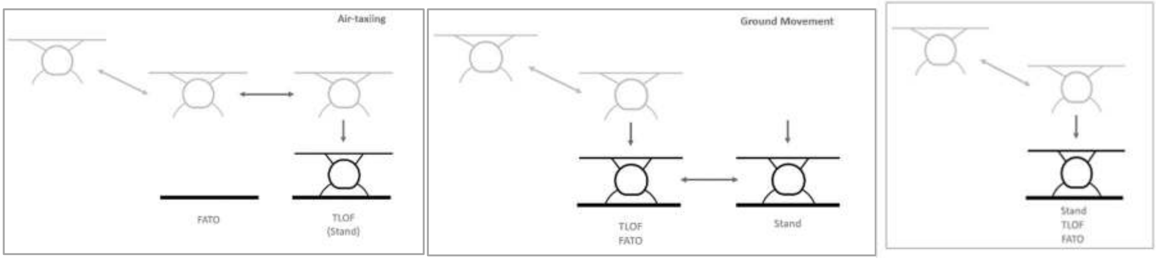


**Figure 30: Air taxiing and Ground movement vertiport configuration**

For capacity and contingency reasons, it is desirable to provide more than one TLOF/FATO since the TLOF/FATO may need to be 'reserved' for the outgoing flight for a specified period after take-off to account for contingency. Providing one 'spare' FATO/TLOF at the vertiports for all flights may satisfy this requirement.

When considering vertiports for passenger VTOL aircraft operations, EASA is distinguishing different kinds of vertiports (see Figure 31: Vertiport Classification from Operations Perspective [102]).

As per EASA SC VTOL, VTOL aircrafts certified in the category enhanced, need to satisfy the requirement of continued safe flight and landing (CSFL) and hence be able to continue to the original intended destination or a suitable alternate vertiport after a failure [103]. This enhanced category of VTOLs covers those aircraft which carry passenger on board.

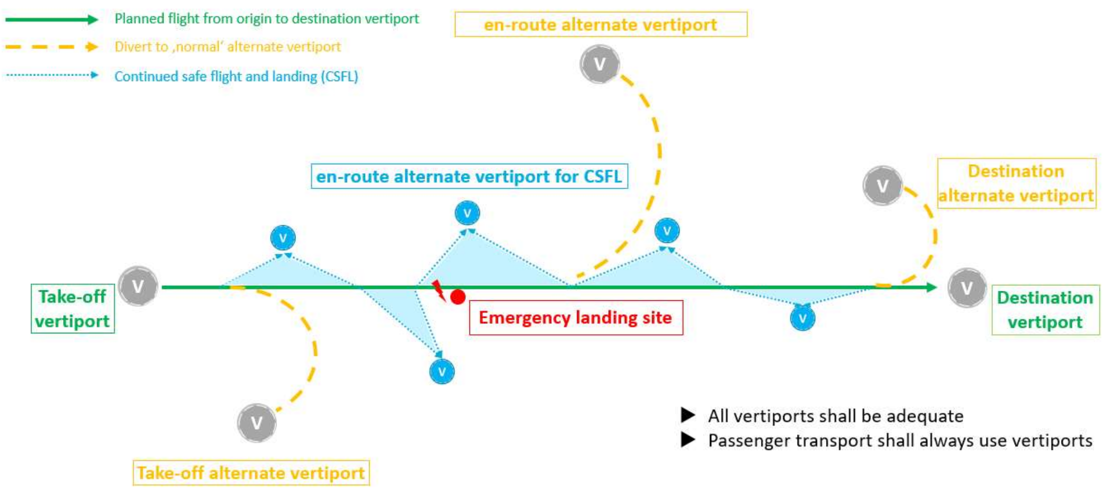


**Figure 31: Vertiport Classification from Operations Perspective**

The grey circles are normal aerodromes, heliports or vertiports, with the full range of facilities and services required for the operation, that the VTOL vehicle can take-off from. The blue circles are aerodromes for CSFL (heliport or vertiport), that only have a minimum set of facilities and services (to be specified), from which the VTOLs may not be able to take off. For cargo UAS and small UAS operations all operating sites can be used.

- **Take off and destination vertiport**: Each flight originates from a take-off vertiport and is planned and conducted to the destination vertiport.

- **Alternate vertiport**: An alternate vertiport is pre-planned and chosen in case it becomes either impossible or inadvisable to proceed to or to land at the intended destination vertiport. This can be either an alternate take-off vertiport, where the VTOL aircraft would be able to land should this become necessary shortly after take-off, or an alternate en-route vertiport, where the VTOL aircraft would be able to land in the event that a diversion becomes necessary with normal aircraft performance while en-route, or an alternate destination vertiport, where the VTOL aircraft would be able to land should it become either impossible or inadvisable to land at the intended destination vertiport.

- **Alternate en-route vertiports for CSFL**: The alternate en-route vertiport for CSFL complies with the same minimum design requirements as the alternate en-route vertiport. But it only has to fulfil a minimum set of services with respect to the aircraft and CSFL operations.

- **Emergency landing site** is excluded from these considerations as emergency landing may be carried out at any possible location, not necessarily at an aerodrome/operating site.

Procedures that need to be defined at vertiports include holding, diversion, arrival sequence, departure sequence, ground operations (charging, ground movement). Due to battery limitations of the incoming eVTOL holding procedures are not an element of nominal operations.

We don't necessarily assume that a human is physically present at the vertiports.

#### 4.2.4.3 Actors

Vertiport Operator: owing to the high levels of automation as well as the quick response times required to accommodate air taxi operations, the vertiports authority will most likely be quite different from traditional airport authorities with manned control towers and be highly autonomous instead. An important building block of vertiports operations is the Vertiport Management system which contains the status of all components and facilities at the vertiports as well as the allocation of resources to individual air taxi operations; it will be used by different entities to book resources, including FATOs.

Vertiport Management System: The Vertiport Management system needs to fulfil a number of requirements, including real-time data provision, verification of the authority booking resources, verification that the vehicle is technically suitable and authorized to operate at the vertiports, low latency, and secure access. The Vertiport Management System should have an undoubtedly transparent and fair process to fulfil all requirements. This includes a new Vertiport Management System service, providing static information and dynamic on (e.g., facilities availability).

USSPs: Following guidance from the European Commission and unlike 'traditional' aviation, present U-space and UAM concepts assume the existence of more than one U-space Service Provider (USSP) in each airspace. The USSP supports the drone operator in the planning and execution of a mission and this includes the authorization of the mission. The fact that more than one USSP can authorize access to limited resources, including the airspace, makes the flight authorization process a non-trivial aspect of U-space.

UAM operator: the commercial entity operating UAS in UAM airspace and offering air taxi services to passengers, either scheduled or ad-hoc. The UAM/UAS Operator and the vertiport operator shall have established an agreement to allow the operator to use the vertiports; this framework agreement concerns aspects such as charges, services, billing, etc. The UAM/UAS Operator is supported by the USSP in the flight planning and flight authorization process, and this includes obtaining access to the vertiports.

Passenger (PAX): the passenger requests, via an application, price and scheduling information for a trip between two vertiports. The UAM/UAS Operator provides the necessary information and once the passenger has consented and paid the agreed services are provided at the vertiport.

The vertiport is assumed to be not exclusive, which means that various UAM/UAS Operators may use it once they have established a framework agreement with the vertiports authority. Each UAM/UAS Operator may choose one of the various USSP offering services in the airspace surrounding the vertiport.

#### 4.2.4.4 Vertiport location, airspace, and flight rules

For the initial concept and use cases we assume Zu airspace located inside class G (uncontrolled) airspace. This would cover most vertiports located in urban areas but exclude vertiports in the vicinity of airports which are surrounded by class D airspace.

VFR traffic will not be allowed to operate in class Zu airspace and hence in the airspace surrounding the vertiport. This is a necessary restriction because 'remain well clear of' principles used in VFR have no defined separation or safety distance and are hence difficult to deal with in operations involving remotely piloted vehicles. Traffic inside Zu airspace surrounding the vertiports is assumed to be fully cooperative with UFR flight rules. Maturity Levels (MLs) 2 and 3 operations with a pilot on-board will also adhere to UFR, not VFR. Although technically and operationally there is no difference for ML 4 operations, we initially assume day flights based on safety considerations.

In an evolution of the above, we will consider vertiports based in the premises or the vicinity of an airport (i.e., airspace class C or D). In this case, air taxi operations will require some form of interaction (through U-space) with ATM and will be clearly shown for ATC on the HMI for ATCOs situational awareness. This integration with ATM needs to be further defined/clarified.

In class G the vertiport shall be published on the AIP with the commonly used arrival and departure routes in order to create awareness with VFR community.

During CORUS-XUAM WP3-WP4 workshop held on March 2022, there was a clear answer from that participants that instead of defining procedures (e.g., STARs 0or SIDs), this should be a defined geometry/volumetry that will depend on the operation.

#### 4.2.4.5 Vertiport access and authorization of the U-plan

Whilst vertiports with lower traffic demand may not have such an area, we assume that the majority of vertiports is surrounded by a Vertiport Traffic Zone (V-TZ); the vertiports is under the responsibility of the vertiport operator and its actual state and operations plans are subject of the vertiport management system which is accessible to the vertiports operator and the USSPs. Vertiport Traffic Zone is U-space airspace, having an adequate approach area which is a protected one and in possession of the set of rules defined. V-TZ is part of the U-space airspace where specific procedures and rules are applied and that each flight (with whatever USSP is used) needs to follow them. The stress lies here on a probable interaction with the Vertiport operator/management system.

Flight planning and authorisation are performed by the USSP providing service to the UAM operator wishing to land at the vertiports. This includes booking of vertiports access. Details have yet to be defined but it may well be that *InterUSS* will be used not only for booking access to the airspace resources but also to the vertiports (ASTM standard F3548-21). T*he exact role of the vertiports authority has yet to be defined if the booking of vertiports access is done by the USSP based on the vertiports information management system.*

Vertiport access booking is the booking of a, potentially limited, resource. It does not authorize the vehicle to take-off or land. For this, the take-off/landing clearance is required which will be obtained shortly prior to the actual operations. The exact concept of clearance of UAM vehicles exceeds this section and has yet to be defined, however, suffice it to say that stepwise clearances, with clearance limits similar to traditional aviation, seem to have a number of advantages when compared to clearing the whole mission at take-off; these advantages concern the ability to better accommodate uncertainty, capacity aspects, lost-link procedures, and other contingencies.

Vertiport Operator should define the requirements (in the agreement, e.g., noise, environment, dimension) to operate in that vertiport. Vertiport should ensure the vehicle can comply those requirements.

Vertiport communicates dynamically the status of their facilities but is not its responsibility. The Drone Operator should decide if the vertiport can be used or not.

Equally out of scope of this section is the question of prioritization; rules defining prioritization need to be (a) compliant with regulation and (b) treat different operators equally and reproducibly. Once prioritization principles beyond present regulations (which prioritize emergency operations) have been defined, it is likely that they relate to airspace access and vertiports alike.

### 4.2.5 Airspace Type

#### 4.2.5.1 Background (may be deleted or moved to the framework)

#### 4.2.5.2 Current ICAO airspace classification

ICAO Annex 11 presents the classification of airspaces in Section 2.6. The definitions refer to flight rules which are described in Annex 2. Annex 11, 13th Edition, March 2001, Section 2.6 is reproduced here in its entirety:

2.6 Classification of airspaces

2.6.1 ATS airspaces shall be classified and designated in accordance with the following:

*Class A*. IFR flights only are permitted, all flights are provided with air traffic control service and are separated from each other.

*Class B*. IFR and VFR flights are permitted, all flights are provided with air traffic control service and are separated from each other.

*Class C*. IFR and VFR flights are permitted, all flights are provided with air traffic control service and IFR flights are separated from other IFR flights and from VFR flights. VFR flights are separated from IFR flights and receive traffic information in respect of other VFR flights.

*Class D*. IFR and VFR flights are permitted and all flights are provided with air traffic control service, IFR flights are separated from other IFR flights and receive traffic information in respect of VFR flights, VFR flights receive traffic information in respect of all other flights.

*Class E*. IFR and VFR flights are permitted, IFR flights are provided with air traffic control service and are separated from other IFR flights. All flights receive traffic information as far as is practical. Class E shall not be used for control zones.

*Class F*. IFR and VFR flights are permitted, all participating IFR flights receive an air traffic advisory service and all flights receive flight information service if requested.

*Note.— Where air traffic advisory service is implemented, this is considered normally as a temporary measure only until such time as it can be replaced by air traffic control. (See also PANS-ATM, Chapter 9.)*

*Class G*. IFR and VFR flights are permitted and receive flight information service if requested.

2.6.2 States shall select those airspace classes appropriate to their needs.

In addition, ICAO Annex 2, Section 3.1.10 defines restricted areas, and below that section is reproduced from Annex 2, Tenth Edition, July 2005:

3.1.10 Prohibited areas and restricted areas

Aircraft shall not be flown in a prohibited area, or in a restricted area, the particulars of which have been duly published, except in accordance with the conditions of the restrictions or by permission of the State over whose territory the areas are established.

#### 4.2.5.3 Observations on the current ICAO airspace classification

The ICAO classes A to G are only defined in terms of IFR and VFR. This means anything which is not either IFR or VFR cannot fly in these airspaces. Stated another way, if a new flight rule is created (e.g. our UFR) then it cannot fly in the above as defined. Either we need to propose a redefinition of the airspace classes or define new ones.

Restricted areas are a means to overcome that constraint by creating volumes that have and airspace class definition of their own, distinct from the ICAO defined classes A to G.

#### 4.2.5.4 EU regulations

EU regulation 2019/947 Article 15 describes geographic zones defined for the purposes of regulating the operation of UAS. It states:

Article 15 - Operational conditions for UAS geographical zones Regulation (EU) 2020/639

1. When defining UAS geographical zones for safety, security, privacy or environmental reasons, Member States may:

(a) prohibit certain or all UAS operations, request particular conditions for certain or all UAS operations or require a prior flight authorisation for certain or all UAS operations;

(b) subject UAS operations to specified environmental standards;

(c) allow access to certain UAS classes only;

(d) allow access only to UAS equipped with certain technical features, in particular remote identification systems or geo awareness systems.

2. On the basis of a risk assessment carried out by the competent authority, Member States may designate certain geographical zones in which UAS operations are exempt from one or more of the 'open' category requirements.

Paragraph 3 is about data format. EASA NPA 2021-09 proposes acceptable means of compliance and guidance material for this article. EU regulation 2021/664 Article 2 defines U-space Airspace as a special geographical zone.

'U-space airspace' means a UAS geographical zone designated by Member States, where UAS operations are only allowed to take place with the support of U-space services;

#### 4.2.5.5 CORUS ConOps

The CORUS ConOps [93], defines X, Y, Za and Zu volumes, and states that to enter { Y, Zu, Za } requires an approved operation plan, delivered by means of a U-space service. This requirement can be used to limit access to volumes.

#### 4.2.5.6 U-space airspace

The Airspace relevant in this work is one of the U-space airspace volumes: Y, Zu and Zz. This U-space airspace has been created as a Geo-zone (2109/947 Art 15) within an existing ICAO airspace. Its creation erases the previous quality of the ICAO airspace. These are Restricted Areas in ICAO terms. The previous airspace class is recovered if the U-space airspace is dynamically de-allocated.

As in the case of ICAO airspace classes, the volume type impacts all aircraft in the volume.

Briefly the following minimum set of services are supplied:

- Y: Strategic conflict resolution, conformance monitoring, traffic information, emergency management (As 2021/664)
- Zz: as Y + DCB, tactical conflict resolution advisory service
- Zu: As Y + DCB, tactical conflict resolution instructions

In any of these, access is contingent on an operation plan having been accepted. In each, dependent surveillance is required. (In 2021/664 terms, Network Identification)

Technical & performance requirements may apply in the volume, for example compatibility with some means of communication, or navigation performance within some bound. Other constraints or requirements may also be attached to the volume such as speed limits or limits on the uncertainty expressed in the U-plan.

#### 4.2.5.7 Summary table

| ICAO | 2019/947 Geo Zone | 2021/664 U-space airspace | CORUS-XUAM | Remarks |
|---|---|---|---|---|
| Restricted Area | Yes | Yes | Y | No tactical separation service supplied by U-space |
| Restricted Area | Yes | Yes * | Zu | Tactical separation service supplied by U-space.<br>Only UFR flights permitted. |
| Restricted Area | Yes | Yes * | Zz | Tactical separation advice supplied by U-space |
| Restricted Area | Yes | No | X | Conditions might apply |
| G VLL | Yes | No | X | Conditions apply<br>UAS fly below VFR limits but in effect conform to VFR flight rule |
| G VLL | No | No | X | UAS fly below VFR limits but in effect conform to VFR flight rule |

| ICAO | 2019/947 Geo Zone | 2021/664 U-space airspace | CORUS-XUAM | Remarks |
|---|---|---|---|---|
| G above VLL, ABCDEF | No | No | Not U-space | For U-space users such airspace would probably be marked a Y volume and any U-space operation plan penetrating this airspace will either not be approved or will be subject to conditions or warnings. |
| ABCDEF | No | No | Za | Za if and only if the flight's entry into the airspace is enabled by a U-space planning process that includes ATC approval. |

* 2021/664 describes something approximating Y. Zu and Zz are considered as extending Y

### 4.2.6 Flight rules

ICAO Rules of the Air date back to October 1945 when the first international recommendations for Standards, Practices and Procedures for the Rules of the Air were established and ultimately amended into Annex 2. The Standardised European Rules of the Air (SERA) includes the transposition of Annex 2 into European law. The legislative framework for SERA includes Regulations (EU) 923/2012, amendment Regulations (EU) 2016/1185 and the Aviation Safety (Amendment) Regulations 2021 applies to all European Union states and the United Kingdom (as per the EU Withdrawal Act 2018). Additional flight rules are also applied at the state-level (for example the UK's Air Navigation Order), which are designed to align with SERA and ICAO standardisation.

The common European 'Rules of the Air' are detailed into 14 sections:

1. Flight over the high seas
2. Applicability and compliance
3. General rules and collision avoidance
4. Flight plans
5. Visual Meteorological Conditions, Visual Flight Rules, Special VFR and Instrument Flight Rules
6. Airspace Classification
7. Air Traffic Services
8. Air Traffic Control Services
9. Flight Information Service
10. Alerting Service
11. Interference, Emergency Contingencies, and Interception
12. Services related to Meteorology – Aircraft observations and reports by voice communications
13. SSR transponder
14. Voice communication procedures

There are two distinct Flight rule categories:

1. *Visual Flight Rules (VFR)*; flown in Visual Meteorological Conditions (VMC)
2. *Instrument Flight Rules (IFR)*; flown in either Visual or Instrument Meteorological Conditions (IMC)

Special VFR is more of an exception-based rule set, for VFR flights that do not meet the requirements for VFR (typically VFR minima) when operating in controlled airspace.

Classification of airspace are based on the permitted flights rules and the Air Traffic Services required to be provided by a state appointed authority, such as an ANSP, in accordance with ICAO airspace classification (class A-G). Classifications for different volumes of airspace take into consideration a range of factors such as density of air traffic, types of operations and requirements for aircraft equipage.

Currently, there are no specific flight rules for new airspace entrants such as UAM, UAS or RPAS in the SERA or ICAO Annex 2. Moreover, Rules of the Air, which specifically include flight rules, right-of-way, altitude above people and obstructions, distance from obstacles and types of flight rules, all of which, as written, are incompatible with the intended operations within some UTM/U-space systems.

#### 4.2.6.1 U-space Flight Rules

A new set of flight rules, recognising the specificities of unmanned, remotely piloted and/or autonomous aircraft is required. The new rule set should address the needs and requirements unique to users of U-space, incl. addressing specific challenges from the adoption/application of existing flight rules. U-space Flight Rules (UFR) shall apply uniquely to airspace users in receipt of U-space services within U-space airspace. Aircraft and pilots that adhere to standardised U-space equipment interfaces, and operate within U-space Airspace Volumes, shall operate under UFR.

The principle behind UFR is to enable aircraft operations that cannot conform to either VFR, SVFR or IFR in all operational conditions. Whilst in some operating cases it might be possible for UAM to operate under VFR if piloted, however, more advanced UAM use cases are not capable of “see and avoid” procedures if the aircraft are uncrewed. Likewise, UAM may be accommodated by IFR in some instances, however, again the reliance on “see and avoid” with VFR traffic in class D and E airspace will limit the usability of such approach since many urban environments are within a class D control zone of a nearby airport. In addition, current IFR separation minima may not be suitable for effective UAM operations in more congested airspace. The aircraft participating in U-space are therefore required to be supported by a set of U-space services for that airspace volume. The required U-space services and their interface with other ATS depends on the airspace classification.

UFR is for operations in U-space volumes for airspace users that are consuming U-space services. UFR is based on deconfliction service(s) for separation provision (safety layer 1) and on-board technologies (DAA/SAA) for collision avoidance (safety layer 2).

It shall be expected that aircraft conforming to UFR are required to:

- Be Electronically Conspicuous to the ground system(s) and to other aircraft within the U-space Airspace.
- In receipt of a traffic information service(s) (either by directly consuming the EC signal, or via USSP) as required, with respect to other aircraft
- Adhere to any [Digital] ATS clearance/instruction deemed necessary by the controlling authorities
- Have any air traffic separation service managed by a U-space service

Aircraft operating under UFR are *not* expected to received voice communications from ATS units.

U-space Mandatory Zone aircraft operating in a U-space Mandatory Zone (UMZ) shall be required to make their position known to U-space through a defined procedure. States shall be responsible for defining the required process for making aircraft Electronically Conspicuous to U-space.

### 4.2.6.2 ATS Airspace classification for UFR

Interoperability between existing ATS units and U-space services will be essential for the integration of UFR flights with VFR, SVFR and IFR flights. There will be a need to share operational information between existing ATS units and U-space systems to ensure safe and efficient operations depending on the ATS airspace classification. Transfer of responsibility for control of an aircraft across boundary will also consider the U-space airspace requirements as this may not involve direct separation control of a UFR flight, but rather the exchange of flight information for the purpose of traffic information.

(a) Class $A_U$. UFR flights are permitted.
(b) Class $B_U$. UFR flights are permitted and provided with a U-space control service. UFR flight are separated from IFR and VFR. UFR flights can receive digital ground to air or ground to ground communications through an authorised ATM/UTM interface. UFR flight shall be subject to ATC clearance.
(c) Class $C_U$. UFR flights are permitted and provided with a U-space control service. UFR flight are separated from IFR flights and receive digital U-space traffic information about VFR flights. UFR flights can receive digital ground to air or ground to ground communications through an authorised ATM/UTM interface. UFR flight shall be subject to ATC clearance, provided through the UTM system.
(d) Class $D_U$. UFR flights are permitted and provided with a U-space control service. UFR flights are provided with digital U-space traffic information about all other flights. UFR flights can receive digital ground to air or ground to ground communications through an authorised ATM/UTM interface. UFR flight shall be subject to ATC clearance.
(e) Class $E_U$. UFR flights are permitted and provided with a U-space control service. UFR flights are provided with digital U-space traffic information about all other flights. UFR flights can receive digital ground to air or ground to ground communications through an authorised ATM/UTM interface. UFR flight shall be not subject to ATC clearance.
(f) Class F is not considered since it is no longer applied in Europe
(g) Class $G_U$. UFR flights are permitted. UFR flights are provided with digital U-space traffic information if requested and available. UFR flights receive digital ground to air or ground to ground communications through an authorised ATM/UTM interface. UFR flight shall be not subject to ATC clearance.

| **ICAO Airspace Classification** | **B** | **C** | **D** | **E** | **G** | **Restricted area** | | |
|---|---|---|---|---|---|---|---|---|
| U-space classification | | | | | | Y | Zu | Zz |
| Tactical Separation Provided | UFR <-> IFR, U(S)VFR | UFR <-> IFR, SVFR | UFR <-> IFR, SVFR | No Separation | No Separation | No | Yes | No (Advice only) |
| U-space Traffic Service | UFR <-> VFR, UFR | UFR <-> VFR, UFR | UFR <-> VFR | UFR <-> IFR, SVFR, UFR | UFR <-> IFR*, SVFR*, UFR | yes | yes | yes |
| Speed limit | TBD | TBD | TBD | TBD | N/A | probably | probably | probably |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Radio | None | None | None | None | None | No | No | No |
| ATS Clearance required? | Yes | Yes | Yes | No | No | No | No | No |

**Table 58: ICAO Airspace Classification**

* Only in UMZs

### 4.2.6.3 U-space Tactical Conflict Management

CORUS-X discriminates between strategic and tactical conflict resolution. Strategic conflict management is explored more in detail within the lifecycle of the U-plan in Section 3.11. while this section focuses on the provision of tactical conflict management within U-space.

Aircraft operating under UFR may expect to receive conflict management provided by U-space. It is the role of U-space to assign responsibility for conflict management and separation provision to the appropriate entity to ensure UFR flights are safely separated from other aircraft, as regulated by the State. This may include a combination of mandated U-space services, co-operative self-separation, defined UFR routes and UMZ concepts to achieve separation from other flights.

Where it is the responsibility of the remote pilot or aircraft operator to maintain (self) separation from other aircraft, a Detect and Avoid (DAA) system may be used. ICAO Annex 2 defines DAA as "*the capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action*". This capability primarily aims to ensure the safe execution of an RPAS flight and fully integrate with other airspace users that would otherwise be "seen and avoided".

In U-space airspace where a conflict management system is required to ensure effective separation provision, DAA systems can also be used for the purpose of maintaining safe separation minima.

Separation minima will be performance-based depending on the airspace procedures and structures, such as the use of dedicated U-space corridors and the assurance of Position, Navigation and Timing. The precise *method* of conflict management, be that a combination of strategic, pre-tactical and/or tactical, will be overlayed on the ATS airspace classification as a U-space layer: X, Y or Z.

U-space layers are hierarchical requirements that are used appropriately to mitigate hazards and airspace congestion:

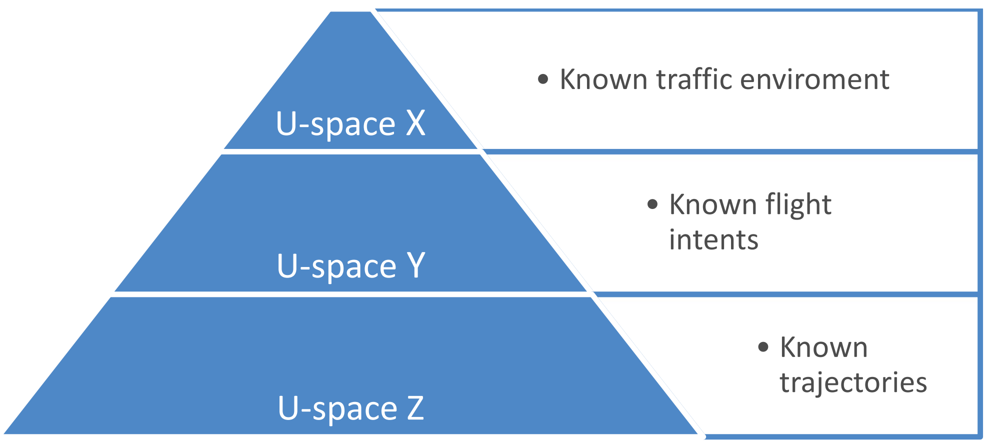


**Figure 32: Hierarchical requirements for U-space airspace to mitigate hazards and airspace congestions.**

#### 4.2.6.4 U-space X Layer Volume – Low traffic density flight rules

In airspace where capacity is not constrained, and aircraft can safely self-separate, the U-space layer will be designated "X". In this U-space airspace, there is no requirement to share flight intent for the purpose of strategic or (pre-)tactical conflict resolution. All potential conflicts will be resolved tactically, and separation will remain the sole responsibility of the pilots or operators. To enable BVLOS operations within U-space Airspace X Layer, it is the responsibility of the state to approve DAA systems that will independently provide flight separation for BVLOS flights operating under UFR.

UFR flights shall be expected to make themselves known through an electronic conspicuity (also referred as e-conspicuity) device to the U-space system. The requirement for discovering and tracking UFR flights will be defined by the U-space layer requirements for the specific airspace volume. Examples of a U-space X Layer requirements may include a mandatory use of either: ADS-B, FLARM, Pilot Aware Sky Echo and/or Remote ID.

In airspace classes that do not have a known traffic environment, such as class-G without a TMZ, states have to include the following:

- Manage the layer as a temporary danger area, notified as a NOTAM
- Declare a U-space Mandatory Zone that requires all airspace to conform to the U-space X layer requirements
- Require the DAA function of UFR flights to be certified to independently avoid all co-operative and non-co-operative crewed aircraft.

#### 4.2.6.5 U-space Y Layer Volume – Medium traffic density flight rules

In airspace where the UFR flights have a reasonable chance of coming into conflict with other aircraft and the aircraft cannot guarantee safe efficient self-separation, the U-space layer will be designated "Y". In this U-space airspace, UFR flights will have the same requirement for defined for discovering and tracking as a U-space X layer *and in-addition* are required to declare a flight intention to the U-space system before entering the U-space airspace. If the intended flight becomes intersected with another UFR flight (in both space and time), then the U-space system must attempt to separate the planned flights. In the first instance, the system shall exchange detailed flight intension details for the intersecting region, including a precise flight plan to collaboratively re-plan so that the respective UFR flight may become "Strategically Deconflicted".

Where the UFR flights cannot be strategically deconflicted from other UFR flights before entering the U-space Airspace, the aircraft pilot or operator is still required to maintain separation using an authorised DAA system. It is the responsibility of the state to appoint an authority to manage the number of *in-flight* conflicts occurring and provide sufficient flight information to support the DAA systems.

U-space Y layer requires a known traffic environment of all crewed aircraft and is only possible controlled airspace or a TMZ. UFR flights shall receive the digital ground to air or ground to ground communications through an authorised U-space ATM/UTM interface. Flight authorisation for UFR flights in the U-space Y layer volumes is normally delegated by the ATS unit to a U-space service provider.

To separate the UFR flights from VFR, SVFR or IFR traffic, the U-space system may restrict flights within the U-space airspace. Flight restrictions are passed to U-space about VFR, SVFR and IFR flights entering U-space Y layers that will restrict the operations of UFR flights that do not meet the DAA system requirements for conflict management. Where a restriction is issued on the U-space airspace, the DAA systems are primarily considered a collision avoidance function and must yield to the air traffic under ATS unit control.

#### 4.2.6.6 U-space Z Layer Volume – High traffic density flight rules

In airspace where the UFR flights require a tactical conflict management system is required for safe and efficient control of an airspace, the U-space layer will be designated "Z". In this U-space airspace, UFR flights will be required to declare a flight intention to the U-space system before entering the U-space airspace. In this U-space airspace, UFR flights will have the same requirement defined for discovering, tracking and flight intent sharing as a U-space Y layer and *in-addition* are required to cooperate with tactical U-space conflict management instructions.

Separation minima shall be provided for UFR flights by U-space depending on the airspace classification and separation procedures. U-space shall be responsible for maintaining safe separation between UFR and IFR in all U-space Z layers; collision avoidance remains the responsibility of the pilot or operator. U-space can make use of DAA systems that directly cooperate with the U-space tactical conflict service providing they meet the performance requirements.

The use of dedicated U-space corridors, performance navigation and visual tracking can be used by U-space to maintain UFR flight separation. UFR flights shall require clearance by U-space to enter a U-space corridor. U-space conflict management shall be responsible for re-planning UFR flight intentions that are restricted.

### 4.2.7 Airspace structure

There are different airspace structures which are interesting from the point of view of UAM, the use of Layers and Corridors and the use of the Dynamic Airspace Configuration (DAC).

#### 4.2.7.1 Layers

#### 4.2.7.2 Layers for traffic organisation

The "semi-circular rule" is an oft used term in aviation and refers to layering traffic according to direction in order to reduce the probability of collision. Variations on this have been often proposed, such as Irvine & Shaw 2004[17] proposed a scheme with traffic restricted to fly only certain headings in dedicated layers, Metropolis[18] propose "geo vectoring" grouping arcs of traffic heading into layers, and the BUBBLES project applies the semi-circular rule in the VLL.

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[17] https://www.researchgate.net/publication/256503816_Layers_of_parallel_tracks_a_speculative_approach_to_the_prevention_of_crossing_conflicts_between_cruising_aircraft

[18] https://homepage.tudelft.nl/7p97s/Metropolis/

#### 4.2.7.3 Layers relating to performance

AMU-LED have proposed a higher performance layer above a lower performance layer. Higher performance may be obtained at higher altitude due to better radio propagation[19].

A simple way to manage this in CORUS terms may be the vertical composition of two volumes with different performance requirements.

#### 4.2.7.4 Open questions about layers

How does a flight to move from one layer / volume to the other or through other layers to the ground, for example if the layers are dedicated to directions or flight performance?

If layers are defined in terms of constant gravitational potential, that is relative to mean sea level (the geoid) then they will interfere with terrain and obstacles. There will be occasions when aircraft must climb or descend to the next corresponding layer in the stack, passing through all the others. The benefits of layers in terms of reduced horizontal collision risk may be countered by increased vertical collision risk

If layers are defined relative to ground level, they may require additional climbing and descending.

A CARS is indispensable when layers are used. These layers should be referenced to the same datum used by CARS (e.g.: WGS84). This shall ensure proper vertical separation and conformance of aircraft using the layers.

Dedicated vertical corridors linking the layers can solve the problem of needing to change. For example, in the case of a high performance layer above, corridors can be defined near the vertiports so that UAM traffic directly ascends to the high performance layer after take-off, an vice-versa for landing.

Another question regarding layers and vertiports is how are vertiports (including the approach and departure paths) integrated into the layers? These operations basically require changing vertical levels, increasing the vertical collision risk as well. The U-space airspace surrounding some vertiports will be V-TZ. Transition areas , in vicinity of V-TZ, or part of V-TZ can be a way of handle this problem.

#### 4.2.7.5 Corridors

In an environment with a limited number of vertiports it may be interesting to try to connect them with corridors, implemented as relatively narrow U-space airspaces. The advantages include:

- Limiting the regions subject to UAS noise or the risk of falling debris in case of an accident
- Constraining the flights to regions with sufficiently good CNS
- Limiting the amount of airspace 'taken away' from existing aviation. (The advantage may be small as the corridors render much of the rest of the airspace useless.)

Disadvantages include:

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[19] Comment from Prof JV Balbastre of UPV & BUBBLES

- Flights which cannot follow the plan – for whatever reason – fall out of U-space. This may require the flights switch to either IFR or VFR as appropriate. That requirement may be a disincentive for contingency plans to be followed.
- Traffic may be concentrated increasing collision risk.

#### 4.2.7.6 Dynamic Airspace Configuration

Dynamic Airspace reConfiguration is a contingency procedure described in 2021/664 in which controlled airspace, which has been converted into U-space airspace, is converted back into controlled airspace.

The expected result of this is chaotic unless a) contingency plans already exist for each flight in the airspace and b) a notice period sufficient to execute those plans is given. In effect this is an emergency procedure that needs to be rehearsed (like a fire drill).

### 4.2.8 Type of vehicles

Vehicle classification based on EASA Concept paper on usage of U-space (TBD):

| Aircraft | EASA Classification | Pilot on Board | Use of U-space Services | Level of Automation | Notes |
|---|---|---|---|---|---|
| Manned Aviation | N/A | Yes | No usage of U-space services | None | GA, HEMS, etc. |
| Manned UAS | Type #3 | Yes | No usage of U-space services | None | Initial Phase, POBA |
| Manned UAS | Type #3 | Yes | Possible Usage of U-space services | Some flight phases may be automated | Later Phase |
| Unmanned UAS | Type #2 | No | Yes | Remote piloted/ automated/ Autonomous | Different level of autonomy is possible; for more automated flights there is no remote pilot but a 'fleet manager' |

**Table 59: Type of vehicles**

An Air taxi Service shall have the characteristics of common transportation modes, such as regular taxis and subways.

| CHARACTERISTICS | REGULAR TAXI | SUBWAY and BUSES | AIR TAXI |
|---|---|---|---|
| On-Demand Availability | Yes | No | Yes |
| Vehicle Routing | Real-Time | Pre-defined | Real-time |
| Number of segments per trip | Single | Single/Multiple | Single/Multiple |
| Vehicle Capacity | Low | High | Low |
| Trip Distance | Short, Medium or Long | Short, Medium or Long | Long or Very Long |
| Ride Fare | Medium | Low | High |
| Vehicle Travel Speed | Low | Moderate | High |
| Trip Duration Uncertainty | High | Low | Low |

| Ridesharing | Shared and non-shared | Shared | Shared and non-shared |
|---|---|---|---|

**Table 60: Common transportation modes characteristics compared with air taxi [105].**

The experience of requesting an Air taxi Service should be similar to the process of booking a standard on-demand and regular mobility services. Typically, a registered customer will enter the pickup and drop-off locations using an ad-hoc web-service application (e.g., Uber Taxi Service). Depending on the trip information, the platform will estimate the travel time for all relevant/applicable transportation modes, such as air and regular taxis. If an Air taxi Service is feasible, then a customer may avail of the service depending on his relevant attributes like willingness-to-fly, trip cost, and transit-time sensitivity.

An Air taxi Service could also be constituted by multiple segments as follows:

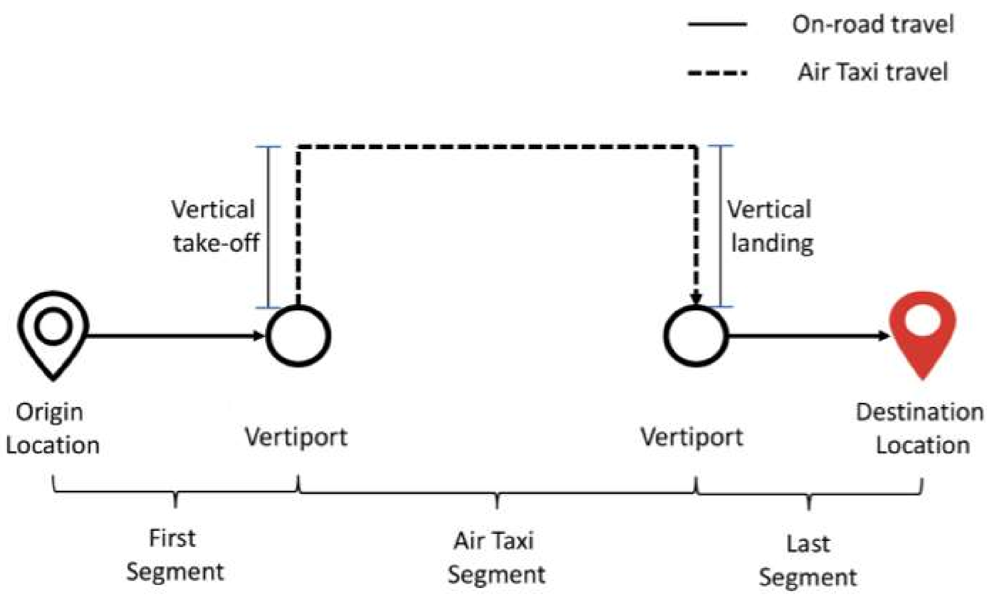


**Figure 33: Air taxi service point to point segments.**

The first segment (commute from the pickup location to a vertiport) could be facilitated via on-road car/taxi/other means of public transport trips or just walking from an airport gate to the relevant vertiport located close to the terminal. Subsequently, the longest segment of the trip could be covered by an air taxi, where the passenger is transported from the origin vertiport to the destination station. Finally, the last mile of the trip (i.e., travel from destination vertiport to the drop-off location) could be complemented by a regular taxi service. However, if the first or last segment of the trip is in close proximity to the designated vertiport, then the customer may be directed to walk.

The majority of UAM/AAM use cases are scoped around the 'air taxi' size aircraft. Aircraft capacity can vary from 1 – 5 passengers for local or regional flights.

Routes under use cases are focussed on short or local journeys. Significant numbers of use cases describe "short hop" or "last mile" transportation models of distances of under 100 miles.

As anticipated, many use cases are considering piloted Air taxi aircraft, although longer-term ambitions include autonomous or AI-driven flight control systems. Many of the aircraft systems do however introduce advanced technology-driven systems, beyond conventional aircraft design.

Within this context, to it is strategically important to:

- Define an efficient network that is relying on optimal vertiports location;
- Integrate Air taxi Services with other existing Ground Mobility options.

### 4.2.9 Rules of Separation

Among the different projects exploring the rules of separation between UAS, is relevant the SESAR ER project, DACUS, where in the Separation Management deliverable D5.2. [94] they define the different alternatives and rules for the provision of the separation management process.

In this context, separation can be either provided by:

- A U-space service provided by a service provider from a ground station.
- Self-separation, provided by the vehicles itself.

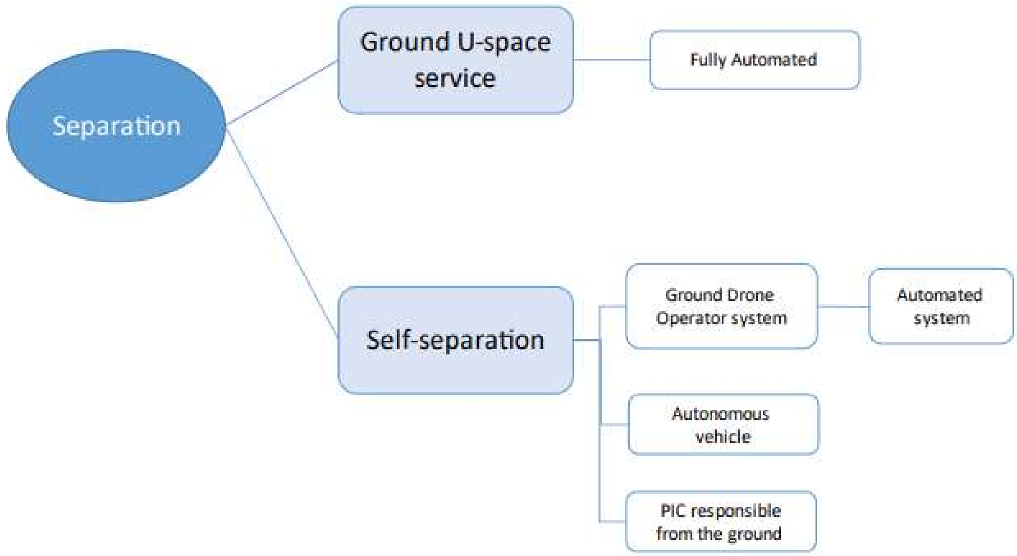


**Figure 34: DACUS D5.2. Rules for separation management schema.**

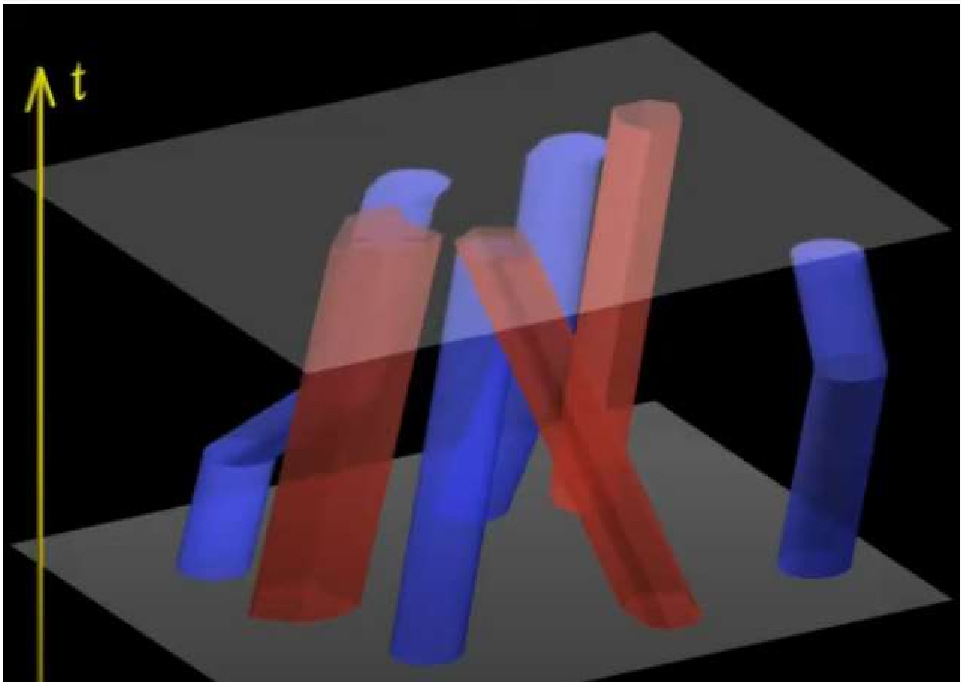


Figure 35: 4D trajectories (blue) abiding a set of moving obstacles (red)

#### 4.2.9.1 Self-separation

Self-separation is expected in "uncontrolled airspace", such as U-space classes X and Y as defined in the CORUS CONOPS [93]. This part of U-space is expected to be fairly large and have a low traffic density. Types of self-separation, as found above in DACUS D5.2, Figure 34, are separation provided by a Ground Drone Operator Systems, self-separation provided by the Autonomous vehicle itself and finally VLOS (Visual Line of Sight) flights with PIC (Pilot in Command) on ground, responsible for visual separation. This is in some ways equal to today's Class G airspace with mainly manned VFR traffic.

#### 4.2.9.2 Ground U-space service centralized with one or more actors.

Ground-based separation is expected in Zu airspace by USSP throughout the use of separation service in U-space.

Firstly, an initial strategic deconfliction is made when the operator is applying for authorization of a flight, before its RTTA (i.e., xx minutes before ETD), when the U-plan is received. This is similar to what we see in manned aviation today with NM, Network Manager to avoid congestion in the airspace. The initial strategic deconflictions takes this a step further though, since this also aims to de-conflict the 4D flight path within reason depending on the timeframe to ETD.

For the strategic and pre-tactical phase, deconfliction data gathering is necessary to get a baseline. As the operations grow, more data will come and we'll learn from it and will manage the uncertainties, decrease the margins etc. Based on this approach, the vision of the project is that separation management will be more conservative in the beginning and more efficient later on. Data needs to be gathered locally, carefully checking whether data from one place is usable or not in another place.

The adherence to the flight route is vital; allowing deviations up to 5-10% of the route will create unnecessary conflicts in the analysis of the strategic and pre-strategic deconfliction. RNP 95% containment… should it be better, under 1%? Decrease of the containment violation probability, during the initial implementations, may be achieved with larger safety margins (see below a schematic figure from BUBBLES D4.1. [95] and the simulation results on containment from an ATM Seminar 2021 paper [96], by Airbus and Johns Hopkins University on evaluation of UTM strategic deconfliction through end-to-end simulation).

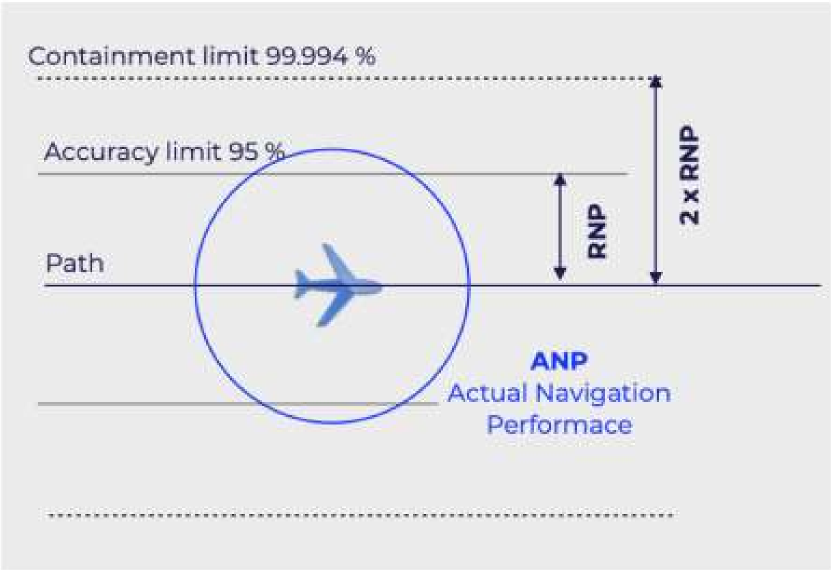


**Figure 36: RNP Accuracy and Containments limits, BUBBLES Project**

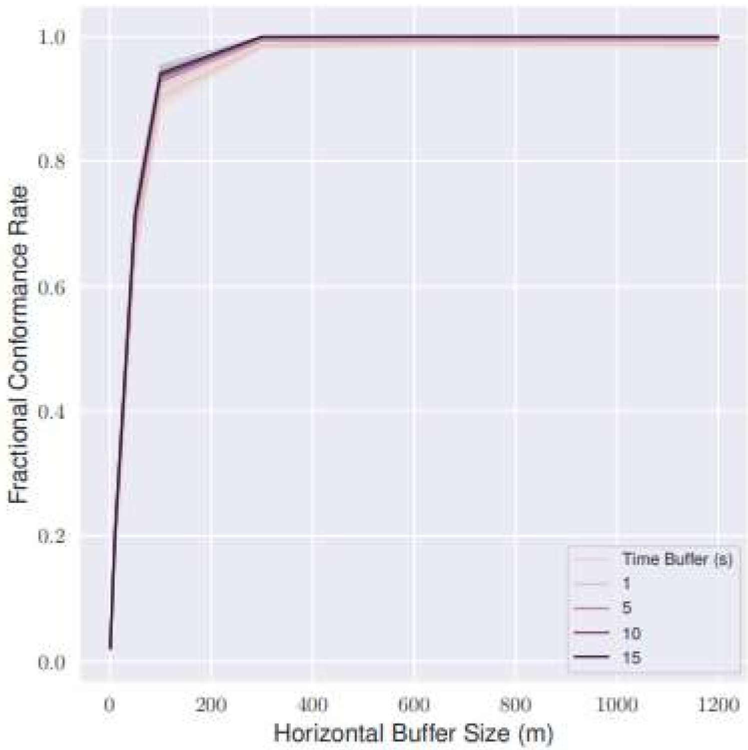


**Figure 37: ATM Seminar [96], Conformance rate as a function of the volume horizontal buffer across a variety of volume time buffers.**

Next, for the pre-tactical deconfliction phase, when the flight activation is requested, for example within 3-5 minutes to ETD, the deconfliction service will take into account the actual airspace situation. Airspace situation received from USSP with an MTCD-like algorithm to identify risks and---most importantly---conflicts that can be solved before T/O, e.g., in the form of rerouting or change of en-route flight altitude will provide an update on the U-plan.

Finally, when the flight is activated, all separation provided is tactical, no matter what the source of issue is: weather (wind), delay, non-conformance, performance degradation, etc.

This is expected to be a common procedure, that will enable to increase traffic density and to allow a free route concept in U-space. A remark must be done on not to confuse free route airspace (FRA) with free flight: free route airspace will work just fine e.g., from vertiport to a waypoint, then directly to another waypoint, then to vertiport; free flight is totally unpredictable since no rules apply, you fly as you wish and want).

All UTM systems need to have the same parameters, to be able to detect all conflicts, to have the same picture and use the same resolution for all conflicts that need to be resolved. Prediction is necessary in systems used by USSPs as the predictability is an important part of all deconfliction in the U-space, including sequencing at (vertiports, hubs, etc.)

Communication is vital too; in particular, information about off-nominal events must be transmitted immediately to involved drone(s) and presented with a solution that will take them to an alternate Vertiport or apply rerouting. This means a seamless connection for a flight during the whole flight.

A crucial parameter is the separation radius r, below which the loss of separation is declared. SESAR ER4 project BUBBLES [95] looks at the interplay between r and resolution efficiency: for larger r, the separation loss is more frequent, but the vehicles have "more room to manoeuvre"; on the contrary, with smaller r, loss of separation is rare, but conflict avoidance schemes are less likely to work. BUBBLES balances the probability of loss of separation and the probability of collision, given the loss of separation, to determine the level of safety for various values of r (see figure from BUBBLES D4.1 [95] below).

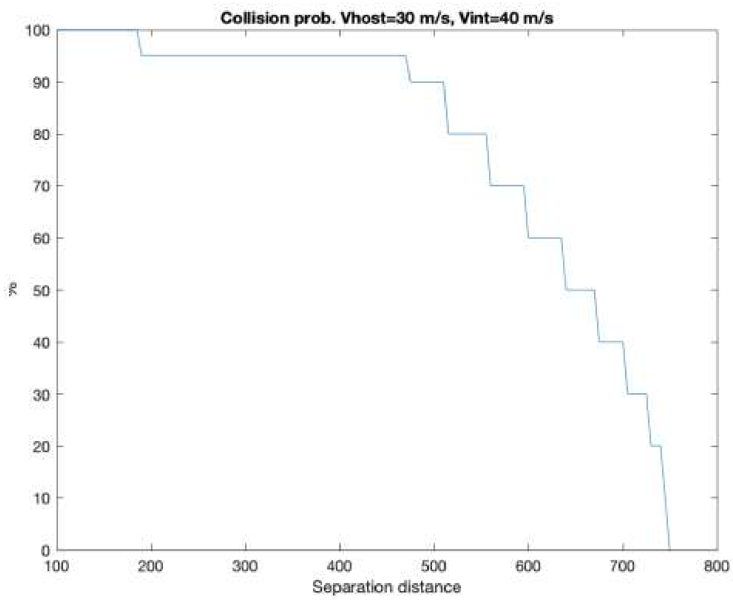


**Figure 38: BUBBLES D4.1. [95] Collision probability versus separation distance.**

In addition, the ATM Seminar 2021 paper from Airbus and Johns Hopkins University [96], reports on simulations results evaluating risk for various r (as well as time uncertainty buffers); see the figure below (see the paper and the presentation for more results plots):

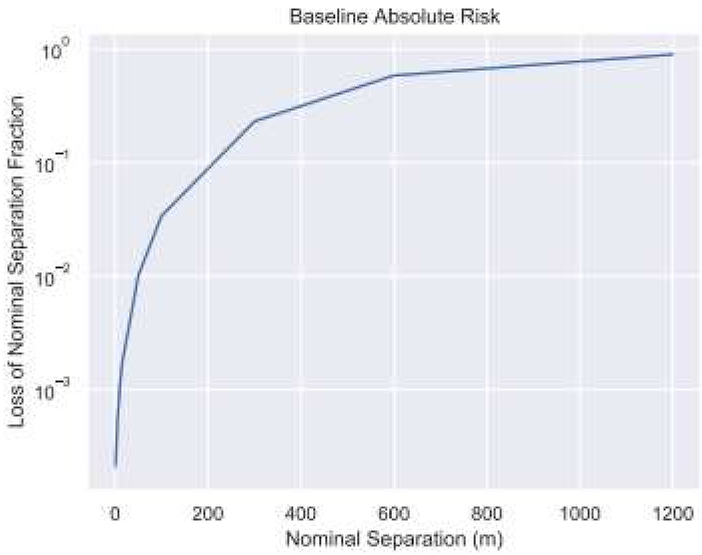


**Figure 39: ATM Seminar 2021, The absolute unmitigated risk as a function of nominal separation.**

DASC 2017 paper from Linköping University and UC Berkeley [97], produced similar graphs also for varying traffic intensity (see the figure below). The main conclusion from the work are sharp thresholds for the risk: for a fixed r, as the traffic increases, at some point the risk abruptly goes from essentially 0 to almost sure. This "tipping point" defines the airspace capacity for the given CNS performance: to avoid the risk, the CNS performance must be decreased before the threshold traffic intensity is reached. For vehicles with hover capabilities, such CNS performance may potentially be improved simply by decreasing the speed, which increases the time-to-act buffer.

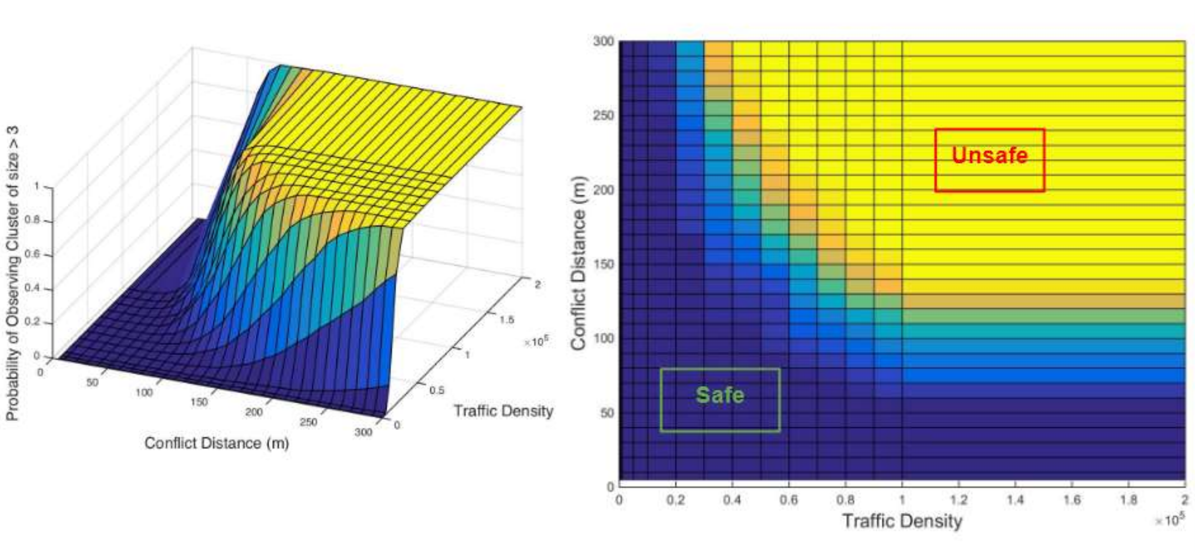


**Figure 40: Probability of safety breach as the function of r and traffic intensity (left 3D graph, right: view from the top)**

### 4.2.10 Processes and flight phases

The lifecycle of a single operation is divided into different flight phases, that categorizes the operational phase during an operation happens and refers to a period within a flight, these includes, the pre-flight, the flight and the post-flight phase.

Also, to consider the different processes and flows of information, it is required to have processes phases, the strategic, pre-tactical, tactical, and post-flight processes phases.

These phases are related in a timeline where the different events are depicted, as represented in **Error! Reference source not found.**.

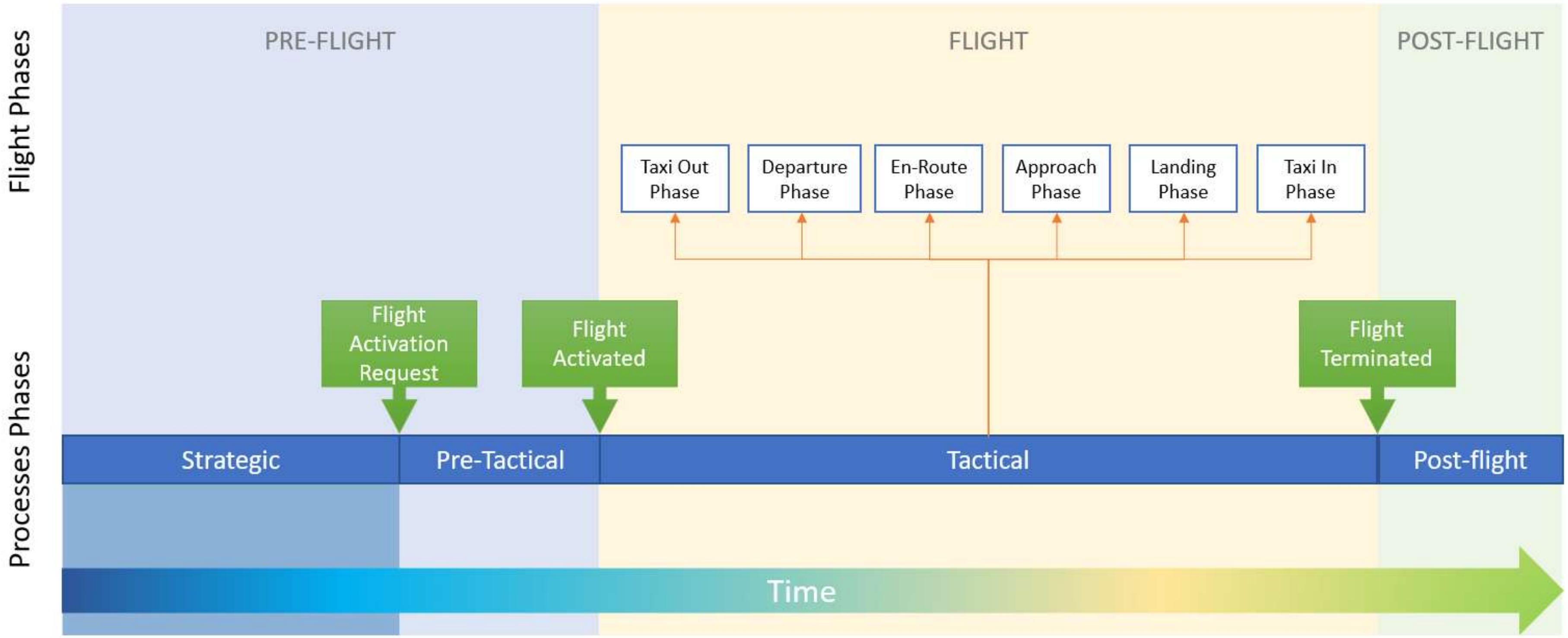


**Figure 41: CORUS-XUAM Process and Flight phases timeline scheme.**

These process phases are used to describe the lifecycle of the processes of an individual UAM operation, and match with the actual names of ATFM and DCB processes phases as defined by ICAO on Doc 4444 PANS-ATM [99], they are used to ensure the optimal traffic flow and to balance the demand with the current capacity of the system, they are divided into:

- **Strategic phase:**

  This process phase is the start point in the lifecycle of an operation, as this phase begins at the point at which the UAM Operator plan its flight intentions into a U-plan. This could occur once the UAM Operator has its intentions clear (e.g., 30 minutes before ETD) or even days before the actual operation, but it is not limited in time.

  In this phase, strategic processes occur, for example to check for imbalances (Demand and Capacity Balancing, DCB processes) and proposes to apply DCB measures to ensure the flight takes place in a safe and an efficient way if they needed. These DCB measures can encompass from long term actions (as e.g., planning on CNS infrastructure update or modification, redesign of the airspace structure, etc.), to medium and short-term measures (as for example to change the route or altitude in the U-plan, or to change/adapt the current airspace configuration, etc.).

  This process phase ends when the **flight activation request** is sent by the UAM/UAS Operator.

- **Pre-tactical phase:**

  This process phase starts then, once the U-plan is approved, and the drone operator has sent the request for flight activation.

  The flight is then freeze and has its RTTA (Reasonable Time to Act) on-going. At that moment, the uncertainty of the estimated time of departure is very low, and so, the probability of anything to change in the flight are very low.

  A final U-plan conflict detection is performed, if any potential conflict is detected (for example with a prioritised flight e.g., an emergency flight), then a modification on the U-plan can be proposed. These modifications are based on a prioritisation schema as defined in Section 4.2.11.3. If no conflicts are detected, the Drone Operator is provided with the final time of departure, slot, runway, and time of arrival.

  This phase ends when the flight receives the flight activation authorisation. This RTTA needs to finish at the same time or before this flight activation authorisation.

- **Tactical phase:**

  This process phase start when the flight is finally activated. The flight phases comprised within the tactical phase are Taxi Out, Departure, Take-Off, Climb/Ascend, En-Route, Descend/Approach, Landing and Taxi In.

  This phase ends after the Landing (or Taxi-In, depending on the vehicle capabilities), when the flight sends the terminated message to the USSP, indicating that the flight is ended.

- **Post-flight phase:**

  This process phase start when the flight is in the status terminated and the UAM vehicle stops moving, the flight closes and securing the vehicle commence. Post flight activities typically includes de-boarding passengers and/or cargo and vehicle servicing activities.

In addition to the process phases, as described in the CORUS-XUAM Operational Framework D3.1. [98], the flight phases of an individual operations are divided into:

- **Pre-flight phase:**

  Any general pre-operational activities related to the management of UAM and independently to the single flight: there are encompassing registration, publication of UAM corridor, operational of UAM and any activity related to the preparation of the individual flight prior to departure, including vehicle pre-flight checks, vehicle charging, flight planning, boarding passengers and/or cargo. This flight phase comprises the process phases of Strategic and Pre-tactical phase.

- **Flight phase:**

  This flight phase comprises the different evolution of the movement of a flight in a single operation including:

  - **Departure:** the period in which the UAM vehicle physically departs from the location A (Vertiport, stand, runway, airfield, etc.) up to the point at which it reaches cruise altitude. Departure includes taxi, take-off, and initial climb

  - **En-Route:** The point at which the vehicle reaches cruise altitude up to the point at which it begins the approach to the destination location/point (Vertiport, stand, runway, airfield, etc.).

  - **Descend/approach:** the period between the UAM vehicle aligning with the optimal track to the assigned destination and reaching the decision point (or decision altitude/flight). Descent is expected to occur within this phase. The UAM pilot will elect to either continue or land or climb to a safe manoeuvring altitude (executing a missed approach).

  - **Landing:** the point at which the decision is made to continue to the destination from the decision point (or decision altitude/height) until the UAM vehicle lands Landing includes taxi-in if needed depending on the UAM vehicle.

- **Post-flight phase:**

  this phase is described in exactly the same way as the Post-flight phase from the process phases described above.

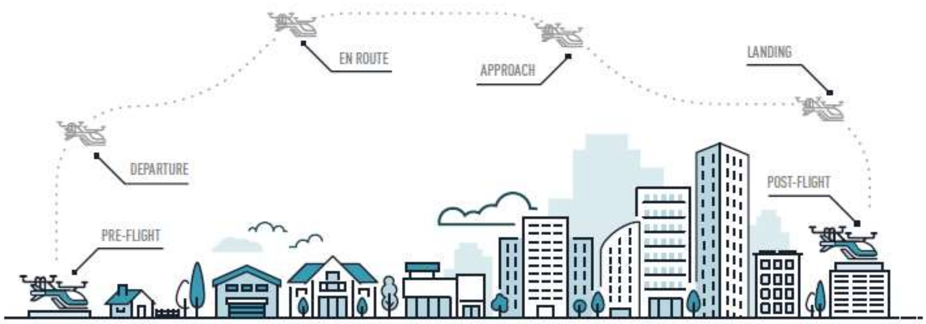


**Figure 42: Operational Framework flight phase representation from EmbraerX and Airservices Australia ConOps for UAM [106].**

## 4.2.11 U-plan - Operational Planning

To process the different operations, it is envisaged the use of a U-plan (previously named Operational Plan), that contains the minimum information required to perform an UAM operation.

### 4.2.11.1 Lifecycle of a U-plan.

The operation plan has a number of distinct phases in its life. This topic is quite large and needs proper discussion. This is just an introduction.

1) Draft. There is a business need, and a plan is being developed.
2) Approved. The plan has been filed, strategically deconflicted and so on. Resources (e.g., airspace, vertiport) are now committed to this flight.
3) Active. The services used in flight are operating. Tracking, emergency management, etc.
4) Ended. The flight is over.

There are a few other states that can usefully be added to that set. Flights may have been approved but then due to changes in circumstances might not be able to be activated. Flights might be already activated and then the same change in circumstances make them activated but not safe. Flights may invoke contingency procedures which means that they are not following the original plan.

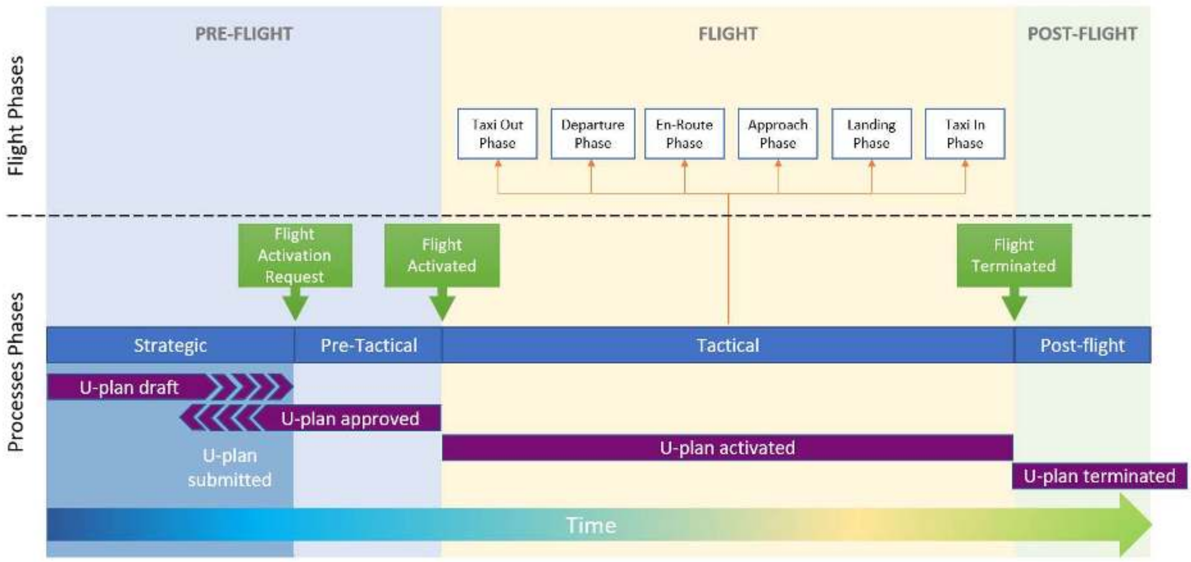


**Figure 43: Timeline schema of the lifecycle of a U-plan within the process and flight phases related.**

#### 4.2.11.2 RTTA (Reasonable Time to Act)

EU Regulation 2021/664 states that first filed U-plan is the first to be served in a basic FIFO methodology (First In, First Out), with the exception of priority flights. This method has some advantages and some disadvantages.

On one hand, the pro of this method is that the certainty of the operations comes early, except for those priority flights which are not common, and secondly its easy implementation.

On the other hand, this methodology discriminates and penalise against businesses that cannot file a U-plan that early (e.g., food delivery, air taxis, etc.). Also, this could lead to an inefficient use of the available capacity, as the network will probably not have time to optimise or to use priority preferences, as UAM/UAS Operators are “rewarded” for filing the U-plan early, increasing the level of uncertainty of the plan filed.

In order to try to solve those issues, RTTA (“Reasonable Time to Act”) was explored.

- <u>Definition from CORUS:</u>

For any drone operation, there is a time period far enough before flight that a disturbance to the operation has minor repercussions. After that time the effect of change becomes harder to accept. (It could be argued that the time depends on the nature and size of the disturbance as well as the type of flight – but this process needs to be simple.)

This time is known as the “reasonable time to act” (RTTA) and can be different for different operation types. No value was specified in the version of the CORUS ConOps.

RTTA impacts how the flight is treated in processes like strategic conflict resolution and dynamic capacity management. Both of these processes need to act as close as reasonably possible to the take-off time of the flight in order to work with the most precise picture of the traffic. At the same time the two services need to avoid an implicit prioritisation based in the order in which operations are planned because this is disadvantageous to operations which cannot be planned long in advance.

If an operation plan has been submitted before its RTTA, then from RTTA until take-off U-space will protect that flight from any further change in all but the most extreme situations.

If an operation plan is submitted later than its RTTA then that flight will be processed at a disadvantage in strategic conflict resolution and dynamic capacity management, the result of those flights might be not being finally able to fly at the desired time and being accommodated when the operation in safe.

- Definition from DACUS:

Other projects have used this term as **DACUS**, an ER4 project based on DCB concept for U-space:

Operation plans submitted after RTTA for that flight are the first candidates to be proposed a plan change. Although there is no advantage to early operation plan submission, there is a limit in the interests of giving other operators some stability. At RTTA a flight becomes “protected” and may be considered as being in its Tactical phase.

Identified "research challenges" with respect RTTA y and its use in U-space DCB:

1. Fair access to airspace versus “Reasonable Time to Act”

The U-space ConOps follows the principle that being first to submit an operation plan brings no advantage regarding flight priority. Conflict resolution and Dynamic Capacity Management actions are implemented a short time before take-off, referred to as “Reasonable Time to Act” or RTTA. At that instant these processes occur on all flights concerned and treat them as equally as possible.

The impact of this “Reasonable Time to Act” on the diverse business models coexisting in the urban areas is subject to further investigation. It is necessary to assess the DCB processes in place to ensure the fair access to the airspace to those business models that can be constrained by the need of providing the Operation Plans before the RTTA.

2. “Reasonable Time to Act” as starting time of the pre-tactical phase

“Reasonable Time to Act” means in practice that areas with high traffic uncertainty will have a pre-tactical phase which is much closer to the departure time of the vehicle than those areas in which the traffic uncertainty is very low. Subsequently, the time given to Drone Operators to react to (and negotiate) DCB measures is greatly reduced in high-uncertainty areas. This strategy aims to incentivize proactive participation of Drone Operators to provide DCB-relevant information early on in the process in order to reduce overall traffic uncertainty, which benefits all Drone Operators aiming to fly in a specific area. Additional incentives include the introduction of virtue points to further promote collaborative behaviour among users.

Further research is needed to set the starting time of the pre-tactical phase, identifying if it will start at a pre-defined time (e.g., 10 minutes prior to the execution), or it will start as soon as a demand certainly value from which the traffic picture can be considered to be “consolidated”. The 1st option could allow Drone Operators to know when they will be requested to adapt their Operation Plans if necessary. The 2nd option could allow Drone Operators to have more time to adapt their Operation Plans. A systematic analysis of the diverse business models in urban environments should be performed to address this question.

The idea that underlies here is explained with an example: Two drone flights with the same departure time but in two areas: Area 1 with high traffic demand uncertainty, and Area 2 will low traffic demand uncertainty. Area 1 will take much longer to get a consolidated traffic picture than Area 2. Therefore, the pre-tactical phase will begin earlier in Area 2 than in Area 1, giving drone operators in Area 2 much more time to adapt to DCB measures than those in Area 1.

- CORUS-XUAM perspective:

From CORUS-XUAM perspective, U-plan could be submitted any time before the activation of the flight. This will affect the performance of the U-space system in order to be efficient in the way strategic measures like DCB and strategic conflict resolution works.

RTTA is related with equity KPA, as the RTTA impacts directly in how the flight is treated in processes like strategic conflict resolution or dynamic and capacity balancing management.

RTTA is then defined as a line drawn in the time, with the capability of balance the flexibility of the user and the efficiency of the strategic services used by the network.

In order to define this line, it takes two perspectives, from

- the **point of view of the network**, in order to ensure safety levels and to reach a certain level of efficiency, the USSP/CISP would need the information of this U-plan as soon as possible, as it needs to process the information regarding the different activities that are going to occur in a certain airspace. This requires a minimum time where decisions and measures are applied (DCB or Conflict management services). On the other side, having the U-plan sooner could imply that the uncertainty for that operation is higher.
- **the perspective of the passenger and the UAM/UAS Operator**, once the USSP/CISP needs to perform a modification in a U-plan due to the strategic services like DCB or conflict resolution, the UAM/UAS Operator will require a minimum time to apply modifications in its intentions. The Operator then would need to balance the uncertainty

The RTTA is a line drawn in the timeline, flight filings not yet at RTTA are stored and ordered, when a flight is after the RTTA then is fixed/frozen, thus no disturbance of its plan is allowed (unless rare priority cases, e.g., emergencies), the flight is then frozen and is protected until the flight is activated. If a U-plan is filed before its RTTA, the system will consider their rules for prioritisation, these aspects to be considered are further detailed in Section 4.2.11.3.

DCB Measures and Strategic conflict resolution then applies their measures based on this priority rules for all flight that filed before RTTA. If a flight is filed before the RTTA, this flight is put on the queue, and will need to be accommodated according to the availability of the network.

The duration of RTTA is not determined yet and may vary based on the operation and the maturity level. An initial estimation based on Volocopter’s Voloport system and eVTOL aircraft characteristics showed that an RTTA of 15 min could be envisaged for Volocopter’s operation (based on the estimation times of 2.5 min for landing, 2.5 minutes for departure and 10 min for charging, making the 15 minutes for the estimated turnaround). This RTTA can be different for different operation types.

A further study on the RTTA concept is needed, to characterise the value for each type of operation.

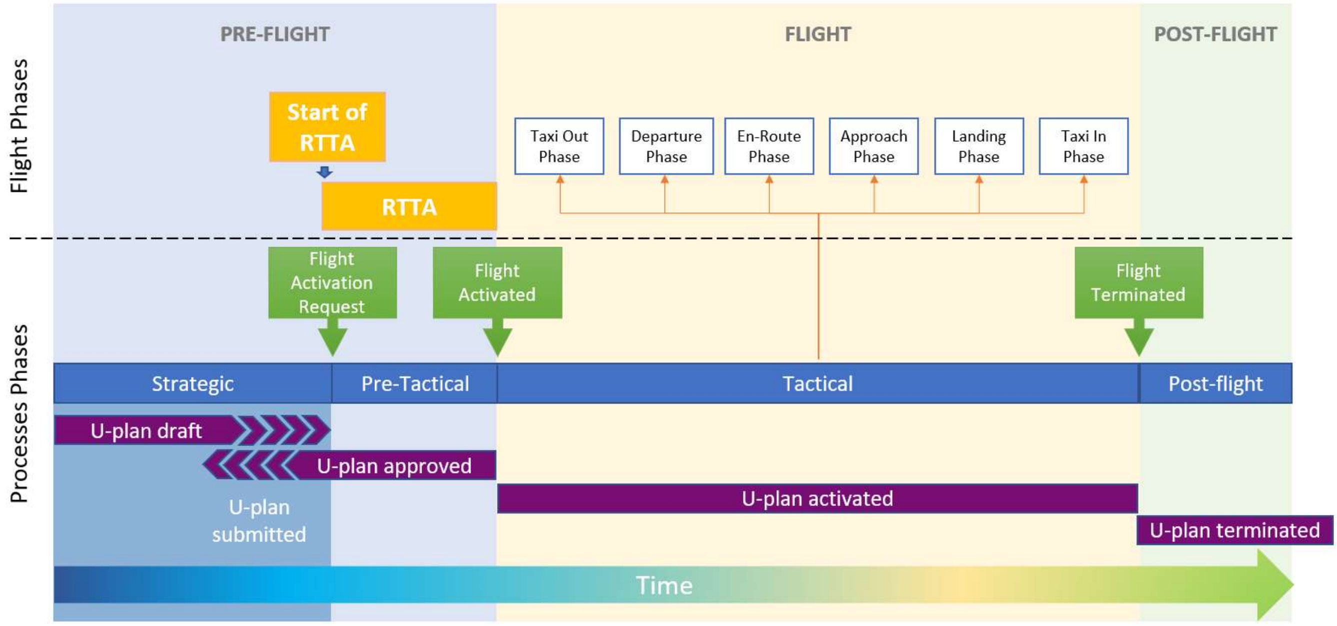


**Figure 44: Visualisation of RTTA in U-plan and process phases timeline relation.**

#### 4.2.11.3 Rules for prioritisation

For flights filing a U-plan before RTTA, they have low uncertainty of this plan until RTTA is reached. Also, their interests and preferences are not really taken into account when applying strategic services like strategic conflict resolution or DCB measures.

To solve this, a set of rules are proposed, which enables a queue prioritisation, improving the uncertainty of the plan for both parties (the network and the users), and improving the equity levels, as the users can express their prioritisations aspects, which increases the fairness in the process.

To make sure that RTTA is a fair element, considering the different points of views of both (network and user), several factors are taken into account like:

- Lead Time (LT):

The Lead Time indicator will specify how long in advance was the U-plan filed. The sooner the plan is filed, the better the prioritisation.

- Accuracy of the plan (Acc):

This indicator will measure the uncertainty of the plan filed. This could be expressed by the UAM/UAS Operator in the filed plan as well as the historic of the UAM/UAS Operator. The more accurate the plan is, the better will be the prioritisation.

- Flexibility (Flex):

For some operations, the time of departure will not be a problem within a time window (E.g., no high limitation on a fixed time of departure), the more flexibility to accommodate changes, the higher the prioritisation will be.

- Start Time (ST):

A key factor in the prioritisation of the queue of traffic will be their start time (e.g., activation time or estimated time of departure). The sooner the Start Time of a flight is, the higher the prioritisation will be.

- Type of mission (ToM):

Finally, the type of mission will be considered, in case a special type of mission is considered, for example for emergencies.

- Precision (P):

The precision of the information sent (e.g., set by the CNS equipment precision on board).

Then, when the flight is filed before RTTA, these flights enter in the pool and they are ordered based on a prioritisation function P which is based on the factors previously mentioned.

$$P(LT, Acc, Flex, ST, ToM, P)$$

This function requires more study and no conclusions was reach on specific values for these functions.

#### 4.2.11.4 What is Provided in the U-plan / Operational Plan

Most flights flying within U-space will be requested to fulfill a U-plan / Operational Plan, this contains a set of information needed for the lifecycle of an operation.

- **4D Volumes** as specified under InterUSS [104] (3D airspace volume within a time window with of the vehicle inside the 4D volume);
- Departure & Destination location;
- Departure time;
- Arrival/Landing time;
- Vehicle operator information, Vehicle registration/Serial Number;
- UAS information: Aircraft CNS Performance equipage;
- Mission Type;
- Flight Identification;
- Contingency Plan;
- Flight Prioritisation;
- Continuous safe flight and landing (CSFL) alternate vertiport.

#### 4.2.11.5 Clearances

Clearances are linked to flight execution, a way of tactical deconfliction. They are needed to increase capacity in more complex areas.

It is agreed to start describing the case where only strategic deconfliction is in place and explore feasibility. The points limiting performance efficiency or capacity will be leading to the need of some tactical deconfliction (i.e., clearances).

A detailed analysis of this will be performed on T3.3. Safety requirements.

#### 4.2.11.6 Approval process of the U-plan:

At least should include these checks process:

- Procedural ATC Check
- Geo-Fencing Check
- Authorisation Check using Aircraft Registry
- Strategic Demand Prediction + Strategic Demand & Capacity Balancing
- Strategic U-plan Conflict Detections

## 4.3 Assumptions

This is a list of assumptions taken into account when describing the environment:

Vertiport Assumptions:

- For initial operations, the capacity of a vertiport is significantly greater than the demand currently. *Anything which should happen will happen promptly.*
- At landing, there will always be stand allocation. The aircraft approaches a FATO then lands at a TLOF and then moves (on the ground) to the stand. The distance from the FATO to the stand is of concern to the Vertiport operator. There will be a negotiation regarding the requirements regarding stand allocation or standing agreements.
- By the time of take-off, the plan must be complete as far as the arrival stand in order for the operator to manage the energy on board.
- The vertiport is not exclusive – flights any operator may use it.
- Each Vertiport operator may have any USSP.
- The vehicle should be compliant with the vertiport's operating licence. (Weight, noise, fire risk, technical equipment, times of operation, …)
- The vertiport operator (most probably) has to have an agreement to allow the operator to use the vertiport, covering the conditions above and in terms of a framework agreement, charges, services, billing, etc.
- Vertiport include an area of storage and battery shift/charging area.
- Early Air taxi vehicles will have a pilot on board to ensure safety, but they will be largely automated type of aircraft. Industry's ultimate vision, after an initial transition period, is to operate them without an on-board pilot.

U-plan activities assumptions:

- Flights covered under scenarios 1 to 4 covers only point-to-point flights (e.g., from vertiport to vertiport.
- The authorisation to fly is a multi-stage process.
- There needs to be a "hypothetical plan mode" to estimate the cost, departure time, arrival time, access to slots, before doing actual flight activation. Once the passenger agrees, the plan needs to be made concrete (low uncertainty).
- The flight planning process is specific for a single flight. The plan is a 4D trajectory right to the arrival stand and is also implicitly a take-off clearance.
- The U-plan contains 4D volumes as defined in the InterUSS platform documentation [104].

- All UTM systems need to have the same parameters, to be able to detect all conflicts, to have the same picture and use the same resolution for all conflicts that need to be resolved. Prediction is necessary in systems used by USSPs as the predictability is an important part of all deconfliction in the U-space, including sequencing at TOLAs (vertiports, hubs, etc.)
- U-plan activities within the short term are focused on Low density Traffic, to solve problems at origin using strategic services (e.g., Strategic Conflict Resolution and Strategic Demand and Capacity Balancing management services)
- U-plan activities within the medium/long term are focused on Medium and high-density traffic, to solve some of the possible problems at origin and some others during real time operations using strategic and tactical services (Strategic and tactical conflict resolution, Strategic and Tactical DCB Management services).

Airspace assumptions:

- The use of the airspace should be fair.
- Airspace is segregated (either under U-space or ATM).
- For the fully automated operations phase, we should support the creation of UAM-specific routes and corridors not interfering with manned aircraft/ATC operations. These corridors will help to standardize and separate UAM operations while helping to simplify/reduce interactions with other existing airspace users and air traffic control.

Traffic Assumptions:

- **Low density traffic** is the traffic set to be manageable by strategic conflict resolution alone without the need of tactical conflict resolution services.
- **Medium and high-density traffic** is the traffic level set that is not only manageable by strategic services but needs of tactical conflict resolution services.
- In the short term, UAM operations for Air taxis will be POBA (Pilot on Board Aircraft).
- There is a need on defining a new flight rule for UAS, UFR is proposed.
- Some initial low-volume UAM operations with a pilot on board could be managed much as helicopter traffic is managed today. However, another set of rules will be needed for the higher-volume and more automated operations that will follow.

## 4.4 Scenarios

For the description of the scenarios, we have focused on two mission types:

- A – Point-to-Point operations (e.g., Passenger transportation. (Air taxi) & Movement of goods (Large cargo depot to depot)).
- B –Area Operations (e.g., Drone inspections, firefighting, etc.)

Also, the scenario will consider one of the timeframes defined in section Time Horizon:

- ST – Short Term (comprising Maturity Level 1 and 2 as from Section 3.1)
- LT – Long Term (comprising Maturity Level 3 and 4 as from Section 3.1)

For each time horizon and mission type there will be two environments, dealing with airspace topics:

- Env1 – Vertiports outside controlled airspace (e.g., airspace X, Y, airspace class G on VLL).

- Env2 – Vertiports are inside controlled airspace (e.g., airport CTR, airspace class D).

List of scenarios:

| Scenario | ID | Mission Type | Time Horizon | Vertiport Environment |
|---|---|---|---|---|
| Scenario 1 | Scn-A-ST-Env1 | A | Short Term | Env1 |
| Scenario 2 | Scn-A-ST-Env2 | | | Env2 |
| Scenario 3 | Scn-A-LT-Env1 | | Long Term | Env1 |
| Scenario 4 | Scn-A-LT-Env2 | | | Env2 |
| Scenario 5 | Scn-B-ST-Env1 | B | Short Term | Env1 |
| Scenario 6 | Scn-B-ST-Env2 | | | Env2 |
| Scenario 7 | Scn-B-LT-Env1 | | Long Term | Env1 |
| Scenario 8 | Scn-B-LT-Env2 | | | Env2 |

### 4.4.1 Scenario 1: Scn-A-ST-Env1

At Scenario 1 (Scn-A-ST-Env1), vertiports exist at various places and air taxi operations are routine between these vertiports.

A vertiport is surrounded by a mini-Approach area (busier vertiports, like this one, will have a V-TZ, Vertiport Traffic Zone), in which the sequences of **departing UAM** vehicle will be managed and eventually **ground holding operations** will be requested.

The flight is from vertiport A to vertiport B, where all vertiports are outside controlled airspace, and so, there is no need to coordinate with ATC the operations.

Landing and departure operations at vertiports will be managed through U-space, a largely automatic system that will perform the necessary control tasks (sequence building, landing clearances, hold instructions, taxi clearances, etc.).

A passenger called ***Pax*** is inside an air taxi and is ready to depart from a vertiport called ***Dep*** to its destination, another vertiport called ***Arr***.

***Dep*** is an urban vertiport and ***Arr*** is a Sub-Urban vertiport.

The air taxi vehicle is in a fit state to fly. It has sufficient range to reach the expected destination plus the required contingency margin. The UAM/UAS Operator behind that air taxi vehicle has successfully fulfilled its intentions in the U-plan.

The vertiports are operating normally. The traffic and weather conditions are compatible with the operation and there is nothing exceptional happening.

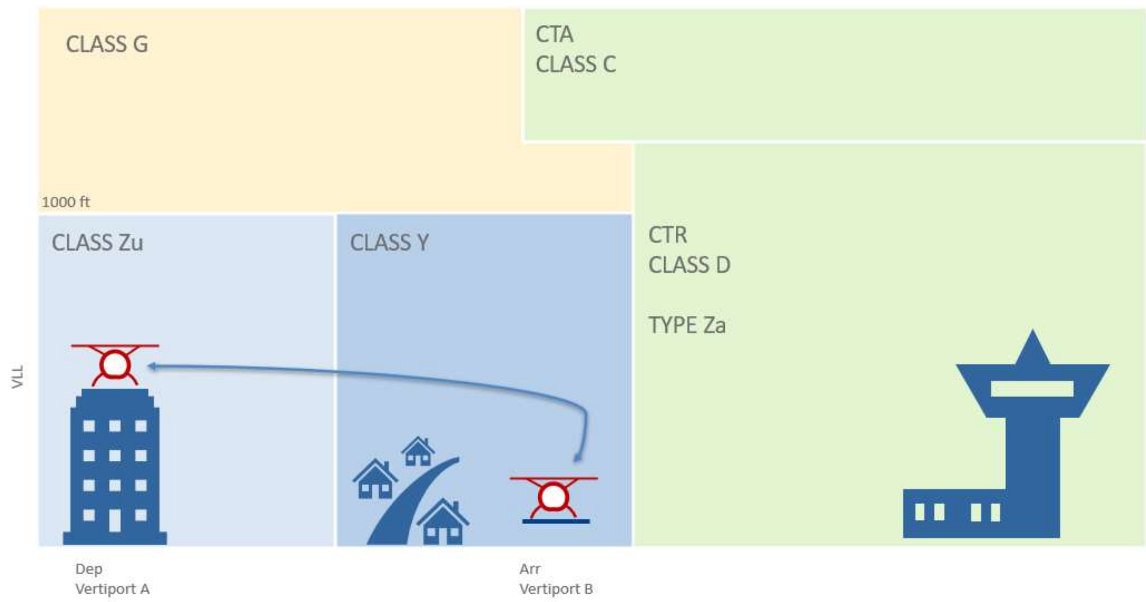


**Figure 45: Diagram sketch of Scenario Scn-A-ST-Env1**

### 4.4.2 Scenario 2: Scn-A-ST-Env2

At Scenario 2 (Scn-A-ST-Env2), vertiports exist at various places and air taxi operations are routine between these vertiports.

A Vertiport is surrounded by a mini-Approach area (busier vertiports, like this one, will have a V-TZ, Vertiport Traffic Zone), in which the sequences of **departing UAM** vehicle will be managed and eventually **ground holding operations** will be requested.

Landing and departure operations at Vertiports will be managed through U-space, a largely automatic system that will perform the necessary control tasks (sequence building, landing clearances, hold instructions, taxi clearances, etc.).

A passenger called ***Pax*** is inside an air taxi and is ready to depart from a vertiport called ***Dep*** to its destination, another vertiport called ***Arr***.

***Dep*** is an urban vertiport, the airspace for the surrounding the vertiport is class Zu. VFR traffic is not allowed. This is G but restricted.

The arrival vertiport ***Arr*** is an Urban vertiport based in the premises or the vicinity of an airport (i.e., **airspace class D**), an Air taxi departure operation will require some form of interaction **(through U-space) with ATM** and will be indirectly submitted to air traffic control monitoring, the corridor established will be U-space type Za.

The air taxi vehicle is in a fit state to fly.

It has sufficient range to reach the expected destination plus the required contingency margin.

The vertiports are operating normally. The traffic and weather conditions are compatible with the operation.

There is nothing exceptional happening.

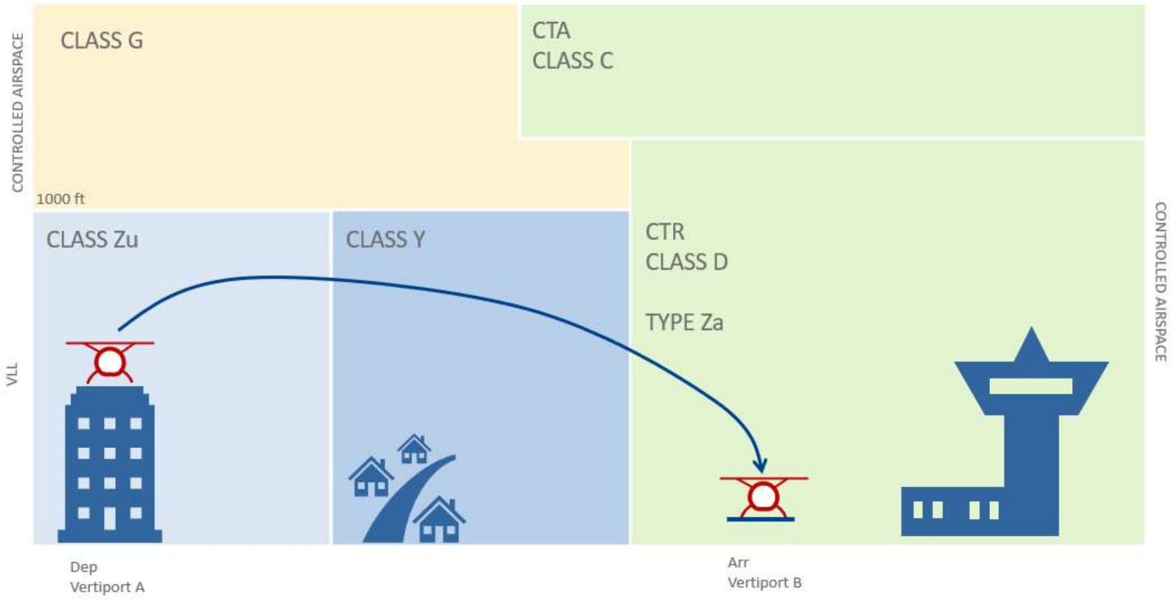


**Figure 46: Diagram sketch of Scenario Scn-A-ST-Env2**

Initial assumptions:

Early Air taxi vehicles will have a pilot on board to ensure safety, but they will be largely automated type of aircraft. Industry's ultimate vision, after an initial transition period, is to operate them without an on-board pilot.

Some initial low-volume UAM operations with a pilot on board could be managed much as helicopter traffic is managed today. However, another set of rules will be needed for the higher-volume and more automated operations that will follow.

## 4.5 Use Cases

### 4.5.1 Scn-A-ST-Env1

Figure 47 contains a summary of the flow of events and processes for a single operation point-to-point for Scenarios 1 and 2 (Scn-A-ST-Env1 Use Cases and Scn-A-ST-Env2 Use Cases).

Each of the blocks in the figure is represented as a use case (or sub-use case), which are analysed in detail in the following subsections. This analysis includes the list of steps in a table that contains the information regarding the roles and responsibilities, the services used, the flow of information, and additional comments.

If required, this use cases can contain information regarding specific assumptions, roles and responsibilities and additional notes to the reader.

These Use Cases are grouped following the U-plan and processes phases:

- Strategic Phase
- Pre-Tactical Phase
- Tactical Phase
- Post-Operations

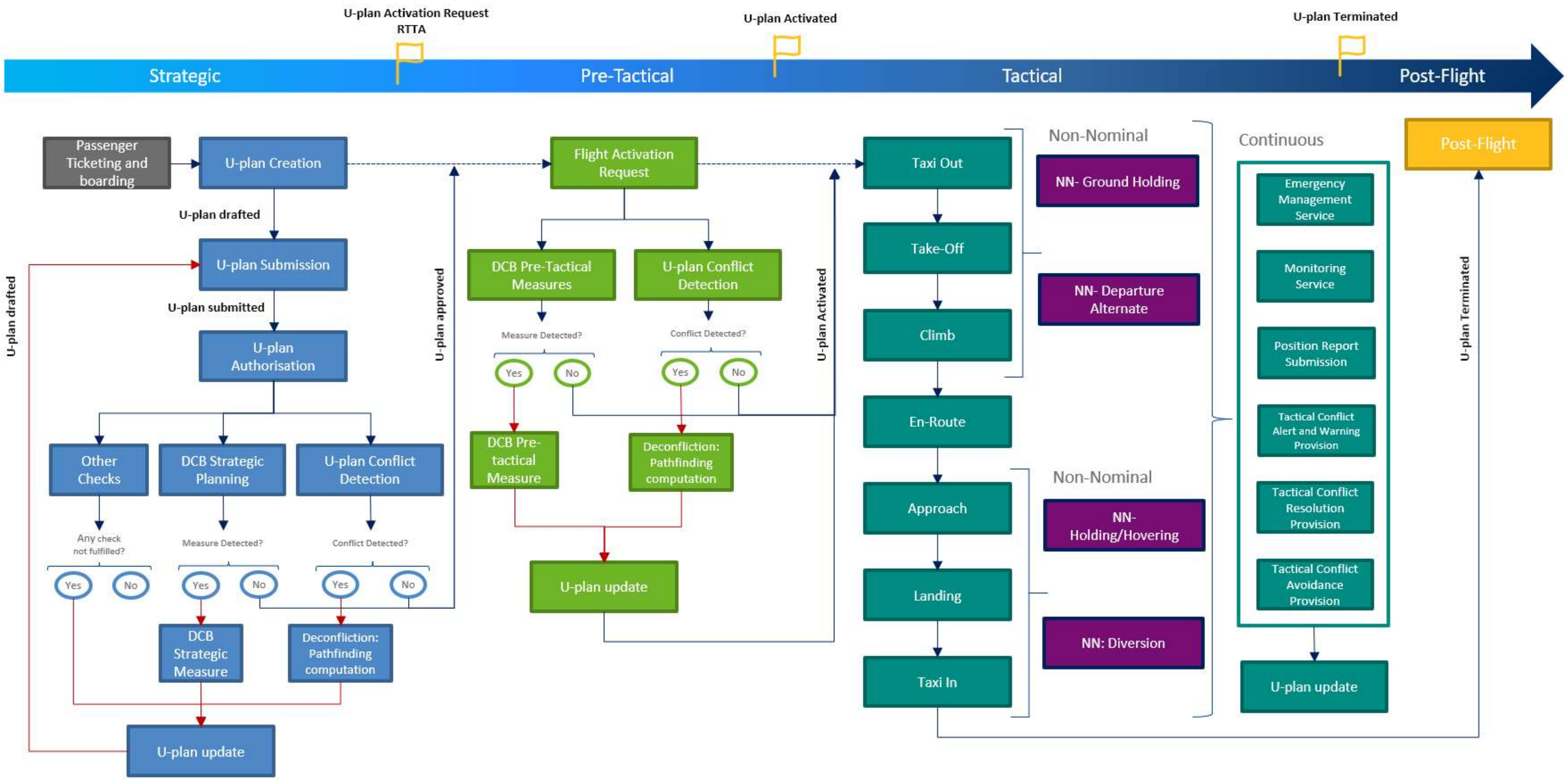


**Figure 47: Summary of Uses Cases Flow through different flight phases.**

#### 4.5.1.1 Strategic Phase

In this process phase, the vehicle is stopped on ground, the process is initiated by a passenger buying/reserving a ticket to fly.

#### 4.5.1.2 Passenger ticketing and boarding

| Step | Action | Trigger | Information transfer | Role From | Role To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | Pax asks ticket sales for a journey to Arr arriving at a desired time in the future or as soon as possible. | Pax | Ticket enquiry | Pax | Ticket salesclerk | | Ticket salesclerk might be a machine (an app) |
| **2** | Generation of a possible operation plan | Ticket enquiry | Estimated departure time, arrival time and cost | Ticket salesclerk | Pax | Operation plan preparation & optimisation<br><br>(Geo-spatial data, Geo-awareness, Operation plan processing - validate mode) | Two cases to be distinguished:<br><br>a) ad hoc flights (no pre planned routes or times): estimate of hypothetical traffic interactions – deconfliction, DCB. A possible 4D route is found and hence the departure and arrival times, as well as cost. Availability of landing slot at Arr is checked.<br>b) Scheduled flights: the request is matched with a repetitive flight plan, which is pre-coordinated and deconflicted in terms of time and flight path. The flight time/slot that is closest and available to the Pax request is identified and blocked. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **3** | Filing operation plan | Confirmation of purchase by Pax | Confirmation of flight (confirmed reservation or purchase) by Pax | Ticket salesclerk | | Operation plan processing<br><br>(Strategic conflict resolution, Demand Capacity balancing) | Triggers "airspace reservation" aspects of U-space.<br><br>Triggers air taxi operations internal processes to allocate aircraft & pilot. (Pilot may be software and/or remote from vehicle)<br><br>Triggers reservation of landing slot at Arr. |
| **4** | Passenger arrival at the vertiport is confirmed | Message(s) sent<br><br>- during passenger's trip to the vertiport,<br>- when entering the vertiport,<br>- when checking-in<br><br>or other events | From mobile device or equipment used during the process | passenger, vertiport staff or automatic when passing certain gates | | | Vertiport security, processes, etc.<br><br>There may be some delay between buying a ticket and the earliest possible departure due to deconfliction, DCB, vehicle preparation, etc. |
| **5** | Activation of operation plan. | RTTA is reached (e.g. assigned aircraft is landed at origin vertiport) | | UAS air operator | | Position report submission & Tracking,<br><br>Monitoring, | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Traffic information,<br><br>Tactical conflict resolution | |

**Table 61 Passenger ticketing and boarding process.**

**Roles identified:**

- Ticket salesman

Interface between the Pax and the Air taxi business systems. Uses the Operation Plan Preparation & Optimisation service and may act as an “interpreter” between it and Pax, for example explaining different options – for example that the lowest cost option arrives later than a more expensive option. The Ticket Sales might be an app or a human and might be separate or integral part of the UAS air operator.

- Vertiport staff

The vertiport staff role (arbitrarily) combines all interactions with Pax after Pax buys ticket from the Ticket Sales. Pax will go through security and eventually go to the vehicle and board it. Vertiport staff take care of this.

- UAM operator

The party setting up, maintaining and distributing the operation plan considering Pax, aircraft and crew needs based on repetitive flight plans or ad hoc flight requests.

#### 4.5.1.3 U-plan Creation

In order to create a U-plan, the UAM/UAS Operator will be assisted by services in order to check the status of the network when introducing its flight intentions.

This will be like a "validation" method in order to check the availability of the route and the actual status and foreseen evolution of it. This would allow the UAM/UAS Operator to know with more certainty which is going to be the status at the moment the flight is performed.

| Step | Action | Trigger | Information transfer | Roles from | Role To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | Identify Departure (Dep) and Arrival (Arr) | UAM/UAS Operator want to perform a flight point to point. | Departure and Arrival information | UAM/UAS Operator | UAM/UAS Operator /USSP | U-plan preparation and optimisation service | |
| **2** | Extract list of available slots to land at Arr | | List of available slots at Arr | UAM/UAS Operator | Vertiport Operator /USSP | U-plan preparation and optimisation service<br><br>Vertiport slot service | |
| **N** | Use proprietary or open-source route-finding methods to calculate candidate trajectories that arrive at Arr at an available time at reasonable cost and risk | | | UAM/UAS Operator | | Operation plan preparation and optimisation service | Open-source route finding methods like InterUSS. |
| **N+1** | Use operation plan processing service in "validate" mode to detect actual conflicts or DCB overloads on candidates, eliminate or modify unusable candidates | | | UAM/UAS Operator | USSP / Vertiport Operator | Operation plan preparation and optimisation service | |

| Step | Action | Trigger | Information transfer | Roles from | Role To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| | (iterative with previous step) | | | | | Operation Plan Processing | |
| **final** | Present candidates to customer | | Details of route and estimated times. | UAM/UAS Operator | Passenger | Operation plan preparation and optimisation service | Each has an estimated cost, departure time, arrival time. |

**Table 62 Validation of U-plan generation use case steps - initial version**

Once the UAM/UAS Operator has validated its intentions, proceeds with the U-plan filing in detail:

| Step | Action | Trigger | Information transfer | Roles From | Role To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | Air taxi operator allocates vehicle to flight | Validation U-plan is OK for UAM/UAS Operator | | UAM/UAS Operator | N/A | Operation plan preparation and optimisation service | |
| **2** | Air taxi operator reserves arrival slot at Arr | | | UAM/UAS Operator | Vertiport Operator | Operation plan preparation and optimisation service<br><br>Vertiport slot service | In order to avoid that U-plan may fail if slot is no longer available, validation mode indicates in real time the status of the slot, as well as the possibility of reservation by another actor. |
| **3** | Air taxi operator submits plan | | U-plan | UAM/UAS Operator | USSP | Operation plan preparation and | Operation plan includes a trajectory described as a series of 4D volumes. |

| Step | Action | Trigger | Information transfer | Roles From | Role To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | | | optimisation service<br><br>Operation Plan Processing | The dimensions of these volumes incorporate the allowable uncertainties of the flight. |

**Table 63 U-plan filing use case steps - initial version**

**Roles Identified:**

- USSP:
  - Provides support information for the creation and validation of the U-plan
  - Receives the submission of the U-plan once is fulfilled for authorisation purpose.
- Vertiport Operator
  - Provides support information for the creation and validation of the U-plan, regarding the slot management for departure and arrival
- Passenger
  - Is the initial input to the UAM/UAS Operator to create the U-plan
  - If the result of the validation activities is positive to the passenger, it is the trigger for the submission of the U-plan for authorisation through the UAM/UAS Operator
- UAM/UAS Operator:
  - Is the link between the passenger transportation demands and the USSP through the filing of a U-plan
  - Is assisted by the USSP and Vertiport Operator U-space services in order to validate and fulfil a U-plan

- Decides to submit the U-plan once is fulfilled to the USSP for authorisation purposes.

#### 4.5.1.4 U-plan Submission

- No limit on time in advance and before the flights takes-off. Taking into account the RTTA (Reasonable Time To Act)
- The U-plan Submission is intended for all UFR flying within U-space in the selected environment (Controlled Airspace, e.g., Airspace Class D)
- What is provided? A U-plan Contains:
    - 4D Volumes
    - Departure vertiport and Time of departure
    - Arrival vertiport and Time of arrival
    - Alternative destination
    - Identification (Vehicle registration/Serial number)
    - Aircraft equipage/performance based
    - Contingency Plan
    - Type of operation

| Step | Action | Trigger | Information transfer | Roles From | Role To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | Air taxi operator submits plan | | U-plan | UAM/UAS Operator | USSP | Operation plan preparation and optimisation service / Operation Plan Processing | Operation plan includes a trajectory described as a series of 4D volumes. The dimensions of these volumes incorporate the allowable uncertainties of the flight. |

**Table 64 U-plan submission Use Case.**

#### 4.5.1.5 U-plan Authorisation

The USSP receives the information from the U-plan submitted by the UAM/UAS Operator, then there are a series of steps and checks for that U-plan for review:

Checking broadly consists of the following steps:

- Syntax check. Does whatever have arrived resemble a flight plan enough that it can be read?
- Semantic check. Are all the expected pieces of information present?
- Authorisation-check using the e-Registration service. Is there some reason this operator or this pilot or this drone should not be flying?
- Construction of a probabilistic 4D model of the flight's likely airspace occupancies. (Equally to a Trajectory) using the plan and the Weather Information service.

- Geo-Fencing check. The probabilistic 4D model is compared with drone aeronautical information to discover if it is flying where it should in terms of geo-fences.
- Strategic conflict-management check. The probabilistic 4D model is compared with the models for other flights. Those where the probability of loss of separation exceeds some minima are dealt with, as described in 6.1.4
- Demand prediction (in U3). The models of all flights are combined to generate a traffic demand prediction.
- DCB (in U3). The demand prediction is examined to discover when the conditions are met to say that capacity is exceeded, as described in the Section 4.5.1.8

If all the above checks are correct, then the U-plan is approved and the UAM/UAS Operator/UAS FMS receives the approval, otherwise is rejected, the UAM/UAS Operator/UAS FMS receives a rejection and is requested to modify the U-plan to be resubmitted.

| Step | Action | Trigger | Information transfer | Roles involved: From | Roles involved: To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | Submit U-plan | U-plan Has been created | U-plan | UAM Operator | USSP | Operational Plan Service | |
| **2** | Check U-plan | USSP receives the U-plan | | USSP | USSP | Operational Plan Service | The USSP receives the information from the U-plan submitted by the UAM/UAS Operator, then there are a series of steps and checks for that U-plan for review as described before. |
| **2.1** | Expand plan into probabilistic occupancy | | | | | Operation Plan Processing | |
| **2.2** | Compare occupancies with airspace availability | | | | | Operation Plan Processing | |
| **2.3** | Detect conflicts | | | | | Strategic conflict resolution service | Conflicts result in negotiation with the U-plan preparation and optimisation service to achieve resolution |
| **2.4** | Detect DCB overloads | | | | | Capacity management service | Overloads result in negotiation with the U-plan preparation and optimisation service to achieve resolution |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2.5** | Check airspace, noise and other constraints | | | | | Operation Plan Processing | |
| **3 a.** | Send U-plan Approval | All processes in the check are satisfied | U-plan Approval | USSP | UAM Operator | Operational Plan Service | |
| **3 b.** | Send U-plan Rejection | Something is not complying with the U-plan check. | U-plan Rejection | USSP | UAM Operator | Operational Plan Service | |
| **3 c.** | Sends U-plan modification request | | | | | | |

**Table 65 U-plan Submission & Authorisation**

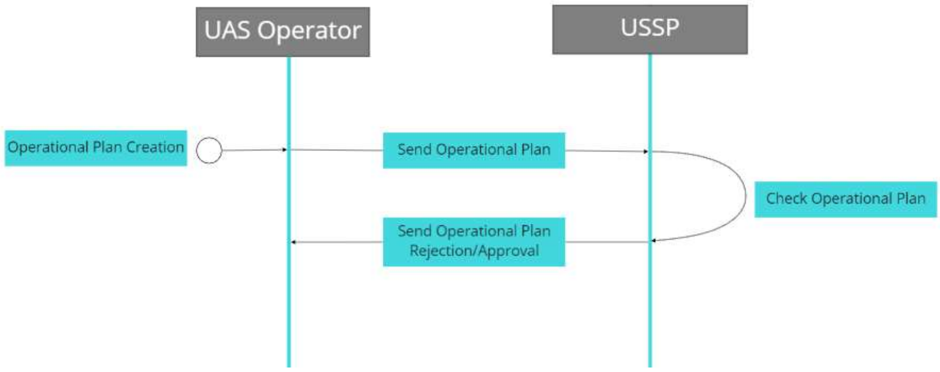


**Figure 48: U-plan action/role diagram resume**

**Assumptions:**

- Flight Plans and U-plans are accurate
- Flight intents can be described without a flight plan, but flight intents need to be known.
- U-plan can be submitted any time (before and after RTTA).
- The use of fulfilment of U-plans are fair.
- The contractual part of the U-plan once is approved is relevant for the payment of the service.
- The U-plan is needed to execute the flight safely with strategic deconfliction to cope with the limited resources dealing with a Demand and Capacity balancing system, where the demand is below the capacity and to execute the flight efficiently

#### 4.5.1.6 U-plan conflict detection

The U-plan conflict detection consists of the following steps:

- The USSP receives the U-plan submitted by the UAM Operator and expands the plan into probabilistic occupancy (Weather Information service and performance model derived from the Digital logbook service)
- Using information on airspace availability and probabilistic occupancy, the USSP evaluates the probability of intersection of the submitted U-plan's 4D volume with already reserved 4D Volumes in space-time (InterUSS), with geofenced areas (GeoAwareness service) and with congested airspace (DCB). DSS of InterUSS helps with the discovery of the conflicting plans and facilitates data transfer using the S2geometry framework (in which 2D cells along a space-filling curve are turned into a sequence of 4D volumes by specifying the floor and the ceiling of each occupied cell, as well as the min and max times during which the cell is occupied).
- If the probability is too high, then the U-plan is returned rejected to the UAM Operator to be possibly revised to ensure the proper separation criteria (the revision process is described in 6.1.1.6).
- A new U-plan is then proposed to the USSP for authorisation and the conflict detection routine is repeated.

**Assumptions:**

- The available airspace is identified and is known to USSP (hopefully in InterUSS soon): the USSP has information about all relevant constraints in the whole region of the requested operation (such as 4D volumes reserved by other airspace users, geofences, restricted areas, airspace structure and others)
- The Flight/U-plans are accurate
- Uncertainties are correctly accounted for during computation of the required 4D Volume.
- The UAM Operator has the relevant information about the uncertainties.

**Delimitations**

- Noise and visual pollution is not taken into account at this stage
- Fairness (including economic mechanisms for ensuring and evaluating it) are to be worked out in further research

| Step | Action | Trigger | Information transfer | Roles involved: From | Roles involved: To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | USSP Receives flight activation | UAM/UAS Operator is requesting flight activation. | Flight Activation request | UAM/UAS Operator | USSP | | |
| **2** | USSP Analyses all U-plan received 4D Volumes | USSP is analysing the flight activation request | | USSP | USSP | Strategic conflict resolution services,<br><br>GeoAwareness service<br><br>Weather service. | Using information on airspace availability and probabilistic occupancy, the USSP evaluates the probability of intersection of the submitted U-plan's 4D volume with already reserved 4D Volumes in space-time (InterUSS), with geofenced areas (GeoAwareness service) and with congested airspace (DCB). DSS of InterUSS helps with the discovery of the conflicting plans and facilitates data transfer using the S2geometry framework (in which 2D cells along a space-filling curve are turned into a sequence of 4D volumes by specifying the floor and the ceiling of each occupied cell, as well as the min and max times during which the cell is occupied). |

| Step | Action | Trigger | Information transfer | Roles involved: From | Roles involved: To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **3a** | USSP activates flight | No problems found in the analysis performed. | | USSP | UAM/UAS Operator | | If there is no problem, then the U-plan is returned approved/activated to the Operator. |
| **3b** | USSP ask for U-plan updated/modification | Intersection probability high found. | U-plan modification/update request | USSP | UAM/UAS Operator | | If the probability is too high, then the U-plan is returned rejected to the Operator to be possibly revised to ensure the proper separation criteria (the revision process is described in 6.1.1.6). |

**Table 66 U-plan conflict detection Use Case.**

### 4.5.1.7 Deconfliction of U-Plan: Pathfinding computation

The deconfliction protocol consists of the following steps, implementing Reg 664's requirement 10(6) "U-space service providers shall establish proper arrangements to resolve conflicting UAS flight authorisation requests received from UAM/UAS Operators by different U-space services providers."... :

- When USSP rejects a proposed U-plan, the USSP informs the Operator about the rejection.
- If the Operator is willing to use an updated U-plan, the USSP sends the Operator several conflict-free candidate plans, taking into account the risks and efficiency of the operation (the paths may be computed, e.g., by tools as in [9]).
- If the Operator accepts one of the candidate plans, the Operator informs the USSP about it, and the steps below are not followed.
- If the Operator is willing to try a plan outside of the candidate plans suggested by the USSP, the Operator requests from the USSP the details on which grounds the Operator's Plan was rejected.
- The USSP informs the Operator on occupied airspace time volume with which the proposed Operation Plan was in conflict.
- The Operator then revises the Operation Plan taking into account the new constraints and actively facilitating DSS to avoid conflicting with any other constraints not involved previously.
- The UAM/UAS Operator submits the new Operation Plan back to the USSP for new approval and the U-plan Authorisation routine is repeated.

**Assumptions:**

- The USSP has information about all relevant constraints in the whole region of the requested operation (hopefully in InterUSS soon).
- The Operator has necessary technical means to revise the U-plan.

**Delimitations:**

- The timings (RTTA, how long in advance before the departure should the U-plan be sent by the Operator, how fast should the USSP reply Yes/No to the Plan, how soon should the Operator accept/reject a candidate, how often and how many times may the Operator retry Plan submission, etc)
- The acknowledgements that may need to be sent between the Operator and the USSP (authorisation request received, authorised plan receipt ack, etc.) are not described

**Notes:**

- As InterUSS develops, deconfliction may be supported by the corresponding Entities types (or similar)

| Step | Action | Trigger | Information transfer | Roles involved: From | Roles involved: To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | USSP Receives flight activation | UAM/UAS Operator is requesting flight activation. | Flight Activation request | UAM/UAS Operator | USSP | | |
| **2** | USSP Analyses all U-plan received 4D Volumes | USSP is analysing the flight activation request | | USSP | USSP | Strategic conflict resolution services,<br><br>GeoAwareness service<br><br>Weather service. | Using information on airspace availability and probabilistic occupancy, the USSP evaluates the probability of intersection of the submitted U-plan's 4D volume with already reserved 4D Volumes in space-time (InterUSS), with geofenced areas (GeoAwareness service) and with congested airspace (DCB). DSS of InterUSS helps with the discovery of the conflicting plans and facilitates data transfer using the S2geometry framework (in which 2D cells along a space-filling curve are turned into a sequence of 4D volumes by specifying the floor and the ceiling of each occupied cell, as well as the min and max times during which the cell is occupied). |

| Step | Action | Trigger | Information transfer | Roles involved: From | Roles involved: To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| **3a** | USSP activates flight | No problems found in the analysis performed. | | USSP | UAM/UAS Operator | | If the there is no problem, then the U-plan is returned approved/activated to the Operator. |
| **3b** | USSP request for U-plan updated/modification | Intersection probability high found. | U-plan modification/update request | USSP | UAM/UAS Operator | | If the probability is too high, then the U-plan is returned rejected to the Operator to be possibly revised to ensure the proper separation criteria. |
| **4b** | UAM/UAS Operator implement a change of its 4D route | | | UAM/UAS Operator | Pilot On Board / FMS | | |

**Table 67 Deconfliction of U-planning: Pathfinding Computation.**

#### 4.5.1.8 Strategic DCB Planning Measures Management

The ambition should always be able to deliver fair and optimal system capacity meaning reducing the impact on requested operations. Primarily this is done by elaborating with available capacity tools as described further down.

It is noted that local environmental constraints need to be considered in the application of strategic DCB measures. The environmental parameters will aim to on a general level set the boundaries for the distribution of the services based on the characteristics of the area / landscape, expected noise and visual noise and density of population.

One U-space service is relevant in this case **Dynamic Capacity Management.** (Source CORUS CONOPS Vol 1, 2019)

The table below suggest affected actors, identify services and allocation of roles. An assumption is that the USSP contains functionality to integrate data like U-plans/Operation Plan, weather, environmental constraints, airspace availability etc. and based on these data calculate the actual enablers needed i.e. Airspace, Vertiport etc. to serve the demand from the U space users.

To demand and capacity balancing a number of measures can be taken, a few examples are shown below. This shall be evaluated further to find all possible actions that could have a positive impact on the capacity.

a) Act on capacity
    a. Airspace reconfiguration, as additional airspace, routes, areas and altitude layers.
    b. Vertiport availability, the assumption is that Vertiports will be scalable, an increase of Vertiport availability could be changing the opening hours (i.e., open for some more hours or open earlier than planned).
    c. Improve CNS infrastructure, optimising separation based on PBN, adaption of speed ETA
    d. Optimize separation criteria's incorporating weather parameters, as reduced separation minima in good weather conditions and vice versa.

b) Act on demand:
    a. Re-routing
    b. Level changes depending on performance.
    c. Adaption of speed
    d. Apply time adjustments, including advance/delay departure/arrival times to a U-PLAN/Operational Plan. (Like a CTOT)
    e. Cancellation of flights as a final step in adverse situations.

| Step | Action | Trigger | Information transfer | Roles involved: From | Roles involved: To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | Establishing predicted system capacity | Information from actors* | Message regarding capacity change | Vertiports, Municipality, Regulator, Police, MET-office, information from ATC etc. | USSP | Dynamic Capacity Management | *environmental constraints, regulations national and local |
| **2** | Identification of critical parts for successful mission | U-plan/Operation Plan received | U-plan/Operation Plan | UAM/UAS Operators | USSP | Dynamic Capacity Management | |
| **3** | Validation of Operation Plans and generation of 4d trajectories | U-plan/Operation Plan | | USSP, with the help of a technical system | USSP | Dynamic Capacity Management | |
| **4** | Identification of conflicts in Operation Plans | Conflict analysis | U-plan/Operation Plan | USSP, with the help of a technical system | USSP | Dynamic Capacity Management | |
| **5** | Analysis of estimated demand vs available capacity including safety and social aspects | Demand and capacity data | | USSP, with the help of a technical system and the consolidated constraints from ATC, society etc. | USSP | Dynamic Capacity Management service | |
| **6** | Take action with regard to identified imbalances | Analysis result | Decision regarding capacity changes preference is to add capacity | USSP, with the help of a technical system | USSP | Dynamic Capacity Management | |

| Step | Action | Trigger | Information transfer | Roles involved: From | Roles involved: To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| | | | rather than restrict availability | | | | |
| **7** | Analysis and follow up | Previous operations | | USSP in first case. Depending on the magnitude of the results municipality, regulator, operator may be involved. ATC may be involved depending on. | USSP | Dynamic Capacity Management | Trigger possible adjustment of parameter for the airspace and possible directions for the operators. Feedback to society actors. |

Table 68 Table presenting the steps for the Strategic Dynamic Capacity Balancing measures

Sources; DACUS project 2021 and CORUS ConOps Vol 1 2019.

Once the measure is computed, if affects different U-plans, these measures are sent to UAM/UAS Operators to start a negotiation where the UAM/UAS Operator can:

1) Accept the measure and update/modify its U-plan.
2) Reject the measure and cancel its U-plan
3) Send a counter proposal to the previously sent proposed modification from the USSP. The cycle starts again until a solution is accepted or rejected and so no approving the U-plan.

These measures finally end in a U-plan update or modification.

### 4.5.1.9 U-plan Update/Modification

During the draft status of a U-plan or even when the U-plan is approved, the UAM/UAS Operator and the USSP can request to update or modify any element of the U-plan content as in section 4.2.11.4 in an iterative process until the flight request its flight activation.

This can also occur either the UAM/UAS Operator has the need to update or modify its flight intentions (e.g., change of the route, its 4D volumes, etc.) or the USSP/CISP needs to apply any correction within the U-plan due to any of the checks involving the U-plan authorisation process (4.5.1.5).

UAM/UAS Operator U-plan Update request:

| Step | Action | Trigger | Information transfer | Roles involved: From | Roles involved: To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | Modify/update of U-plan | UAM/UAS Operator needs to update or modify its U-plan | Update its U-plan | UAM/UAS Operator | UAM/UAS Operator | Flight Planning Management /U-plan Management | UAM/UAS Operator has the need to update or modify its U-plan. |
| 2 | Send /Re-submit the updated or modified U-plan (4.5.1.4) | U-plan is sent to USSP | U-plan updated | UAM/UAS Operator | USSP | Flight Planning Management /U-plan Management | U-plan is sent, and its status is changed to drafted if it was previously approved, the is re-submitted accordingly to (4.5.1.4). |
| 3 | U-plan Authorisation (4.5.1.5) | The new U-plan has been resubmitted | U-plan updated | USSP | USSP | Flight Planning Management /U-plan Management | As in section (4.5.1.5). |

**Table 69 U-plan Update/ Modification Use Case.**

In the case of the USSP/CISP requesting the modification or update, it should take into account the RTTA and its priority as indicated in section 4.2.11.2 and 4.2.11.3.

| Step | Action | Trigger | Information transfer | Roles involved: From | Roles involved: To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | Need of U-plan modification or update. | Any of the Authorisation checks performed by the USSP in 4.5.1.5 is not fulfilled in the submitted U-plan. | | USSP | USSP | Flight Planning Management /U-plan Management | Any of the Authorisation checks performed in 4.5.1.5 is not fulfilled in the submitted U-plan. U-plan needs to be modified and its status is changed to drafted. |
| **1a** | U-plan Conflict Detection: Deconfliction using pathfinding | USSP sent UAM/UAS Operator a proposal for modification on the route and its 4D volumes. | U-plan modified proposal | USSP | UAM/UAS Operator | Flight Planning Management /U-plan Management & Strategic Conflict Resolution | Accordingly, to 4.5.1.7. Continue on step 3. |
| **1b** | U-plan affected by DCB Strategic Measure | USSP sent UAM/UAS Operator a proposal for modification on the U-plan to accommodate a DCB Strategic Measure | U-plan modified proposal | USSP | UAM/UAS Operator | Flight Planning Management /U-plan Management & Strategic DCB Management | As in section (4.5.1.8) |
| **2b** | Negotiation of change | Drones Operator receives a modification proposal and can negotiate to accept or propose new modification. | U-plan modified proposal | UAM/UAS Operator | USSP | Flight Planning Management /U-plan Management & Strategic DCB Management | A negotiation is opened to allocate the Strategic DCB Measure, this can be 1) Accepted, 2) Rejected or 3) Counter proposed |
| **2b-1** | Measure accepted | The measure is accepted by UAM/UAS Operator. | Measure message | UAM/UAS Operator | USSP | Flight Planning Management /U-plan Management & | Continue on step 3 |

| Step | Action | Trigger | Information transfer | Roles involved: From | Roles involved: To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | | | Strategic DCB Management | |
| **2b-2** | Measure rejected | The measure is rejected by UAM/UAS Operator. | Measure message | UAM/UAS Operator | USSP | Flight Planning Management /U-plan Management & Strategic DCB Management | U-plan is rejected and is not approved. End of the process. |
| **2b-3** | Counter proposal | There is a counter proposal measure sent to USSP. | Measure message | UAM/UAS Operator | USSP | Flight Planning Management /U-plan Management & Strategic DCB Management | After sending a counter proposal, it iterates the cycle starting in step 1, USSP evaluating the need of update or not. |
| **3** | Send /Re-submit the updated or modified U-plan (4.5.1.4) | U-plan is sent to USSP | U-plan updated | UAM/UAS Operator | USSP | Flight Planning Management /U-plan Management | The U-plan is re-submitted accordingly to (4.5.1.4). |
| **4** | U-plan Authorisation (4.5.1.5) | The new U-plan has been resubmitted | U-plan updated | USSP | USSP | Flight Planning Management /U-plan Management | As in section (4.5.1.5). |

**Table 70 U-plan Update/ Modification for Conflict resolution and DCB processes.**

#### 4.5.1.10 Pre-tactical Phase

The pre-tactical phase is design for those last moment measures where flight disturbance is minimum, as the UAM/UAS Operator has already requested for U-plan activation, the certainty of the flight is really high, and it is ready to start moving. Also, in this phase it is considered the allocation of high priority flights (e.g., emergency flights). At that moment, the U-plan should be in the status of approved, after requesting the activation of the U-plan, the RTTA of that flight is close to be reached, and so the flight is in the status of freeze, where not many changes can be accommodated either by the UAM/UAS Operator or by the network (USSP or CISP in case of multiple USSP).

During the U-plan activation process, pre-tactical DCB and pre-tactical conflict resolution processes are checked and applied if needed as follows:

#### 4.5.1.11 Pre-tactical U-plan conflict detection

During the pre-tactical phase, the process followed for the U-plan conflict detection is the same as applied during the Strategic phase as described in section 4.5.1.6.

The flight is in this moment close to RTTA, and has requested for the flight activation, the uncertainty of the flight is now very low and the flight is frozen.

Only small adjustments in its U-plan or changes due to high priority flight are considered here (e.g., emergency operations). The second has a low probability to occur.

**Assumption:**

- Emergencies operations has low probability to occur, and so, the disturbances in the pre-tactical phase due to this are rare.
- Small adjustments are considered as the ones that the Drone Operator and the network (i.e., the USSP or the CISP) are able to accept or pre-accept without negotiation after RTTA without major consequences of the operation and business. No specific values are set in this part of the project.

#### 4.5.1.12 Pre-tactical DCB Measures

The ambition should always be able to deliver fair and optimal system capacity meaning reducing the impact on requested operations. Primarily this is done by elaborating with available capacity tools as described further down.

It is noted that local environmental constraints need to be considered in the application of strategic DCB measures. The environmental parameters will aim to on a general level set the boundaries for the distribution of the services based on the characteristics of the area / landscape, expected noise and visual noise and density of population.

One U-space service is relevant in this case **Dynamic Capacity Management.** (Source CORUS CONOPS Vol 1, 2019).

The table below suggest affected actors, identify services and allocation of roles. An assumption is that the USSP contains functionality to integrate data like U-plans/Operation Plan, weather, environmental constraints, airspace availability etc. and based on these data calculate the actual enablers needed i.e., Airspace, Vertiport etc. to serve the demand from the U space users.

To demand and capacity balancing a number of measures can be taken, a few examples are shown below. This shall be evaluated further to find all possible actions that could have a positive impact on the capacity.

c) Act on capacity
    a. Airspace reconfiguration, as additional airspace, routes, areas and altitude layers.
    b. Vertiport availability, as increased Vertiport availability as opening hours, the assumption is that Vertiport will be scalable.
    c. Improve CNS infrastructure, optimising separation based on PBN, adaption of speed ETA
    d. Optimize separation criteria's incorporating weather parameters, as reduced separation minima in good weather conditions and vice versa.

d) Act on demand:
    a. Re-routing
    b. Level changes depending on performance.
    c. Adaption of speed
    d. Apply time adjustments, including advance/delay departure/arrival times to a U-PLAN/Operational Plan. (like a CTOT)
    e. Cancellation of flights as a final step in adverse situations.

| Step | Action | Trigger | Information transfer | Roles involved: From | Roles involved: To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | Establishing predicted system capacity | Information from actors* | Message regarding capacity change | Vertiports, Municipality, Regulator, Police, MET-office, information from ATC etc. | USSP | Dynamic Capacity Management | *environmental constraints, regulations national and local |
| **2** | Identification of critical parts for successful mission | U-plan/Operation Plan received | U-plan/Operation Plan | UAM/UAS Operators | USSP | Dynamic Capacity Management | |
| **3** | Validation of Operation Plans and generation of 4d trajectories | U-plan/Operation Plan | | USSP, with the help of a technical system | USSP | Dynamic Capacity Management | |
| **4** | Identification of conflicts in Operation Plans | Conflict analysis | U-plan/Operation Plan | USSP, with the help of a technical system | USSP | Dynamic Capacity Management | |
| **5** | Analysis of estimated demand vs available capacity including safety and social aspects | Demand and capacity data | | USSP, with the help of a technical system and the consolidated constraints from ATC, society etc. | USSP | Dynamic Capacity Management service | |
| **6** | Take action with regard to identified imbalances | Analysis result | Decision regarding capacity changes preference is too add capacity | USSP, with the help of a technical system | USSP | Dynamic Capacity Management | |

| Step | Action | Trigger | Information transfer | Roles involved: From | Roles involved: To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| | | | rather than restrict availability | | | | |
| **7** | Analysis and follow up | Previous operations | | USSP in first case. Depending on the magnitude of the results municipality, regulator, operator may be involved. ATC may be involved depending on. | USSP | Dynamic Capacity Management | Trigger ev. adjustement of parameter for the airspace and possible directions for the operators. Feedback to society actors. |

Table 71 Table presenting the steps for the Strategic Dynamic Capacity Balancing measures

Sources; DACUS project 2021 and CORUS ConOps Vol 1 2019

#### 4.5.1.13 Tactical Phase

#### 4.5.1.14 Departure and Taxi Out

| Step | Action | Trigger | Information transfer | Roles involved From | Roles involved To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | Calculate/select taxiing path (optional) | | Taxiing path calculated and sent to pilot | UAM/UAS Operator | UAM/UAS Operator | A new service needed to provide taxiing path (for drone operator, vertiport operator) | Pilots receives the bay number and the taxiing path. |
| 2 | Send taxi clearance and departure request | | Taxiing path calculated and sent to pilot | UAM/UAS Operator<br><br>Pilot | USSP | | Optional. Depending on the need of the vehicle of taxiing. |
| 3 | Send taxi and departure clearance | | Taxi and departure clearance information | USSP /<br><br>Vertiport Operator | UAM/UAS Operator | A new service needed?<br><br>To deal with DCB capabilities for vertiport? Or Automatic taxiing clearances issuing? | Vertiport operator or U-space system receives the calculate taxiing path and proceed to approve or reject the taxi clearance. |
| 4 | Calculate departure sequence and path | Passenger is inside Air taxi, and wants to departs from | N/A | UAM/UAS Operator.<br><br>U-space systems | UAM/UAS Operator. | A new service needed?<br><br>Weather Service | Pilot inform about his/her position in the departure sequence and the ascent path to be followed. |

| Step | Action | Trigger | Information transfer | Roles involved From | Roles involved To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| | | vertiport A (departure) | | | | | |
| **5** | Implement departure procedure | | | Pilot on Board | N/A | | |
| **6** | Send "departure" information | UAS take off | Send UAS take off message to U-space | Pilot on Board | UAM/UAS Operator | | Pilot or automated system informs U-space system that the UAS is finally taken off. |

**Table 72 Departure and Taxi Out UC**

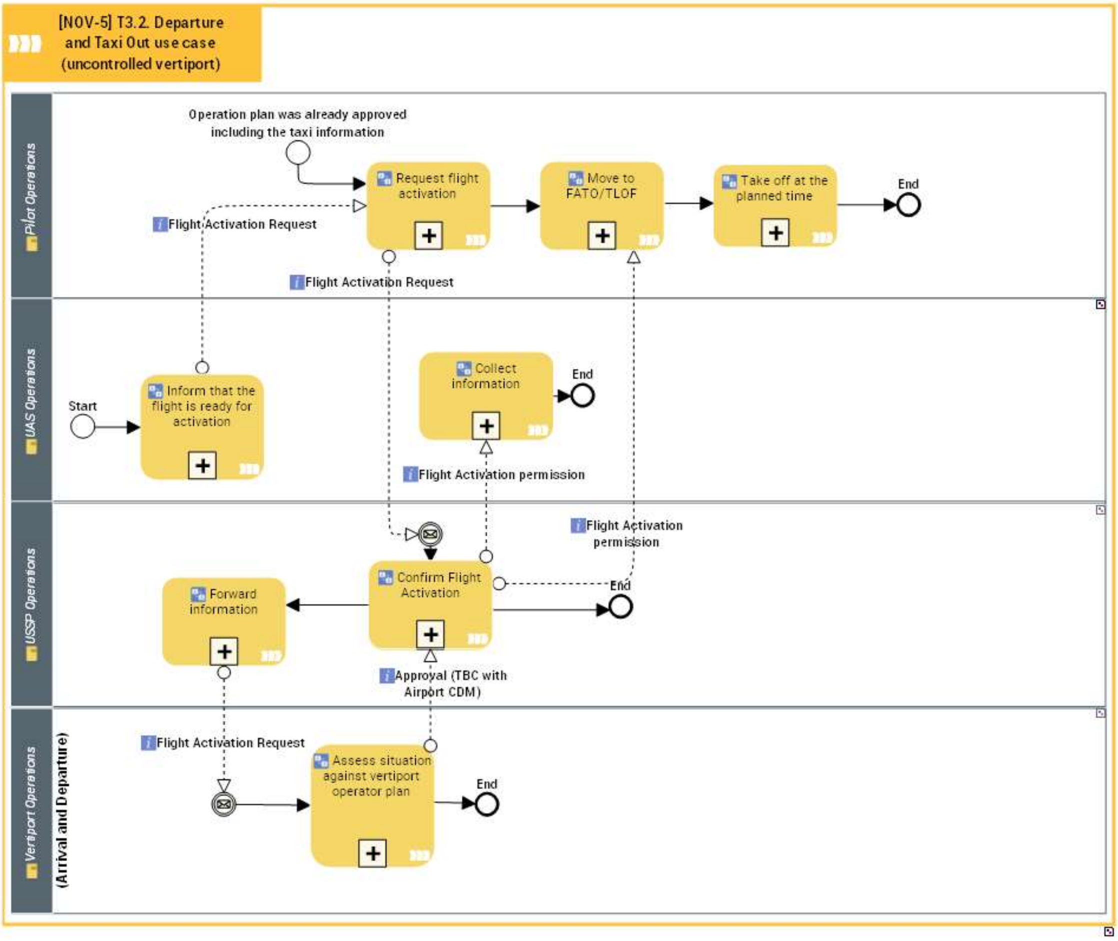


**Figure 49: Departure and Taxi Out Use Case**

#### 4.5.1.15 En-Route

This "use case" is a poor fit for the usual form. Use cases often describe a sequence of steps. In the en-route phase there are very few steps but there are many simultaneous processes, each waiting for a triggering event. To explain this each will appear as a separate use case which will be shown being triggered.

| Step | Action | Trigger | Information transfer | Roles involved From | Roles involved To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | Climb to cruise altitude, Accelerate to cruise speed | End of departure phase (ATZ cleared) | Confirmation & acknowledgment of departure radar contact | U-space system | Pilot | Surveillance Data Exchange | Used by U-space to inform an aircraft that it is identified using an approved surveillance source. Pilot to respond with acknowledgment |
| 2 | Follow planned route to point where approach process starts | Aircraft has achieved cruise altitude and cruise speed | Clearances, advice and requests | See "continuous" steps below | | | |
| 3 | Decelerate to speed as applicable for UAS approach procedure<br><br>Descend to arrival point. | End of cruise phase | Confirmation & acknowledgment of arrival radar contact | U-space system | Pilot | Surveillance Data Exchange | See step 1 |
| 4 | Enter arrival use case | Aircraft cleared for approach | Approach clearance | U-space system | Pilot | Traffic Information | Control of aircraft handed |

| Step | Action | Trigger | Information transfer | Roles involved From | Roles involved To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | | | | over to arrival vertiport |
| **Continuous** | Submit position reports to the tracking service | SSR (Secondary Surveillance Radar) | Position | Aircraft | Ground system | Surveillance Data Exchange | |
| **Continuous** | Follow and act on the information coming from the Tactical conflict resolution service | Potential loss of separation | Tactical clearance and instructions according to deconfliction strategy | U-space system | Pilot | Tactical Deconfliction Service | |
| **Continuous** | Use the Emergency Management service to inform of an emergency | Non-nominal/contingency event | Declaration of emergency | Pilot | U-space system | Emergency Management Service | Pilot informs U-space system of an emergency |
| **Continuous** | Follow and act on the information coming from the Emergency Management service | Declaration of emergency received | Tactical instructions | U-space system | Pilot | Emergency Management Service | System issues tactical instructions to assist in emergency |
| **Continuous** | Follow and act on the information coming from the Monitoring service | Airspace volume proximity | Warning of non-conformance | U-space system | Pilot | Conformance Monitoring Service | Takes place when aircraft diverges from planned trajectory or U-space corridor, |

| Step | Action | Trigger | Information transfer | Roles involved From | Roles involved To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | | | | or is nearing a geofence with a forbidden zone |
| **Continuous** | Follow and act on the information coming from the Traffic Information service | Traffic proximity | Warning on presence of traffic | U-space | Pilot | Traffic Information Service | Takes place when other aircraft become close |

**Table 73 En-route UC**

### 4.5.1.16 Landing and Taxi In

**Initial assumptions:**

Early Air taxi vehicles will have a pilot on board to ensure safety, but they will be largely automated type of aircraft. Industry's ultimate vision, after an initial transition period, is to operate them without an on-board pilot.

Some initial low-volume UAM operations with a pilot on board could be managed much as helicopter traffic is managed today. However, another set of rules will be needed for the higher-volume and more automated operations that will follow.

A Vertiport may be surrounded in the beginning by a mini-Approach area (a V-TZ, Vertiport Traffic Zone), in which the sequences of arriving UAM vehicle will be managed and abnormal procedures such as holding operations will be conducted.

Landing operations at Vertiports (both departure and arrival) will be managed through U-space specialised functions, a fully automatic system that will perform the necessary control tasks (sequence building, landing clearances, hold instructions, taxi clearances, etc.). When operating in Vertiport(s) based in the premises or the vicinity of an Airport, an Air taxi landing operation will require some form of interaction (through U-space) with ATM and will be indirectly submitted to air traffic control monitoring.

| Step | Action | Trigger | Information transfer | Roles involved From | Roles involved To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **0** | Calculate path to the vertiport | At the beginning of the flight. | Landing sequence info and descent path calculated and sent to pilot | UAM/UAS Operator | USSP | A new service/specialised U-space function needed?<br><br>Weather Service? | Pilot/Flight Management system is informed about his/her position in the landing sequence and the approach path to be followed. |
| **1** | Send landing clearance request | eVTOL following planned route to entry point where arrival process starts/ entering V-TZ | Landing clearance request | UAM/UAS Operator | USSP / Vertiport Operator | A new service needed? | Slot was pre-planned and confirmed before take-off.<br>The clearance to initiate landing procedure is sent to check if the approach sequence and path is still correct. |
| **2** | Issue approach/landing clearance | | Transfer of the approach/landing clearance. | USSP / Vertiport Operator | USSP | A new service needed?<br>To deal with DCB capabilities for vertiport? Or Automatic landing clearances issuing? | Vertiport Operator receives the calculated approach sequence and path provided by the Pilot through the USSP and process the clearance request to issue the clearance. Any inconvenience regarding the availability/occupancy of the Vertiport landing pad shall be |

| Step | Action | Trigger | Information transfer | Roles involved From | Roles involved To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | | | | promptly communicated by the Vertiport Operator to the relevant USSP. |
| **3** | Implement landing procedure till touchdown | | | Pilot/Flight Management system | N/A | | |
| **4** | Send "landed" information | eVTOL landed | Send eVTOL landed message to U-space | UAM/UAS Operator | USSP | | Pilot/Flight Management system inform U-space system that the UAS is finally landed. |
| **5** | Calculate take-off/departing path/Send take-off clearance request | | Take-off/departing path calculated and sent to pilot | UAM/UAS Operator | Pilot on Board | A new service needed to provide take-off/dep path (for drone operator, vertiport operator?) | Pilots/Flight Management system receives the take-off/dep path bay. |
| **6** | Send taxi clearance | | | USSP | UAM/UAS Operator | A new service needed?<br>To deal with DCB capabilities for vertiport? Or Automatic taxiing clearances issuing? | Optional - Vertiport operator or U-space system receives the calculate taxiing path and proceed to approve or reject the taxi clearance. |
| **7** | Taxi till bay/engine off | Taxi clearance received | | UAS Operator | Pilot On Board | | Optional – Depending if the vehicle needs taxiing. Hovering or using GME. |

| Step | Action | Trigger | Information transfer | Roles involved From | Roles involved To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **8** | Termination of U-plan. Passengers disembark | Pilot/Flight Management system confirm ready to disembark | Send eVTOL operation ended message to U-space | UAS Operator | USSP | U-plan deletion/store. | USSP Change the status of the U-plan to terminated. Post-flight phase starts.<br>Vertiport Operator provides passenger assistance to the passenger to disembark. |

**Table 74: Air taxi Flight: Landing on an uncontrolled vertiport**

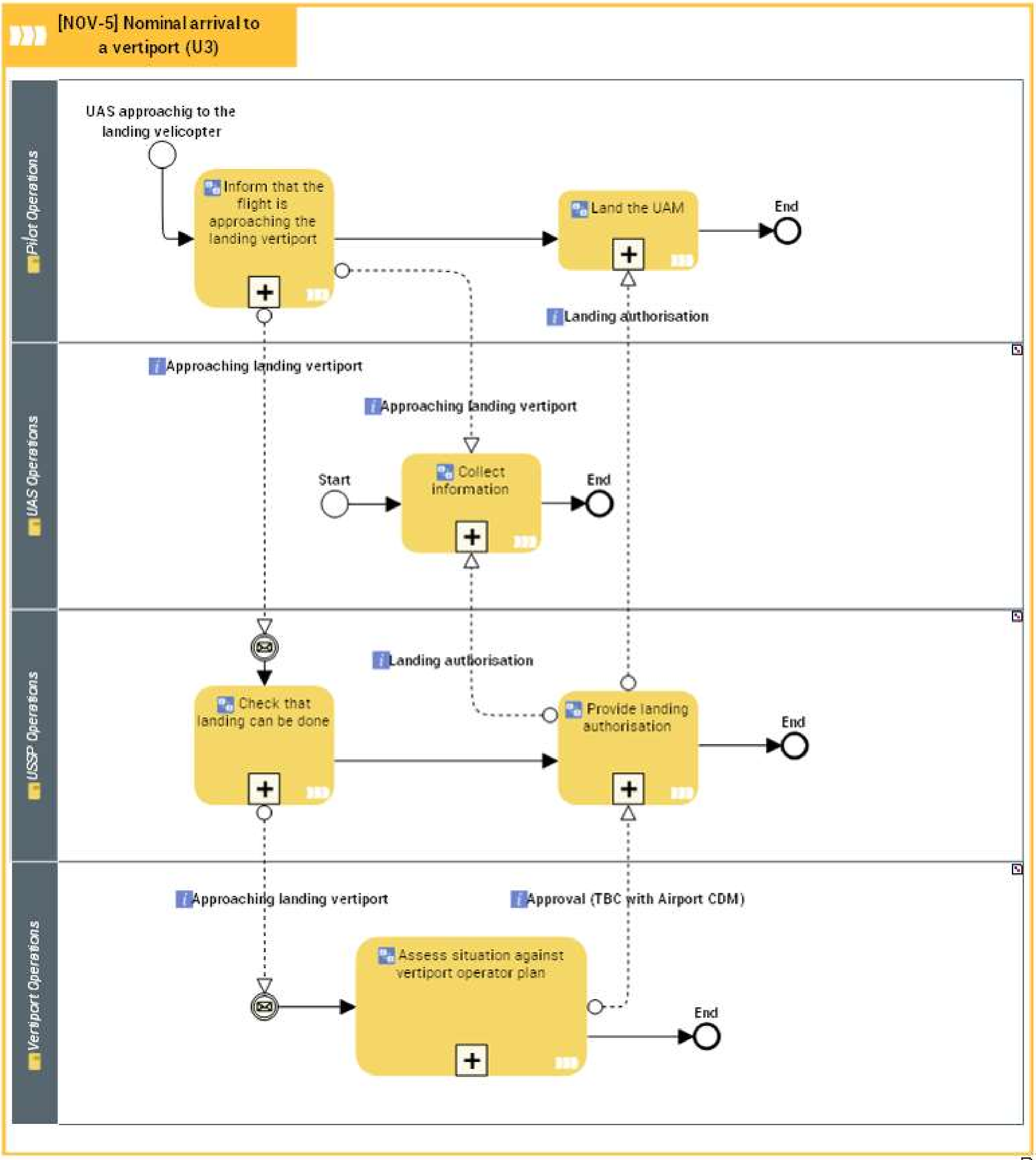


**Figure 50: Arrival and Taxi-In Nominal Use Case flow diagram.**

## Roles identified:

- UAS Operator:

Legal entity performing one or more drone operations and accountable for those drone operations. The UAM/UAS Operator can have several roles that involve it in different U-space use cases, including the planning of flights and their execution.

- Vertiport Operator:

A vertiport is an example of an aerodrome for UAS. Each vertiport has an operator, that will be concerned by the provisions and optimal use of the services to UAS (such as recharging) and to passengers and/or cargo.

- Pilot on Board/Flight Management System:

Pilot may be a human or software or some combination (Flight Management System). Pilot may be on the aircraft or remote or some combination. Pilot has responsibility for the safe execution of the flight. Pilot response times, reliability and other performance criteria meet the operational minima for the airspace.

### 4.5.1.17 Routine Sub-Use Cases

### 4.5.1.18 Position report submission

There are different versions of the position report submission service use case. The full table form is probably not very useful to describe them. The overall use case is in the time frame of the flight.

| Step | Action | Trigger | Information transfer | Roles involved From | Roles involved To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | Establish a connection to the position report service. | Activation of the flight (stated by the pilot AND engine swich ON) | Flight id, session id | Pilot | U-space system | Tracking service<br><br>Operation plan processing service | There needs to be some authentication of the source (e.g. digital signature).<br><br>Tracking service will associate this stream of position reports (identified by the session id) with the previously planned flight. Something should let the tracking service recognise that this stream is allowed to do this.<br><br>The state machine of the flight is maintained in the operation plan processing service. The flight has an activated state and only in this state are position reports accepted. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **many** | Transmit position reports | Connection established with position report service | ID, position, altitude, heading, speed, ground station location & elevation, time mark, emergency status | Aircraft | U-space system | Tracking service | Information transferred as defined in Remote ID scheme |
| **final** | End connection to the position report service | Ending of the flight (stated by the pilot AND engine swich OFF) | Report on end of flight | Pilot | U-space system | Tracking service<br><br>Operation plan processing service | There is an ended state for the flight |

**Table 75 Submit position reports: login to U-space systems based approach**

Position reports may be sent by the UAS to U-space. If sent by the aircraft directly this may be via the mobile internet (LTE etc). Alternatively, position reports may be sent by another entity to U-space: for example, there might be a surveillance service offered by a mobile telephone service provider based on data extracted from “cell towers.”

Under this alternative methodology, the report submission process for each “open” session may be based on the following steps (from the perspective of the U-space systems) in a nominal situation:

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | Wait for position report | A logon action has been realized | | U-space system / Surveillance service provider (not necessarily a U-space actor, e.g. telephone service provider) | | Position report submission sub-service | |
| **2** | Receive position report | Position report arrives | Position report | UAS | U-space system / Surveillance service provider (not necessarily a U-space actor, e.g. telephone service provider) | Position report submission sub-service | Position report is sent for processing by the tracking service |
| **3** | Acknowledge position report | Position report received | Acknowledgement of position report | U-space system / Surveillance service provider (not necessarily a U-space | UAS | Position report submission sub-service | Adds a layer of safety in ensuring the pilot is aware there is a |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | actor, e.g. telephone service provider) | | | transmission problem |

**Table 76 Receive position reports: nominal sub-use case**

The following table describes a non-nominal case in which no report is received in time, triggering the intervention of the Emergency Management Service.

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | Wait for position report | A logon action has been realized | | U-space system / Surveillance service provider (not necessarily a U-space actor, e.g. telephone service provider) | | Position report submission sub-service | |
| **2** | No report received in time | Time limit for next report passes with no report received | | U-space system / Surveillance service provider (not necessarily a U-space actor, e.g. telephone service provider) | | Position report submission sub-service | |
| **3** | Warn pilot directly | No report received in time | Warning of missing report | U-space system / Surveillance service provider (not necessarily a U-space actor, e.g. telephone service provider) | Pilot | Emergency Management Service | Adds a layer of safety in ensuring the pilot is aware there is a transmission problem. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | Emergency Management Service described in further detail in 4.5.1.21 |

**Table 77 Receive position reports sub- use case, non-nominal form - initial version**

Further escalation should be triggered by the monitoring service. If the flight has more than one session ID, then the other may still be available. The tracking service should fuse these. If the tracking service has only an old position for the flight it is the monitoring service that will trigger a non-conformance.

### 4.5.1.19 Tactical Conflict Detection and Warning Provision

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | Predict imminent loss of separation | Track update | | U-space Service Provider | | • Tracking Service<br>• Tactical Conflict Detection Service | At each track update, or some similar interval, the tactical conflict detection service tests for loss of separation.<br><br>What imminent means will depend on the specific aircraft involved. |
| 2 | Warn of detection of conflict | Imminent loss of separation detected | Warning of imminent loss of separation | U-space Service Provider | Pilot(s) | Emergency Management Service | Pilots involved in the conflict are made aware of the issue |

#### 4.5.1.20 Tactical Conflict Resolution Provision

The tactical conflict resolution service is described here as issuing instructions. This description combines the actions of the pilot and the service:

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved To | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | Identify manoeuvre that will preserve separation | Tactical Conflict Detection service has identified an imminent loss of separation and has warned the pilots involved | | U-space Service Provider | | Tactical Conflict Resolution Service | |
| **2** | Transmit instruction to pilot | Necessary manoeuvres identified | Deconfliction instructions | U-space Service Provider | Pilot(s) | Tactical Conflict Resolution Service | |
| **3** | Change course of plane | Instructions received | | Pilot(s) | | | |

**Table 78 Tactical conflict resolution sub-use case**

Non-nominal:

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | Warn pilot directly | Separation-preserving manoeuvre | | USSP/Pilot(s) | Pilot(s) | Conformance monitroing | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | instruction not received (not found, delayed, deemed infeasible,etc) | | | | | |
| **2** | Follow RA from ACAS (Xu) | | | Pilot(s) | | | |
| **3** | Change course of plane | | | Pilot(s) | | | |

**Table 79a Tactical conflict resolution sub- use case, non-nominal form - inital version**

#### 4.5.1.21 Emergency Management Service

The U-space Emergency management service combines several functions.

1. It allows a pilot to report an emergency with their aircraft
2. It provides some assistance to a pilot whose aircraft is in an emergency condition
3. It warns a pilot of any nearby aircraft which is in an emergency and may pose a danger
4. It warns a pilot of dynamic changes to the airspace, which are typically made to ensure safety or security
5. It warns a pilot of irregularities in connection with U-space system; e.g. periodic reports are not being sent or received

The 1st, 2nd and 3rd cases are combined here. The Air taxi we are discussing is a "nearby aircraft" to that having an emergency.

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | Pilot A reacts to a warning on the remote piloting station that indicates that the GNSS receiver on the aircraft is unable to determine the position. The aircraft guidance is now reliant on inertial navigation which has significant drift. Pilot A alerts the emergency management service of the problem and that the conformance limits may be breached. | Warning on RPS | ID, latest position | Pilot | USSP | | GNSS jammers are openly sold on far eastern websites.<br><br>There should be a set of proposed messages that can be sent to the emergency management service. |

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **2** | Emergency management system acknowledges the report. | | | USSP | | Emergency management system | |
| **3** | Emergency management system advises Pilot A that the nearest recommended ditching place is the river and that flying east to get there will not cross the path of any flight expected in the next ten minutes. | | | USSP | Pilot | Emergency management system<br>(Operation plan processing system) | |
| **4** | Emergency management system advises Pilot B that A's aircraft is to the north of their Air taxi and has lost GNSS. | | | USSP | Pilot | Emergency management system | |
| **5** | Pilot A maintains course, despite the uncertainty of the reported position increasing dramatically | | | Pilot | | | |
| **6** | Pilot A UAS regains GNSS, the warning disappears. The reported position is sent | | UAS position | Pilot | USSP | | |

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **7** | Pilot A signals to the emergency management system that the emergency is over. | | | Pilot | USSP | Emergency management system | |
| **8** | The emergency management advises pilot B that the danger has passed. | | | USSP | Pilot | Emergency management system | |

**Table 80 Emergency Management sub- use case - inital version**

#### 4.5.1.22 Monitoring Service

Each instance of the monitoring service provides conformance monitoring for one aircraft. As well as warning the pilot of non-conformance, it reacts to the loss of tracking, for example after an aircraft has crashed. The Monitoring service operates from the moment the flight is activated until the moment the operator signals that the flight has ended.

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | Initiate monitoring | Flight activation | | Pilot | | Operation plan processing service | The operation plan processing service has a database of operation plans. The Monitoring service reads the appropriate operation plan from the database.<br><br>The operation plan processing service can allow some updates to plans which should be transferred to the monitoring service |
| I | Monitor conformance | Track update,<br><br>Plan update | | | | Tracking<br><br>Operation plan processing service | There are two levels of non-conformance. Recoverable and unrecoverable. SORA and ASTM WK63418 both cover these |
| I+1 | Warn of recoverable non conformance | | | Pilot | USSP | | |

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **N** | Monitor conformance | Track update,<br><br>Plan update | | | | Tracking<br><br>Operation plan processing service | |
| **N+1** | Warn of unrecoverable non conformance | | | Pilot | | | |
| **N+2** | Change flight state to “contingency” | | | | | Operation plan processing service | After an unrecoverable non conformance the flight shall follow a contingency plan. |
| **Final** | End monitoring | | | | | | |

**Table 81 Monitoring service sub- use case - initial version**

### 4.5.1.23 Traffic Information service

The traffic information service has two distinct functions.

- It provides a view of the air situation.
- If operating for a pilot, it can warn of the approach of aircraft towards the pilot's own ship.

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **1** | Initiate traffic info | Flight activation | | | | Traffic Information | |
| **I** | Identify tracks in area of interest | Track update | | | | Traffic Information, Tracking | |
| **I+1** | Forward extract of tracks in area of interest appropriate for viewer | | | USSP | Pilot, USSPs | Traffic Information | Authentication of viewer and what they can be shown is required |
| | | | | | | | |
| **N** | Check for traffic "in proximity" to the flight | Track update | | | | Traffic Information, Tracking | |
| **N+1** | Detect traffic "in proximity" to the flight | | | | | Traffic Information | |

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **N+2** | Advise pilot | | | USSP | Pilot | Traffic Information | |
| | | | | | | | |
| **Final** | Stop traffic information | Flight end | | | | | |

**Table 82 Traffic Information service sub- use case - initial version**

### 4.5.1.24 Contingency Sub-Use Cases

### 4.5.1.25 Ground Holding Procedure

Several unexpected events could happen that could interfere with the implementation of the planned departure/take off phase (e.g., departure platform occupied, taxi bays busy, temporary U-space system outage…). This could require the implementation of holding procedures; point 2 of the normal procedure will become:

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **2.0** | Alert the U-space System there is an unforeseen event temporarily blocking the departure procedure | Unforeseen event temporarily blocking the departure procedure | Alert on potential delay to departure | Vertiport Operator | U-space systems | New service needed, internal to the Vertiport Operator ("manual" input of the issue) (See section 3.4.3 on Vertiport Management System service) | The vertiport detects an issue that will prevent this flight from departing at the scheduled time |
| **2.1** | Alert UAS pilot of potential delay to departure | Alert received of an unforeseen event temporarily | Alert on potential delay to departure | U-space systems | Pilot | Flight Activation & Deactivation Service | Pilot to be alerted of a non-nominal event taking place |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | blocking the departure procedure | | | | | |
| **2.2** | Calculate & send holding time instructions | Requirement for a new departure schedule | Holding time calculated and sent to pilot | U-space systems | Pilot | U-Plan Processing Service | Pilot receives a hold instruction and the holding times to be followed |
| **2.3** | Confirmation of reception of hold instructions | Reception of hold instructions | Acknowledgement of hold instructions | Pilot | U-space systems | | Pilot confirms reception of instructions |
| **2.4** | Implement hold | Confirmation of reception sent | | Pilot | | | Possible constraints are checked against, and the pilot decides to implement the hold. |
| **2.5** | Hold terminated/resume departure/ implement take off procedure | End of blocking event | Termination of hold/ resume take off sent to pilot | U-space systems | Pilot | | Pilot receives hold exit instructions and an updated sequence information and landing path. |

**Table 83 Ground Holding Process UC**

### 4.5.1.26 Take-Off Alternate Vertiport Procedure

In case there is an unforeseen problem on-board the vehicle or at the destination vertiport during the flight that prevents the vehicle from landing at the intended vertiport, there is need to identify an alternate vertiport that can service the non-scheduled landing on the flight.

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **2.0** | Issue detected on-board OR at the destination vertiport, requiring landing at planned alternate vertiport | | | Pilot / Vertiport Operator | | Vertiport Management Service | |
| **2.1** | Request alternate vertiport for landing clearance due to non-nominal event | Issue detected on-board OR at the destination vertiport | • Landing request<br>• Reasons for non-scheduled landing request | Pilot | Vertiport Operator | Common Information Service | The pilot identifies their preferred alternate vertiport and issues a request for landing |
| **2.3** | Evaluation of alternate vertiport | Request for alternate vertiport received | | Vertiport Operator | | Vertiport Management Service | Alternate vertiports are evaluated for providing a landing slot for the aircraft |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2.4.a** | Request for alternate vertiport accepted | Evaluation of alternative vertiports complete | Confirmation of landing slot | Vertiport Operator | Pilot | | If the vertiport can accept the request, confirmation of slot is sent to the pilot |
| **2.4.b** | Request for alternate vertiport rejected | Evaluation of alternative vertiports complete | • Rejection of landing request<br>• Proposal for 2nd option vertiport | Vertiport Operator | Pilot | | If the vertiport cannot accept the request, rejection of request is sent to the pilot along with a proposal for another option at a different vertiport |
| **2.5** | Confirmation of reception of instructions | Reception of alternate vertiport instructions | Acknowledgement of alternate vertiport instructions | Pilot | Vertiport Operator | | Pilot confirms reception of instructions |
| **2.6** | Implement alternate vertiport instructions | Confirmation of reception sent | | Pilot | | | Pilot executes instructions |

**Table 84: Alternate Vertiport Process UC**

### 4.5.1.27 Holding/Hovering Procedure

Several unexpected events could happen that could prevent the normal execution of the plan (e.g., landing platform occupied, taxi bays busy, temporary U-space system outage, temporary local weather – wind gusts, priority flights present…). This could require the implementation of holding procedures; point 2 of the en-route procedure will become:

| Step | Action | Trigger | Information transfer | Roles involved | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| **2.1** | Alert pilot on need for holding/hovering procedure | Unforeseen event preventing normal execution of the plan | Alert on unforeseen event taking place | Vertiport Operator/ U-space systems | Pilot | Emergency Management Service | Pilot to be alerted |
| **2.2** | Calculate holding path/holding instruction | Pilot has been alerted | | Vertiport Operator/Air taxi Operator | | | Operator evaluates what holding procedures are required and whether the vehicle can perform them. If it cannot, it becomes an Alternate Vertiport Procedure |
| **2.3** | Provision of holding instructions to pilot | Holding path calculated | • Holding path/hover spot<br>• Estimated time of hold | Vertiport Operator/Air taxi Operator | Pilot | | Pilot/FMS are sent instructions to carry out the procedure |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2.4** | Pilot confirms reception of holding instructions | Reception of holding instructions | Acknowledgment of instructions | Pilot | Vertiport Operator / Air taxi Operator | | Pilot confirms reception of holding instructions |
| **2.5** | Implement hold | Acknowledgment of instructions | | Pilot | | | Pilot/FMS evaluate battery status in relation to estimated time of hold |

**Table 85 Holding/Hovering Process**

#### 4.5.1.28 Post-flight Phase

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | Vehicle Check-up | Passenger has disembarked | Report | Pilot, operator | | Internal communication between pilot and operator | (Semi)automatic process in nominal cases, more manual if something non-nominal happened during the flight Pilot reporting information not just on flight but also vehicle performance (battery, mechanics, etc) |
| 2 | Archiving operational info | Flight has ended | Ops data | USSP | | Digital Logbook | Flight is considered completed once landing procedure is over |
| 3 | Feedback to manufacturer | Something unusual detected OR periodic feedback request | Feedback on vehicle performance | Operator to manufacturer | | Technical support / warranty | This feedback might be actually requested by the manufacturers periodically |
| 4 | Maintenance | Vehicle needs maintenance as per pilot report OR per | Maintenance Report | Operator, maintenance team, authority | | Operator carrying out maintenance, perhaps | Responsibility is on the operator even if activity is outsourced to manufacturer Maintenance report needs |

| Step | Action | Trigger | Information transfer | Roles involved from | Roles involved to | Services involved | Remarks |
|---|---|---|---|---|---|---|---|
| | | periodic maintenance | | | | outsourced to manufacturer | to be sent to authority for certification |
| **5** | Validation/certification of maintenance activities | Receipt of maintenance report | Confirmation of airworthiness | Authority to operator | | Certification of vehicle after maintenance | Operator had sent maintenance report to authority.<br>Authority confirms vehicle is ready to re-join the fleet |
| **6** | Charging | Vehicle is active in the fleet (not in maintenance) and fit for its next flight, except charge | Amount charged/batteries swapped | Vertiport operator to operator | | Charging | Should this be done at pre-flight to avoid battery decay?<br>Vehicles might be designed for either direct charging or battery swapping (not in scope of vehicle operations; more relevant to vertiport logistics/operations)<br>Vehicle remains at gate during charging procedures |
| **7** | Crew swapping | End of pilot shift<br>Vehicle is charged | Pilot(s) swapped | Operator, pilot | | Working shifts | Should this be done at pre-flight?<br>Crew will most likely be of 1 pilot<br>Done at control room if remotely piloted |

**Table 86 Post flight UC**

### 4.5.2 Scn-A-ST-Env2

This contains the Use cases modified/adapted to Scn-A-ST-Env2, which adds the complexity of UAM operations flying within ATC Airspace. Main changes with respect Scenario 1 happen in the Strategic Phase, in order to coordinate with ATC to stablish UAM corridors within ATC airspace.

#### 4.5.2.1 Strategic Phase

#### 4.5.2.2 Passenger ticketing and boarding

There is no change with respect section 6.1.1.1

#### 4.5.2.3 U-plan Creation

There is no change with respect section 6.1.1.2

#### 4.5.2.4 U-plan Submission

There is no change with respect section 6.1.1.3

#### 4.5.2.5 U-plan Authorisation

Additional checks are performed in order to check with ATC the procedures needed to fly in controlled airspace:

- Procedural ATC check. The probabilistic 4D model is compared with drone aeronautical information to discover if ATC permission is needed for any parts of the flight.

#### 4.5.2.6 Pre-tactical Phase

There is no change with respect section 6.1.2

#### 4.5.2.7 Tactical Phase

There is no change with respect section 6.1.3

#### 4.5.2.8 Post-flight Phase

There is no change with respect section 6.1.4

## 4.6 Performance and Operational Requirements

On the table of UCs, the requirements are identified, just the identifier linked to a certain step of the UC. This section develops the requirements identified, providing description, type, and all relevant fields.

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **Unique number identifying the requirement.** | This attribute provides a short description of the requirement. | Baseline area considered in the "Consolidated report on SESAR U-space research and innovation results" document. | This text is the core part of the requirement. Ideally, the description should ensure the requirement is Necessary, Justifiable, Feasible, Measurable, Clear and concise and Complete. | This field indicates the environment where the requirement applies in terms of Urban, Sub-urban, Rural, Maritime and/or Forestry. | Information (free text) provided by the project to complement the description of the environment. | Operational or Performance | Information (free text) provided by the project to justify the requirements. |
| **CORUS-XUAM-001** | Temporary segregation of area | 2. Airspace management and geofencing | The tactical geofencing service shall enable authorised users to segregate areas dynamically and temporarily. | All environments | The segregation must be done "safe" | Operational | Provides flexibility to the system, especially with emergency operations. |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **CORUS-XUAM-002** | Dynamic geofencing | 2. Airspace management and geofencing | The dynamic geofencing system shall provide drone operators and users with coordinates of dynamic geofence polygons with a minimum accuracy level of 1 metre. | All environments | | Performance | Enables drone operators and users to remain aware of active area borders and thus respect them. |
| **CORUS-XUAM-003** | Safety requirement s for U-space service providers deriving from specific operational risk assessment (SORA) | 2. Airspace management and geofencing | In accordance with SORA Annex E, the provision of external services (as the U-space services) shall comply with safety requirements. The higher the SAIL, the most demanding are these requirements. For operations dealing with SAIL IV, service providers shall be subject to oversight mechanisms (a competent third party shall be involved). | All environments | | Operational / Safety | Ensures compliance with U-space regulations on safety requirements. |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **CORUS-XUAM-004** | Transaction time requirement for pre-tactical geofencing | 2. Airspace management and geofencing | The pre-tactical geofencing service shall deliver information with a maximum transaction time of 120 seconds. | All environments | | Performance | Ensures timely pre-tactical geofencing data exchanges. |
| **CORUS-XUAM-005** | Continuity requirement for pre-tactical geofencing | 2. Airspace management and geofencing | The pre-tactical geofencing service shall deliver information with a continuity (max tolerable probability of interruption of service per flight/hour) equal to 1E-02. | All environments | | Performance | Ensures timely pre-tactical geofencing data exchanges. |
| **CORUS-XUAM-006** | Availability requirement for pre-tactical geofencing | 2. Airspace management and geofencing | The pre-tactical geofencing service shall deliver information with an availability (max tolerable probability of non-availability of service per flight/hour) equal to 1E-02. | All environments | | Performance | Ensures timely pre-tactical geofencing data exchanges. |
| **CORUS-XUAM-007** | Integrity requirement for pre- | 2. Airspace management and geofencing | The pre-tactical geofencing service shall deliver information using a software with a | All environments | | Performance | Ensures viable pre-tactical geofencing |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| | tactical geofencing | | minimum design assurance level (DAL) equal to C. | | | | data exchanges. |
| **CORUS-XUAM-008** | Transaction time requirement for tactical geofencing | 2. Airspace management and geofencing | The tactical geofencing service shall deliver information with a maximum transaction time of 10 seconds. | All environments | | Performance | Ensures timely tactical geofencing data exchanges. |
| **CORUS-XUAM-009** | Continuity requirement for Tactical Geofencing | 2. Airspace management and geofencing | The tactical geofencing service shall deliver information with a continuity (max tolerable probability of interruption of service per flight/hour) equal to 1E-05. | All environments | | Performance | Ensures timely tactical geofencing data exchanges. |
| **CORUS-XUAM-010** | Availability requirement for tactical geofencing | 2. Airspace management and geofencing | The tactical geofencing service shall deliver information with an availability (max tolerable probability of non-availability of service per flight/hour) equal to 1E-05. | All environments | | Performance | Ensures timely tactical geofencing data exchanges. |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **CORUS-XUAM-011** | Integrity requirement for tactical geofencing | 2. Airspace management and geofencing | The tactical geofencing service shall deliver information using a software with a minimum DAL equal to B. | All environments | | Performance | Ensures viable tactical geofencing data exchanges. |
| **CORUS-XUAM-012** | Human-machine interface | 2. Airspace management and geofencing | Geofencing information should be received and displayed through by the ground control station so as enhance human performance and to allow for automation. | All environments | To be further understood and discussed. ATS may tweak the rules of the airspace which may then be translated to the operator and impacting on the mission. | Performance | Enables human oversight and automation of geofencing services. |
| **CORUS-XUAM-013** | Strategic deconfliction capabilities | 4. Conflict management | The strategic deconfliction service shall be capable of detecting conflicts between flight plans and of proposing reasonable modifications to the flight plan to the flight planning management | | | Operational | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| | | | service (alternative flight plan, different time slot…). | | | | |
| **CORUS-XUAM-014** | Flight plans information kept in strategic deconfliction service | 4. Conflict management | The strategic deconfliction service shall have access to a cloud data base (or other distributed structures) where all the known U-plans are stored. | | | | |
| **CORUS-XUAM-015** | Impact of Flight planning management, Pre-Tactical Geofencing, Tactical geofencing and Emergency Management services on | 4. Conflict management | Flight planning management, pre-tactical geofencing, tactical geofencing and emergency management services shall be used as M3 mitigation to the ground risk in SORA. | | | Safety | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| | SORA based-risk assessment. | | | | | | |
| **CORUS-XUAM-016** | Safety requirements for U-space service providers deriving from SORA assessment. | 4. Conflict management | In accordance with SORA Annex E, provision of external services (as the UTM services) shall comply with safety requirements. The higher the SAIL, the most demanding are these requirements. For operations dealing with SAIL IV, service providers shall be subject to oversight mechanisms (a competent third party shall be involved). | | | Safety | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **CORUS-XUAM-017** | Integrity requirement for strategic deconfliction | 4. Conflict management | The strategic deconfliction service shall deliver information using a software with a minimum design assurance level (DAL) equal to B | | | Performance | |
| **CORUS-XUAM-018** | Vertical separation in VLL airspace | 4. Conflict management | The U-space shall ensure a common reference frame for vertical separation of drones in VLL airspace. | | | Operational | |
| **CORUS-XUAM-019** | Alternative/update of U-plan | 4. Conflict management | The flight planning management service shall propose alternative routes to users in case of conflicting plans due to changes in the environmental conditions. | | | Operational | |
| **CORUS-XUAM-020** | Mission plan status accessibility | 4. Conflict management | The system shall inform the operator of modifications of the U-plan to confirm that the accepted route is still | | | Operational | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| | | | valid or if there has been any modification. | | | | |
| **CORUS-XUAM-021** | Trajectory alerts processing for pre-tactical de-confliction | 4. Conflict management | The operator shall receive alerts to modify drone trajectories in order to avoid potential conflicts with other drone operators or manned aviation. | | | Operational | |
| **CORUS-XUAM-022** | Mission Request privacy of information provided | 4. Conflict management | The system shall not show information about other drone operators. | | | Operational | |
| **CORUS-XUAM-023** | Area density | 4. Conflict management | During the validation phase, the system should take into account the availability of the area, considering all the missions within the same space/time horizon. | | | Operational | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **CORUS-XUAM-024** | Raise conflict alert | 4. Conflict management | The conflict detection service shall raise conflict alerts to drone operator 1 and 2 based on the deconfliction functionality. | | | Operational | |
| **CORUS-XUAM-025** | Trajectory alerts reception | 5. Monitoring | In case the flight is going to be conducted in a volume that cannot be geocaged for the user, the operator shall be alerted if a minimum separation distance with other drones cannot be maintained, to guarantee that the risk of collision is negligible over populated areas and low enough in sparsely populated areas. | | | Operational | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **CORUS-XUAM-026** | Pilot accessibility to nearby unmanned traffic information | 5. Monitoring | Operators shall be able to receive the location of nearby drones and other aircraft, although not their private data (Traffic Information), to improve situational awareness. | | | Operational | |
| **CORUS-XUAM-027** | Geographical extension of the information | 5. Monitoring | The traffic information service shall provide all the relevant information about traffic within a geographic bounding volume dimensioned large enough to ensure the safety of all the operations contained within. | | | Performance | |
| **CORUS-XUAM-028** | Bounding volume for emergency procedures | 5. Monitoring | The traffic information service shall extend the information area for a certain operation in case of emergency procedures has been | | Related to dynamic airspace reconfiguration, esp. 664 Art10.10. | Performance | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| | | | activated in the surroundings of its bounding volume. | | | | |
| **CORUS-XUAM-029** | Mission Request privacy of information provided | 5. Monitoring | The system shall not show information about other drone operators | | | Operational. | |
| **CORUS-XUAM-030** | Traffic information to operators | 5. Monitoring | In urban or high drone density areas, the system should provide traffic information to operators to allow adequate situational awareness. | | Regulation 664 traffic information related. | Performance | |
| **CORUS-XUAM-031** | VFR information | 5. Monitoring | The system should provide information of geo-caged areas to VFR aviation. | | Complement 1.3 "Helicopters/VFR traffic position" with info flow in the opposite direction | Performance | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **CORUS-XUAM-032** | Monitoring | 5. Monitoring | The system shall allow monitoring of the functional status of each capability | | | Performance | |
| **CORUS-XUAM-033** | Display of the flight track of drones | 5. Monitoring | The UTM system shall display the tracks of the drones to:<br>- other drone operators<br>- The authority responsible for the area | | | Performance | |
| **CORUS-XUAM-034** | Front end track filtering | 5. Monitoring | The UTM system shall filter the tracks to show:<br>- Non cooperative tracks<br>- Cooperative tracks<br>- Fused tracks<br>- A combination of the upper | | | Performance | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **CORUS-XUAM-035** | Maximum allowed latency in UTM system of 1 second | 5. Monitoring | The UTM system shall show all the data (positions, tracks, zones, alerts,...) with a maximum latency of 1 second. | | AMCGM to 664 Ammex V will say differently: diff latency for diff info, percentage of time it's within the limit (demanding 100% is harsh), etc. NB: same applies to "Transaction time requirement for pre-tactical geofencing" and "Transaction time requirement for tactical geofencing" from "2. Airspace management and geofencing". Note how other requirements in 2. do specify availability (=probability) | Performance | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **CORUS-XUAM-036** | e-Conspicuity | 5. Monitoring | UFR flights shall be e-conspicuity enabled to fly within U-space | | | Performance | |
| **CORUS-XUAM-037** | Vertiport Management Service | 5. Monitoring | A Vertiport Management service will provide information static and dynamic of the vertiport facilities to be used. | | | Operational | |
| **CORUS-XUAM-038** | Data recording and auditing | 5. Monitoring | The service shall record all activity. All activity must be recorded for post analytical review, this includes all inputs, analysis, and rerouting decisions and commands. | | | Operational | |
| **CORUS-XUAM-039** | Provision of location information to authorities | 5. Monitoring | The system shall provide registered tracks to Law Enforcement or aviation authorities, when required. | | | Operational | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **CORUS-XUAM-040** | Provision of mission plan information to law enforcement agencies | 5. Monitoring | Law enforcement agencies shall be able to access mission plans when required. | | | Performance | |
| **CORUS-XUAM-041** | User profiling | 5. Monitoring | The system shall allow user profiling: restricted content and functionality will be accessible depending on the profile of the authenticated user. The accessibility of each content and function must be configurable by the supervisor. | | | Operational | |
| **CORUS-XUAM-042** | Mission plan information to Law Enforcement agencies | 5. Monitoring | The system shall provide access to Mission Plans to Law Enforcement agencies when required. | | | Operational | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **CORUS-XUAM-043** | Provision of drone log access to authorities | 5. Monitoring | The system shall provide access to drone logs and registered tracks to law enforcement and aviation authorities | | | Operational | |
| **CORUS-XUAM-044** | Tracking logging | 5. Monitoring | The tracking service shall log all the data for at least one month | | Regulation 664 Art 15.1(g) | Operational | |
| **CORUS-XUAM-045** | Integrity alerts | 5. Monitoring | The operator should receive alerts if the navigation system is not able to provide an accurate position. | | | Operational | |
| **CORUS-XUAM-046** | Connectivity | 5. Monitoring | The selected communication infrastructure shall provide connectivity between the central system and all nodes. | | | Performance | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **CORUS-XUAM-047** | Safety requirements for U-space service providers deriving from SORA assessment. | 5. Monitoring | In accordance with SORA Annex E, provision of external services (as the UTM services) shall comply with safety requirements. The higher the SAIL, the most demanding are these requirements.<br>For operations dealing with SAIL IV, service providers shall be subject to oversight mechanisms (a competent third party shall be involved). | | | Safety | |
| **CORUS-XUAM-048** | Flight plan approval | 7. Interface with air traffic control | A flight conformance module built in the FPM service shall be the instance responsible for approving or rejecting the individual flight plans based on defined rules and prioritization criteria | | | Operational | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **CORUS-XUAM-049** | Communication | 7. Interface with air traffic control | The system shall allow the communication between ATCO/manned aviation pilots and operator/pilot through:<br>R/T or<br>D/L or<br>general voice communication means | | | Performance | |
| **CORUS-XUAM-050** | Datalink ATC voice performance | 7. Interface with air traffic control | The C2 Link system may offer, for the relay of ATC voice services, at least the following performance:<br>Voice latency: 400 ms (maximum)<br>Availability: 99,998% (minimum) | | | Performance | |
| **CORUS-XUAM-051** | Provision of drone information to ATM system in controlled airspace | 7. Interface with air traffic control | ATM systems shall receive drone positions, identification and foreseen trajectories in the proximity of airporsts or controlled airspace | | | Operational | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **CORUS-XUAM-052** | Alarm to supervisor | 7. Interface with air traffic control | The system shall provide alarms to ATM systems in case of drone deviations near controlled airspace | | Safety requirement for non-nominal scenarios. | Operational + Safety | |
| **CORUS-XUAM-053** | Vertical separation in VLL airspace | 7. Interface with air traffic control | U-space shall ensure a common reference frame for vertical separation of drones in VLL airspace. | | Separation/Conflict management | Performance | |
| **CORUS-XUAM-054** | Sensors for Collaborative ATC Interfacing | 7. Interface with air traffic control | A sensor or a set of sensors shall be available to measure the altitude. | | | Operational | |
| **CORUS-XUAM-055** | Redundancy of communication channel for U-space information exchange | 7. Interface with air traffic control | Since U-space information exchange is expected to rely on cellular networks (e.g. LTE or 5G), a redundant communication channel (e.g. satellite-based) represents a safety mitigation in areas where coverage of such networks is not ensured. | | Safety requirement for non-nominal scenarios. | Safety | |

| Identifier | Title | U-space consolidated report area | Description | Environment | Additional Information | Type of requirement | Rationale |
|---|---|---|---|---|---|---|---|
| **CORUS-XUAM-056** | Connectivity | 7. Interface with air traffic control | The selected communication infrastructure shall provide connectivity between the central system and all nodes. | | | Operational | |

Table 87 Requirements

# 5 Safety and Contingency in UAM Operations

## 5.1 Introduction

The Safety and Contingency Requirements in UAM Operations chapter focuses on ensuring the safe and efficient operation of Urban Air Mobility (UAM). The section is divided into four main parts or sub-sections: Air Risk Impact Assessment, Continued Safe Flight and Landing in Alternate Vertiports (CSFL), Flight Planning and De-Confliction, and Airspace Assessment.

The Air Risk Impact Assessment section examines the potential risks and impacts of different flight trajectories, corridors, and vertiport locations, while also protecting other airspace users. In this section, the physical and logical structures of the corridors, trajectories, and vertiports have been explored. This includes identifying potential risks and impacts associated with different flight paths and proposing strategies to mitigate possible risks.

The Continued Safe Flight and Landing in Alternate Vertiports (CSFL) section outlines strategies for safely redirecting and landing in alternative vertiports in the event of an emergency. A tool based on the Voronoi tessellation algorithm has been developed and tested to assess the impact of different distributions of vertiports on individual or collective contingencies in the U-space to UAM flights, by placing vertiports in various locations.

The Flight Planning and De-Confliction section discusses how to plan and coordinate flights to minimize conflicts and ensure safe operation. Simulations have been performed to study the advantages and disadvantages of different pre-flight deconfliction methods, including First Filed First Served (FFFS) and Reasonable Time to Act (RTTA).

The Airspace Assessment section covers the classification of airspace for integrated operations, taking into account the CORUS volumes, X, Y, and Z considering pre-flight, in-flight, and post-flight phases. It also includes the Unmanned Flight Rules (UFR), which apply uniquely to airspace users in receipt of U-Space services within U-Space airspace. UFR is based on deconfliction service(s) for separation provision and on-board technologies (DAA/SAA) for collision avoidance.

## 5.2 Air Risk Impact Assessment

### 5.2.1 Trajectories

The type of trajectories used in Urban Air Mobility (UAM) operations is a critical factor to consider in terms of both safety and the capabilities and performances of the unmanned aerial vehicle (UAV). In order to ensure the safety of other airspace users, a combination of U-space services and the type of trajectories may be utilized. When designing trajectories, potential social, noise, and visual impacts as well as the presence of ground populations must be considered.

The urban environment presents unique challenges for UAM operations due to the presence of obstacles and more dynamic changes in the environment. Aircraft may also operate close to obstacles, as illustrated in Figure 51.

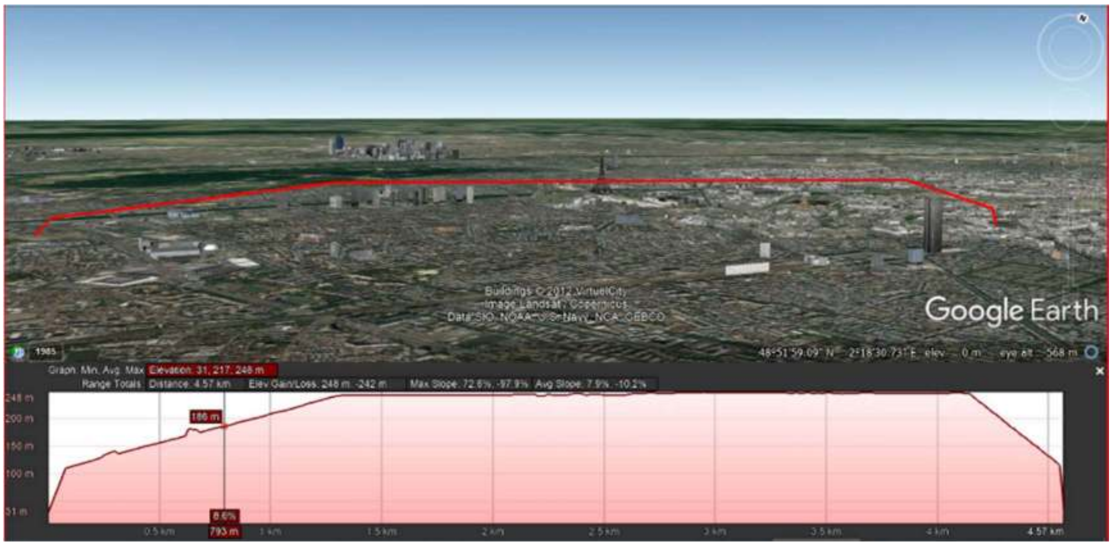


**Figure 51: Example of UAM trajectory**

This figure depicts an example of a UAM trajectory in the Paris area of France, created using the Google Earth tool as part of a vertiport model. The horizontal and vertical profiles of the trajectory can be observed, with three differentiated parts in the vertical trajectory: an ascent with two different angles, a cruise phase, and a descent with again two additional angles. Therefore, the take-off, cruise flight, descent, and landing phases, as well as the altitude changes during these flight conditions, can be observed in the figure.

#### 5.2.1.1 Comparing Free and Predefined Routes in UAM

In aviation, a free route is a route that is not predetermined or fixed, but rather is determined in real-time based on the needs and conditions of the flight. Free routes allow pilots and air traffic controllers to choose the most efficient and safe route for a flight, taking into account factors such as weather, traffic, and airspace restrictions.

On the other hand, a predefined route is a route that is established in advance and is typically used for flights that follow a regular or predictable schedule. Predefined routes can be used for a variety of purposes, including optimizing airspace usage and reducing the workload of air traffic controllers.

Predefined routes may be modified in real-time based on changing conditions, but they are generally less flexible than free routes


**Figure 52: Finding the middle ground between Free Routes and Predefined**

Free and predefined routes are defined, and their advantages and disadvantages are discussed in Table 88:

| Concepts | Features | Pros | Cons |
|---|---|---|---|
| **Free Route** | Free to plan a route between a defined entry point and a defined exit point. (Not applicable to take-off and landing) | Shortest path<br>Flexibility for the AU | Unpredictability<br>Complex ATC coordination |
| **Predefined Route** | A route is planned prior to departure | Better predictability<br>Organized traffic (Standardized procedures) | More restricted operations<br>Not optimal flight paths |

**Table 88: Pros and Cons of Free and Predefined Routes**

In addition, the UAV routes and the concepts are presented in Sesar JU project, Metropolis 2 project [19] to assess the most effective balance between strategic and tactical separation. It is proposed that the fundamentals for concrete solutions for U-space U3/U4 services that are needed to enable high-density urban aerial operations, with a unified approach to the following Uspace services: strategic deconfliction, tactical deconfliction, and dynamic capacity management. Different concepts such as the centralized concept, the hybrid concept and the distributed concept are described to address both strategic and tactical deconfliction of the drone traffic over urban areas. For example, in centralized concept, the main feature of the output is that the flight plans are conflict-free. A flight plan is assigned as a polygonal path in a fixed layer without changing layers on route.

#### 5.2.1.2 Flight Paths during take-off and landing

The present design concept of flight paths during take-off and landing, which is based on the EASA' study [20] on Urban Air Mobility, has presented use cases such as air taxis and medical deliveries.

VTOL aircraft can take-off and land vertically by definition. However, limitations can occur vertically during initial part of take-off with an angle as due to obstacles throughout the trajectory of the flight, while the rest of the flight path may be shallow.

For UAM flights, it is necessary to consider the use cases that are related to the type of trajectories needed, as well as the safety implications of each flight path. In this context, EASA's study proposed a series of flight paths which can be used for their take-off and landing operations.

A roof-top vertiport is shown in Figure 2 on the left with a 'clear' green trajectory, which indicates that a VTOL can take off from this vertiport without obstruction. A vertiport at ground level indicates that the same VTOL would not be able to take off from there because its trajectory is too shallow, and so there would be an obstruction. This means that this aircraft is not capable of taking off from this vertiport since its performance is lower.

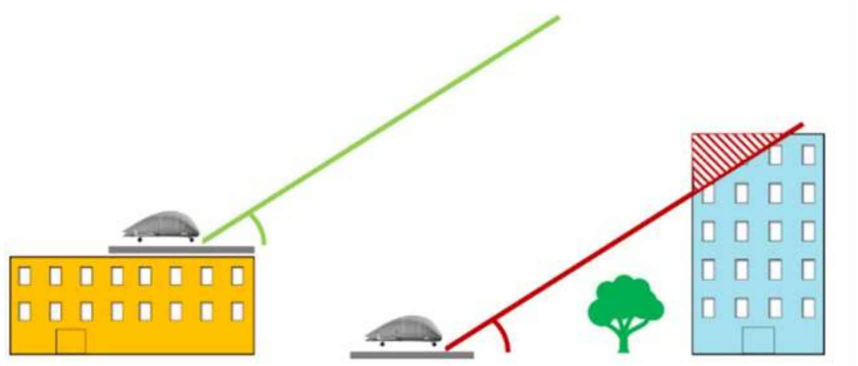

Figure: 2 A roof-top vertiport [20]

Additionally, EASA provides broad requirements that ensure Urban Air Mobility is adaptable to support all urban settings and types of VTOLs.

- **Vertical take-off**

Figure 3 shows a profile designed for vertical take-offs in an obstacle-rich environment. A large portion of the trajectory is vertical. Certain failures are also manageable under these conditions.

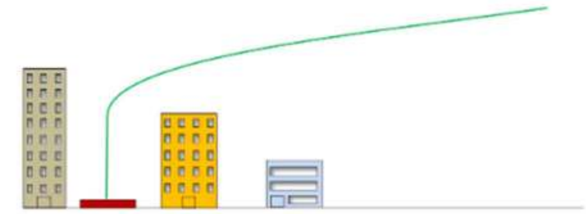

Figure: 3 Vertical take-off [20]

- **Conventional take-off**

Figure 4 shows the VTOL taking off in an open area without obstacles. VTOL types and missions might also benefit from a small runway for rolling starts, increasing their energy efficiency. It is important to take into account that there may be a dip in the trajectory when certain failures occur.

Figure: 4 Conventional take-off [20]

- **Elevated conventional take-off**

Figure 5 illustrates how VTOLs launch from elevated places in a city (like rooftops of tall buildings), even when certain failures such as mechanical and structural failures, issues related to flight manoeuvres may cause the trajectory to dip.

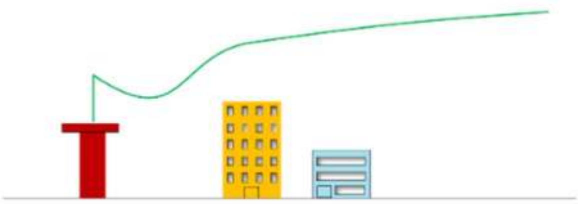

Figure: 5 Elevated conventional take-off [20]

In addition to take-off profiles presented above by EASA, two more sets of objectives are considered when deciding on the location and kind of vertiports and VTOL trajectories. The aircraft can be certified in two categories: Basic or Enhanced.

In Basic category, lower safety objectives are set depending on the number of passengers transported by the VTOL, such as 0-1, 2-6 or 7-9. It can be used for non-commercial air transport of passengers, outside congested areas such as in the countryside. In non-congested areas VTOLs can perform a controlled emergency landing in many ways. Landing can be outside a vertiport but must be controlled as it is shown in Figure 6, similarly to what a helicopter or aeroplane can achieve in case of power-loss.

Figure: 6 Landing in basic category aircraft [20]

In the Enhanced category, the highest safety objectives are set in accordance with the flights in busy city / urban skies, or for Commercial Air Transport of passengers (Air Taxis). In congested areas such as cities, a VTOL is expected to perform a "continued safe flight and landing". Figure 7 shows an example of a VTOL possible landing locations in an urban area. The immediate landing might not be possible in a city outside of a vertiport.

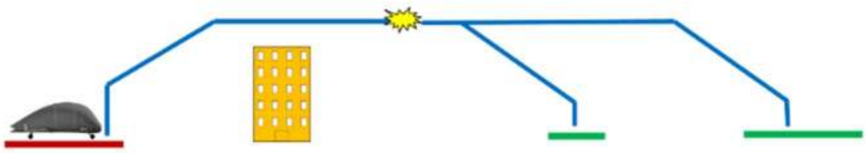

Figure: 7 Landing in enhanced category aircraft [20]

### 5.2.2 Corridors

Corridors are three-dimensional (3D) volumes of airspace which are proposed to ensure the safety of unmanned aerial vehicles (UAV). There are important safety concerns: when to establish corridors, the reasons which can trigger the need for these kind of route structures and the parameters that need to

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be determined to make the corridors safe to operate in. In addition, presence of obstacles, CNS performance and aircraft encounters are also discussed.

Corridors are conceived as tools to manage the traffic:

- Target traffic can use the corridors applying established limitations
- The rest of the traffic can only enter the corridor under certain conditions

FAA's approach [21] to the relationship between UAM, UTM, and ATM operations within different airspace classes are shown in Figure 8. According to FAA, ATC separation services are not involved in UAM corridors. On the other hand, the corridors are the actual mechanism which establishes the separation between UAM and other operations. Performance requirements such as Sense & Avoid capabilities and manoeuvrability will be implemented in each corridor to increase efficiency of the operations. Different corridors may have different requirements. As it is seen in Figure 8, UAM aerodromes will be available, and they will be connected by corridors for point-to-point operations. FAA considers more complex design to go beyond point-to-point operations. [22]

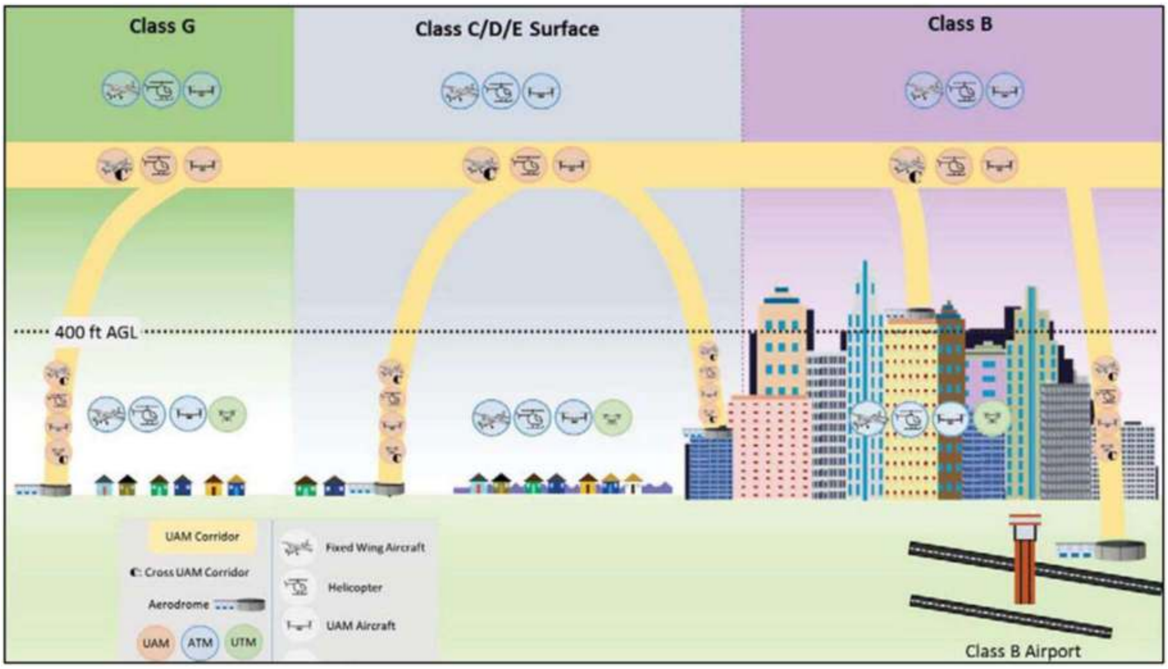


Figure: 8 Airspace by FAA [21]

Figures 9 and 10 represent "double-sided" corridors. In these figures UAVs move in two different directions; these can be identified by using indications such as different colours located in each side of the UAV. A minimum safety altitude should be set, under which the UAV cannot go lower. Figure 11



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illustrates the altitude changes in corridors. It is also identified the need to keep the distance between the UAV and the highest obstacle in the area.

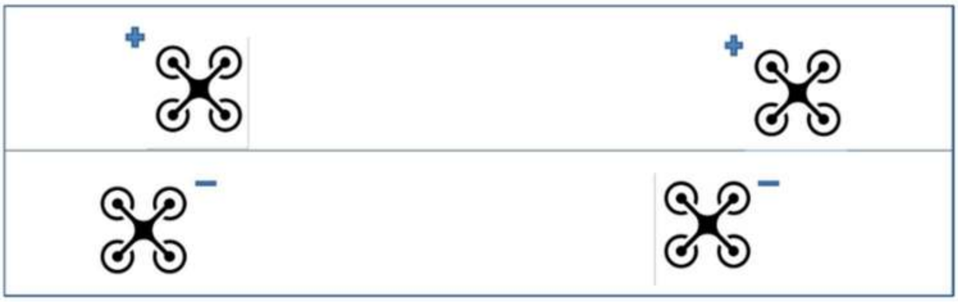

Figure: 9 Double-sided corridors top-view

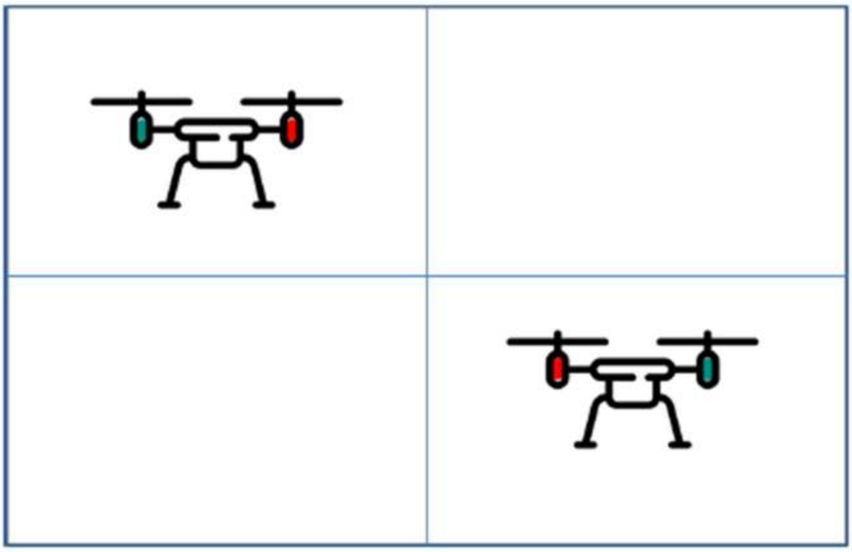

Figure: 10 Double-sided corridors side-view

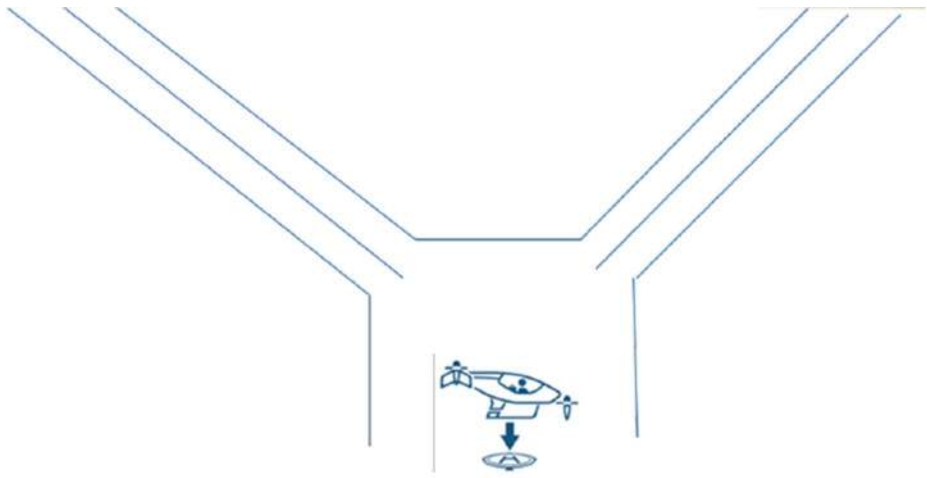

Figure: 11 Double sense Corridors

Size of the corridors can also be used to ensure the safety of operations within them if there are disturbances such as severe weather (wind, rain or visibility). BUBBLES project [23] can be used as a source of information for designing air corridors' sizes to ensure the safety and efficiency of UAM operations. In addition, the DLR blueprint "*Concept for urban airspace integration*" [24] can be utilized to integrate corridors in UAM. For example, a poorly equipped UAV such as a delivery drone may require larger separation to other airspace users due to the limited manoeuvrability or Sense & Avoid equipment with a smaller detection range.

An example of double-sided corridor dimensions is explored in Demonstration Exercise #2.2, where the minimum dimensions of a corridor with vertical traffic separation were calculated to meet a navigation performance (RNP) requirement of 0.02 NM for all U-space users. The resulting dimensions are shown in Figure 53. In the same concept, the cross-section dimensions may be larger in certain locations to incorporate existing airspace limitations, e.g. maximum & minimum allowed altitudes of traffic.

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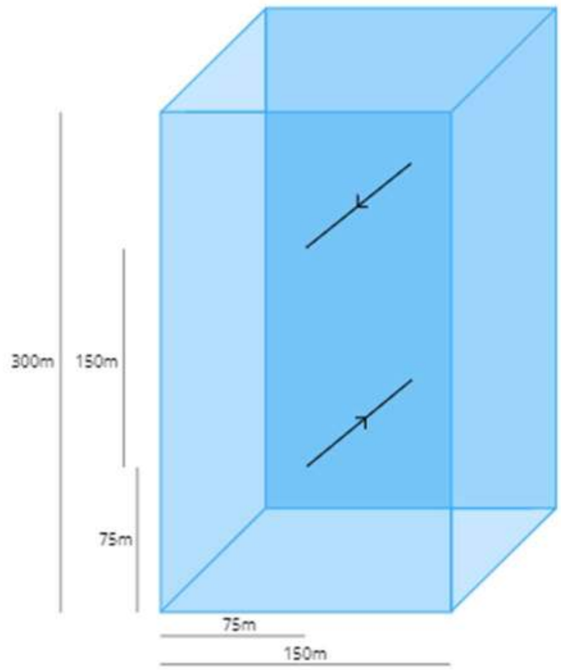
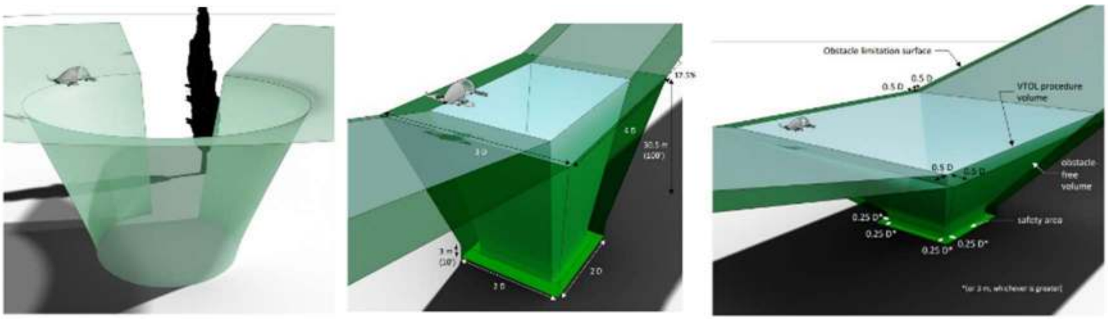



Figure 53: corridor cross-section from Demonstration Exercise #2.2, showing minimum dimensions

### 5.2.3 Vertiports

In this section the air risk impact assessment for the vertiport environment is discussed. UAM operations in vertiports designed to minimize air risk are considered in detail. Different approaches to vertiports are also discussed. Omnidirectional and directional types of approaches are shown in Figure 12.

Prohibited sector e.g., to avoid an obstacle is illustrated in Figure 12a in the omnidirectional obstacle-free volume. This is a perspective view in which a vertiport presented in an obstacle-free volume with omnidirectional approach and take-off climb surface and prohibited sector.




a) Omnidirectional [25] b) Directional [25] c) Directional (with wider funnel) [25]

Figure: 12 Different approaches to vertiports [25]

The funnels of a vertiport with a directional approach are also illustrated in different locations in Figure 13. In this figure, the VTOL-capable aircraft can perform a vertical take-off and landing in these potential vertiports.

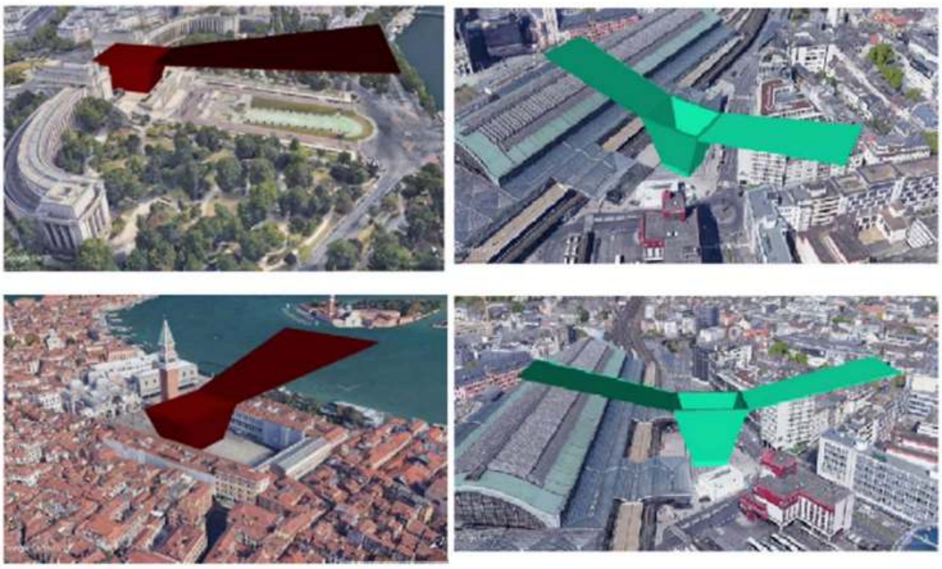


Figure: 13 The funnels of a vertiport [25]

Vertiports are also categorized as shown in Table 2. Category-1 defines vertiports as whether taxiing is allowed or not. On the other hand, Category-2 considers vertiports depending on types of take-off. [DETAIL EXPLANATION NEEDED]

| **Category-1** | **Category-2** |
|---|---|
| Vertiport with taxiing | Conventional take-off |
| Vertiport without taxiing | Elevated conventional take-off |
| | Vertical take-off |
| | Mixed types of trajectories allowed |

Table 2: Different kinds of vertiports

Physical requirements are set for vertiports to allow simultaneously take-off and landing, such as the distances between final-approach and take-off areas (FATOs) in obstacle-free volume [25] shown in Figure 14 . Generic vertical take-off and landing procedure parameters are also presented in Table 3.

| **Parameter** | **Description** |
|---|---|
| $h_1$ | Low hover height |
| $h_2$ | High hover height |
| $TO_{width}$ | Width at $h_2$ |
| $TO_{front}$ | Front distance at $h_2$ |
| $TO_{back}$ | Front distance at $h_2$ |
| $FATO_{width}$ | Width of the FATO |
| $FATO_{front}$ | Front distance on FATO |
| $FATO_{back}$ | Back distance on FATO |
| $\theta_{app}$ | Slope of approach surface |
| $\theta_{dep}$ | Slope of departure surface |

Insert project logo here

Table 3: Generic vertical take-off and landing procedure parameters [25]

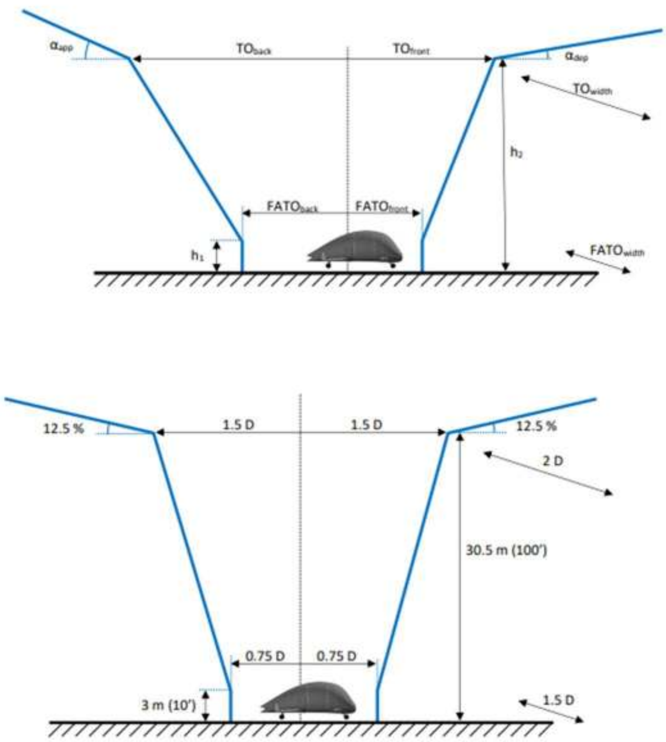



Figure: 14 Generic vertical take-off and landing procedure parameters [25]

**Operational Constraints**

Operational constraints in vertiports are considered and the details are shown in Figure 15. In this figure air taxiing, ground movement and the details of the vertiport operations are presented. [REFERENCE] [DETAIL EXPLANATION NEEDED]

The list of constraints is described as follows:

- Whether landing on rooftops in city area or not
- Wind effects during landing and take-off
- Comfort of the passengers during vertiport operations

- Emergency procedures such as escape routes and alternate A/C power

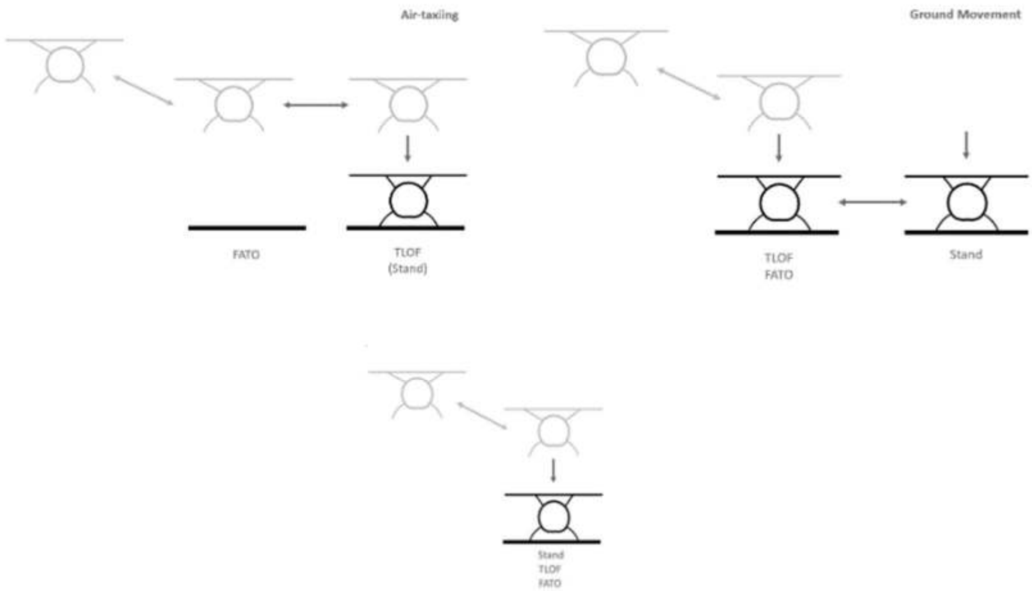



Figure: 15 Physical configuration of vertiports [REFERENCE] COMMENT!!!

The Paris sandbox scenario for vertiport to vertiport is presented in Figure 16. In this figure the extension of the vertiport funnels and the trajectory between the vertiports are shown. The details of the vertiport are shown in Figure 17. Different colours and shapes are illustrated to represent corridors in blue colour, local altitude limit in Orly Airport in orange colour, and the vertiport volume in Orly is in pink colour.

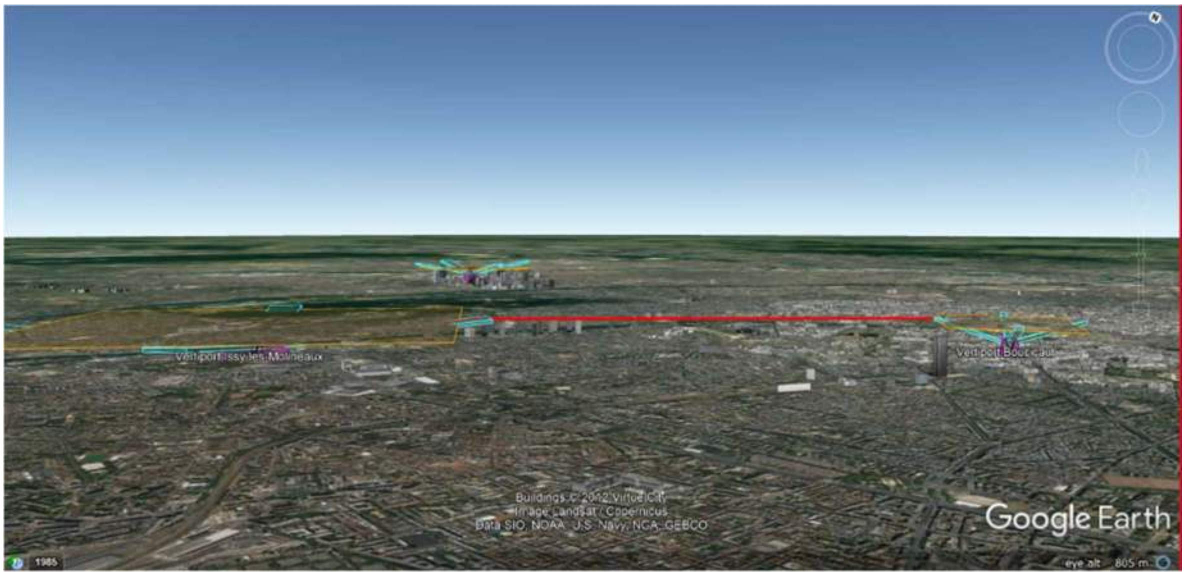



Figure: 16 Paris sandbox scenario


Figure: 17 Vertiport in Paris sanbox scenario

## 5.3 Continued Safe Flight and Landing

*A probabilistic approach*

### 5.3.1 Capacity planning for Continued Safe Flight and Landing sites and alternative vertiports in Urban Air Mobility

Electrically powered aircraft envisaged for use in Urban Air Mobility have limited energy storage on board. In order to avoid critical low energy situations during execution of flights, operations are foreseen to be deconflicted prior to flight. This means that there is a high probability that the entire flight will be flown as planned, and no additional time is spent airborne. However, not every flight may be completed as planned; for example, technical difficulties with the aircraft, unforeseen capacity problems at the destination vertiport or unexpected weather changes may cause the need for deviating to an alternative landing site. Also in these cases, it is essential that the flight can be completed before the energy on board is running critically low. It is therefore important that sufficient capacity at alternative landing sites is available.

This article discusses the modelling of the probability of use of alternate landing sites and the relation between the number of flights in an area and the required alternate landing site capacity. It also investigates the benefits of a U-space service that coordinates the use of alternate landing sites.

### 5.3.2 Continued Safe Flight and Landing Concept (CSFL)

Aircraft certified in the SC-VTOL enhanced category must be operated such way that in case of a non-catastrophic failure to a flight critical system, the aircraft can safely continue its flight and land at a designated landing site. This Continuous Safe Flight and Landing (CSFL) landing site may not be the original intended destination; it can be any site along the route that has been found suitable and designated as a possible CSFL site.

In the flight planning phase, the operator must consider the locations of CSFL sites and the CSFL characteristics of the aircraft when designing the route of the flight, to ensure that at any time during the flight, in the case of a system degradation, the aircraft is within range of at least one available CSFL site.

The CSFL sites may be regular vertiports used for normal UAM operations, or they may be sites specifically created and designated only for CSFL purposes. Since, in urban environments the cost of having landing areas is rather high, it is desirable to minimise CSFL sites due to economical reasons, both in number and in occupied surface area.

To analyse the probability of use of an CSFL alternate it important to distinguish between two categories of events that may lead to the use of a CSFL site.

*Independent events:*

In this category are those events that affect only a single flight.

Examples are:

- Technical failures on the aircraft
- Passenger emergencies
- Unforeseen unavailability of landing slot, affecting a single flight.

If Vertiport Y serves as a CSFL site for flights to Vertiport X, each flight into X will have a low probability of needing to divert to CSFL site Y for technical reasons. The probabilities are independent between flights.

*Dependent events:*

In this category are those events that affect multiple flights.

Examples are:

- Vertiport closure (e.g. fire), affecting all incoming flights
- Unforeseen meteorological events
- U-space system degradation

If Vertiport Y serves as the only alternate of Vertiport X, each flight into X will have a low probability of need to divert to Y in case X becomes unavailable. But these probabilities are not independent. If X closes, each flight approaching to X will divert to Y.

The safety objectives for each failure condition are:

| | | Failure Condition Classifications | | | |
|---|---|---|---|---|---|
| | **Maximum Passenger Seating Configuration** | **Minor** | **Major** | **Hazardous** | **Catastrophic** |
| **Category Enhanced** | - | $\leq 10^{-3}$ FDAL D | $\leq 10^{-5}$ FDAL C | $\leq 10^{-7}$ FDAL B | $\leq 10^{-9}$ FDAL A |
| **Category Basic** | **7 to 9 passengers** | $\leq 10^{-3}$ FDAL D | $\leq 10^{-5}$ FDAL C | $\leq 10^{-7}$ FDAL B | $\leq 10^{-9}$ FDAL A |
| | **2 to 6 passengers** (see note A) | $\leq 10^{-3}$ FDAL D | $\leq 10^{-5}$ FDAL C | $\leq 10^{-7}$ FDAL C | $\leq 10^{-8}$ FDAL B |
| | **0 to 1 passenger** (see note A) | $\leq 10^{-3}$ FDAL D | $\leq 10^{-5}$ FDAL C | $\leq 10^{-6}$ FDAL C | $\leq 10^{-7}$ FDAL C |
| [Quantitative safety objectives are expressed per flight hour] | | | | | |

**Figure 54: Safety Objectives from EASA SC-VTOL**

Failure conditions definition:

Failure conditions are defined as effects on the aircraft and its occupants, both direct and consequential, caused or contributed to by one or more failures, considering relevant adverse operational or environmental conditions. Failure conditions may be classified according to their severity as follows (AMJ 25.1309):

1. **Minor.** Failure conditions that would not significantly reduce aeroplane safety, and which involve crew actions that are well within their capability.

•

2. **Major.** Failure conditions that would reduce the capability of the aeroplane or the ability of the crew to cope with adverse operating conditions to the extent that there would be, for example, a significant reduction in safety margins or functional capabilities, a significant increase in crew workload or in conditions impairing crew efficiency, or discomfort to occupants, possibly including injuries.

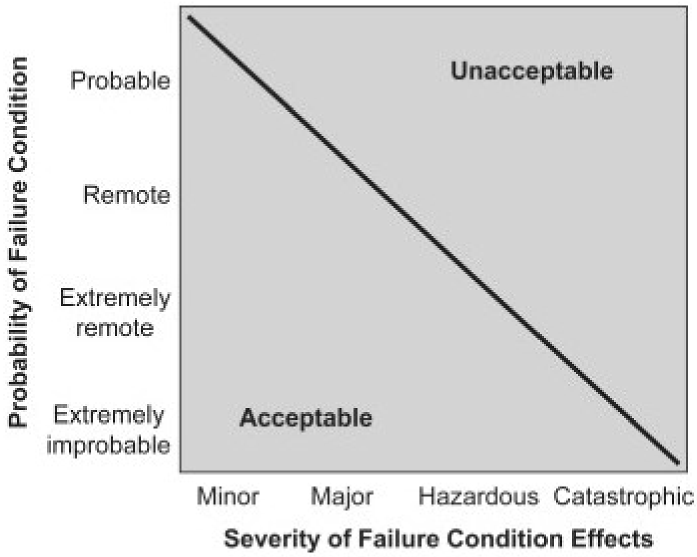
•

3. **Hazardous.** Failure conditions that would reduce the capability of the aeroplane or the ability of the crew to cope with adverse operating conditions to the extent that there would be
   (a) A large reduction in safety margins or functional capabilities
   (b) Physical distress or higher workload such that the flight crew cannot be relied on to perform their tasks accurately or completely, or
   (c) Serious or fatal injury to a relatively small number of the occupants.
   •
4. **Catastrophic.** Failure conditions that would prevent continued safe flight and landing.

An **inverted relationship** between the **severity** of the failure conditions and the **probability** of occurrence is established. Hence,

| | | | |
|---|---|---|---|
| 1 | Minor failures | Become | Probable |
| 2 | Major failures | Become | Remote |
| 3 | Hazardous failures | Become | Extremely remote |
| 4 | Catastrophic failures | Become | Extremely improbable |

Each of the above probabilities has a maximum value assigned, which depends on the type of aircraft considered—for example, in the case considered above, extremely improbable is $10^{-9}$, as we have already seen; extremely remote is $10^{-7}$; remote is $10^{-5}$, and so on.


Unacceptable
Acceptable
Probability of Failure Condition
Probable
Remote
Extremely remote
Extremely improbable
Minor
Major
Hazardous
Catastrophic
Severity of Failure Condition Effects

| | | | | | |
|---|---|---|---|---|---|
| Effect on aeroplane | No effect on operational capabilities or safety | Slight reduction in functional capabilities or safety margins | Significant reduction in functional capabilities or safety margins | Large reduction in functional capabilities or safety margins | Normally with hull loss |
| Effect on occupants excluding flight crew | Inconvenience | Physical discomfort | Physical distress, possibly including injuries | Serious or fatal injury to a small number of passengers or cabin crew | Multiple fatalities |
| Effect on flight crew | No effect on flight crew | Slight increase in workload | Physical discomfort or a significant increase in workload | Physical distress or excessive workload impairs ability to perform tasks | Fatalities or incapacitation |
| Allowable qualitative probability | No probability requirement | <...Probable...> | <...Remote...> | Extremely <.................> Remote | Extremely improbable |
| Allowable quantitative probability: Average probability per flight hour on the order of: | No probability requirement | $<10^{-3}$ Note 1 | $<10^{-5}$ | $<10^{-7}$ | $<10^{-9}$ |
| Classification of failure conditions | No safety effect | <...Minor...> | <...Major...> | <...Hazardous...> | Catastrophic |

Note 1: A numerical probability range is provided here as a reference only. The applicant is not required to perform a quantitative analysis, nor substantiate by such an analysis, that this numerical criteria has been met for minor failure conditions. Current Transport category aeroplane products are regarded as meeting this standard simply by using current commonly-accepted industry practice.

**Figure 55: Classification of failure conditions**

The conservative assumption is that if an aircraft diverts to a CSFL site, it will not be able to move from the FATO after it has completed its unscheduled landing due to technical difficulties with the aircraft. And thus, the CSFL FATO will be unavailable to other aircraft after the event.

Let Cap_Y be the available capacity (i.e. number of FATOs) of the alternate vertiport Y.

Let P_csfl,A be the probability per flight hour that a specific aircraft A encounters and independent event causing a need to divert to a CSFL site.

For initial calculation, let's assume that P_csfl,A is constant during the entire flight and that it is the same for each aircraft.

*A more advanced analysis could consider higher probability in the first segment of the fight, as well as increasing probability towards the end of the flight.*

*The higher probability in the first segment will be driven by the transient mechanical and thermal loads on the components of the aircraft during that segment. If there is a latent technical defect on the aircraft, it is more likely to manifest itself during this transient phase.*

*The higher probability towards the end of the flight is mainly driven by operational choices. If during the flight a probability emerges that the aircraft cannot land at the destination, the operator will likely defer the decision to deviate to a later moment, when the outcome will be clearer. For this reason, CSFL sites later along the flight route will likely see a higher probability of being used.*

Scenario 1: analysis of a technical degradation affecting single flight

Let's assume a vertiport pair connected by flights of 30 minutes. Each flight is divided into 7 segments for which a different CSFL port is designated. For the first and last 2.5 minutes there is the possibility to return to vertiport of departure respectively continue to the original destination. The remaining 25 minutes are covered by 5 en-route CSFL sites covering a segment of 5 minutes each.

Each of the en-route CSFL sites has the capacity of accommodating a single vehicle. Thus, after a single aircraft has deviated to the site, the site is no longer available.

In case a hazardous event happens to flight A, and no available CSFL site can be reached, the outcome can conservatively be assumed to be catastrophic.

*A less conservative assumption would take the possibility into account that an emergency landing could be made at an unprepared and ad-hoc selected landing site.*

Questions to be answered:

How many aircraft can use this route simultaneously without the probability of a catastrophic event being too high? *(need to define the acceptable probability of a catastrophic event)*

How many aircraft can simultaneously plan the same CSFL site as alternate for a portion of their flight?

If a CSFL site becomes unavailable during a flight, does the flight need to deviate/reroute or is it acceptable to continue as planned even though a part of the route is not covered by an available CSFL site?

If a CSFL site becomes unavailable just prior to flight, does the flight need to stay on the ground/reroute or is it acceptable to continue as planned even though a part of the route is not covered by an available CSFL site?

#### 5.3.2.1 List of events that may cause multiple flight to deviate to alternate landing site simultaneously.

- Vertiport closure
  - Fire
  - Technical
- U-space degraded / closed
  - CNS
  - USSP Service layer
    - Single USSP
    - All USSP
    - CISP down
  - Manned aircraft emergency crossing U-space
- Meteorological
  - Unexpected weather degradation

Normal conditions

Contingencies

Abnormal conditions

e.g. Weather

Fault conditions

Failure in the aircraft

In the UTM system

Reference ESRM (Extended / Safety Reference Material)

### 5.3.3 Voronoi Diagrams to determine the probability of occupancy of CSFL vertiport

A **Voronoi diagram** is a partition of a plane into regions close to each of a given set of objects. In the simplest case, these objects are just finitely many points in the plane (called sites). For each site there is a corresponding region, called a **Voronoi cell**, consisting of all points of the plane closer to that site than to any other.

**Figure 56: Interactive Voronoi diagrams cells determination**

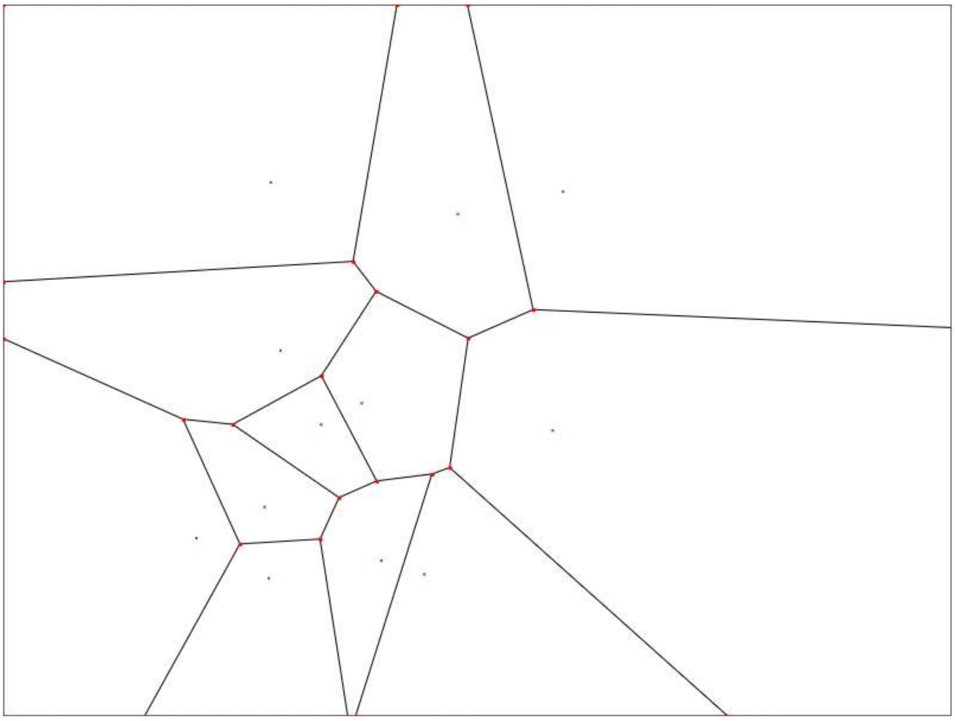


**Figure 57: Example of a Voronoi Diagram with 12 sites**

The sites of a Voronoi diagram can represent a set of vertiports in a given area.

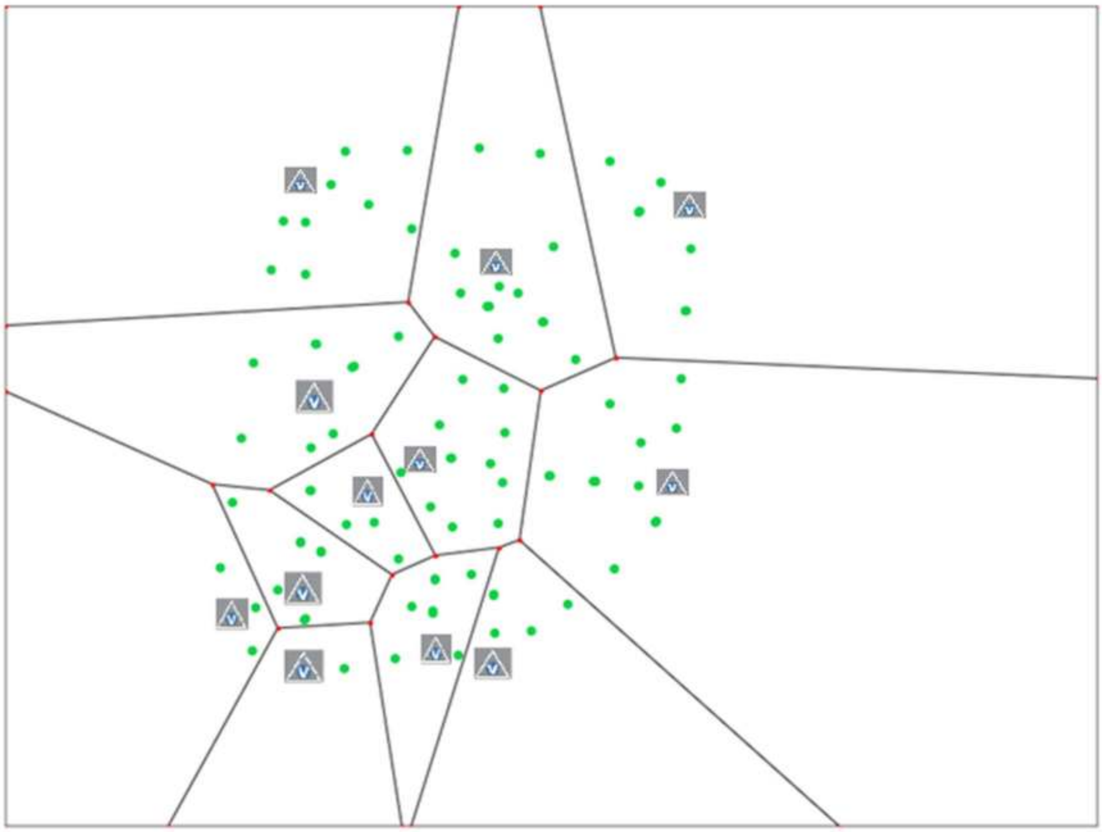
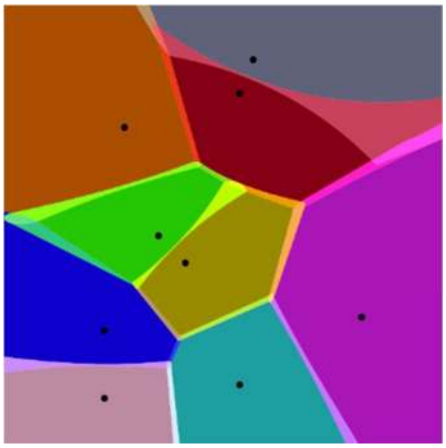


**Figure 58: Example of 75 flights and 12 Vertiports in a given area**

With 75 flights in average happening simultaneously and 12 vertiport in the area we have a ratio of flight/vertiport of 6,25 flights. In average those are the flights that would correspond to each cell. What we can see in practice is that we have one cell with one single flight at a certain moment in time while there are another two cells with up to eleven flights at the same time instant. This gives a variability in a range from [1,11] in number of flights handled in a single cell.

The number of flights per cell in this case seems to be driven by three main factors, the total amount of traffic in the airspace, the number of direct connections from the vertiport in the cell with other adjacent vertiports and the total distance between the vertiport in one cell and the rest of the vertiports in the adjacent cell.

#### 5.3.3.1 Probability of the shadow occupancy of a vertiport



Uncertainty areas located in the border of two cells. These areas will assign an equal probability to the two vertiports in opposite sides to be utilize as CSFL site.

What happen in the event of the closure of one of the vertiports?

The new Voronoi diagram it's calculated and the UAS assigned to the cell that is closed it will be assigned to adjacent cells depending on the new configuration.

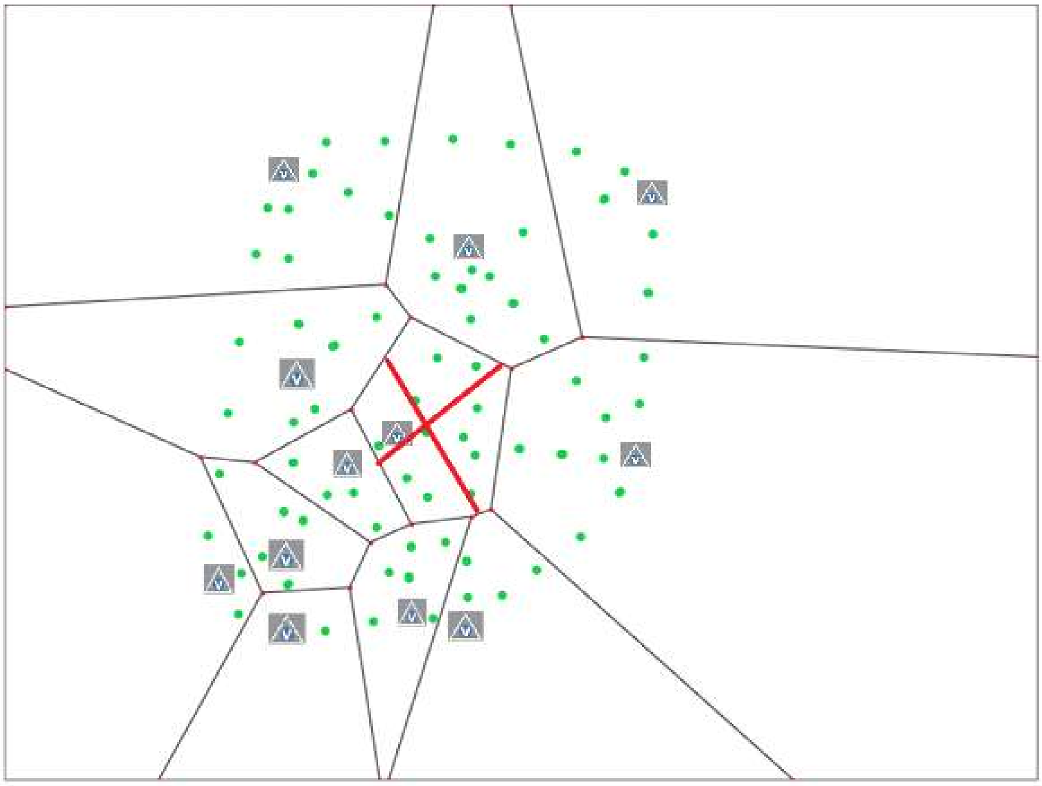


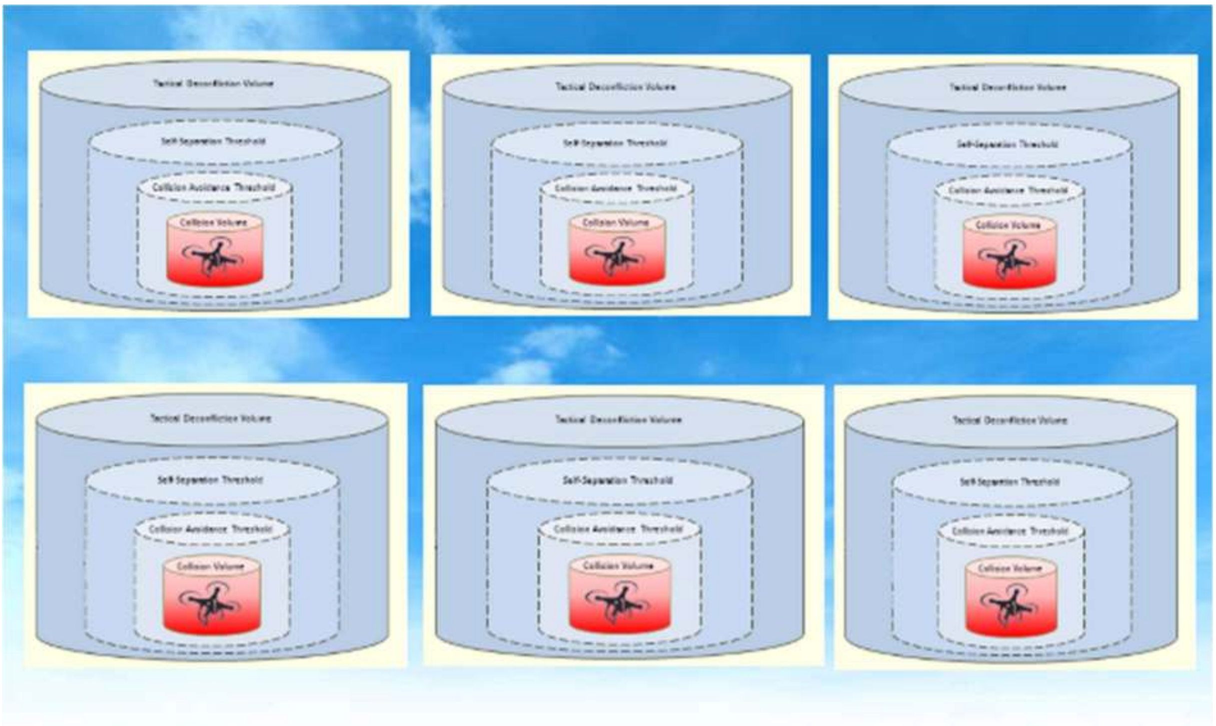
**Figure 59: Example of closure of a vertiport**

Questions to be answered (Part 2):

Q: What drives the limit to the number of drones that we can accept in an environment?

There are two limiting factors drive the number of drones that can be accepted in an airspace volume:

- The first one is a volumetric factor where certain number of drones and their respective deconfliction volumes have to fit in a volume of airspace to guarantee a specific level of safety in terms of mid-air collisions.
- The second is related to vertiport capacity in two different ways
    - Number of parking pads the vertiport may have
    - The number of UAS vertiports can manage (throughput)




A further question would be, having certain number of vertiports in an area, what is the amount of traffic that can be handled?

Defining the following parameters for a UAM environment:

$V_i = \ Vertiport\ i\text{-}th\ in\ the\ area$

$N = Total\ number\ of\ vertiports\ in\ the\ area$

$P_i = Number\ of\ parking\ pads\ available\ in\ vertiport\ i$

$Tp = Total\ number\ of\ parking\ pads\ in\ the\ area$

$P_a = Average\ number\ of\ available\ pads\ per\ vertiport\ in\ the\ area$

We can define the total number of pads in the area as:

$$Tp = V_1 \cdot P_1 + V_2 \cdot P_2 + \cdots + V_N \cdot P_N = N \cdot P_a$$

$Tp$ is a limiting factor for the number of flights we will have in our UAM environment.

We could define…

Rough assumptions for the Vertiport Stands and FATOs:

- Assume x-number of movements per hour.
- Stands capacity

Two types of cites: Vertiports and CSFL sites

CSFL site will have one 1 stand capacity which will be zero once it's occupied.

### 5.3.4 Further questions to be answered

Q: Probabilities for the failure of a vertiport have to be researched.

Q: If a vertiport closes how this does affect to aircraft that were not going to land there but had it as CSFL vertiport during its route.

Q: We have the case when the vertiport closes. Who is affected by this.

- Whoever has this vertiport as a destination will be affected.
- Anybody who has this vertiport as a departure alternate will be potentially affected.
- Anybody who has this vertiport as a landing alternate will be affected.
-

Q: When do we start using emergency landing sites? What is the criteria for that? Assume that not everything can be solved beforehand.

One proposal is not to use the vertiports at the highest capacity when they have CFSL purpose. There will be always some available spots to accommodate flights with contingencies.

Business case questions were also raised.

Q: Who is going to pay for the capacity that is claimed by alternate reservations?

Some system for route taxes might be proposed in this regards.

Q: For ETOPS, only one alternate airport is considered. They don't need to expect more. Can we accept the same for UAS? What are the possibilities here? Discuss about this and give probabilities giving assumptions.

List of factors that makes a vertiport not available:

- Technical failure of some system of the vertiport
- All landing spaces are occupied (It has been used as an alternative for some other flight already)
- External factors (like a fire nearby)
- Weather
- Authorities closing the airspace corresponding to that vertiport (Local environment)

## 5.4 Pre-flight de-confliction

*Simulation study*

### 5.4.1 Introduction to Methods for volume-based pre-flight de-confliction

To achieve successful integration of Urban Air Mobility in densely populated airspaces, the risk of mid-air collision with other aircraft is a critical concern. Pre-flight de-confliction processes enable operators to fly safely separated from other aircraft, as long as all aircraft in a given airspace volume are flying as planned. However, this may come at a high efficiency cost, as a portion of the airspace is 'reserved' for each user when volume-based de-confliction is used. In addition, a residual risk is latent: in case any aircraft exits its approved volume, there will be a collision risk that may require additional mitigation.

This study discusses different methods for volume-based pre-flight de-confliction and analyses their performance in dedicated simulations. The analysis of residual risk and the use of tactical mitigations will be addressed in a separate document.

### 5.4.2 Volume-based pre-flight de-confliction

The process for pre-flight de-confliction can be modelled via the closed loop illustrated in Figure 60. This process is formed by the following elements:



- **The pool of U-plans.** Is a list containing all active and planned flights. Each individual flight in the pool corresponds to an operational intent or U-plan. This should include enough information about the operation, such as the expected activation time, the planned 4D trajectory, the time when the U-plan was filed, the flight priority, and the expected uncertainties (both in temporal and spatial dimensions).
- **The deconfliction scheme.** Is the method upon which de-confliction is based. The deconfliction scheme established the criteria that trigger the conflict search, and the selection of U-plans to be considered for conflict search and update function. In the present document, two different methods based on distinct principles will be addressed: first-filed first-served (FFFS) and reasonable time to act (RTTA).
- **The conflict search.** The act of searching for possible predicted conflicts among a given set of operational intents. In the present document, the method to conduct a conflict search is volume-based, in which each operational intent is defined by one or multiple 4D volumes which include the planned trajectory and a buffer that accounts for uncertainties. A conflict is predicted if the 4D volumes of different U-plans intersect. Upon prediction of a conflict, the update function is triggered.
- **The update function.** Modifies the U-plans to eliminate conflicts, according to the criteria set by the deconfliction scheme. These changes can be of varied nature, such as issuing delays, modifying trajectories, varying speeds, or outright rejecting a filed U-plan. When different types of modifications can be issued to different U-plans, a set of optimisation criteria are needed to get a safety acceptable result (e.g.: no conflict) with an efficient set of changes (e.g.: minimize changes imposed to U-plans).

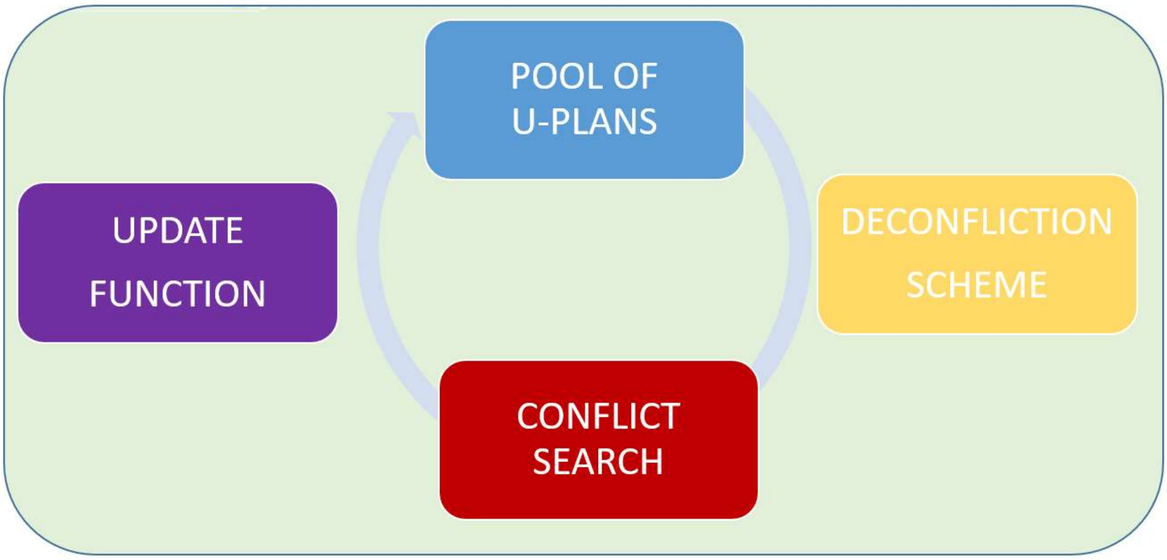



**Figure 60. Closed loop for pre-flight de-confliction**

In the present document, three 3 different models that follow 2 distinct approaches have been considered:

- FFFS (first-filed first-served): flights are deconflicted and locked (i.e., no more changes expected) at the moment they are filled. This means that the conflict search is executed upon submission of a U-plan, and the update function only considers modifications to that U-plan, unless U-plans with a lesser priority are involved. This method provides early fillers with advantage versus late fillers, as this method acts like a reservation of airspace. Nonetheless, this method also has drawbacks: penalizes late fillers, which may lead to fairness concerns, and is more affected by uncertainties and changes, due to de-confliction possibly being done quite in advance.
- RTTA (reasonable time to act): this approach is based on the idea that, if deconfliction is pushed closer to flight activation, the inherent reduction of related uncertainties may be related to better results. Also, this does not discriminate U-plans regarding how early the operational intents were submitted in advance, which can help achieve fairness in this sense. Two different models for RTTA have been proposed:
    - 1-parameter model: flights are deconflicted a given time in advance related to their expected activation time, which is the only parameter in this model (e.g.: five minutes before activation). Only one flight is deconflicted on each occasion, which is locked after the deconfliction. This method is simple and quick but might have lower overall

performance than the following 3-parameter model, as by considering only 1 aircraft to be changed, it cannot find a solution other than a local minimum.

- 3-parameter model: flights with activation time within a certain time window are deconflicted. This process is repeated with a given frequency. The three involved parameters are: the period between two consecutive conflict searches, the width of the time window, and the distance between the instant when conflict search is executed and the start of the time window. These three parameters can be expressed in units of time. This method tries to find better solutions than the 1-parameter model by looking at a wider scope, effectively acting like a sliding window. However, the computational cost is quite high, as multiple combinations of modifications of planned flights can be executed to resolve conflicts. In addition, the three parameters of the model are subject to mathematical constraints to ensure that the sliding window effectively covers all operational intents. While the theory behind this method has been discussed in the project, it has not been implemented in the simulation tool, due to lack of resources, being marked as a future development.

### 5.4.3 Simulation tool description

To compare the performances of the FFFS and RTTA (1-parameter) models, a simulation tool has been developed. The tool generates a 2D grid, with a traffic pattern corresponding to Figure 61.

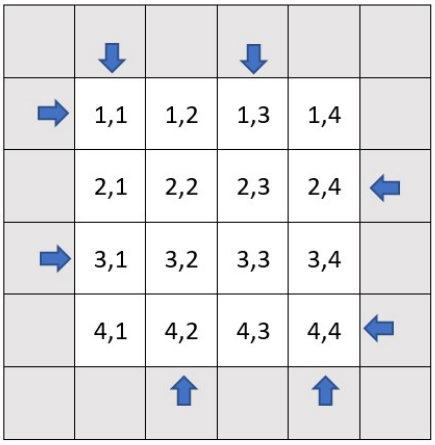



**Figure 61. 2D grid simulated by the tool**

A traffic sample is generated based on certain input parameters, and then the volume-based pre-flight deconfliction loop is run within the simulation. The simulation includes a primary loop, that represents the passing of time from the beginning until the end, and a secondary loop, which executes the deconfliction functions when needed. The primary loop simulates the submission of new U-plans, calls the secondary loop as required, and the simulates the execution of operations according to their de-conflicted U-plans. On the other hand, the secondary loop predicts the future state of the simulation executing a conflict search and modifying U-plans to solve any existing conflict, according to the applicable rules. To modify U-plans, only delays have been considered as an option. When a conflict is predicted, a U-plan is increasingly delayed until no more conflicts arise during the prediction.

The following parameters are inputs for the simulations:

- **Grid size:** the number of rows and columns of the grid (n x n square).
- **Duration**: the total duration of the simulation (primary loop) obtained as the multiplication of the grid size and a duration coefficient.
- **Uncertainty values:** measures the temporal uncertainty of activation of a flight. Represents the time window in which an operation is expected to be activated and start. The bigger the uncertainty, the bigger the 4D volumes linked to the operation. Therefore, the 4D volume of an operation with uncertainty 0 only occupies 1 cell at each instant. If uncertainty is increased to 3, the 4D volume will have a size of 7 cell at each instant (the baseline one, plus three forwards, and three backwards). Different values can be defined for different operations, and also for planned vs active flights.
- **Traffic:** defines the speed of traffic in terms of cells advanced per unit of time. Also, determines the total number of aircraft that will be simulated, each linked to a U-plan. To this purpose, a density parameter is defined, ranging from 0 to 1. Density represents the average percentage of the total available airspace that is occupied by 4D volumes of aircraft during a simulation. This means that using a 10% occupation, 10% of the cells in the grid will be occupied in average. The total number of flights is computed according to the density, uncertainty, grid size, and simulation length. Hence, a higher density will increase the number of aircraft, while a higher uncertainty will reduce this number, due to the greater 4D volumes resulting from the increased uncertainty.
- **RTTA:** the values for the 3-parameter model (not used) and the 1-parameter model, in time units.
- **Uncertainty distribution:** to create a representative traffic sample, three classes of U-plans have been considered: early, medium, and late fillers. These are classified according to the time between filing and expected activation time. Early fillers are expected to file long in advance, and the contrary for late fillers. These inputs allow to define the proportion of early, medium and late fillers, and which are the time between filing and activation for each class. The thresholds represent the total number of flight lengths that the flights are filed in advance. As an example, given the data from Table 89, early fillers always fill in less than 20 times the

length of flight, normal fillers do in less than 5 times, and late fillers always fill in less time in advance that what a flight takes to complete.

The simulation tool consists in the following modules:

- Traffic generator: generates a set of U-plans according to the inputs listed above.
- Main loop: executes the primary loop of the simulation. Three different versions:
  - No-deconfliction: does not call any de-confliction method. Used as comparison.
  - FFFS: calls the FFFS de-confliction whenever a U-plan is submitted.
  - RTTA: calls the RTTA de-confliction whenever a U-plan is close to activation (when time remaining to activation is equal to RTTA parameter)
- De-confliction: implemented as a function that performs the conflict search and update functions when called by the main loop. Two versions:
  - FFFS: for FFFS de-confliction
  - RTTA: for RTTA de-confliction
- Post-analysis: reads results of the simulations and computes output by means of statistical analysis.
- Visualisation: reads results of the simulations and generates 2D visualisation of the grid. Can simultaneously show the 2D grid from the three cases (no deconfliction, FFFS, and RTTA) to allow comparison.

### 5.4.4 Simulated scenarios

A total of 4 different scenarios have been simulated in this study. The criteria to define each simulation is the following:

1) All flights are subject to the same level of uncertainty, both at planning and active phases.
2) Flights have different uncertainty according to the classification of the operation among early, normal, or late fillers. Early fillers have the most uncertainty, while late fillers have the least. This uncertainty is not modified upon activation. The lower level of overall uncertainty leads to increased traffic compared to 1), with the same volume density.
3) Is similar to 2) but in addition to having different uncertainty values when planned, these uncertainties are reduced to a minimum value upon activation of the flight.
4) Equal uncertainty levels as in simulation 1) but with increased density to match the number of flights from simulations 2) and 3).

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Apart from the uncertainty values among 1), 2), and 3), and the density from simulation 4), the rest of input parameters have not been modified among simulations. The following table collects all the input data that define the simulations:

| | Simulation inputs | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | General | | | Uncertainty values | | | | | | Traffic | | | RTTA | | | | Uncertainty distribution | | | | | |
| | | | | Planned | | | Active | | | | | | 3-model | | | 1-model | Proportion | | | Thresholds | | |
| # | Grid size | Duration coef | Duration | Early | Normal | Late | Early | Normal | Late | Speed | Density | Flight number | UR | LT | UT | RTTA | Early | Normal | Late | Early | Normal | Late |
| 1 | 50 | 100 | 5000 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 0,05 | 1389 | 1 | 5 | 6 | 5 | 25% | 50% | 25% | 20 | 5 | 1 |
| 2 | 50 | 100 | 5000 | 4 | 3 | 2 | 4 | 3 | 2 | 1 | 0,05 | 1786 | 1 | 5 | 6 | 5 | 25% | 50% | 25% | 20 | 5 | 1 |
| 3 | 50 | 100 | 5000 | 4 | 3 | 2 | 1 | 1 | 1 | 1 | 0,05 | 1786 | 1 | 5 | 6 | 5 | 25% | 50% | 25% | 20 | 5 | 1 |
| 4 | 50 | 100 | 5000 | 4 | 4 | 4 | 4 | 4 | 4 | 1 | 0,064 | 1786 | 1 | 5 | 6 | 5 | 25% | 50% | 25% | 20 | 5 | 1 |

**Table 89. Simulation input parameters**

In addition, the following graphics show the temporal distribution of flights regarding activation time (Figure 62), filing time (Figure 63) and elapsed time between filing and activation (Figure 64).

It can be noted (Figure 62) that the number of simultaneous flights at the beginning of the simulation is lower, but soon reaches a relatively constant value, considering the noise due to the randomized distribution.

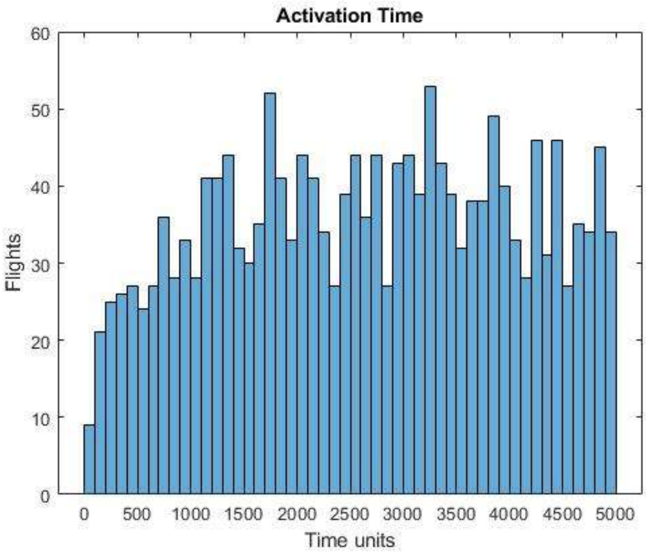


**Figure 62. Distribution of activation time**

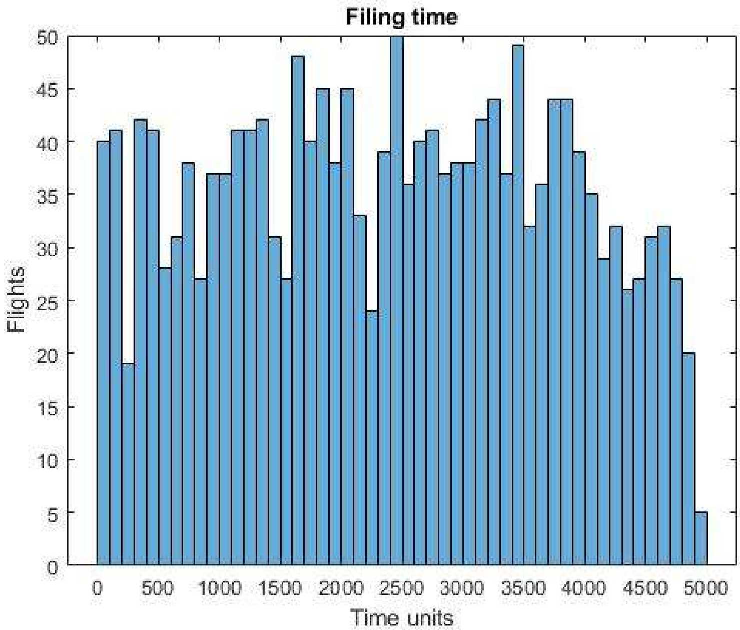


**Figure 63. Distribution of filing time**

In Figure 64, the peak in low FTA values shows the concentration of the 25% late fillers within [0, 50], compared to the distribution of the 25% early fillers in [250, 1000].

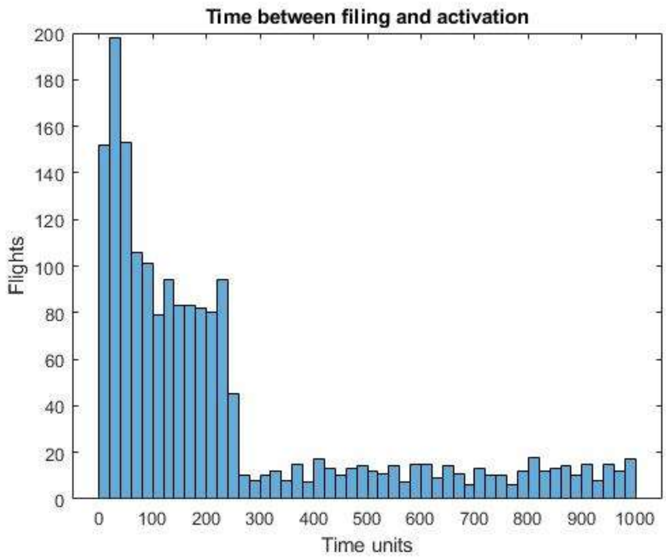


**Figure 64. Distribution of time between filing and activation**

### 5.4.5 Results

Figure 65 shows the 2D plot of the grid in a given instant during the simulations, drawing the 4D volumes related to in-flight aircraft. The traffic sample corresponds to simulation 4). In the leftmost graphic, the unmitigated case is shown, in which the traffic sample is simulated without adding any delays. The centre plot shows the result of the delays proposed by the FFFS method to avoid conflicts, while the rightmost plot shows the results of the delays proposed by the RTTA method to the same traffic sample. The same instant is represented in the three pictures. Note how several conflicts are shown in the leftmost grid, represented in green color.

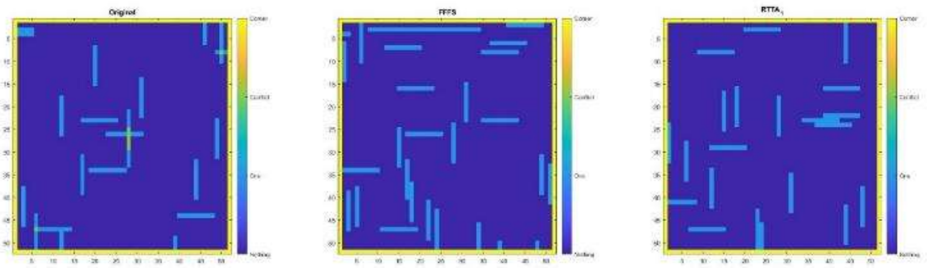


**Figure 65. Simulation of 2D flights with different pre-flight de-confliction strategies: no de-confliction (left), FFFS (centre), RTTA (right)**

Table 90 and Table 91 collect the results for the performed simulations for the FFFS and RTTA methods, respectively.

| | Outputs FFFS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Early | | | | Normal | | | | Late | | | | Global | |
| | % delayed | Avg delay | Max delay | Occupation | % delayed | Avg delay | Max delay | Occupation | % delayed | Avg delay | Max delay | Occupation | Avg delay | Occupation |
| 1 | 25,91% | 3,21 | 42 | 0,98% | 73,31% | 18,29 | 151 | 2,92% | 83,05% | 28,66 | 162 | 4,42% | 16,99 | 2,79% |
| 2 | 30,34% | 4,60 | 63 | 1,22% | 68,75% | 14,69 | 121 | 3,10% | 80,25% | 18,73 | 121 | 4,56% | 13,15 | 3,01% |
| 3 | 33,10% | 4,46 | 70 | 1,13% | 71,52% | 14,14 | 92 | 3,12% | 75,96% | 16,20 | 93 | 4,37% | 12,30 | 2,95% |
| 4 | 34,64% | 5,14 | 71 | 1,18% | 77,28% | 20,77 | 147 | 3,65% | 90,72% | 39,20 | 213 | 5,50% | 21,54 | 3,51% |

**Table 90. Results for FFFS method**

| | Outputs RTTA_1 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Early | | | | Normal | | | | Late | | | | Global | |
| | % delayed | Avg delay | Max delay | Occupation | % delayed | Avg delay | Max delay | Occupation | % delayed | Avg delay | Max delay | Occupation | Avg delay | Occupation |
| 1 | 80,78% | 14,64 | 61 | 3,85% | 77,86% | 14,08 | 56 | 3,80% | 77,30% | 13,84 | 82 | 3,61% | 14,16 | 3,76% |
| 2 | 80,77% | 13,86 | 57 | 3,67% | 75,60% | 10,74 | 48 | 3,51% | 67,90% | 8,06 | 38 | 3,41% | 10,83 | 3,53% |
| 3 | 75,86% | 11,74 | 52 | 2,28% | 67,99% | 8,45 | 57 | 2,23% | 59,33% | 5,65 | 39 | 2,20% | 8,56 | 2,24% |
| 4 | 89,15% | 18,59 | 66 | 5,25% | 85,95% | 18,71 | 74 | 4,99% | 85,07% | 17,93 | 82 | 4,83% | 18,49 | 5,01% |

**Table 91. Results for RTTA method**

The following can be appreciated:

- In the FFFS method, early fillers are rewarded while late fillers are greatly penalized, being subject to higher average and maximum delays. Normal fillers stay in between.
- In the RTTA method, we appreciate a similar treatment to all operators in simulations 1) and 4), while late fillers appear to be rewarded in simulations 2) and 3). The reason behind this is that their volumes are smaller, which reduces their delay
- Comparing simulations 3) and 4), the impact of the uncertainty can be seen (same number of flights, but much higher delays in 4))

### 5.4.6 Conclusions

- Uncertainty has a great impact on delay.
- The reduction in uncertainties is better leveraged in the RTTA method
- The RTTA method has overall less delays
- The RTTA method does not have fairness issues
- The FFFS method provides great advantage to early fillers
- Also, there are many future developments, such as refinement of planned operations reducing their uncertainty (only reduction on activation tested in this study). In addition, the RTTA method with 3 parameters could prove useful if successfully applied. There is interest in machine learning approaches using reinforcement learning.

## 5.5 Flight rules and Airspace Classification

*Open discussion*

### 5.5.1 Introduction to flight rules discussion and airspace classification

The aim of this document is to set a common ground for discussion of the topics Airspace classification and Flight rules within T3.3 of the project. The following two sections are taken from the latest version of the ConOps, meant as the baseline to be considered. Then, some open questions are described.

### 5.5.2 From the ConOps, regarding AIRSPACE CLASSIFICATION

#### 5.5.2.1 CORUS volumes

The U-space ConOps edition 3 [1] describes some U-space "Volumes" in which different services should be used. The whole airspace is either X, Y or Z. The aim was a simple scheme for easy comprehension.

- X: No conflict resolution service is offered.
- Y: Pre-flight (“strategic”) conflict resolution is mandatory
- Z: Pre-flight (“strategic”) conflict resolution and in-flight (“tactical”) conflict resolution are mandatory

For Y and Z an approved plan is required. In both Y and Z the pilot / UAS should be connected to U-space during flight to allow sending of position information and receipt of warnings, traffic information and so on.

The descriptions below are for a flight wholly in that airspace. For flights penetrating multiple airspaces, the conditions for each must be applied for that portion of the flight.

### 5.5.2.1.1 X volume

In X volumes flights need no plan and receive no separation service.

#### 5.5.2.1.1.1 X, Pre-flight

The UAS operator should in some circumstances be registered, see 3.1. The UAS operator should make use of the geo-awareness service before flight, to load relevant data into the UAS, if appropriate and to confirm that the volume is X, see 3.4. The operator may make use of other services as appropriate (or as mentioned in the SORA for the flight, if there is one), for example: weather, see 3.8, geographic information, see 3.9.

#### 5.5.2.1.1.2 X, In flight

No “tactical” separation service is available. The UAS operator remains responsible at all times for ensuring safe operation.

The UAS needs to be identifiable and will either have to direct remote identification, see EU regulations 2019/947 [4] and 2019/945 [5], or make use of a network identification service, see 3.2.1.

The operator may make use of services as they are available and needed by the circumstances, for example vertical conversion service (3.19), vertical alert and information service (3.20), emergency management (3.12)

#### 5.5.2.1.1.3 X, Post flight

An accident and incident reporting service is available, see Section 3.13.

### 5.5.2.1.2 Y volume

Y volumes fulfil two roles. In the edition 3 ConOps [1] these were mentioned. UAS flight in a Y volume requires an approved plan. In Y volumes the plans are deconflicted before flight. The two purposes of Y are:

- The Y volume can exist primarily to limit access

- The Y volume can exist to enable flight with strategic deconfliction

##### 5.5.2.1.2.1 Y, Pre-flight

The UAS operator should in some circumstances be registered, see 3.1. The UAS operator should make use of the geo-awareness service before flight, to load relevant data into the UAS, if appropriate and to confirm that the volume is Y, see 3.4.

Every flight must have an approved U-plan, see **Error! Reference source not found.**. Approved U-plans do not conflict due to the strategic conflict prediction, see **Error! Reference source not found.**, and resolution services, see **Error! Reference source not found.**.

##### 5.5.2.1.2.2 Y, In flight

The U-plan shall be activated to commence flight, see **Error! Reference source not found.**

The flight shall make use of the following services unless their use is waived for the specific airspace:

- **Error! Reference source not found.** service, see **Error! Reference source not found.**
- **Error! Reference source not found.** service, see **Error! Reference source not found.**
- **Error! Reference source not found.** service, see **Error! Reference source not found.**
- **Error! Reference source not found.** service, see **Error! Reference source not found.**, including **Error! Reference source not found.**, see **Error! Reference source not found.**
- **Error! Reference source not found.** services, see **Error! Reference source not found.**
- Error! Reference source not found., SEE Error! Reference source not found.

##### 5.5.2.1.2.3 Y, Post flight

The U-plan shall be ended by the operator, see 3.5.2.5. An accident and incident reporting service, see **Error! Reference source not found.**, is available. The operator may consult the digital logbook, see **Error! Reference source not found.**

#### 5.5.2.1.3 Z volume

A Z volume is a volume in which there is a tactical conflict resolution service. Three versions of Z exist:

- Za in which Air Traffic Control manage all the traffic. Such airspaces may exist at an airport. The expectation is that ATC will communicate with UAS through U-space services.
- Zu in which U-space will provide a tactical conflict resolution service
- Zz in which U-space will provide a tactical conflict advisory service

Za is an existing controlled airspace. This ‘Za’ label is for the UAS community only.

##### 5.5.2.1.3.1 Za, Pre-flight

The UAS operator should in some circumstances be registered, see 3.1. The UAS operator should make use of the geo-awareness service before flight, to load relevant data into the UAS, if appropriate and to confirm that the volume is Za, see 3.4.

Every flight must have an approved U-plan **Error! Reference source not found.**. The plan will need to be approved by ATC by means of the procedural interface with ATC, see **Error! Reference source not found.**. That procedural interface may result in various conditions being specified.

##### 5.5.2.1.3.2 Zu & Zz, Pre-flight

The UAS operator should in some circumstances be registered, see 3.1. The UAS operator should make use of the geo-awareness service before flight, to load relevant data into the UAS, if appropriate and to confirm that the volume is Zu or Zz, see 3.4.

Every flight must have an approved U-plan, see **Error! Reference source not found.**. Approved U-plans do not conflict due to the strategic conflict prediction, see **Error! Reference source not found.**, and resolution services, see **Error! Reference source not found.**. The U-plan will be subject to dynamic capacity management, see **Error! Reference source not found.**

Strategic conflict resolution in Zu and Zz may operate with a higher residual risk of conflict than in Y, as there is a tactical process afterwards.

##### 5.5.2.1.3.3 Za, In flight

The flight shall be activated to commence flight, see **Error! Reference source not found.**

The flight shall make use of the following services unless their use is waived for the specific airspace:

- Network identification service, see 3.2.1. Other surveillance may be mandated.
- Collaborative interface with ATC, see **Error! Reference source not found.**

##### 5.5.2.1.3.4 Zu, Zz, In flight

The U-plan shall be activated to commence flight, see **Error! Reference source not found.**

The flight shall make use of the following services unless their use is waived for the specific airspace:

- **Error! Reference source not found.** service, see **Error! Reference source not found.**
- **Error! Reference source not found.**, see **Error! Reference source not found.**, and **Error! Reference source not found.**, see **Error! Reference source not found.**
- **Error! Reference source not found.** service, see **Error! Reference source not found.**
- **Error! Reference source not found.** service, see **Error! Reference source not found.**
- **Error! Reference source not found.** service, see **Error! Reference source not found.**, including **Error! Reference source not found.**, see **Error! Reference source not found.**

- **Error! Reference source not found.** services, see **Error! Reference source not found.**
- **Error! Reference source not found.**, SEE **Error! Reference source not found.**

In Zu, the **Error! Reference source not found.** service issues instructions that the UAS must follow. In Zz the **Error! Reference source not found.** service issues advice. Because of the different likelihood of resulting action, the tactical conflict resolution advice in Zz may be issued earlier than would be the case for the tactical conflict resolution instructions in Zu.

#### 5.5.2.1.3.5 Za, Zu, Zz, Post flight

The U-plan shall be ended by the operator, see 3.5.2.5. An accident and incident reporting service, see 3.13, is available. The operator may consult the digital logbook, see 3.16

### 5.5.2.2 Synthesis

The following table explains the relationship of the different U-space volumes to EU regulations and ICAO airspaces. Note below SVFR is a form of VFR and is usually not mentioned as a separate flight rule.

The U-space Volumes

| ICAO | 2019/947 UAS Geographical Zone | 2021/664 U-space airspace | CORUS-XUAM | Flight rules | Remarks |
|---|---|---|---|---|---|
| G above VLL,<br>ABCDEF | No | No | Not U-space | IFR (3,4) & VFR | For U-space users such airspace would probably be marked a Y volume and any U-space operation plan penetrating this airspace will either not be approved or will be subject to conditions or warnings. |
| ABCDE | No | No | Za | IFR (3)<br>& VFR | Za if and only if the flight's entry into the airspace is enabled by a U-space planning process that includes ATC approval. |
| G VLL | No | No | X | VFR & IFR (4) | Conditions apply<br>UAS fly below VFR limits but in effect conform to VFR |
| Restricted Area | Yes (1) | No | X | VFR | Restrictions may apply:<br>Geo-zones can exist to manage which UAS flights are allowed |

| ICAO | 2019/947 UAS Geographical Zone | 2021/664 U-space airspace | CORUS-XUAM | Flight rules | Remarks |
|---|---|---|---|---|---|
| Restricted Area | Yes (1) | No | Y | Dependent on the restriction | Potentially a no fly zone for UAS |
| Restricted Area | Yes (1) | Yes | Y | See 5 & 6, below | No tactical separation service supplied by U-space |
| Restricted Area | Yes (1) | Yes (2) | Zu | UFR<br>See 5, below | Tactical separation service supplied by U-space. |
| Restricted Area | Yes (1) | Yes (2) | Zz | See 5 & 7, below | Tactical separation **advice** supplied by U-space |

**Table 92: Volumes**

Notes:

1) ) 2019/947 [4] article 15 does not state that geographic zones are restricted areas. U-space airspaces created as a result of 2021/664, 665, 666 are expected to be restricted areas due to the obligation on manned traffic to be conspicuous.

2) 2021/664 describes something approximating Y. Zu and Zz are considered as extending Y

3) IFR only in A.

4) IFR unlikely in G in many countries

5) UFR is defined as how to fly in Zu. In Zu there is U-space tactical conflict resolution, hence UFR includes obeying U-space tactical conflict resolution. It is expected that Zu only supports UFR and all aircraft in Zu must follow UFR.

6) An airspace which is a U-space airspace according to EU 2021/664 [8] & [11], most closely matching the CORUS volume Y, is one aimed at supporting BVLOS operations by means of strategic conflict resolution. Hence flights in the airspace do not follow UFR as flown in Zu, as tactical support is limited to traffic information. EU 2021/664 foresees entry of VFR or IFR traffic into U-space airspace as being an emergency procedure in which U-space traffic "take appropriate measures." Hence it should be noted IFR and VFR traffic are not catered for in Y volumes.

7) The flight rule in Zz is not UFR as flown in Zu.

### 5.5.3 From the ConOps, regarding FLIGHT RULES

This section briefly introduces the topic of the rules of the air for flights receiving U-space services. This topic is the subject of ongoing work as this edition of the ConOps is being prepared and this section will be enlarged in the next edition.

#### 5.5.3.1 Rules of the Air

ICAO Rules of the Air date back to October 1945 when the first international recommendations for Standards, Practices and Procedures for the Rules of the Air were established and ultimately amended into Annex 2 [13]. The Standardised European Rules of the Air (SERA) [12] includes the transposition of Annex 2 into European law. The legislative framework for SERA includes Regulations (EU) 923/2012, amendment Regulations (EU) 2016/1185 and the Aviation Safety (Amendment) Regulations 2021 applies to all European Union states and the United Kingdom (as per the EU Withdrawal Act 2018). Additional flight rules are also applied at the state-level (for example the UK's Air Navigation Order), which are designed to align with SERA and ICAO standardisation.

There are two distinct flight rule categories defined in Annex 2 [13] and SERA [12] :

- Visual Flight Rules (VFR); flown in Visual Meteorological Conditions (VMC),
- Instrument Flight Rules (IFR); flown in either Visual or Instrument Meteorological Conditions (IMC).

Special VFR is more of an exception-based rule set, for VFR flights that do not meet the requirements for VFR (typically VFR minima) when operating in controlled airspace.

#### 5.5.3.2 Avoidance of collisions

- Section 3.2.1 requires that aircraft not come too close to other aircraft
- Section 3.2.2 on right of way describes decisions and actions based on assessments of the relative positions and motions of other aircraft

In Visual flight rules, there is the expectation that the pilot of each aircraft is aware of what is around his/her aircraft by means of sight.

Annex 2 [13] chapter 5 describes instrument flight rules. In essence the flight either benefits from a separation service or traffic information.

### 5.5.4 UFR

U-Space Flight Rules (UFR) shall apply uniquely to airspace users in receipt of U-Space services within U-Space airspace. Aircraft and pilots that adhere to standardised U-Space equipment interfaces, and operate within U-Space Airspace Volumes, shall operate under UFR.

The aim of UFR is to be a flight rule that works for remotely piloted aircraft, without the pilot being able to look out of the window. Instead, the pilot should be informed about the relative positions of aircraft by other means.

The principle behind UFR is to enable aircraft operations that cannot conform to either VFR, SVFR or IFR in all operational conditions. Whilst in some operating cases it is possible for UAM to operate under VFR if piloted as visual line of sight (VLOS), however, more advanced UAM use cases may not be capable of “see and avoid” procedures if the aircraft are uncrewed. Likewise, UAM may be accommodated by IFR in some instances, however, their separation minima may not be suitable for effective operations in more congested airspace, such as the CTR. The aircraft participating under UFR are therefore required to be supported by a set of U-Space services for a particular airspace volume. The required U-Space services and their interface with other ATS depends on the airspace classification.

UFR is for operations in U-Space volumes for airspace users that are consuming U-Space services. UFR is based on deconfliction service(s) for separation provision (safety layer 1) and on-board technologies (DAA/SAA) for collision avoidance (safety layer 2).

It shall be expected that aircraft conforming to UFR are required to:

- be Electronically Conspicuous to the ground system(s) and to other aircraft within the U-Space Airspace,
- be in receipt of a traffic information service(s), as required, with respect to other aircraft,
- adhere to any [Digital] ATS clearance/instruction deemed necessary by the controlling authority,
- have any air traffic separation service managed by a U-Space service.

Aircraft operating under UFR are not expected to receive voice communications from ATS units.

U-Space Mandatory Zone: aircraft operating in a U-Space Mandatory Zone (UMZ) shall be required to make their position known to U-Space through a defined procedure. States shall be responsible for defining the required process for making aircraft Electronically Conspicuous to U-Space.

### 5.5.5 Open questions

This section presents a series of open questions related to the ConOps, that might be tackled in T3.3.

- What makes UFR UFR?
    - Is it the fact that aircraft are unmanned?
    - Is it the fact that operations are provided with new services?
    - Is it the fact that these aircraft need specific RoW rules?
    - Other?
- According to ConOps, UFR are to be applied to airspace users in receipt of U-space services.
    - What about unmanned aircraft operating in CORUS X volumes, not considered U-space by EU regulation? Can these users really accommodate to other existing flight rules (VFR, IFR)? Is there a separate need of flight rules for unmanned aircraft which operate outside U-space?
    - Can (or even, should?) manned aircraft (e.g. initial UAM services) which operate in U-space airspace operate in UFR? (i.e.: UFR not limited to unmanned but to U-space).
    - Other?
- Existing flight rules are defined based on how the pilot gets information from its surroundings
    - VFR according to VMC, based on visual feedback
    - IFR according to IMC (or VMC), based on instrumental feedback
    - How to use a similar approach for the definition of flight rules for U-space airspaces?
        - Pilots are not located in the cockpit (possible exceptions?)
        - Information is always received through technical means
        - Is it reasonable to keep this division for UFR and consider two subsets, one based on visual (e.g.: VLOS, or FPV cameras, onboard pilot?) and other on instrumental (either onboard or U-space-based)?
        - InterUSS defines two types of operational intents (U-plans): trajectory-based and volume-based. Should this classification be captured in the UFR?
            - for example, regarding RoW in Y airspaces, where a conflict appears within a trajectory-based and an area-based operation. The area-based operation would be able to change its trajectory to avoid the collision without requiring changes to the U-plan. The same action would be hard for the other operation. Should we then consider in these scenarios that trajectory-based flight plans have the RoW?
            - Area-based operations require more flexibility, are related to more uncertainty, and are more likely to have a remote pilot.
            - Trajectory-based operations favour the use of higher levels of automation (including the lack of a remote pilot), and are more efficient in terms of airspace use.
            - How does automation affect UFR?





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        - Having two sets of UFR (one VFR-like and other IFR-like) can be an interesting approach, but it remains a task to draw a line that defines both. Does it depend on the kind of information received by the (auto)pilot? Does it depend on the automation level? Does it depend on trajectory or volume based plans?
        - Should we also have subsets of the two UFR sets depending on the type of airspace? (X,Y,Z,Zz,Zu). The above example is a case of Y. The ConOps already acknowledges that Zz and Zu do not follow the same UFR
- Given that VLOS flight is defined by unaided continuous visual contact between pilot and aircraft, is it possible to carry pure VLOS in U-space airspace, considering that there is a requirement to receive the services? (for example, while the pilot looks at a screen to receive traffic information service they lose visual contact with the aircraft). Should UFR carry any consideration related to VLOS, BVLOS, EVLOS, FPV, etc?
    - Based on the experience of project BUBBLES, the performance of a pilot in VLOS conditions is unreliable, especially in cases in which there are several aircraft operating in the vicinity, in which it is very easy to lose track of your aircraft and confuse it with others. In addition, it is very hard to visually identify the relative position and distance of other aircraft, from a VLOS point of view.
- For airspace classification: could a solution be a matrix-based scheme in which, in addition to the existing ICAO airspace class (ABCDEFG), the airspace might also be designated a U-space airspace class?
    - An advantage is that it would require minimum modification to already existing flight rules and airspace classes
    - However, it requires the definition of the rules for unmanned aircraft in this airspace classes
    - And also, very important, to define the interfaces between the air traffic under U-space and under ATM.
    - Previous discussions in T3.3 included an example of classification of U-space airspaces as UA, UB, UC, etc, mimicking how VFR and IFR are separated.
        - UA would mean a U-space airspace in which aircraft only fly IFR-like rules and are separated by a tactical service.
        - UB would mean a U-space airspace in which VFR-like and IFR-like are possible, and separation is provided to all users by tactical services
        - UE would mean a U-space airspace in which VFR-like and IFR-like operations can be conducted, but separation services are not provided by U-space.
        - The above UA and UB are possible examples of Zu volumes, while UE represents a Y volume and also similar to EU regulation U-space airspace.

- However, this classification does not provide any clue regarding how VFR/IFR interact with U-space operations.

- Section 3.5.2.1. Strategic conflict prediction of the ConOps considers two approaches.
  - 1) Each point of the desired trajectory becomes a four-dimensional volume
  - 2) Each point of the desired trajectory is surrounded by four dimensions by a field of probability that the aircraft is present.
  - The method proposed in EU regulation 2021/664 article 10(2)(b) requires flights authorisations to be "free of intersection.", and it is more alike the approach 1), by defining 4D volumes that contain the aircraft 95% of the time.
  - The use of this method also means that the occurrence of a tactical conflict implies a contingency status in which at least 1 aircraft is not conforming to their U-plan. If there are no unconformities, no tactical conflicts would be expected, as all flight paths are deconflicted prior to flights.
  - However, for approach 2), the consequences are different. Since it is understood that there will be a certain overlap (an accepted flight plan has a risk below an acceptable threshold of having tactical conflicts, even if the flight always complies with its plan)
  - Approach 1) is easiest to implement, and seems aligned with EU regulation. However, it might be 'less efficient' from an airspace usage point of view, as each operation is reserving airspace for its own use. Approach 2), on the contrary, would allow more efficient use of airspace, and tackle any residual risk with the use of tactical deconfliction methods (either a service of remain well clear executed by pilots)
  - During the RTTA discussions in T3.3, the two approaches were considered for the theoretical discussion: Approach 1) named as deterministic, and 2) named as probabilistic. Approach 1) was used to develop the model and simulations.
  - Does any of the above have any impact in the topic of airspace classification or the use or flight rules? Our main topics in this question are related to>
    - the use of the airspace as a resource,
    - the underlying conditions of use of a service (i.e.: tactical deconfliction as a contingency or not),
    - how operations should be conducted (i.e.: having a explicit 4D volume in which operations need to be conductor or having a field of probability)

# 6 Social Acceptance of Urban Air Mobility

This chapter is produced by T3.4 Social Acceptance of Urban Air Mobility. It is a study which purpose is to identify aspects that have an impact on the societal acceptance of the UAM and propose solutions to mitigate those aspects that have a negative impact.

This will lead to make recommendations for the ConOps adaption and to suggest improvements and/or complements to the regulatory framework for filling in the gaps.

## 6.1 Public surveys

The CORUS-XUAM project has undertaken a review of surveys that cover public acceptance of drones with the aim to address public concerns and have mitigation measures in place to facilitate a seamless acceptance of drones in our urban skies. The surveys reviewed are from various organisations (air traffic service providers, industry, research, universities, airspace security agencies) and countries (Australia, Germany, Brazil, USA, China, Korea, etc.), and were conducted between 2015 and 2022, being 2018 the inflection point in which drones were considered for the first time as new entrant vehicles to share urban transport. Below, a summary is provided in chronological order divided in two subsections: before the start of CORUS-XUAM and after it.

### 6.1.1 Till 2020

In 2015, Clothier et al. [113] studied the risk perception and the public acceptance of drones in Australia. The objectives of this study were to investigate whether the public perceives the risks of drones differently to that of conventionally piloted aircraft, to provide guidance for setting safety requirements for drones, and to understand how the terminology used to describe the technology influences how the public perceives the risk. In this research, it was found that that terminology had a minimal effect on public perceptions. However, this may change as more information about the drone technology and risks and benefits of their usage become available to the public.

In 2016, the Office of Inspector General of the United States Postal Service published a report [114] on the public perception of drone delivery in the United States. This report refers to an online survey that was administered, in June 2016, to a sample of 18 to 75 year-old residents in all 50 states and the District of Columbia to understand the current state of public opinion on drone delivery for potential customers. The survey showed, among other things, that most Americans like the concept of drone delivery rather than dislike it, but that many have yet to make up their minds. Different groups have different levels of interest in drone delivery. Drone malfunctions were the main concern of the public, but other concerns included misuse, privacy, potential damage and nuisance.

In 2017, Lidynia et al.[115] conducted a survey of 200 people (laypersons and active drone users) living in Germany about their acceptance and perceived barriers for drones. The survey questions were about the general evaluation of civil drone technology, barriers, demography and further user factors. The survey results show that user diversity strongly influences the acceptance of drones and perceived barriers. Active drone pilots were more concerned by a risk in possible accidents, while lay people were more concerned about the violation of their privacy (the routes that drones should and should not be allowed to use).

In 2018, an online survey from NATS [116] the UK airspace service provider, showed that drone acceptance can range from 45%, when seen as a generic technology tool, to 80%, when they are used in emergency situations.

A deep market study conducted by NASA [117] forecasts that, in the coming years, there will be numerous markets in which drones will have a stake. As a novelty, additional operations, such as passenger transport by unmanned aircraft or 'air taxis', are expected to grow exponentially. Air taxis operations will reduce the travel times of part of the commuting traffic to city centres and contribute to decongesting ground transport by up to 25% . Urban Air Mobility (UAM) is emerging as the new concept for drones' future business. In the US, the concept will later be extended to include also manned electrical vehicles with vertical take-off and landing capabilities, known as eVTOL, under the new term Advanced Air Mobility (AAM). The paper shows the acceptance level goes up to 55% with the development of new safety technologies, the improvement in air flow network and automation of the flights.

In 2019, Airbus also conducted a survey [118] about the public perception of UAM. The Airbus survey covered four cities/countries around the world, Los Angeles, Mexico City, New Zealand, and Switzerland, and collected 1540 responses. Results revealed that 44.5% of respondents supported or strongly supported UAM and that 41.4% of respondents thought UAM was safe to very safe. This suggests that the initial perception of UAM is quite positive.

The same year, a meta-analysis from Legere of former US public surveys [119] and the DLR survey to 832 German citizens [120], showed acceptance levels of 60% and 49% respectively. The meta-analysis focused on the different acceptance levels per mission, with public missions having higher acceptance than private/commercial uses. The German survey provides results about major public concerns. The most important one was the misuse of drones for crime (91%) and the violation of privacy (86%). Both surveys refer to generic (small) drones involved in missions such as police surveillance or search and rescue. In 2020, Tan et al. [121], surveyed in 2020 the opinion of more than $1,000$ citizens from Singapore. Delivery drones and passenger vehicles were considered to have an average acceptance of 62%.

### 6.1.2 From 2021

In 2021, an EASA survey [122] conducted a comprehensive "Study on the societal acceptance of Urban Air Mobiltiy in Europe" and obtained the highest acceptance (83% of the respondents had a positive initial attitude towards UAM, and 71% is ready to try out such service). The UAM proposed was composed of passenger electrical vehicles (manned and unmanned), cargo drones and also surveillance drones (unmanned). Special emphasis was given to the different types of passenger vehicles (manned eVTOL, vectored thrust, lift & cruise and multicopters) and also to concerns related to the environment. Four thousand people from seven different countries (cities of Barcelona, Budapest, Hamburg, Milan, Paris and the cross-border region Öresund) were also requested to respond about safety, security and cybersecurity, environment (including urban wildlife), noise, privacy and infrastructure. Top ten key results are shown in Figure 66.


**Figure 66** - Key results from the EASA survey. Source [EASA2019]

Also, from 2021 three new surveys [123][124][125] focused on analysing the demand for future UAM services as main focus. The questions were addressed to the public as potential customers. Kloss and Riedel [124] surveyed almost 5,000 people from Brazil, China, Germany, India, Poland and the US. Acceptance was measured for different missions (6 using eVTOL and 4 using cargo-drones) and found out that only 27.3% of the people declare willingness to try passenger drones, mostly for commuting, business trips or travels to/from airport). On the contrary, the willingness to use cargo drones paying twice or more as of today was 57.8%.

More positive were the responses from Lundqvist's survey [125]. This survey was conducted among almost 500 people from 5 EU regions (in the Netherlands, England, Spain, Croatia and Poland). Respondents were mainly connected to drone operators or their business. The general positive attitude towards drones was up to approximately 70%. Specific questions about concerns included safety, environment and privacy issues. Finally, Park and Joo's survey [123] was conducted in South Korea to more than 1,000 citizens, plus 44 experts. The willingness to use UAM (both passenger and cargo) was 47%, and decreasing when the automation of the vehicles increased.

Near Dublin there is nowadays a drone company (Manna) performing home deliveries. In parallel to this activity the Dublin City Council published a survey to 902 respondents across all demographics [128]. The rate of positive feelings towards drone technology was very high (84%), with much higher rates (92-97%) when drones are used for public services (emergencies, planning, environment, traffic). Concerns about privacy are still high (75%), and safety and misuse has been declared by half of the respondents. Interestingly 60% felt it would be essential for any member of the public to get information about the purpose/ownership of the drone openly.

In 2022 a new survey polled more than 1,000 Americans statistically representative of the US society [127]. With a different culture than European citizens in remote shopping (an 80% declares to receive packages at home regularly) the survey revealed that 58% of the Americans are in favour of using drones for delivery and are ready to pay more (1 dollar -41%- to more than 10 dollars -18%-). Still, the rate of respondents that prefer drone delivery not to happen is 16%. Almost half of the people declared to be open to purchase a permanent landing pad on their property. Declared concerns were about the possibility to lose or ruin the package content (43%) and to lose the human interaction (19%).

New studies about social acceptance of UAM, but involving less participants are shown below. In [130] 47 persons, generally very interested in technology and having already used drones, participated in an immersive experiment using virtual reality (with helmet-mounted display). The scenario showed a square at the main station of a large city with a high volume of traffic. Five different vehicles were included using virtual reality. Four drones were flying at constant altitude and speed over the city roads. Sounds were realistic and adjusted according to the distance or went completely off. Three different runs were performed with increasing density and flight altitudes (10-15-20-50-100 m). Altitude has a significant effect on feeling comfortable. While at 10 m the comfortability was measured as 5.8 (over 7), at 50 m it was 6.23. In all cases the responses were more positive to higher altitudes. There are no significant differences in flight noise between the scenarios with and without drone sounds. In all cases responses are more negative the more drones were flying.

A second scenario showed an air-taxi in a continuous descent from 200 m to a rooftop. The comfortability of this scenario was (statistically significant) lower than for drones (4.87). Authors suggest that landing zones should be placed not too close to people in order to ensure better acceptance.

Interestingly, the former responses about UAM concerns pointed to the violation of privacy as the major concern, but after the simulation this concern was reduced from 5.49 (over a Likert scale of 7) to 4.89, being still the highest concern. Also, noise had a significant difference before and after (going down from 4.34 to 3.79, the lowest of all the evaluated issues!) Most participants (25%) did not hear drones in the different scenarios. In fact, all concerns were reduced except criminal actions and accidents, pointing that the exposure to drones creates a better perception of UAM (42.6% more positive attitude vs 25% more negative).

A research work evidenced the fact that a user-centred mobile application could increase trust in commercial drone flights used for last-mile delivery and reduce the concerns in terms of safety and privacy [131]. The delivery service is paired with an application for customers and bystanders that allow customers to control how the drones can collect their personal information when entering their private property. An online survey was conducted to 41 users exposed to two different privacy-protected versions of the application. For instance, the app shows a map of the current no-fly-zones, which in one version (high privacy) all properties are automatically but, under user's request can be removed from the no-fly list. Reversely, the second version (more transparency) proposes an opt-out request to add a property to the no-fly list. Responses were clearly in favour of the high privacy version. In respect to the concerns, the most common concerns were the loss of packages due to delivery to the wrong address, injury to bystanders from dropped packages, and damage to property.

In the contest of the ASSURED–UAM project, a technical online survey involving 34 experts with heterogeneous expertise and affiliations (industry, research, citizens, infrastructures, operators) was conducted to explore the expectations about UAM as a potential new element of sustainable urban mobility [129]. An online survey was prepared collecting opinions about benefits, integration, costs, propulsion, safety, security, regulatory and social concerns. Major agreements were achieved in the necessity of: converting existing urban infrastructure to cost-effective UAM infrastructure (partially agreement 62%), cities to issue specific regulation for the use of land (59%), standard methodologies developed for security risk assessment (59%) and that U-Space services shall allow safe integration of pilot UAM services within the cities (partially agreement 59%).

### 6.1.3 Surveys at a glance

In Figure 67, the surveys are shown according to their main focus, such as public acceptance (blue) or market analysis (green). The number of surveys for each year from 2015 to 2021 can be seen on the vertical axis. The different types of drones (surveillance, cargo and passenger) covered by each questionnaire are also indicated by a picture.

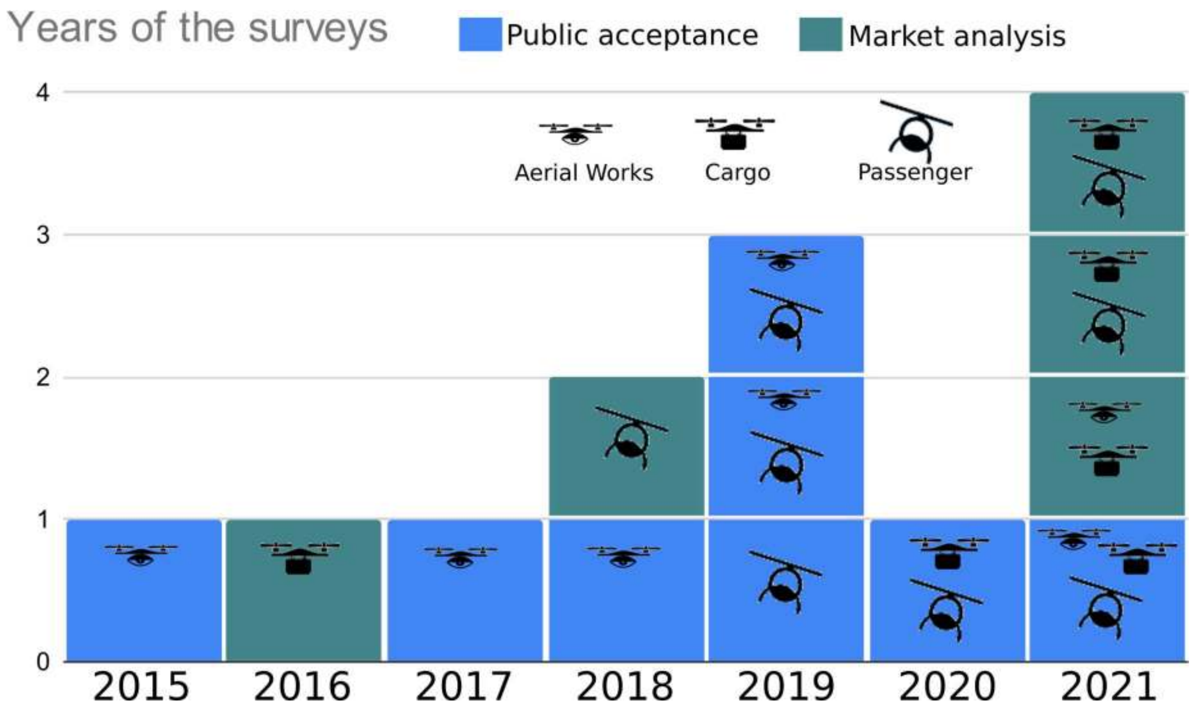


**Figure 67** - Summary of the surveys per year, aim and proposed vehicles

A growing interest in passenger drones can be observed starting from 2018 to 2021. Conversely, the interest in surveillance drones has been decreasing. This may be a reason why privacy concerns have been decreasing over the years in these surveys, while noise and environmental concerns have increased.

As an overall metric, the level of acceptances of drones and of urban air mobility are shown in Figure 68. Each bar represents one survey and they are sorted by years to try to show the trend across time. Again, the colour indicates the focus of the survey, blue for public acceptance and green for market analysis.

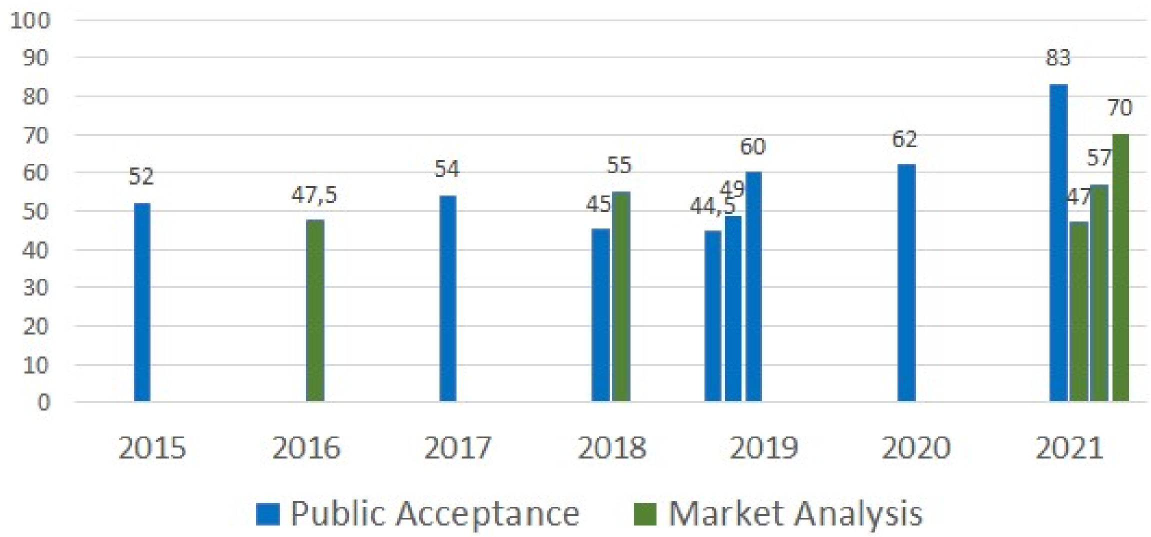


**Figure 68** - Acceptance levels of drones and/or UAM per survey (in %)

Although public opinions vary with time/country, numbers show that between half and three-fourths of the public accepts the deployment of business -related drone operations. As can be seen in the figure, there is not a clear trend over the years on the public acceptance levels. The maximum in six years was 83 %, however, the other surveys of the same year had diverse results.

The way questions are proposed in these surveys partly explains these differences. In the EASA survey, with the highest acceptance value, the question was the *general attitude towards urban air mobility*. In the Park and Joo survey [123], also conducted in 2021, but from a market analysis perspective, the question that obtained 47 % of positive responses were about the *publics' willingness to use UAM in its initial phase*. This diversity on the questions shows how difficult it is to compare survey results.

Surveys, in general, have a first set of questions to classify the public according to their age, gender, and economic status, but also their knowledge about drones, so the answers can be further studied by groups. Typically, females, elders and less educated people have a slightly lower acceptance of drones than the other groups. On the contrary, experts in the field are generally more concerned about safety than laypersons.



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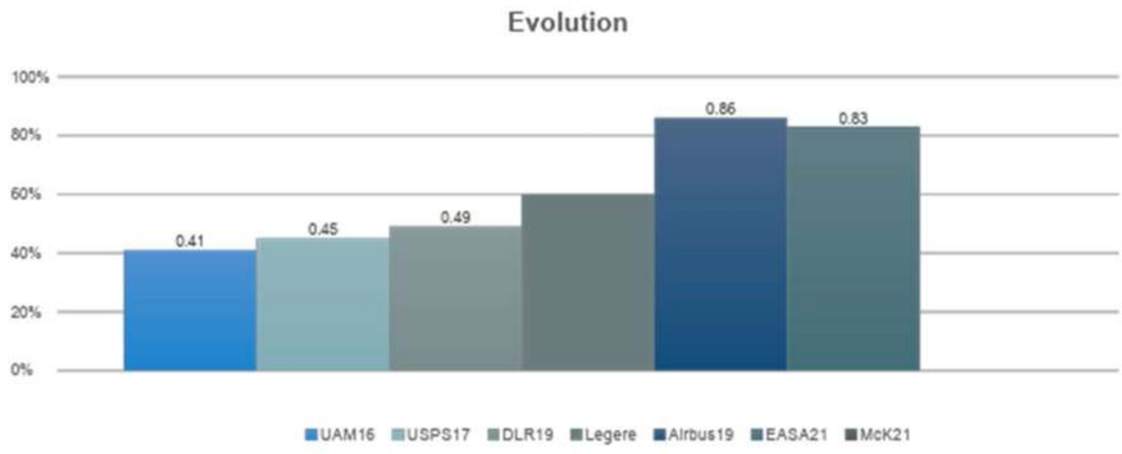


**Figure 69 - Evolution of acceptance over years**

Most surveys are also usually accompanied by a scenario of drone usage, and in the surveys on market studies the scenarios include a forecast about the cost of the services. Many unknowns are yet to be unveiled: Will safety increase or decrease? Will the projected drone service costs/times be achievable? Will drones generate the expected economic growth? For the moment, only predictions can be provided when conducting surveys, whereas the survey results show clearly that the costs of drone services, as well as the time saved, have a high impact on responses. Drone operations related to health and welfare always have a high level of acceptance, while leisure or business related to leisure are always the least accepted drone operations.

In most recent surveys, we found that quantitative data are obtained from the questionnaire responses, while qualitative information is obtained from a set of persons who are interviewed separately, and whose responses are analysed with more detail. Typically, this set of responses, referred to as *experts*, is used to validate and interpret the responses of questionnaires. However, experts' answers usually point towards a positive attitude to drones, as confirmed during the first CORUS-XUAM stakeholder workshop.

This workshop analysed the most critical elements related to UAS/UAM operations along with possible solutions that could enable a sustainable and accepted expansion of drone operations in and around the European cities. In particular, the 5th day of the workshop was dedicated to the analysis of societal impact of drone operations and possible mitigation measures. The responses to the questions in Table 93Table 1 showed a high acceptance rate among the 66 workshop participants, same as happened in the surveys with the experts' answers.

| Options (Multiple Choice) | |
|---|---|
| I am a potential passenger of a taxi-drone | 63 % |
| I am a potential client of a delivery-drone | 89 % |

Table 93. Please check the option(s) that apply/applies to you.

### 6.1.4 Public concerns

In addition to acceptance, most surveys include questions about public concerns, but they do not use an equivalent set of concerns or the same terminology. To highlight this fact, we used word clouds to process the surveys addressing "public concerns" (see Figure 70). In words clouds, the most frequently used terms within a document are displayed in larger font size.

In these word clouds, public concerns related to drone operations are mostly focused on safety, environment, privacy, and noise. Terms such as Animals, Visual, and Waste are classified as an environmental concern, while others such as Risk and Danger are considered as safety concerns. In addition, we see terms related to the economy (e.g., Cost and Liability) or to other topics such as Regulation or Ethics.

Insert project logo here


**Figure 70** - Words clouds highlighting the public concerns on the different surveys

Looking at the evolution over the years the trends are not always clear (see Figure 71). While visual pollution, noise and, to some extent, privacy seem to be becoming a less important issue when UAM takes over other surveillance/country tasks, the perceived safety has not a clear trend.


**Figure 71 -** Evolution of main concerns over the years

In the CORUS-XUAM, the workshop participants were asked to select the top three concerns for them, and the results are shown in Table 94. As most of them came from the aviation sector, it is not surprising to see that the safety concern was selected as the major concern.

| Options (single choice) | |
|---|---|
| Safety / (Cyber)Security | 59% |
| Environmental impact (noise, emissions, visual,...) | 33% |
| Privacy | 9% |

Table 94- Please select which of the three main concerns is most important for you.

It is worth mentioning some specific issues that yield 'Not in my backyard' responses. The location of vertiports is a good example. People are open to the concept, but would not be happy to have one near their home or office.

## 6.2 Societal concerns mitigations proposed to the VLDs

The full list of societal concerns identified by the CORUS-XUAM project is, organised in four main areas, the following:

- **Environment**: Noise impact; Emissions impact, Impacts on animals and flora; Recycling; Impact of Climate change; Visual pollution; Loss of Privacy / Intrusion; Nuisance;
- **Safety**: Safety concerns; Security concerns, Cybersecurity;
- **Fairness**: Lack of Transparency; Cost of services; Competency; Liability;
- **Economy**: Jobs; Economic Viability; Demand.

Since the environmental area has many items, and the noise and privacy are highly mentioned as concerns, we treat noise and privacy separately from the environment. The purpose of this section is analysing each societal concern, while we also hint at possible mitigation measures, especially those applicable to CORUS-XUAM VLDs.

### 6.2.1 List of mitigation actions

The procedure to define the mitigations was produced after several brainstorming sessions: The societal concerns captured in the surveys were analysed. For each concern, we determined possible actions that could help to minimise its negative perception. The result was a list of mitigation measures, in which each item is an individual action. Further analysis showed that many mitigation ideas were useful to more than one concern.

The list mitigations was presented and discussed in the CORUS-XUAM workshop. The majority of the participants felt that it was a good start (details can be seen in Table 95) but it was still incomplete. During the debate, new potential actions were proposed and added to the existing ones. The full list is given in Appendix A.

| **Options (single choice)** | **Split** |
|---|---|
| The list is a good starting point | 85% |
| The list has important omissions | 11% |
| The list is exhaustive and complete | 4% |

Table 95: CORUS-XUAM Workshop responses about the list of mitigations

Once the list of mitigation actions was extended with the participants' contributions, an analysis was performed using the double classification process: first providing a category to each action and then an effort level, as required to implement that action.

In more detail, the analysis started by categorising each mitigation measure according to the scope in which it can be applied. We have established four different scopes or categories as follows:

| **Category** | **Content** |
|---|---|
| Regulation and policy | This category contains the mitigations that should be part of a regulation made by the authorities |

| | |
|---|---|
| Operational and ConOps | This category includes the mitigation measures related to rules and regulations that enable the safe integration of drones with other airspace users |
| Human Response and Metrics | This category relates to mitigation measures that engage the public |
| Tool and Technologies | This category includes mitigation measures that can be built into or used by drones |

Table 96. Categorisation of the mitigations

Figure 72 shows some examples of mitigation for each category. Note that simply rewording slightly a mitigation can move it from one category to another. For instance, "Setting up countermeasures to criminal/illegal use of drones" was categorised under "tools and technologies", but rephrasing it to "Make mandatory the use of countermeasures ..." would have categorised it under "regulation and policy".

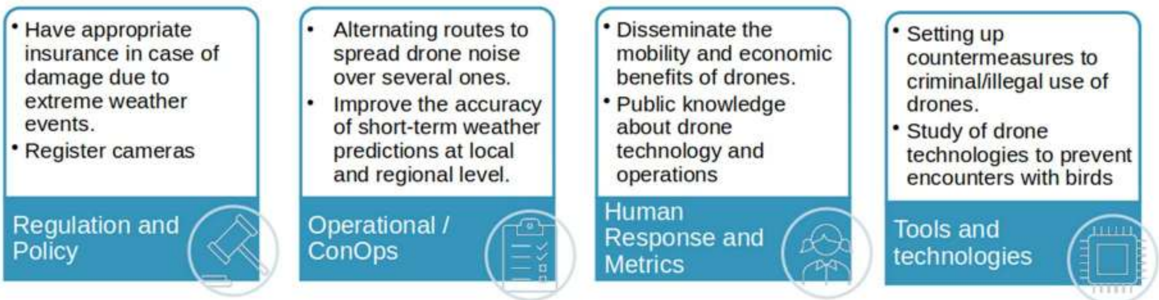


**Figure 72 -** Examples of mitigations by category

In addition to the category, we assigned each mitigation a second classification in three effort levels "easy", "medium", and "difficult", according to its ease of implementation in terms of resources and time. Figure 73 shows a mitigation example for each of the three levels of ease of implementation. For example, the mitigation "Creating an independent authority to investigate accidents / incidents / complaints related to drone operations'' is considered to be difficult to implement at the moment because it requires a high level of agreement between stakeholders. In particular, this mitigation



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measure shall involve regulation bodies, which have to follow a lengthy period of legal procedures. In contrast, the mitigation "Limit minimum altitude" is an operational action that is easy to implement.

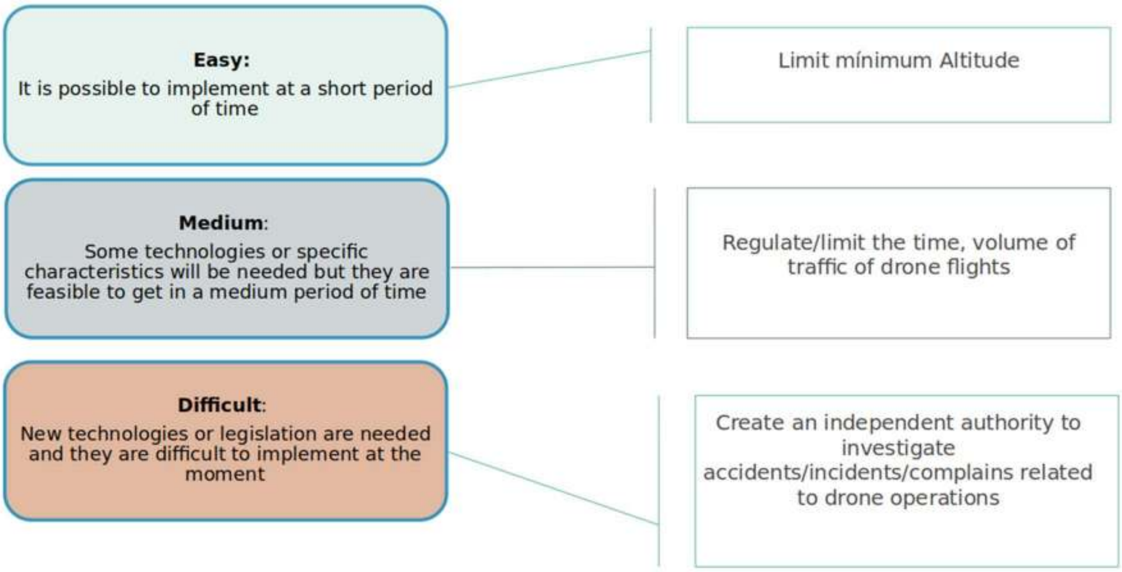


**Figure 73** - Example of mitigations by ease of implementation

Figure 73 gives the split of the proposed mitigations according to their category (a) and to the easiness of implementation (b). While the ease/difficulty of the implementation are quasi-evenly divided, the categories involving regulation are the most proposed actions, but the human response and conops actions represent also more than half of the actions.

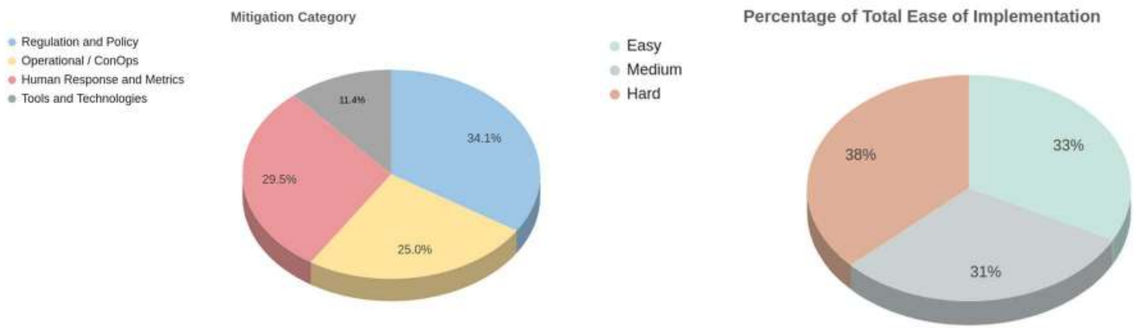


**Figure 74-** Category and Easy of Implementation classifications of the list of mitigations

It can be observed that more than 60% of the mitigation measures are found to be achievable in a short or medium time, either because the necessary applied science exists today or because the required technologies are under development. However, 38% of the mitigation measures are still considered complex to implement, which means that there is still a long way to go in the research and development of new technologies and the regulations that make these mitigations possible.

### 6.2.2 Prioritisation of the mitigation actions

Given the long list of mitigation measures, we proposed a method to rank them from highest to lowest priority. Mitigations were scored using a dynamic table: For each mitigation was scored with a count equal to the number of concerns they were applicable to. The concerns used to score the mitigations were the following 17:

| | | | | |
|---|---|---|---|---|
| Noise | Climate change | Safety | Loss of Privacy / Intrusion | Cost of services |
| Emissions | Visual pollution | Security | Lack of Transparency | Competency |
| Animals & flora | Demand | Cybersecurity | Jobs | Liability |
| Recycling | Economic Viability | | | |

Table 97. Concerns about Urban Air Mobility

The effects of an action can have positive impact against one concern but negative to another, thus in this process a +1 or -1 could be accounted for to each action. For instance, one mitigation that reduces visual impact may have a negative effect on the safety of the surrounding traffic, but at the same time may be neutral for natural life and for privacy.

The total score for a mitigation action is calculated by summing all its scores. For example, the mitigation of "Limit minimum altitude" affects many concerns such as noise, animals & flora, visual pollution, safety, security and loss of privacy at the same time, all in a positive way, thus its final score is +6. This is similar to the process used in the safety operational risk assessment (SORA) methodology [126]. The final sum of the values of a mitigation provides a numerical proxy of the impact of its applicability. The higher the number, the more positive the impact to mitigate societal concerns.

### 6.2.3 Prioritisation of the mitigation actions

Using the process explained above and selecting the items with the highest score, we obtained the top-10 mitigation actions proposed, which are listed in Table 98Table 98.

| **Top 10 mitigation measures** | **Concerns mitigated with this measure** |
|---|---|
| M1 - Limit minimum altitude | Noise impact, Impacts on animals & flora, Visual pollution, Safety Concerns, Security Concerns, Loss of Privacy / Intrusion |
| M2 - Establish no-fly zones for drones | Noise impact, Impacts on animals & flora, Visual pollution, Safety Concerns, Security Concerns, Loss of Privacy / Intrusion |
| M3 - Identify a strategic location for vertiports | Noise impact,Emissions impact, Impacts on animals & flora, Visual pollution, Safety Concerns, Security Concerns |
| M4 - Public knowledge about drone technology and operations | Loss of Privacy / Intrusion, Lack of Transparency, Competency, Economic Viability, Demand |
| M5 - Avoid/limit hovering drone flights | Noise impact, Impacts on animals & flora, Visual pollution, Loss of Privacy / Intrusion |





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| | |
|---|---|
| M6 - Promote the use of renewable energy sources to recharge batteries (Use of SAF[20] for hybrid drones) | Emissions impact, Recycling, Impact of Climate change, Economic Viability, Demand |
| M7 - Ensure proper maintenance processes and controls (for batteries to extend their life cycle) | Emissions impact, Recycling, Impact of Climate change, Safety Concerns |
| M8 - Work with eco-friendly drones (re-cycling parts) | Emissions impact, Recycling, Impact of Climate change, Economic Viability |
| M9 - Ensure that the cost of drone services commensurate | Cost of services, Competency, Jobs, Economic Viability |
| M10 - Developing a risk and safety culture in the drone industry | Competency, Jobs, Economic Viability, Demand |

Table 98. Top-10 mitigations

Figure 75 shows the score and the effort classification of each of these 10 mitigations measures. More than half are easy to implement. The two that are considered the most difficult to achieve today are those related with vehicle construction and maintenance (M7 - Ensure proper maintenance processes and controls for batteries to extend their life cycle and M8 - Work with eco-friendly drones and re-cycling parts). As the drone industry is not yet consolidated, other priorities more related to cost and safety are under consideration now, but in the future, these environmental aspects shall prevail.

[20] Sustainable Aviation Fuels


**Figure 75 -** Top-10 mitigations scores and classification

### 6.2.4 Selected mitigation actions for the VLDs

As a final step, we have selected a new subset of mitigation measures that could be applicable to very large (drone flight) demonstrations (VLDs) being prepared within the CORUS-XUAM project. They were mainly from the Operational/ConOps category, but not exclusively.

VLDs are at the heart of CORUS-XUAM. They demonstratethe integrated operations of UAS/UAM and manned aircraft with the advanced forms of interaction given by the U-space services. Scenarios in urban, sub-urban, and inter-city, as well as in and near ATM-controlled airspace and airports are demonstrated, with focus on different types of missions such as passenger transport, delivery, emergency response, and surveillance. The VLDs use different U-space deployment architectures and state-of-the-art technologies. They take into account the coordination between ATC and U-space, including interaction with ATCOs and pilots. The VLDs will combine eVTOLs flights with other traffic, and operations in the CTRs of major airports.

The mitigation measures proposed for the VLDs are mainly those that can be implemented by the U-space service providers or by other partners involved in the VLD. The following tables are providing the mitigations that we believe are applicable to flight demonstrations of CORUS-XUAM. These mitigations have been grouped according to the areas they influence: flight plan, dissemination and communication actions, vehicle selection and others.

Meetings were held separately with each VLD to discuss the applicability of the proposed list of mitigation measures in advance, during their planning phase.

| Mitigation action | Areas |
|---|---|
| Limit hovering drone flights | noise |
| Fly direct routes to avoid unnecessary path extension and minimise the time in the air | noise, economy, environment |
| Alternating routes to spread drone noise over several ones | noise |
| Limit minimum altitude | privacy, noise |
| Set the speed limits of UAM flights according to the area being crossed | environment, noise |
| Respect no-fly zones for drones | environment, noise |
| Review the urban land use below the flight plan | environment, safety, privacy, security, noise |

Table 99. List of mitigation actions on the **flight plan** design

From this list most VLDs responded that hovering was not foreseen, and in those that planned hovering, its duration was minimised. The flight routes were carefully selected to limit the ground risk and avoid no-flight zones, so in this case the SORA/STS measures were inline with the improvement of societal acceptance. In some VLDs, the no-flight zone was extended to avoid flying over natural areas. Only the Spanish VLD could apply alternative return routes, although the software did not finally take this into account.

The speed and altitude were selected using the vehicle performances and the SORA altitude limits. There were few possibilities to set higher altitudes with current regulation, which is against the societal preference of having higher altitudes for drones.

| Mitigation action | Areas |
|---|---|
| General aviation pilots' engagement in activities about UAM | fairness, safety, economy |
| Public engagement activities about drone technology and operations | transparency |
| Disseminate the environmental benefits of drones and disseminate results (emission savings) | transparency, economy |
| Disseminate the mobility and economic benefits of drones | transparency, economy |

Table 100. List of **dissemination** actions

Few VLDs had the capability to undertake dissemination actions in advance. Most dissemination actions were done at the Open day, after or during the VLD. The main exception is the Swedish VLD that had a great implication of the involved municipalities, with several meetings and attendance of external bodies of the consortium. This was a step forward to UAM acceptance. A summary of the discussion about the societal acceptance meeting held within the Open Day of the Swedish VLD can be found at Appendix B.

With the exception of the consortium representative from AOPA, the general aviation pilots were engaged only when they had to participate in the demonstration. More extensive communication with this group is clearly needed.

| Mitigation action | Areas |
|---|---|
| Work with eco-friendly drones (recycled parts) | environment |
| Study of drone technologies to prevent encounters with birds | environment, economy |
| Measure noise at different altitudes/spots | noise |
| Ensure that electronic devices on drones (cameras, sensors, etc.) cannot be used to infringe on privacy | privacy |
| Limit type/positions of cameras | privacy |

Table 101. List of mitigation actions applicable to **drones**

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Privacy was not an issue in any of the VLDs. Most of the vehicles involved had no camera on board, or were flying in non-highly-populated areas.

Audio recordings were captured and results will be given in section 3.4.

No significant interaction with birds was observed, other than some seagull observing the drones at the beach for several seconds.

No one had reported the use of recycled parts on their vehicles.

| Topic | Mitigation action | Areas |
|---|---|---|
| Vertiport | Identify a strategic location for vertiports | safety, noise, economy |
| Vertiport | Design optimised arrival and departure operations | environment, economy, noise |
| Security | Use different methods (e.g., advance encryption standards or regular cyber-attack tests) to improve the security of communications at the U-space system | (cyber)security |
| Security | Have a U-space service capable of detecting any deviant behaviour of a drone | safety, security |
| Security | Strictly limit the access of third parties to video recordings during and after a drone mission | privacy |

Table 102. List of other mitigation actions

The vertiports selected for the VLDs using eVTOL and fixed-wing aircraft were necessarily taken from existing aerodromes: Pontoise in France, Grottaglie in Italy, and Cochstedt in Germany. Also Swedish VLD was selecting existing aerodromes for its inter-city flight.

When the involved aircraft were small multi-rotor UAS (Spain, Belgium, but also Italy and Paris) there was more flexibility in selecting the vertiport. But as the flights were not to be repeated constantly in a business process, the only reasons for the location was safety.  The same applies to the designed arrival and departure procedures.

Encryption was mainly present in the intra-uas communication (vehicle to ground station), but not in the U-space communications. There was no time to add an additional layer of encryption in many of the VLDs.

CHECK HOW MANY VLDs HAD ENCRIPTION

All VLDs were able to monitor and recognise any drone with a deviant behaviour thanks to the tracking service of the U-space.

## 6.3 Societal Acceptance Questionnaires in CORUS-XUAM

In order to capture the opinion of the people involved and attending to the VLDs a classification of the roles and the major interest was done. According to CORUS-XUAM ConOps Version 3.10 (see chapter 8 on Architecture) the stakeholders that will interact with U-space are the ones shown in the Figure 76:

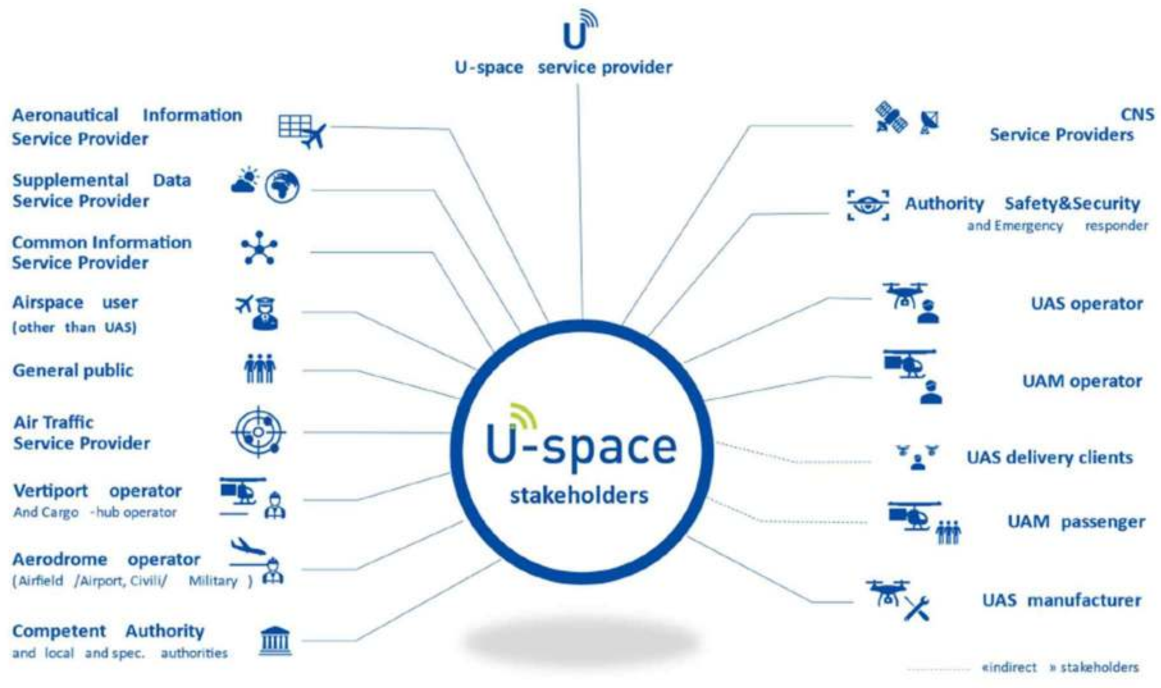


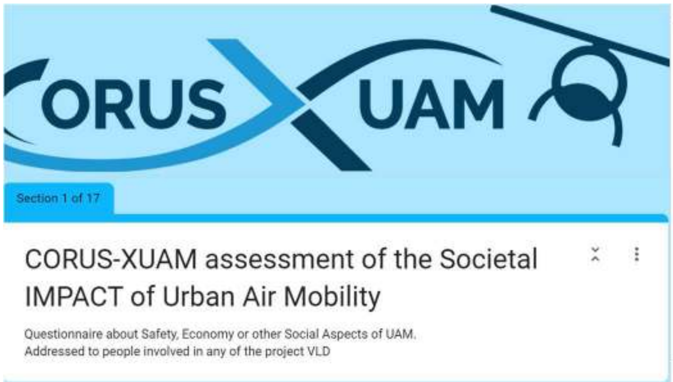

Figure 6: Stakeholders

**Figure 76** U-space ConOps 3.10 stakeholders

For the questionnaires these stakeholders have been aggregated according to their main interests (keep safety standards, obtain economic benefits or improve the quality of citizens' life) in the following profiles:

| Comply with **safety** standards | Obtain **economic** benefits | Improve the quality of citizens' life (**political**) |
|---|---|---|
| Airspace managers<br><br>(Air Traffic service providers,<br><br>Aviation Safety Agencies,<br><br>Aeronautical Information service providers,<br><br>Common Information service provider,<br><br>Airport Operator) | Citizens (as UAS delivery clients / UAM passenger) | Citizens (as general public) |
| Other Airspace Users (pilots) | Drone operators<br><br>(includes also UAM operators) | HEMS (Emergency Responders,<br><br>Law enforcement,<br><br>Medical Urgent Transport) |
| | Drone Industry (includes manufacturer) | Local and regional administrations (includes competent authority) |
| | U-space service providers (includes Supplemental Data service providers,<br><br>Vertiport operators,<br><br>Aerodrome operator,<br><br>CNS service providers) | |

For each one of these profile groups a Questionnaire was proposed. Questionnaires were available online using a unique point of access through the following link. A QR-code was disseminated to facilitate people to access the questionnaire and respond to the questions.




https://forms.gle/byEJMCgU2wkLHXSg8

Taking advantage of the fact that most of the profiles were filled with project partners, two time sets were defined for them: before the VLD and after the VLD. The aim of this duplication is to check the effect of the VLD experience in the opinions.

Ten questionnaires were prepared and distributed to the different profiles. Questions are shown in the following table, organised by KAP and by profile. In the Results subsection the plots show a word to represent the question. To easily make the link between the question and the plot, the selected **word** is highlighted in boldface.

| KPA | Profile | Question (only post-VLD questions are shown) |
|---|---|---|
| - | all | In which VLD have you participated? |
| Safety | Airspace Managers, Agencies, etc. | How do you see the contribution of U-space services in providing **safety** during the VLD now? |
| | | Do you think that the demonstrated U-space services and technologies will promote new aviation safety **standards**? |
| | | How did U-space manage the interaction of drones - **manned** aircraft, if any? |

| | | |
|---|---|---|
| | | How did you find the situational **awareness** provided by U-space about the drones traffic? |
| | | What do you think should be the maximum **elapsed time** from request of a geo-fence till activation? |
| | | If any **ATM** - U-space interaction was proven in the VLD, how did the high-level of **automation** of U-space affect this interaction? |
| Safety | Other Airspace Users | Did U-space services demonstrate their ability to provide **safety** to manned aircraft? |
| | | Can access to the U-space airspace be considered **fair** during the VLD? |
| | | How was the good situational **awareness** provided by U-Space to other airspace users ? |
| | | |

| KPA | Profile | Question (only post-VLD questions are shown) |
|---|---|---|
| Economical | Drone operator<br>UAM operators | How useful did you find U-space? Do you think U-space will help to increment your drone **business**? |
| | | How long in advance (**anticipation**) did you have to notify U-space about your drone flights? |

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| | | |
|---|---|---|
| | | How **flexible** did you find that U-space has been with last minute changes, if any (do not respond if you did not have any change)? |
| | | What has been your experience with the integration of the system that **connected** your drone with the U-space? Was it costly? |
| | | What has been your experience about the need for personnel (or their training -**cost**-) caused by U-space? |
| | | What has your experience of the U-space services in providing **safety** between drones? (do not respond if your drone flight alone) |
| | | What has been your experience of the U-space services in providing advice (**awareness**) to drones about the environment (obstacles, weather)? |
| | | What has been your experience of the U-space in terms of the level of **confidentiality** of your flight? |
| | U-space Service Providers<br><br>Supplemental Data service providers<br><br>Vertiport operators<br><br>Aerodrome operator<br><br>CNS service providers | Which has been your experience about the complexity of **connecting drones** to your USSP system? |
| | | What has been your experience about the complexity of **connecting** your USSP system with other **USSPs** (do not answer if there were no more USSPs)? |

| | | |
|---|---|---|
| | | Which has been your experience about the role of the **CISP** (do not answer if there were no CISP)? |
| | (Other) Drone Industry | How useful did you find U-space for your **business**? |
| | | U-space solutions/systems were added to your products for the VLD. Do you think these solutions/systems will **impact** your business benefits? |

| **KPA** | **Profile** | **Questions** |
|---|---|---|
| Economical | Citizens<br><br>(as UAS delivery clients / UAM passenger) | Do you think that in the near future you may hire a drone service, such as the one being demonstrated today (**client**)? |
| | | How much are you ready to pay for a fast drone service, such as the one being demonstrated today **(service cost**)? |
| | | How many companies offering drone services would you like to have (**competition**)? |
| | | What are your expectations about the cost of flying commercial aircraft? Will there be any change caused by drones and U-space? (**EffectACCost**) |
| | | If you have a **business**: Would you use drones (or U-space) to grow your local business? |
| Political | Citizens | How do you think drones will affect the **natural life** (birds and plants) in urban environments? |

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| | | |
|---|---|---|
| | (as general public) | |
| | | Being mostly electrical powered, will drones help to reduce CO2 **emissions**? |
| | | How did you feel about the perceived **noise** level of the drones during the VLD? |

| KPA | Profile | Questions |
|---|---|---|
| Political | Emergency Responders<br><br>Law enforcement<br><br>Medical urgencies | How do you see drones in helping HEMS (**emergencies**) and other civil services? |
| | | How do you see U-space services in managing (**SafeExecution**) interactions of HEMS and drones? |
| | | Do you think that U-space **geofences** are useful for the safe execution of a priority operation? |
| | | Do you think that U-space provides a good situational **awareness** of other traffic surrounding HEMS ? |
| | | Do you think that U-space improves the **safety perception** of an emergency operation? |
| | | What do you think should be the maximum elapsed **time** from your request of a geofence to its activation in U-space? (**Time2Geofence**) |

| | | |
|---|---|---|
| | | Do you think that the high-level of **automation** of U-space is convenient for emergency tasks? |
| | | Do you think that U-space is treating correctly the level of **confidentiality** of your flight? |
| | Local and Regional Administrations (competent authority) | How does local/regional administration see the deployment of drones in the urban environment?<br><br>(**UrbanDrones**) |
| | | To what extent can drones (and U-space) contribute to improving the provision of local services to citizens? (**useful**) |
| | | How urban air mobility will affect the local administration in terms of administrative **workload**? |
| | | How drones will affect the local administration in terms of **law enforcement**? |
| | | How drones/U-space will affect the local administration in terms of **mobility** surveillance? |

Table 103. List of questions of the social acceptance study

## 6.4 Noise study

ICAO proposes five ways to approach the mitigation of noise annoyance:

1. Reduction of noise at source: new construction technologies, new standards/certification.
2. Operational procedures for noise reduction: limited hovering, optimised procedures, alternating routes.
3. Land use: plan land compatibility, preserve noise sensitive areas.
4. Restrictions: curfews, limits, quotas, nature of flights.

5. Manage community: build tolerance, community engagement, outreach strategy, manage expectations.

Related to the first item above, the current European regulation (EU) 2019/945 [135], to enter into force in January 2023, Part 13 of the annex states "This Part lays down the methods of measurement of airborne noise that shall be used for the determination of the A-weighted sound power levels of UA classes 1, 2 and 3." According to Part 14 these noise measures shall be detailed in the labelling of any unmanned aircraft, given in A-weighted sound power levels in dB. Part 15 provides the limits of noise of drones of classes C1 and C2. Maximum noise limits are set to 85 dB(A) plus some extra noise allowed for vehicles with higher mass, but with maximum decreasing in forthcoming years to 81 dB(A).

PART 15

**Maximum sound power level per class of UA (including transition periods)**

| UA class | MTOM $m$ in gram | Maximum sound power level $L_{WA}$ in dB | | |
|---|---|---|---|---|
| | | as from entry into force | as from 2 years after entry into force | as from 4 years after entry into force |
| C1 | $250 \leq m < 900$ | 85 | 83 | 81 |
| C2 | $900 \leq m < 4\,000$ | $85 + 18{,}5 \lg \frac{m}{900}$ | $83 + 18{,}5 \lg \frac{m}{900}$ | $81 + 18{,}5 \lg \frac{m}{900}$ |

Where 'lg' is the base 10 logarithm.

Table 104 (EU) 2019/945 current noise limits

This tendency to reduce the noise is in accordance with the long-term vision (2050) of ACARE (the Advisory Council for Aviation Research and innovation in Europe) for manned aviation. ACARE proposed, on April 1st 2022, to limit the noise nuisance to the airport perimeter, reaching at 2035 no persons exposed to noise levels (Lden) above 65 dBA. This reduction will be achieved by new operational procedures (continuous descent and noise abatement departures) and by the new technologies.

Noise pressure, in particular db A, is the main indicator used in several experiments such as [122] and [134]. In the EASA study [122] a number of people was participating in an experiment in which several noise sources (helicopter, aircraft, motorbike, bus, drone) at high pressure ($L_{Amax}$,F = 80 dB) were played during 30 seconds. People were requested to provide their level of annoyance, and surprisingly drones were perceived (statistically significant) more annoying (8 over 10) than other vehicles, such as bus (4), motorbike (5) or helicopter (7.2). Reasons reported in the study were related to the familiarity or the noise. Anyway, when the decibels were decreased to 70 and 60, then the level of annoyance of drones reported went down to 6 and 3.5. It is clear that the noise pressure is a very relevant indicator.

A similar experiment is reported in [134] with a number of participants listening to recorded noises during 30 seconds. The noise pressures exposed were 72-73 (low), 78-79 (medium), 86-87 (loud) and (91-92 (very loud) and then requested to respond to a questionnaire about their status. Two new elements were added: a visual imagery of the drone (two different) and the use of a Kansei brain wave analyser. This is a sensor that reads the electromagnetic waves of a human brain and returns the emotional state of the person, classified as stress, concentration, preference, calmness and interest. While the responses were not statistically different between the visualisations, the authors find that some respondents were reporting calm while the sensors said stress. This always happened once the subject had been exposed to a loud sound, previously to the actual exposure under evaluation.

Ivoševic et al. [137] conducted noise measurements of two UAVs of different performance (2.8 Kg quadrotor and 5.6 Kg hexarotor) in flying up and down, hovering, and overflight procedures at one isolated meadow in a large campus of the University of Zagreb. At 50 m distance or less 31 persons, with tested good hearing capabilities, from 21 to 61 years old, listen during 20 minutes each drone and answer a set of questions. Participants declare a generally more negative experience with the hexarotor, which produced higher noise pressure (in $L_{A,max}$ 75.3 dBA), than the quadrotor (70.2 dBA) in outdoor noise measurements at 4.5 metres up-down procedures. These values are both reduced to 72.5 dBA and 65.4 dBA respectively when the flight procedure is cruise at 10 m AGL. The outcomes can be useful for future pilots directly operating the drones during 8 working hours a day. In the case of the hexacopter, in order to stay below the Recommended Exposure Limit (by regulation), the maximum time of operation shall be fixed to 5h40'.

A new document by EASA, currently in public consultation [136] proposes the methodology for specific category operations (low and medium risk, i.e. operations of UAS transporting goods without flying over assemblies of people). The procedures to measure the noise consider level flight (with tests at 50 m of altitude from the recording equipment) and stationary flight (tests at 25 m above measurement point). Environmental conditions, drone mass and speed and recording equipment are detailed and corrections to apply when these can not be met are also given. SUBPART D shall contain the limits of the noise, but this section is still not published. Currently there is no noise limitation level for UAS operating in the specific and the certified categories.

But it is well known that noise propagates in waves that get attenuated with distance. While the interest of the surveillance operation conducted with drones may be to fly as close to the ground as possible if they want to capture more details, the noise impact is less if the flight altitude is high [132]. This same study provides a list of commercial drones and shows the decrease of noise by altitude:

| **DJI Model** | **Mavic Platinum** | **Spark** | **Phantom 4 Pro 2.0** | **Mavic Air** | **Mavic pro** | **Phantom 4 Pro** |
|---|---|---|---|---|---|---|
| Decibels | 70 | 74 | 76.5 | 76 | 79 | 81 |

Number of engines, propellers diameter, rotation speed, blade shape and materials used are the causes for the different values. Also the differences on the exposure level depending on the distance for a Matrice 600 Pro is given in Table 105. As a rule of thumb noise drop-off rate with altitude is -6 dB for every double of distance [132].

| | | | |
|---|---|---|---|
| **Vertical distance (m)** | 20 | 70 | 350 |
| **Horizontal distance (m)** | 15 | 50 | 50 |
| **Decibels** | 74 | 55 | 43 |

Table 105. Decibels of drone by distance

The noise of the drone was previously analysed at different frequencies and different altitudes as seen in the Figure 77:

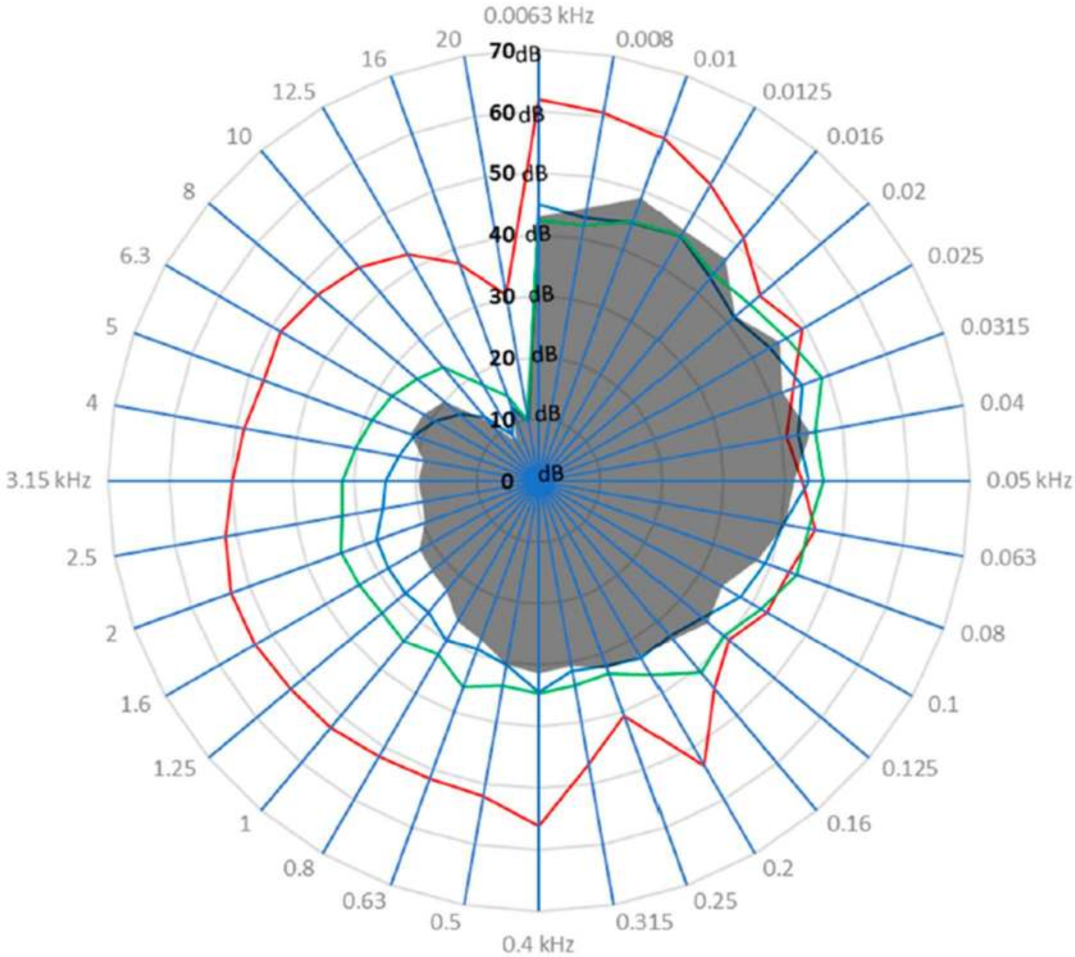


**Figure 77 -** Sound pressure level per frequency of ambient noise and drone noise at different AGL [133]

Observe the importance also of the frequencies of the noise. Ambient noise pressure is almost the same that the drone noise for frequencies 0.02-0.125 KHz, while the lower and especially higher frequencies have much difference with the ambient noise. It is also interesting to see how large the deltas are.

As a general rule, 3dB difference should be audible, 6dB is a significant difference (very perceptible) and 9dB and beyond almost suppresses the lower values entirely because the higher SPL becomes dominant. The grey ambient SPLs are followed closely by the blue line (120m AGL) up to about 0.5 kHz beyond which they start to diverge. The 2kHz octave band (1.6-2.5 kHz values) carries a delta of circa 5-10dB. This would suggest high perceptibility of the UAS noise.

The proximity and even inversion of the SPLs of the UAS noise measurements (Red-Blue-Green lines) between 0.025 kHz and 0.125 kHz is quite intriguing. Considering the fact that the grey area most likely represents a quiet neighbourhood, it could be assumed that the drone noise in that frequency range would be masked to a large extent by the ambient noise levels, regardless of the AGL level of the drone.

To be able to put these numbers in context, Table 106 shows a comprehensive description of the decibel measures.

| LEVEL IN DECIBELS | EVERYDAY EXAMPLE |
|---|---|
| 110dB+ | Jet engine at about 100m |
| 100dB | Jackhammer (pneumatic drill) at close range |
| 80dB+ | Loud highway noise at close range |
| 70dB+ | Louder traffic |
| 60dB | Quiet traffic noise. |
| 50dB | Louder conversation. |
| 40dB | Quiet conversation. |
| 30dB | Birds flying by. |
| 20dB | Watch ticking. |
| 10dB | Rustling or falling leaves. |

Table 106. Decibels (dBA) in context

In general, a rural area is exposed to 45 dB (35 dB at night), a suburban area to 55 dB (45 dB at night) and a city centre to 65 dB (55 dB at night).

But in addition to the noise acoustic factors, Vascik and Hansman [Vascik2018] mention 4 other types of noise annoyance sources, named as non-acoutics factors, that produce "virtual noise". They justify why a noise with a given acoustic factor can create different annoyance levels. An ease example is the day/night time of the noise. The four types are situational, community, privacy and secondary factors. The example day/night, together with day of the week, weather, ambient noise and noise insulation are situational factors. Within the community factors we have demographic aspects, such as income or age, attitude factors, such as familiarity, fear or prognosis about the near future evolution, and personal traits such as individual noise sensitivity or perception of fairness. The privacy factor occurs when the individual's discomfort, given by the aircraft proximity, accentuates the noise annoyance. Examples of privacy factors are the number of times an aircraft flies close to the person, the duration of the noise perception and the altitude of the aircraft. Finally the secondary factors refer to non-auditory sensory events produced by noise. An example is the vibrations that the low-frequencies of the noise of an aircraft can produce in the windows on a house. Dust, shadows or pollution are other known secondary factors that affect civil aviation, although these factors are not probably relevant for future UAM vehicles if they are electric powered.

The effects in quiet areas, such as natural parks and wildlife, are studied by [133]. Authors perform several experiments exposing megafauna from a zoo to drone noise without direct vision between both. Eighteen different species were analysed with a drone flying at 120 m AGL and descending, while a hidden observer taking notes of the first animal behaviour change. The study compared not only the decibels, but also the frequencies involved and the animals audiogram (the range of frequencies that species can listen to), when known. The paper also refers to the visual acuity of these animals, being in general 70%-80% below the humans. The study showed that no animal was reacting with 120 m ALG and the range of reactions started from 100 m (Asian elephant and giraffe) to 40 m (felines). It concludes that surveillance operations using drones should fly at heights from 100 m to 180 m to avoid possible disturbances to natural life. In general disturbances were created by high frequencies according to the audiogram of the animals.

In the urban areas a key element is the identification of the strategic locations for vertiports. Same applies to the design of the airspace. As far as we know there is little work addressing these issues from the societal acceptance perspective. For example, the Metropolis and Metropolis2 SESAR projects have been proposing different airspace structures but the main indicators used where in reference to air safety and flight efficiency.

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# 7 References, Glossary, Acronyms

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## 7.2 Glossary of terms

| Term | Definition | Source of the definition |
| --- | --- | --- |
| UAM Operator | | |

| Term | Definition | Source of the definition |
|---|---|---|
| Aerial work | ''aerial work' means an aircraft operation in which an aircraft is used for specialised services such as agriculture, construction, photography, surveying, observation and patrol, search and rescue, aerial advertisement, etc… | To be approved by CORUS X |
| Aerodrome | 'aerodrome' means a defined area, on land or on water, on a fixed, fixed offshore or floating structure, including any buildings, installations and equipment thereon, intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft; | Regulation (EU) 2018/1139 (Basic Regulation) [10] |
| Aerodrome traffic circuit | 'Aerodrome traffic circuit' means the specified path to be flown by aircraft operating in the vicinity of an aerodrome; | SERA [13] |
| Aeronautical information | 'Aeronautical information' means information resulting from the assembly, analysis and formatting of aeronautical data; | Regulation (EU) 2017/373 [11] |
| Air Traffic Control | 'Air traffic control (ATC) service' means a service provided for the purpose of: (a) preventing collisions:<br>— between aircraft, and<br>— in the manoeuvring area between aircraft and obstructions; and (b) expediting and maintaining an orderly flow of air traffic; | COMMISSION REGULATION (EU) 2015/340 (air traffic controllers' licences) [12] |
| Airborne collision | (Risk area) a collision between aircraft while both aircraft are airborne; or between aircraft and other airborne objects (excluding birds and wildlife); | Regulation (EC) 2020/2034 [14] |

| Term | Definition | Source of the definition |
|---|---|---|
| Aircraft upset | (Risk area) an undesired aircraft state characterised by unintentional divergences from parameters normally experienced during operations, which might ultimately lead to an uncontrolled impact with terrain; | Regulation (EC) 2020/2034 [14] |
| Taxiing | "The aircraft is moving on or above the vertiport surface under its own power prior to take-off or after landing. Taxiing is a phase of the flight" | EUROCAE ED-293 |
| Ground taxiing | "Movement of a wheeled VTOL aircraft for taxiing on a surface of a vertiport" | EUROCAE ED-293 |
| Ground movement | "The movement of the aircraft on the vertiport surface not under its own power prior take-off or after landing by hand or with the assistance of ground movement equipment. Ground movement is not part of the flight" | EUROCAE ED-293 |
| Alternate Aerodrome | "An aerodrome to which an aircraft may proceed when it becomes either impossible or inadvisable to proceed to or to land at the aerodrome of intended landing where the necessary services and facilities are available, where aircraft performance requirements can be met, and which is operational at the expected time of use" | ICAO Annex 6 Part 1 [15] |
| Alternate vertiports | Alternate Vertiport - in addition to 'main vertiports', identified along the route by VTOL Operator (prior to flight) for cases of diversion landings. Two types of alternate vertiports: en route and destination vertiport. Emergency landing is not pre-planned, could be anywhere. | I thought it was already part of the SC VTOL AMC/GM but I cannot find the doc on the internet anymore… |

| Term | Definition | Source of the definition |
|---|---|---|
| Alternate vs. emergency | Alternate Vertiport - in addition to 'main vertiports', identified along the route by VTOL Operator (prior to flight) for cases of diversion landings. Two types of alternate vertiports: en route and destination vertiport. Emergency landing is not pre-planned, could be anywhere. | To be approved by CORUS X |
| ATM services | 'Air traffic management' means the aggregation of the airborne and ground-based functions (air traffic services, airspace management and air traffic flow management) required to ensure the safe and efficient movement of aircraft during all phases of operations; | REGULATION (EC) No 549/2004 [16] |
| ATM system | 'ATM/ANS system' means the aggregation of airborne and ground-based constituents, as well as space-based equipment, that provides support for air navigation services for all phases of flight; | Regulation (EU) 2018/1139 (Basic Regulation) [10] |

| Term | Definition | Source of the definition |
|---|---|---|
| ATM/ANS | 'ATM/ANS' means air traffic management and air navigation services and covers all of the following: the air traffic management functions and services as defined in point (10) of Article 2 of Regulation (EC) No 549/2004; the air navigation services as defined in point (4) of Article 2 of that Regulation, including the network management functions and services referred to in Article 6 of Regulation (EC) No 551/2004, as well as services which augment signals emitted by satellites of core constellations of GNSS for the purpose of air navigation; flight procedures design; and services consisting in the origination and processing of data and the formatting and delivering of data to general air traffic for the purpose of air navigation; | Regulation (EU) 2018/1139 (Basic Regulation) [10] |
| Autonomous operation | 'Autonomous operation' means an operation during which an unmanned aircraft operates without the remote pilot being able to intervene; (source: Regulation (EU) 2019/947)<br><br>An autonomous operation should not be confused with an automatic operation, which refers to an operation following pre-programmed instructions that the UAS executes while the remote pilot is able to intervene at any time (source: GM1 to Article 2(17) of Regulation (EU) 2019/947). | Regulation (EU) 2019/947 [17] and its AMC&GM [18] |

| Term | Definition | Source of the definition |
|---|---|---|
| BRLOS | Beyond Radio Line Of Sight - refers to any configuration in which the transmitters and receivers are not in RLOS. BRLOS thus includes all satellite systems and possibly any system where an RPS communicates with one or more ground stations via a terrestrial network which cannot complete transmissions in a timeframe comparable to that of an RLOS system. | Doc 10019 Edition 2015 [20] |
| BVLOS | Beyond Visual Line Of Sight - is an operation in which the RPA is flown beyond a range where a remote pilot or RPA observer can maintain direct unaided visual contact with the remotely piloted aircraft and the remote pilot in command is using on-board sensors and data to capture, transmit, and use flight parameters throughout the flight mission to ensure safety of flight. | Doc 10019 [20] |
| C2 | Command and Control Link: The data link between the remotely piloted aircraft and the remote pilot station for the purposes of managing the flight. | Doc 10019 [20] |
| Collision on runway | (Risk area) a collision between an aircraft and another object (other aircraft, vehicles, etc.) or person that occurs on a runway of an aerodrome or other predesignated landing area. It does not include collisions with birds or wildlife; | Regulation (EC) 2020/2034 [14] |
| Concept of operation | A Concept of Operations (ConOps) is a user-oriented document that "describes systems characteristics for a proposed system from a user's perspective. | MITRE (Systems Engineering Guide) |

| Term | Definition | Source of the definition |
|---|---|---|
| Congested area | ''congested area' means in relation to a city, town or settlement, any area which is substantially used for residential, commercial or recreational purposes'<br>Aerial operations in congested areas for civil purposes, below certain heights, are today not permitted (refer to SERA.3105 and SERA.005(f)). | Regulation (EU) 965/2012 [21] |
| Contingency procedure | The contingency procedure describes action(s) that the (remote pilot) will engage and the future behaviour of the aircraft in case of one or several system(s) failure(s) which do(es) not put safety at risk at the moment it occurs. | To be approved by CORUS X |
| Controlled airspace | 'Controlled airspace' means an airspace of defined dimensions within which air traffic control service is provided in accordance with the airspace classification; | SERA [13] |
| Cooperative UAS | U-space and UTM-systems fundamentally deal with cooperative UAS, which are UAS that, at appropriate times, submit an operational plan, emit remote identification signals, submit reports of their position to U-Space, and so on. | Definition within the U-space Document "U-space Concept of Operations" from 25.10.2019 (Page 52) |
| DAA | Detect and avoid: The capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action. | Doc 10019 [20] - JARUS AMC RPAS |
| Door2door | Door-to-door is a shipping service where the parcel is collected at the designated address and delivered directly to the destination selected. For UAM, this could be extended to passenger transportation | To be approved by CORUS X |

| Term | Definition | Source of the definition |
|---|---|---|
| Emergency procedure | Emergency procedure is the procedure put in place when safety is at risk. The procedure describes immediate action(s) that the (remote) pilot will engage and future behaviour of the aircraft. The emergency procedure could follow a contingency procedure if the latter was not sufficient. | To be approved by CORUS X |
| eVTOL | Electric Vertical Take Off and Landing - said for an aircraft, powered electrically, which is not a helicopter, able to take-off and land vertically. | |
| excursion | (Risk area) an occurrence when an aircraft leaves the runway or movement area of an aerodrome or landing surface of any other predesignated landing area, without getting airborne. It includes high-impact vertical landings for rotorcraft or vertical take-off and landing aircraft and balloons or airships; | Regulation (EC) 2020/2034 [14] |
| fire, smoke and pressure | (Risk area) an occurrence involving cases of fire, smoke, fumes or pressurisation situations that may become incompatible with human life. This includes occurrences involving fire, smoke or fumes affecting any part of an aircraft, in flight or on the ground, which is not the result of impact or malicious acts. | Regulation (EC) 2020/2034 [14] |
| ground damage | (Risk area) damage to aircraft induced by operation of aircraft on ground on any other ground area than a runway or predesignated landing area, as well as damage during maintenance. | Regulation (EC) 2020/2034 [14] |
| HEMS | Helicopter Emergency Medical Services | |
| IFR | ‘IFR’ means the symbol used to designate the instrument flight rules; | SERA [13] |

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| Term | Definition | Source of the definition |
|---|---|---|
| IMC | 'Instrument meteorological conditions (IMC)' mean meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling, less than the minima specified for visual meteorological conditions. | SERA [13] |
| No fly zones (NFZ) | No Drone Zone: UAS are totally prohibited in this volume unless granted special authorisation (e.g., government UAS)<br><br>Link to Geographical zone, article 15 of UAS regulation<br>When defining UAS geographical zones for safety, security, privacy or environmental reasons, Member States may:<br>(a) prohibit certain or all UAS operations, request particular conditions for certain or all UAS | In U-space they are referring to a "No Drone Zone" |
| Obstacle collision in flight | (Risk area) collision between an airborne aircraft and obstacles rising from the surface of the earth. Obstacles include tall buildings, trees, power cables, telegraph wires and antennae as well as tethered objects; | Regulation (EC) 2020/2034 [14] |
| Operational framework | The operational framework is the description of the technical, procedural, physical and regulatory working environments. | To be validated or improved by CORUS X partners. |
| Other injuries | (Risk area) an occurrence where fatal or non-fatal injuries have been inflicted, which cannot be attributed to any other key risk area; | Regulation (EC) 2020/2034 [14] |
| Populated area | 'Populated area' means an area with clustered or scattered buildings and a permanent human population, such as city, settlement, town, or village; | Regulation (EU) 2020/2034 [14] |

| Term | Definition | Source of the definition |
|---|---|---|
| Remote pilot | 'Remote pilot' means a natural person responsible for safely conducting the flight of an unmanned aircraft by operating its flight controls, either manually or, when the unmanned aircraft flies automatically, by monitoring its course and remaining able to intervene and change the course at any time; | Regulation (EU) 2018/1139 (Basic Regulation) [10] |
| RLOS | Radio Line Of Sight - refers to the situation in which the transmitter(s) and receiver(s) are within mutual radio link coverage and thus able to communicate directly or through a ground network provided that the remote transmitter has RLOS to the RPA and transmissions are completed in a comparable timeframe. | Doc 10019 Edition 2015 [20] |
| RP | Remote Pilot: A person charged by the operator with duties essential to the operation of a remotely piloted aircraft and who manipulates the flight controls, as appropriate, during flight time. | Doc 10019 [20] |
| RPA | Remotely Piloted Aircraft: An unmanned aircraft which is piloted from a remote pilot station. | Doc 10019 [20] |
| RPAS | Remotely Piloted Aircraft System: A remotely piloted aircraft, its associated remote pilot station(s), the required C2 Link and any other components as specified in the type design. | Doc 10019 [20] |
| RPS | Remote Pilot Station: The component of the remotely piloted aircraft system containing the equipment used to pilot the remotely piloted aircraft. | Doc 10019 [20] |
| Rural | "An area with widely scattered development and low density of housing and employment" | American Highway Capacity Manual (HCM) / Alternative: NatGeo |





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| Term | Definition | Source of the definition |
|---|---|---|
| Security | (Risk area) an occurrence where fatal or non-fatal injuries have been inflicted, which cannot be attributed to any other key risk area; | Regulation (EC) 2020/2034 [14] |
| U-space services | U-space service' means a service relying on digital services and automation of functions designed to support safe, secure and efficient access to U-space airspace for a large number of UAS | Regulation (EU) 2021/664 [23] |
| Special VFR | 'Special VFR flight' means a VFR flight cleared by air traffic control to operate within a control zone in meteorological conditions below VMC; | SERA [13] |
| Suburban | "An area with mixture of densities for housing and employment, where high-density non-residential development is intended to serve the local community". | American Highway Capacity Manual (HCM) / Alternative: NatGeo |
| Terrain collision | (Risk area) an occurrence where an airborne aircraft collides with terrain, without indication that the flight crew was unable to control the aircraft. It includes instances when the flight crew is affected by visual illusions or degraded visual environment; | Regulation (EC) 2020/2034 [14] |
| UAM | UAM covers passenger and cargo flights operated in densely populated areas, including air taxis, delivery drones, remotely piloted and autonomous operations. | Airbus Blueprint for the sky, 2018 [24] |
| | Urban Air Mobility (UAM) is an industry term used to describe a system that enables on-demand, highly automated, passenger- or cargo-carrying air transportation services. | MITRE, Urban Air Mobility Airspace Integration Concepts, 2019 [25] |

*Insert project logo here*

| Term | Definition | Source of the definition |
|---|---|---|
| | The transport of people or goods from one aerodrome to another using UAM Corridors (UAM operation). | FAA, NASA UAM Conops v.1, 2020 [26] |
| | UAM vehicles - primarily eVTOLs. First with pilot on board, then remote pilot. For carriage of passengers or cargo. | EmbraerX ConOps [27] |
| UAM Aerodrome | UAM aerodrome – a location from which UAM flight operations depart or arrive. The use of “UAM aerodrome” and “aerodrome” in this ConOps are synonymous. “UAM aerodrome” is used explicitly when the context indicates functionality to support UAM operations that is not present in current NAS operations. | Concept of Operations Urban Air Mobility (FAA) |
| UAM operation | UAM Operations are operations with unmanned aircraft in an urban environment. | To be approved by CORUS X |
| UAM vehicle | An aircraft involved in a UAM operation | To be approved by CORUS X |
| UAS | Unmanned Aircraft System: An aircraft and its associated elements which are operated with no pilot on board. | Doc 10019 |
| UAS | unmanned aircraft system' (UAS) means an unmanned aircraft and the equipment to control it remotely | EU 2019/947 |
| UFR | “U-space Flight Rules” are rules of the air that would be applicable to any aircraft wishing to fly in a U-space volume. | to be approved by CORUS X |
| Unmanned Aircraft | ‘Unmanned aircraft’ means any aircraft operating or designed to operate autonomously or to be piloted remotely without a pilot on board; | Regulation (EU) 2018/1139 (Basic Regulation) |
| Urban | "An area typified by high densities of development or concentrations of population, drawing people from several areas within a region" | American Highway Capacity Manual (HCM) / Alternative: NatGeo |



EUROPEAN PARTNERSHIP

Co-funded by the European Union

| Term | Definition | Source of the definition |
|---|---|---|
| USSP | U-Space Service Provider | EASA |
| Vertiport | 'vertiport' means an area of land, water, or structure used or intended to be used for the landing | Special Conditions VTOL (EASA) |
| VFR | 'VFR' means the symbol used to designate the visual flight rules; | SERA |
| VLOS | Visual Line of Sight operation: An operation in which the remote pilot or RPA observer maintains direct unaided visual contact with the remotely piloted aircraft. | Doc 10019 |
| VMC | 'Visual meteorological conditions' mean meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling, equal to or better than specified minima; | SERA |
| VTOL | Vertical Take Off and Landing - said for an aircraft, which is not a helicopter, able to take-off and land vertically. | To be approved by CORUS X |
| Air Traffic Services | "Air traffic services' means the various flight information services, alerting services, air traffic advisory services and ATC services (area, approach and aerodrome control services). | REGULATION (EC) No 549/2004 |

**Table 107: Glossary of terms**

## 7.3 List of Acronyms and abbreviations

| Acronym | Definition |
|---|---|
| **ACAS** | Airborne Collision Avoidance System |
| **ACAS Xu** | Airborne collision Avoidance System X – the successor to TCAS II Xu – designed for UAV (specifically RPAS) |
| **ADS-B** | Automatic Dependent Surveillance - Broadcast |
| **AESA** | Agencia Estatal de Seguridad Aérea (Spanish NAA) |

| | |
|---|---|
| **AFIS** | Aerodrome Flight Information Service |
| **AGL** | Above Ground Level |
| **AMC** | Acceptable Means of Compliance |
| **AMSL** | Above Medium Sea Level |
| **AMULED** | Air Mobility Urban - Large Experimentation Demonstrations |
| **ANSP** | Air Navigation Service Provider |
| **ARC** | Air Risk Class |
| **ATC** | Air Traffic Control |
| **ATM** | Air Traffic Management |
| **ATS** | Air Traffic Services |
| **ATSP** | Air Traffic Service Provider |
| **ATZ** | Air Traffic Zone |
| **BRLOS** | Beyond Radio Line Of Sight |
| **BVLOS** | Beyond Visual Line Of Sight |
| **C2 link** | Command & Control link |
| **CARS** | Common Altitude Reference System |
| **CBD** | Central Business Districts |
| **CFR** | Code of Federal Regulations |
| **CIS** | Common Information Service |
| **CISP** | Common Information Service Provider |
| **CNS** | Communication Navigation and Surveillance |
| **ConOps** | Concept of Operations |

| | |
|---|---|
| **CORUS** | Concept of Operation for EuRopean UTM Systems |
| **CSFL** | Continued Safe Flight and Landing |
| **CTR** | Controlled Traffic Region |
| **CWP** | Controller Working Position |
| **DAA** | Detect And Avoid |
| **DAC** | Dynamic Airspace Configuration |
| **DACUS** | Demand And Capacity Optimisation in U-space |
| **DCB** | Demand and Capacity Balancing |
| **DFS** | Deutsche Flugsicherung GmbH |
| **DSNA** | Direction des Services de la Navigation Aérienne (french ANSP) |
| **EASA** | European Aviation Safety Agency |
| **EU** | European Union |
| **EATMA** | European ATM Architecture |
| **ETRS89** | European Terrestrial Reference System 1989 |
| **eVTOL** | Electric Vertical Take-off and Landing |
| **FAA** | Federal Aviation Administration |
| **FAR** | Federal Aviation Rules |
| **FATO** | Final Approach and Take-off Area |
| **FDPS** | Flight Data Processing System |
| **FIS** | Flight Information Service |
| **FLARM** | Flight AlARM |
| **FPV** | First Person View |

| | |
|---|---|
| **Ft** | Feet |
| **GM** | Guidance Material |
| **GME** | Ground Movement Equipement |
| **GNSS** | Global Navigation Satellite System |
| **GPS** | Global Positioning System |
| **GRC** | Ground Risk Class |
| **GSM LTE 5G** | Global System for Mobile Long-Term Evolution 5G |
| **HEMS** | Helicopter Emergency Medical Services |
| **ICAO** | International Civil Aviation Organization |
| **IFR** | Instrument Flight Rules |
| **JARUS** | Joint Authorities for Rulemaking of Unmanned Systems |
| **KJ** | Kilo Joules |
| **KTAS** | Knots True AirSpeed |
| **LAANC** | Low Altitude Authorization and Notification Capability |
| **Lb** | Libra |
| **LBA** | Luftfahrt-Bundesamt |
| **LUC** | Light UAS operator Certificate |
| **Maas** | Mobility as a Service |
| **MSDF** | Multi Sensor Data Fusion |
| **MTCD** | Medium Term Conflict Detection |
| **MTOM** | Maximum Take-Off Mass |
| **NASA** | National Air and Space Administration |

| | |
|---|---|
| **NM** | Network Manager |
| **NOTAM** | NOtice To AirMen |
| **NPRM** | Notice of proposed rulemaking |
| **OSO** | Operational Safety Objectives |
| **PAV** | Personal Air Vehicles |
| **POBA** | Pilot On-board Aircraft |
| **RLOS** | Radio Line Of Sight |
| **RP** | Remote Pilot |
| **RPAS** | Remotely Piloted Aircraft System |
| **RPS** | Remote Pilot Station |
| **RTK** | Real-time kinematic |
| **RTTA** | Reasonable Time to Act |
| **SAIL** | Specific Assurance and Integrity Levels |
| **SAR** | Search And Rescue |
| **SDSP** | Supplemental Data Service Provider |
| **SERA** | Standardised European Rules of the Air |
| **SESAR** | Single European Sky ATM Research Programme |
| **SJU** | SESAR Joint Undertaking (Agency of the European Commission) |
| **SMGCS / A-SMGCS** | Surface Movement Guidance and Control System / Advanced Surface Movement Guidance and Control System |
| **SORA** | Specific Operations Risk Assessment |
| **STCA** | Short Term Conflict Alerting |
| **STOL** | Short Take-off and Landing |

| | |
|---|---|
| **STS** | STandard Scenario |
| **SUMP - UAM** | Sustainable Urban Mobility Plan/Policy – Urban Air Mobility |
| **SVFR** | Special Visual Flight Rules |
| **TCAS II** | Traffic Collision Avoidance System version II, an ACAS implemention |
| **TLOF** | Touch-Down and Lift-Off |
| **TMPR** | Tactical Mitigation Performance Requirement |
| **TOLA** | Touchdown and Lift off Area |
| **U1, U2, U3, U4** | U-space service level |
| **UA** | Unmanned Aircraft |
| **UAM** | Urban Air Mobility |
| **UAS** | Unmanned Aircraft System |
| **UAV** | Unmanned Aerial Vehicle |
| **UC** | Use Case |
| **UFR** | U-space Flight Rules |
| **UML** | UAM Maturity Level |
| **UMZ** | U-space Mandatory Zone |
| **USSP** | U-space Service Provider |
| **UTM** | UAS Traffic Management |
| **V2V** | Vehicle to Vehicle |
| **VFR** | Visual Flight Rules |
| **VLD** | Very Large Demonstrator |
| **VLL** | Very Low Level |

| | |
|---|---|
| **VLOS** | Visual Line Of Sight |
| **VMC** | Visual Meteorological Conditions |
| **VO** | Visual Observer |
| **VTOL** | Vertical Take-off and Landing |
| V-TZ | Vertiport Traffic Zone |
| **WG** | Working Group |
| **WGS84** | World Geodetic System, revision 84 |

| Acronym | Definition |
|---|---|
| **ACAS** | Airborne Collision Avoidance System |
| **ACAS Xu** | Airborne collision Avoidance System X – the successor to TCAS II Xu – designed for UAV (specifically RPAS) |
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| **AFIS** | Aerodrome Flight Information Service |
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| | |
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| **BRLOS** | Beyond Radio Line Of Sight |
| **BVLOS** | Beyond Visual Line Of Sight |
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| **CFR** | Code of Federal Regulations |
| **CIS** | Common Information Service |
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| **CNS** | Communication Navigation and Surveillance |
| **ConOps** | Concept of Operations |
| **CORUS** | Concept of Operation for EuRopean UTM Systems |
| **CTR** | Controlled Traffic Region |
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| **DAA** | Detect And Avoid |
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| **KTAS** | Knots True AirSpeed |
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| **Lb** | Libra |
| **LBA** | Luftfahrt-Bundesamt |
| **LUC** | Light UAS operator Certificate |
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| **MTOM** | Maximum Take-Off Mass |
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| **NM** | Network Manager |
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| **PAV** | Personal Air Vehicles |
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| **RPAS** | Remotely Piloted Aircraft System |

| | |
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| **RTK** | Real-time kinematic |
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| **TMPR** | Tactical Mitigation Performance Requirement |
| **TOLA** | Take-off and Landing Areas |
| **U1, U2, U3, U4** | U-space service level |
| **UAM** | Urban Air Mobility |
| **UAS** | Unmanned Aircraft System |
| **UAV** | Unmanned Aerial Vehicle |
| **UFR** | U-space Flight Rules |
| **USSP** | U-space Service Provider |
| **UTM** | UAS Traffic Management |
| **V2V** | Vehicle to Vehicle |
| **VFR** | Visual Flight Rules |
| **VLL** | Very Low Level |
| **VLOS** | Visual Line Of Sight |

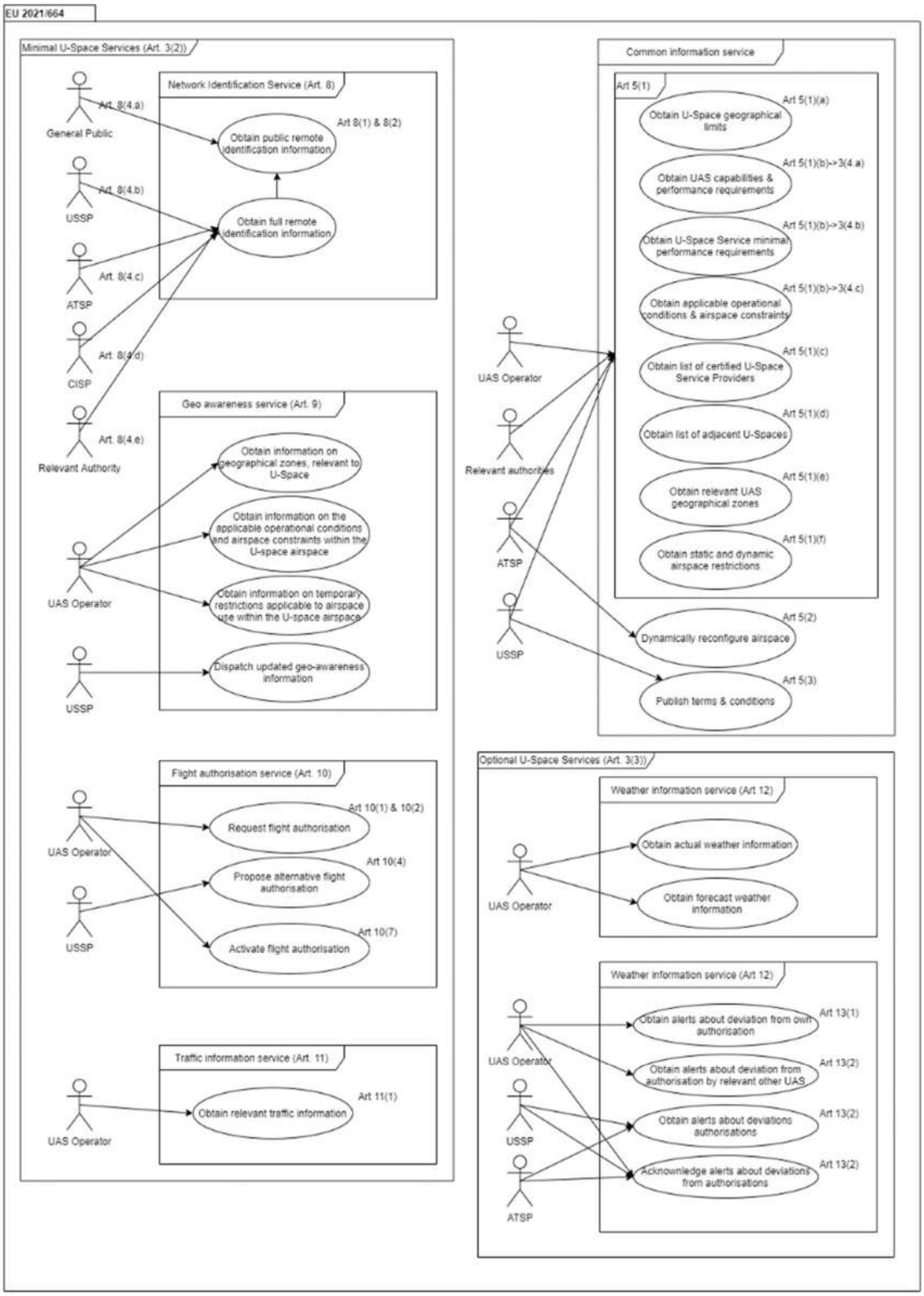
| | |
|---|---|
| **VMC** | Visual Meteorological Conditions |
| **VO** | Visual Observer |
| **WG** | Working Group |
| **WGS84** | World Geodetic System, revision 84 |

**Table 108: List of acronyms and abbreviations**

# Appendix A Use Cases for U-Space services

The diagrams below show the following use cases for U-space services:

- Services as described in regulation (EU) 2021/664
- Weather information service
- Registration service
- Registration assistance service
- E-identification
- Geo-awareness
- Geo-fence provision
- Tracking and position reporting
- Traffic information service
- Operation plan processing


EU 2021/664
Minimal U-Space Services (Art. 3(2))
Network Identification Service (Art. 8)
General Public
Art. 8(4.a)
Art 8(1) & 8(2)
Obtain public remote identification information
USSP
Art. 8(4.b)
Obtain full remote identification information
ATSP
Art. 8(4.c)
CISP
Art. 8(4.d)
Relevant Authority
Art. 8(4.e)
Geo awareness service (Art. 9)
Obtain information on geographical zones, relevant to U-Space
Obtain information on the applicable operational conditions and airspace constraints within the U-space airspace
UAS Operator
Obtain information on temporary restrictions applicable to airspace use within the U-space airspace
USSP
Dispatch updated geo-awareness information
Flight authorisation service (Art. 10)
Art 10(1) & 10(2)
UAS Operator
Request flight authorisation
Art 10(4)
Propose alternative flight authorisation
USSP
Art 10(7)
Activate flight authorisation
Traffic information service (Art. 11)
Art 11(1)
UAS Operator
Obtain relevant traffic information
Common information service
Art 5(1)
Art 5(1)(a)
Obtain U-Space geographical limits
Art 5(1)(b)->3(4.a)
Obtain UAS capabilities & performance requirements
Art 5(1)(b)->3(4.b)
Obtain U-Space Service minimal performance requirements
Art 5(1)(b)->3(4.c)
Obtain applicable operational conditions & airspace constraints
UAS Operator
Art 5(1)(c)
Obtain list of certified U-Space Service Providers
Relevant authorities
Art 5(1)(d)
Obtain list of adjacent U-Spaces
Art 5(1)(e)
Obtain relevant UAS geographical zones
ATSP
Art 5(1)(f)
Obtain static and dynamic airspace restrictions
USSP
Art 5(2)
Dynamically reconfigure airspace
Art 5(3)
Publish terms & conditions
Optional U-Space Services (Art. 3(3))
Weather information service (Art 12)
UAS Operator
Obtain actual weather information
Obtain forecast weather information
Weather information service (Art 12)
Art 13(1)
Obtain alerts about deviation from own authorisation
UAS Operator
Art 13(2)
Obtain alerts about deviation from authorisation by relevant other UAS
USSP
Art 13(2)
Obtain alerts about deviations authorisations
Art 13(2)
Acknowledge alerts about deviations from authorisations
ATSP

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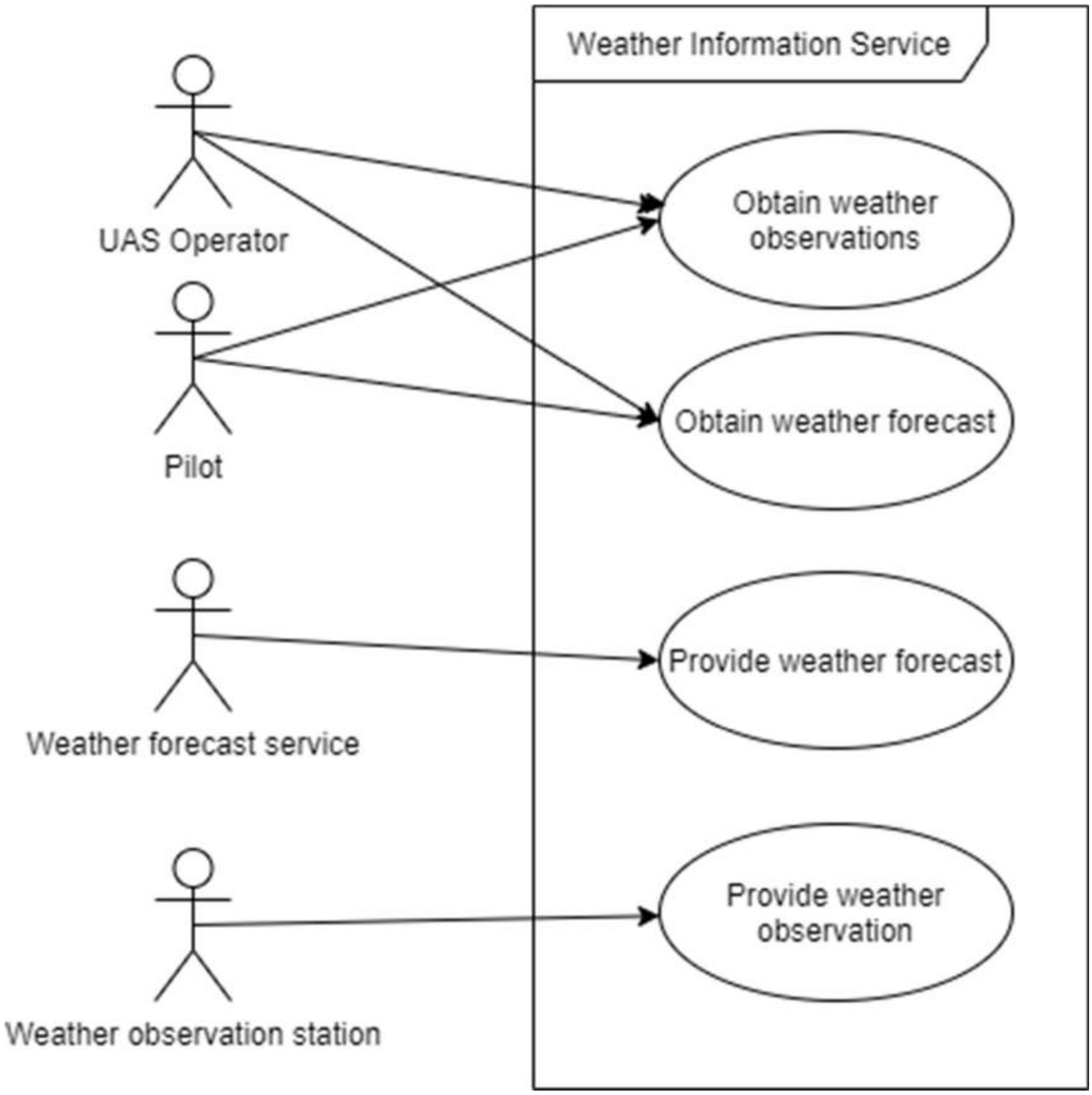
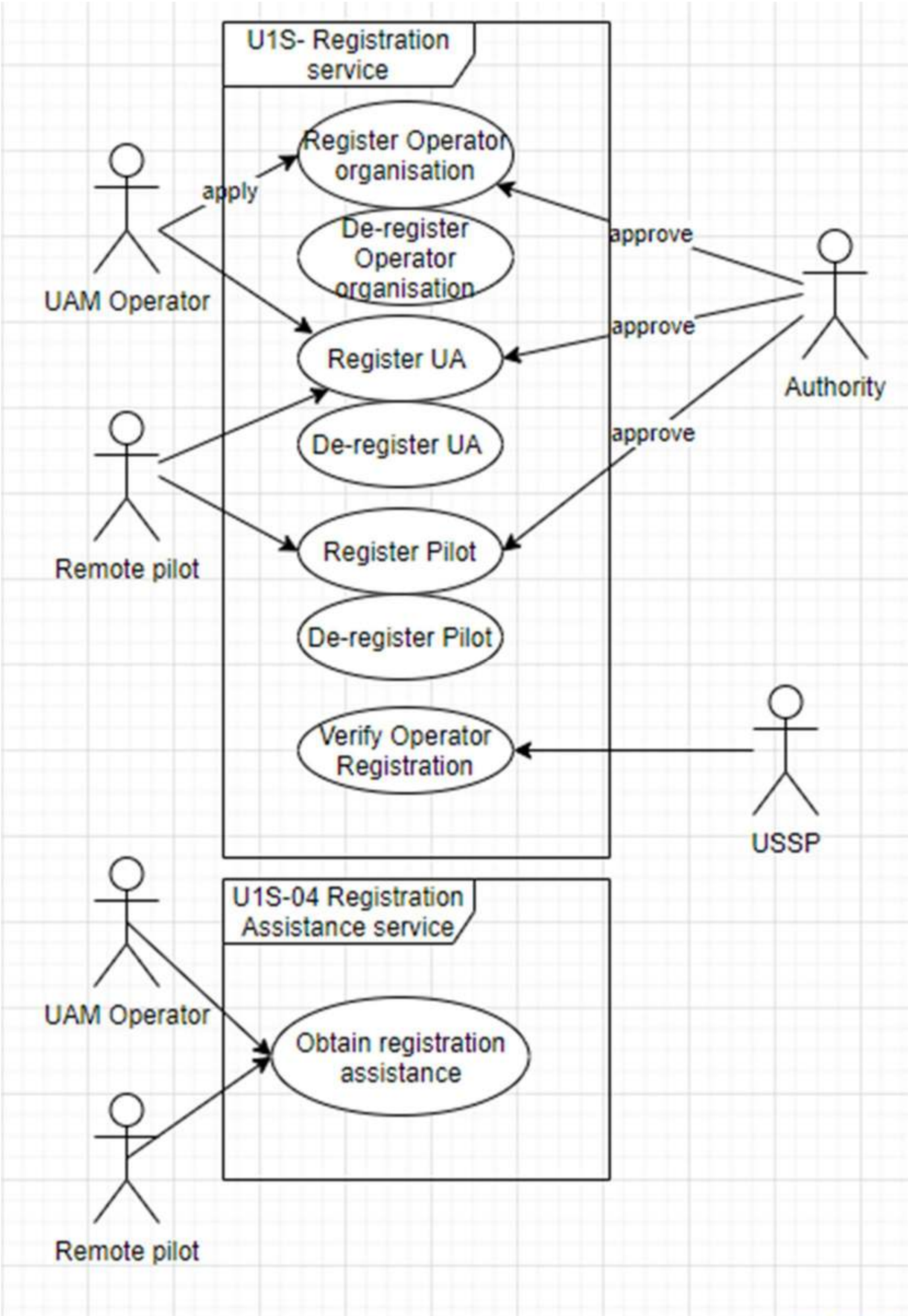
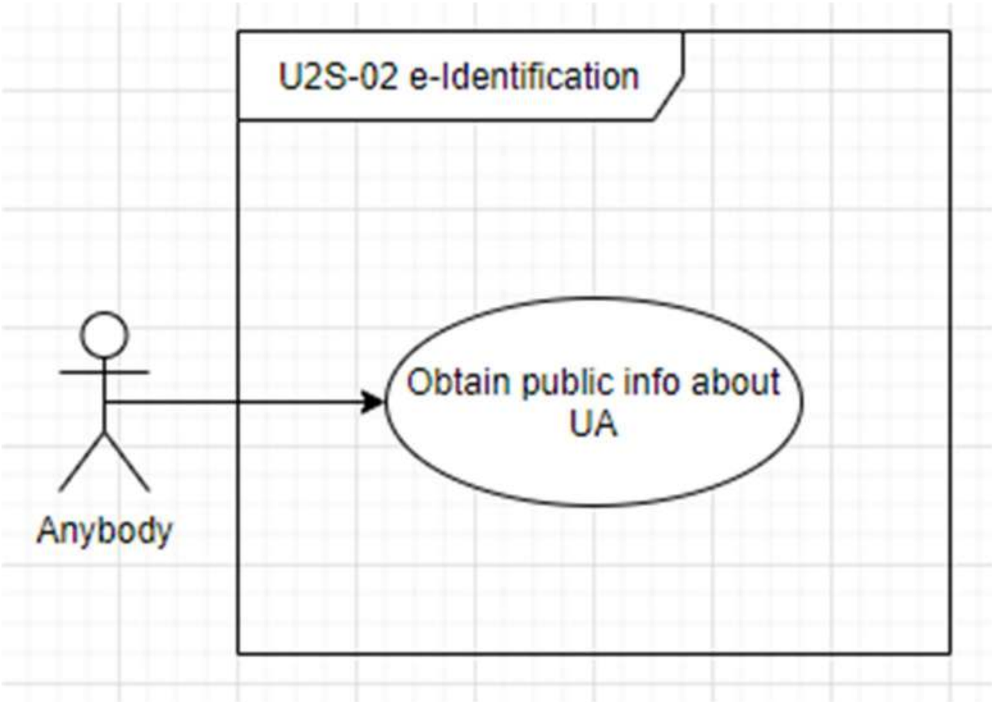



U1S- Registration service
Register Operator organisation
De-register Operator organisation
Register UA
De-register UA
Register Pilot
De-register Pilot
Verify Operator Registration
UAM Operator
apply
Remote pilot
approve
approve
approve
Authority
USSP
U1S-04 Registration Assistance service
Obtain registration assistance
UAM Operator
Remote pilot


U2S-02 e-Identification
Obtain public info about UA
Anybody

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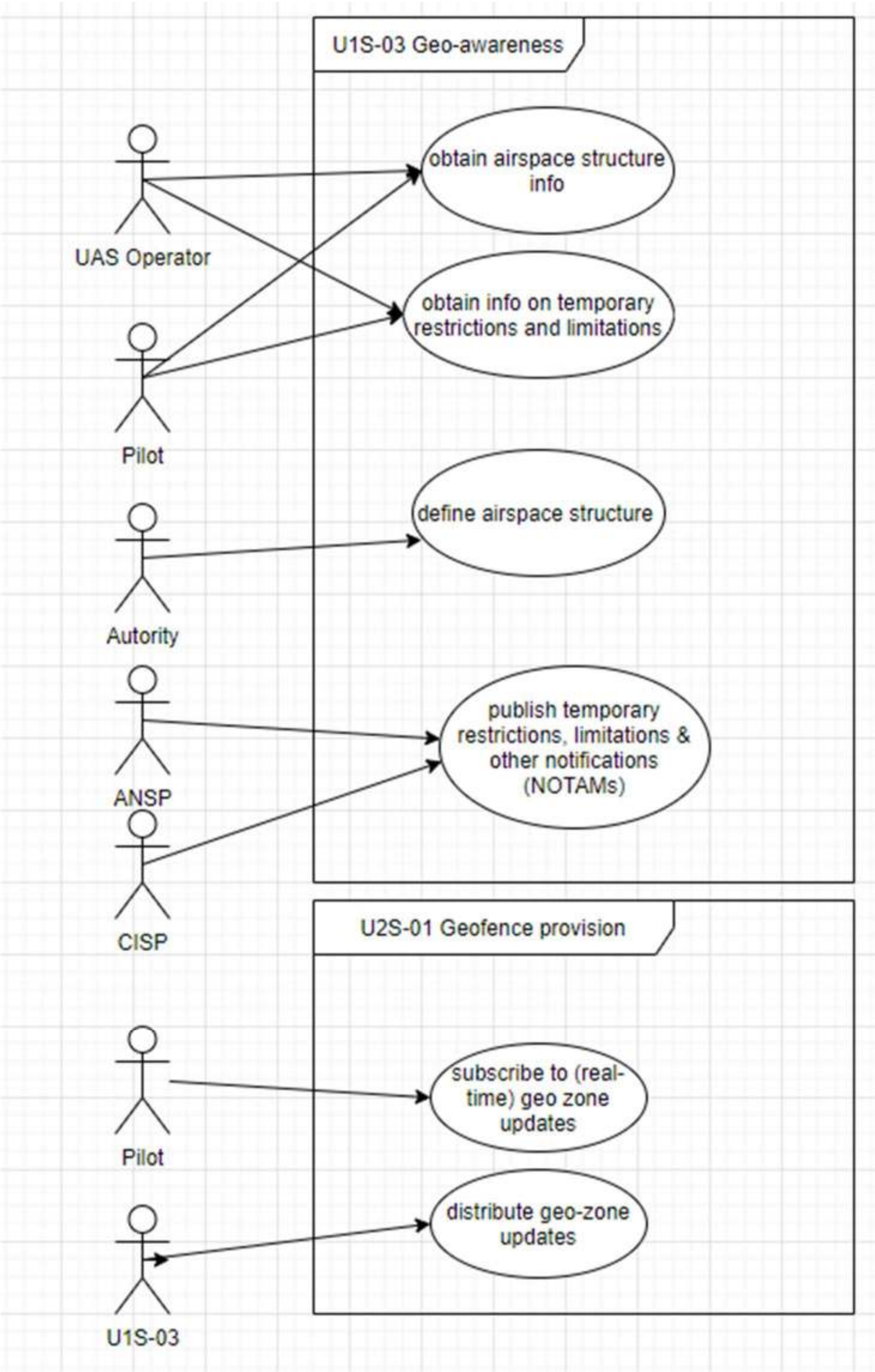
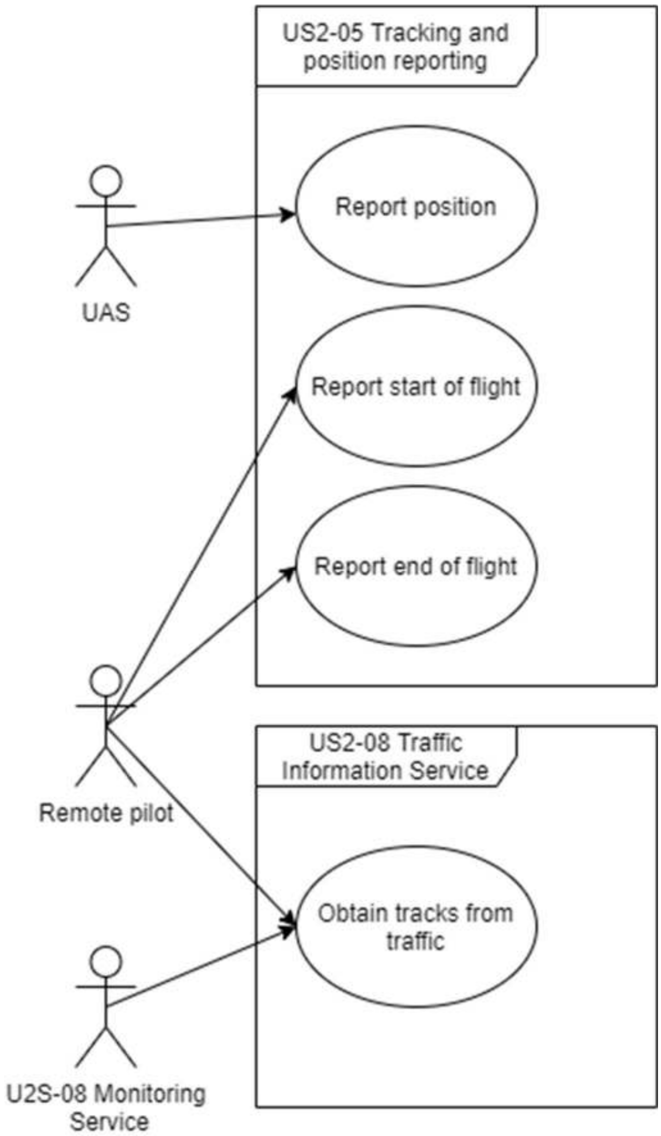
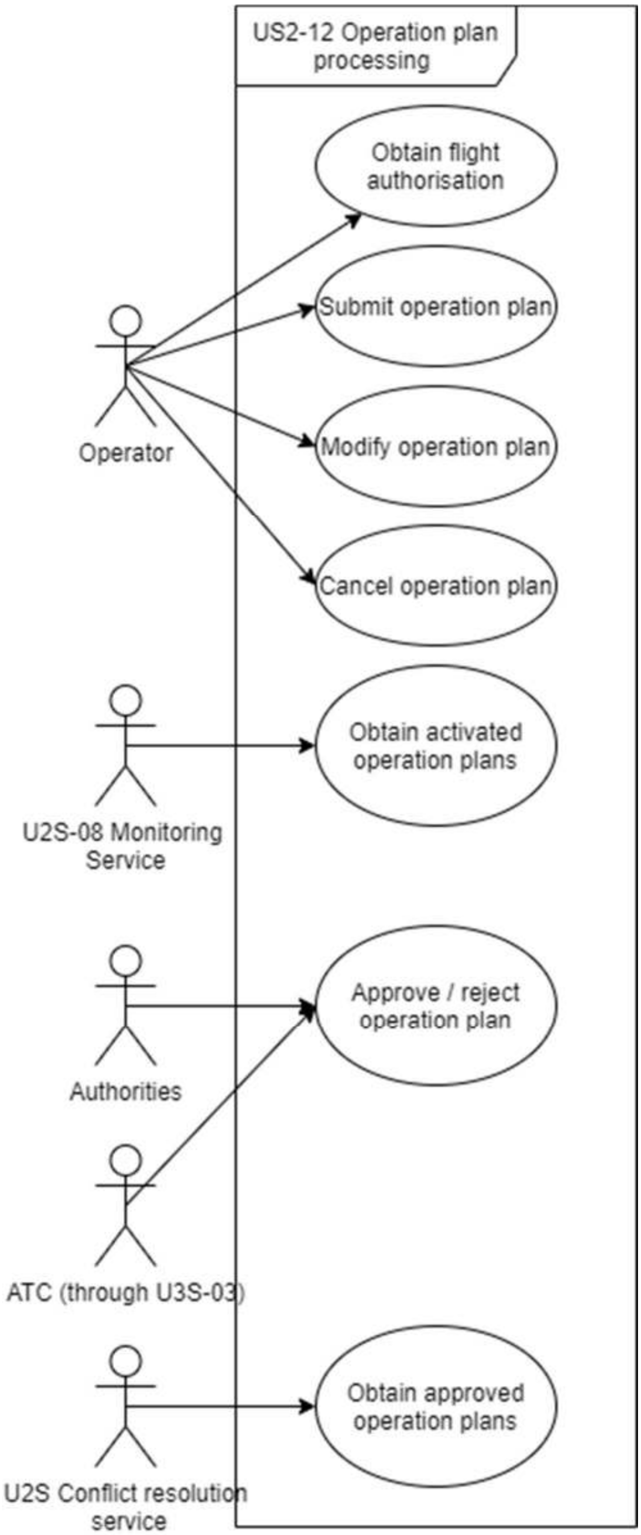




US2-05 Tracking and position reporting
Report position
Report start of flight
Report end of flight
UAS
Remote pilot
US2-08 Traffic Information Service
Obtain tracks from traffic
U2S-08 Monitoring Service


US2-12 Operation plan processing
Obtain flight authorisation
Submit operation plan
Modify operation plan
Cancel operation plan
Operator
Obtain activated operation plans
U2S-08 Monitoring Service
Approve / reject operation plan
Authorities
ATC (through U3S-03)
Obtain approved operation plans
U2S Conflict resolution service

# Appendix B T3.2 Integrated Requirements

The excel file contains additional information, as per example the link with the services

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equirements%20Inte

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VERY LARGE-SCALE DEMONSTRATION

# D2.4 GOF2.0 VLD Updated Service Specifications

| | |
|---|---|
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| Project Acronym: | GOF2.0 |
| Grant: | 101017689 |
| Call: | H2020-SESAR-2020-1 VLD Open 2 |
| Topic: | U-space capabilities and services to enable Urban Air Mobility |
| Consortium Coordinator: | LENNULIIKLUSTEENINDUSE AS (EANS) |
| Edition Date: | 4 November 2022 |
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## Authoring & Approval

### Authors of the document

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Gregor Mogeritsch / FRQ | WP2 | 26.10.2022 |
| Hubert Künig / FRQ | WP2 | 26.10.2022 |
| Peter Cornelius / FRQ | WP2 | 26.10.2022 |
| Thomas Lutz / FRQ | WP2 Lead | 26.10.2022 |

### Reviewers internal to the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Jonas Stjernberg / Robots Expert | WP3 Lead | 1.11.2022 |
| Maria Tamm / EANS | Project coordinator | 3.11.2022 |
| Tanel Järvet / CAFA | WP4 Lead | 3.11.2022 |
| Damian Soliwoda / PSNC | WP2 member | 2.11.2022 |
| Lukasz Gorny-Zajac / DRR | WP2 member | 2.11.2022 |
| Parmentier Remy / VAI | WP2 member | 2.11.2022 |
| Pawel Korzec / DRR | WP2 member | 2.11.2022 |
| Piotr Dybiec / DRR | WP2 member | 2.11.2022 |
| Piotr Luboński / PSNC | WP2 member | 31.10.2022 |
| Piotr Szymaniak / PSNC | WP2 member | 31.10.2022 |
| Sven Jürgenson / Threod | WP3 member | 3.11.2022 |
| Leopoldo Tejada/UML | WP2 member | 2.11.2022 |
| Thomas Wana / DIME | WP2 member | 31.10.2022 |
| Yuhang Yun / EHANG | WP3 member | 30.10.2022 |
| Iris Roehrich / FRQ | WP1 member | 3.11.2022 |

### Approved for submission to the SJU By - Representatives of beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Sami Alkula/FANS | Project Management Group | 3.11.2022 |
| Thomas Neubauer/DIME | Project Management Group | 3.11.2022 |
| Pawel Korzec/DRR | Project Management Group | 3.11.2022 |
| Yuhang Yun/EHE | Project Management Group | 3.11.2022 |
| Damini Gera/AIRB | Project Management Group | 3.11.2022 |



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| Leopoldo Tejada/UML | Project Management Group | 3.11.2022 |
| Tapio Haarlaa/VAI | Project Management Group | 3.11.2022 |
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| Juha Lindstedt/AVIA | Project Management Group | 3.11.2022 |
| Piotr Bratek/PANSA | Project Management Group | 3.11.2022 |
| Tanel Järvet/CAFA | Project Management Group | 3.11.2022 |

**Rejected By - Representatives of beneficiaries involved in the project**

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| | | |

## Document History

| Edition | Date | Status | Author | Justification |
|---|---|---|---|---|
| 00.00.01 | 26.10.2022 | draft | WP2 Lead | |
| 01.00.00 | 4.11.2022 | released | WP2 Partners | Revised and amendments included |

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# GOF2.0

## GOF2.0 INTEGRATED URBAN AIRSPACE VLD

This critical design document is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 101017689 under European Union's Horizon 2020 research and innovation programme.

## Abstract

This deliverable describes the GOF2.0 information exchange services documented at conceptual level, following SWIM principles, which could be used to implement U-space airspace, following guidance material to (EU 664/2021).

For each service specification there is a separate document. These documents are embedded in this document, which acts as bucket. As a preview, the data model of each service specification is copied into this document.

The service specifications are a baseline, built on experience from previous projects and the GOF2.0 project execution.

They have been updated based on D2.2, with better understanding gained in integration and trials. Updates were performed in agreement between the GOF2.0 project partners, which could be considered a governance body for the project execution time.

Currently, the following information exchange services are available:

- Traffic/Telemetry (Appendix A)
- Operation Plan (Appendix B)
- Geozones (Appendix C)
- Registration (Appendix D)
- Operational Message (Appendix E)
- Traffic Conformance Monitoring (Appendix F)
- Network Data (Appendix G)
- Ground Control Integration (Appendix H)
- Drone Flight (Appendix I)
- Weather (Appendix J)



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## List of Tables



## List of Figures

# 1 Executive Summary

**The information exchange services described in this document could be used to implement U-space airspace, following guidance material to (EU 664/2021).**

This document is an update to D2.2 Service Specification. Changes were done mostly in the areas of operation plan and network data. New service specifications were introduced for weather service and drone flight. For convenience, service specifications of D2.2 were again included in this document.

> *"The GOF2.0 Integrated Urban Airspace VLD (GOF2.0) very large demonstration project will safely, securely, and sustainably demonstrate operational validity of serving combined UAS, eVTOL and manned operations in a unified, dense urban airspace using current ATM and U-space services and systems.*
>
> *Both ATM and U-space communities depend extensively on the provision of timely, relevant, accurate and quality-assured digital information to collaborate and make informed decisions." [12]*

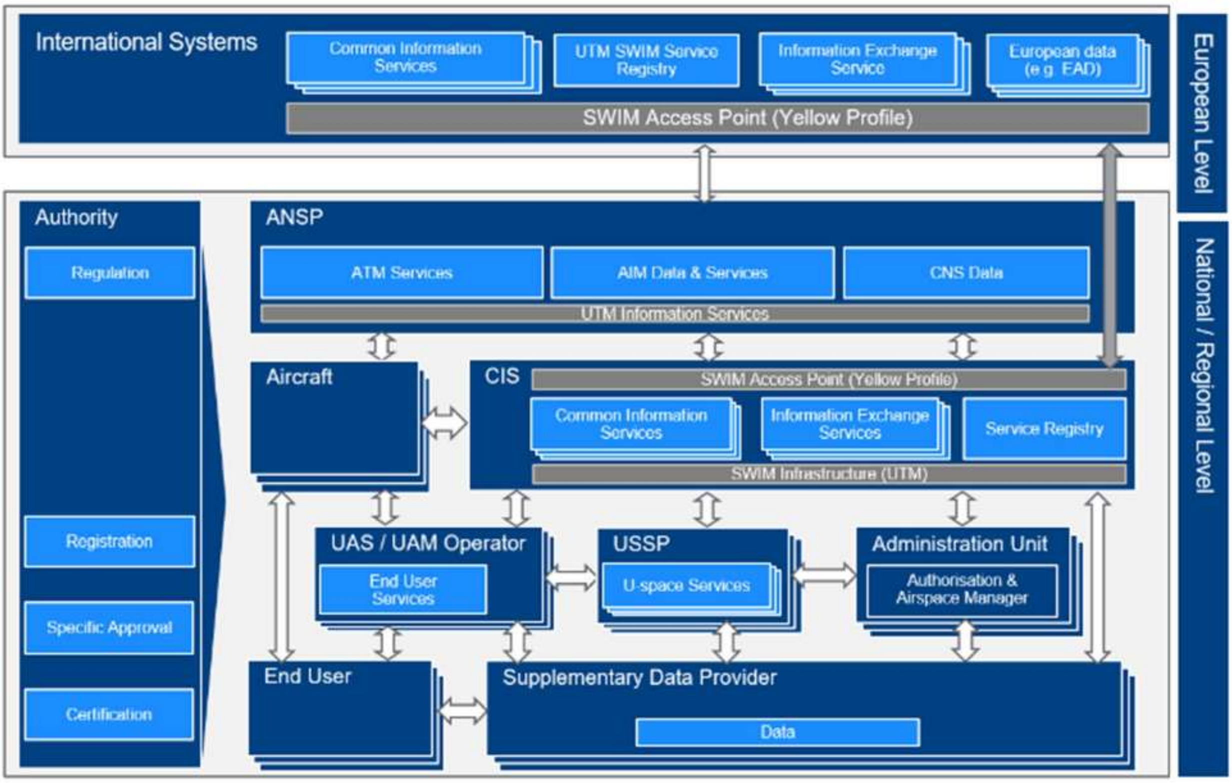


**Figure 1 - High level Architecture based on grant agreement**

Timely, relevant, accurate and quality-assured digital information is exchanged as shown in Figure 1, indicated by the double arrows. They connect stakeholders in the demonstrated UTM / U-space ecosystem. For each type of information exchanged (e.g. Traffic/Telemetry, Operation Plan, Geodata…).

Information exchange services are introduced and described using formal templates, separating logical, technical and runtime concerns. By defining the interfaces in the system, they enable a modular, interoperable, open, and highly resilient system of systems, allowing for technical variants in implementation and deployment.

This deliverable contains descriptions for the information exchange services identified in GOF2 – harmonizing the information flow between respective services.



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# 2 Introduction

## 2.1 Purpose of the document

This deliverable contains service specifications for information exchange services on conceptual level.

## 2.2 Scope

This document contributes to all objectives of the GOF2.0 project, especially those listed below. The focus of this deliverable is indicated in **bold** letters.

- Objective O2: Integrated, lean, modular, resilient, and interoperable system architecture supporting safe integration of all UAM vehicles on national and European level
  - Demonstrate **the exchange** of trajectory, weather, connectivity, and aeronautical **information through information management, supported by SWIM interoperable services**, to enhance collaborative decision-making at network and global levels, and specifically to allow safe and affordable integration of UAM into a shared airspace at high vehicle densities and in mixed traffic scenarios. Demonstrate **interoperability through standardised interfaces for U-space, CIS and ATM information exchanges, to allow seamless U-space/ATM operations for all operational stakeholders.**
  - Project Results: Documented service architecture, **proposals for standardised interface service descriptions**, performance data from validation trials, tracking performance, probability and reliability of identification and authentication, availability of connectivity, availability of communication means for safety notifications and ATC instruction
- Objective O4: Air-ground and ground-air connectivity and sharing of information digitally
  - Showcase technical means to **enable the exchange of digital information** in support of collaborative management of UAM operations and remote provision of U-space/ATM services:
    - Ground-Air Data link using mobile networks
    - Air-ground Data link using mobile networks
    - **Information Exchanges using the SWIM Yellow Profile**
  - Project Results: Automated **data exchange between the supplementary connectivity data providers and the various stakeholders in the system architecture** for pre-flight and flight operations and services plus validation / audit via measurements
- Objective O7: Virtualisation - allowing more dynamic resource allocation
  - Demonstrate modern-day cloud deployment, **general-purpose communication**, and computer processing capabilities to allow for better performing and more cost-efficient U-space/ATM service provision. A Centralized cloud deployment serving





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ANSPs, USSPs and finally all airspace users lead to facilitate data sharing, new synergies, and more cost-efficient management of the U-space/ATM resource network. It facilitates effective interoperability between functional systems.

- Project Results:
  - U-space service catalogue,
  - Operational and technical performance assessment (Response times for automated and manual flight authorisations.)
  - **Data models**,
  - **ICDs**
  - Airspace assessment

- Objective O9: Definition of novel U-space service essential to enable UAM
  - Introduce novel U-space services including concept, definition and validation to serve a safe, orderly and efficient integration of UAM. Within the scope of GOF2.0 the following - but not limited to - services will be defined:
    - mobility data: population densities to calculate ground risks
    - connectivity data to ensure reliable communication links between airborne and ground segments
    - hyperlocal weather information
  - Project Results:
    - U-space services catalogue,
    - **Data models**,
    - **ICDs**

## 2.3 Intended readership

- Authorities
- Air Navigation Service Providers (ANSPs)
- Civil Aviation Authorities (CAAs)
- U-Space / UTM Service Provides
- U-Space / UTM Infrastructure Providers
- Administrative Units
- Supplemental Data or Data Service Providers

- Drone Manufacturer
- Drone Operators
- General Aviation Operators

## 2.4 Structure of the document

The document is a bucket for the Service Specifications embedded in the appendices.

As preview, a copy of the data model for each service specification was copied into the appendices.

Please refer to the respective chapter in the appendices for the specific structure of a Service Specification.

## 2.5 Background

When producing this document and its appendices, several research and standardization activities, as well as projects, initiatives and existing solutions have been considered.

Please refer to the respective chapter in the appendices for the specific background.

## 2.6 Glossary of terms

n/a

## 2.7 List of Acronyms

| Acronym | Definition |
|---|---|
| **UTM** | Unmanned Traffic Management |
| **ATM** | Air Traffic Management |
| **SWIM** | System Wide Information Management |
| **ICD** | Interface Control Document |
| **CIS** | Common Information Service |
| **ANSP** | Air Navigation Service Provider |
| **USSP** | U-space Service Provider |

**Table 1: List of acronyms**



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# 3 References

[2] U-space regulationhttps://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeeting&meetingId=23814)SESAR 2020 GOF USPACE FIMS Design and Architecture – D4SESAR principles for U-space architecture https://www.sesarju.eu/sites/default/files/documents/u-space/SESAR%20principles%20for%20U-space%20architecture.pdf

# Appendix A Traffic/Telemetry

## A.1 Data Model

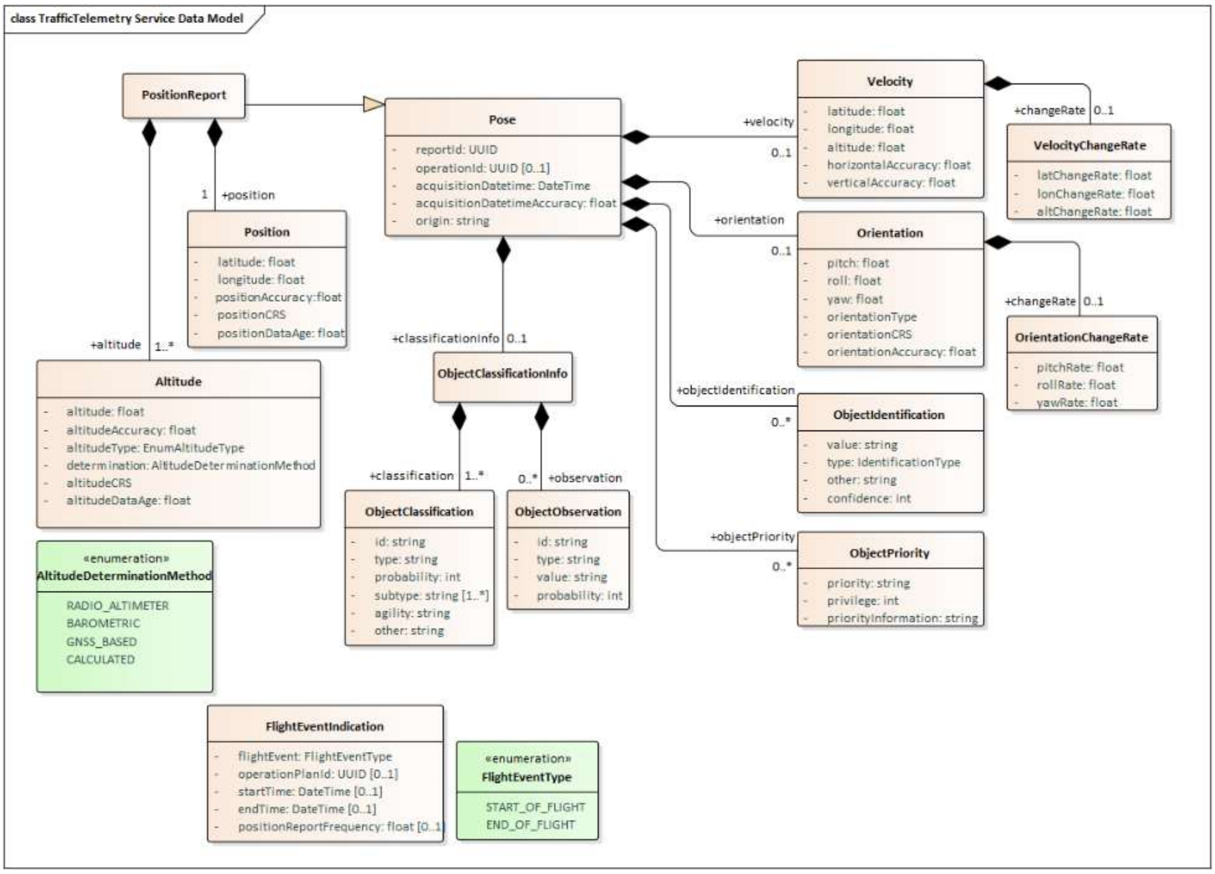


**Figure 2: Traffic / Telemetry Exchange Data Model**

## A.2 Embedded document

D2.4-A GOF2.0 VLD Service Specification

# Appendix B Operation Plan

## B.1 Data Model

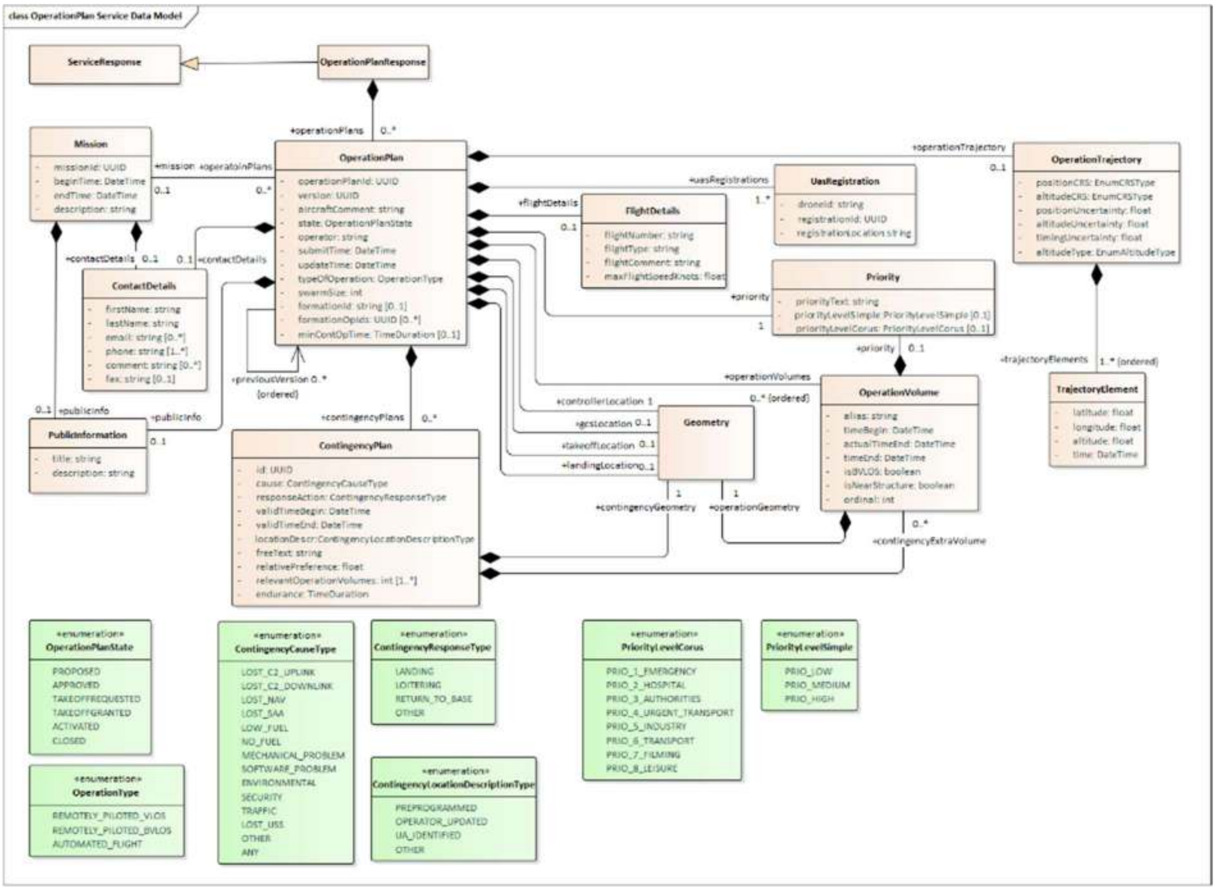


**Figure 3: Operation Plan Exchange Model**

## B.2 Embedded document

D2.4-B GOF2.0 VLD
Service Specification

# Appendix C Geozones

## C.1 Data Model

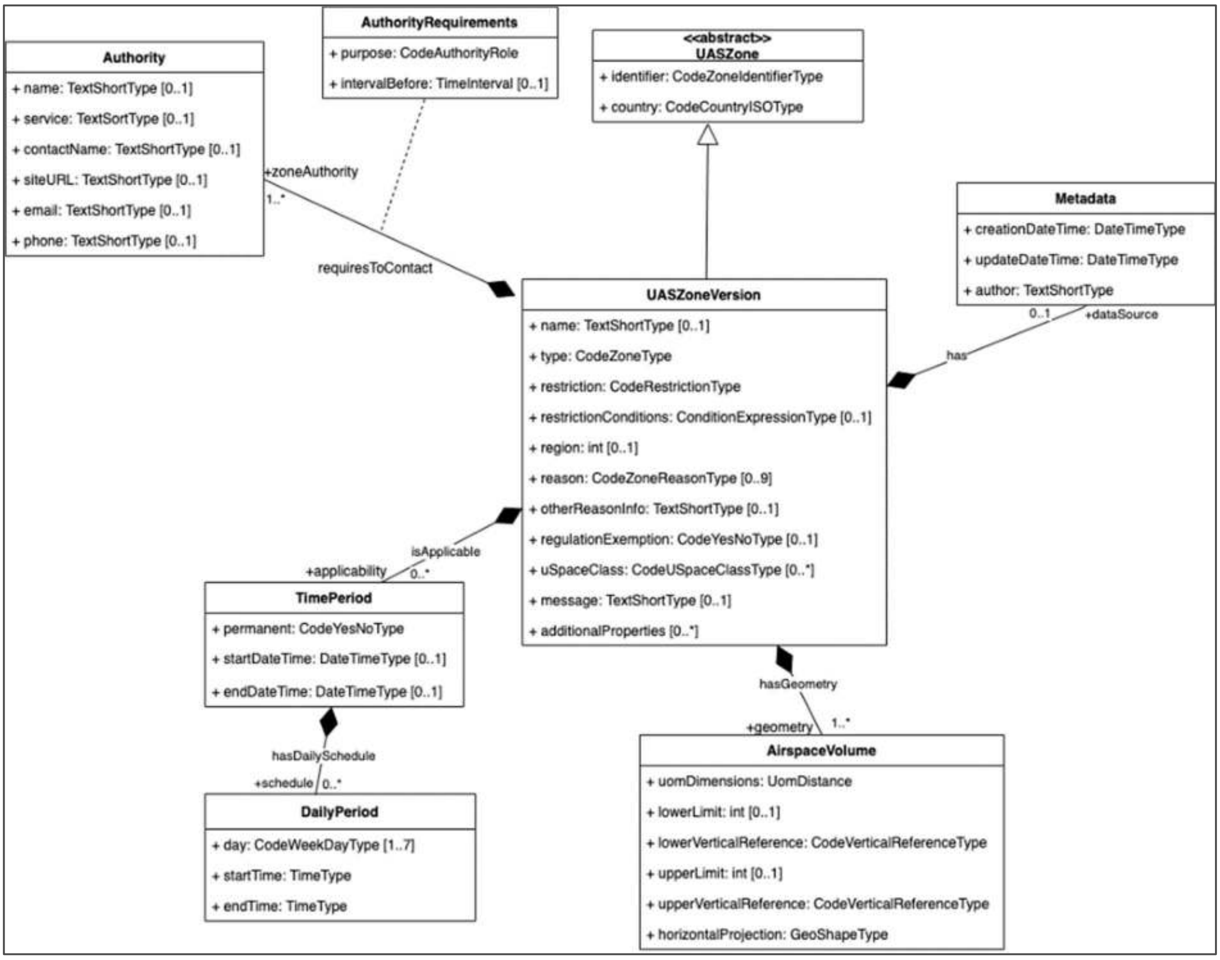


**Figure 4: Geozones Exchange Model**

## C.2 Embedded document

D2.4-C GOF2.0 VLD Service Specification

# Appendix D Registration

## D.1 Data Model

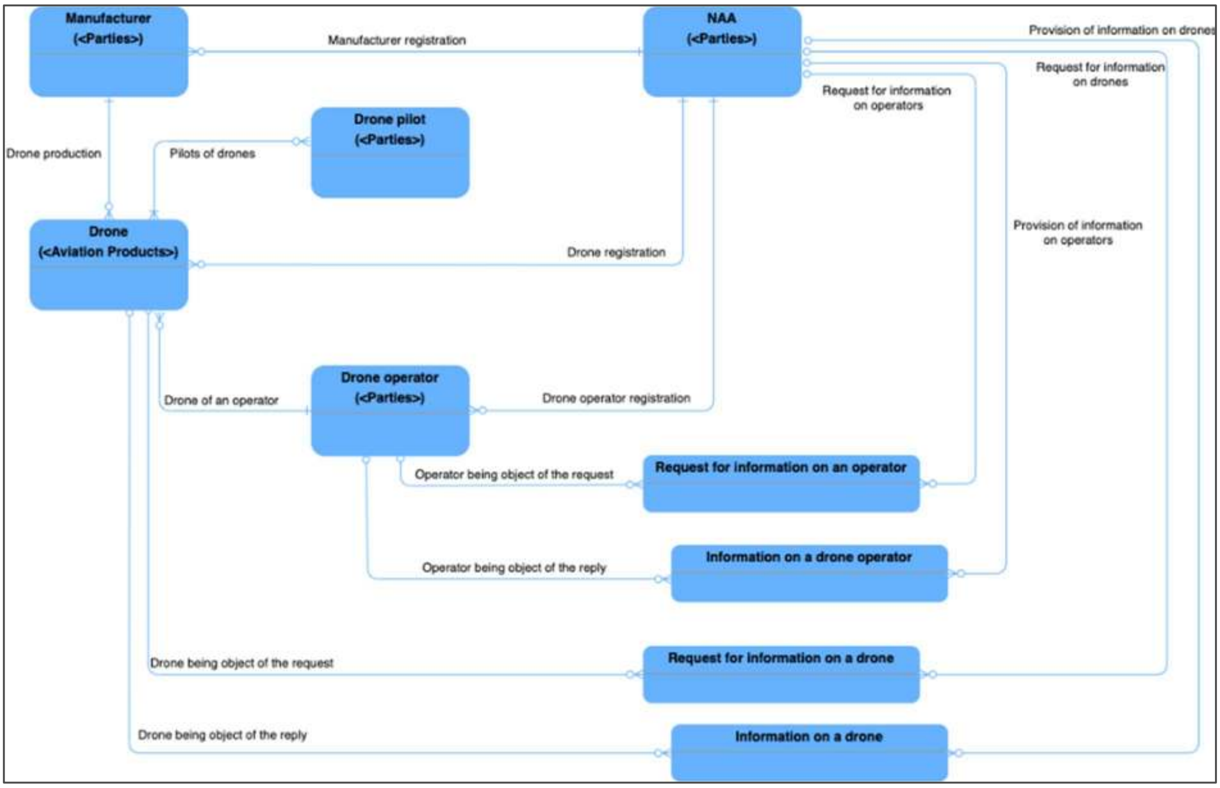


**Figure 5: Registration Exchange Data Model**

## D.2 Embedded document

D2.4-D GOF2.0 VLD
Service Specification

# Appendix E Operational Message

## E.1 Data Model

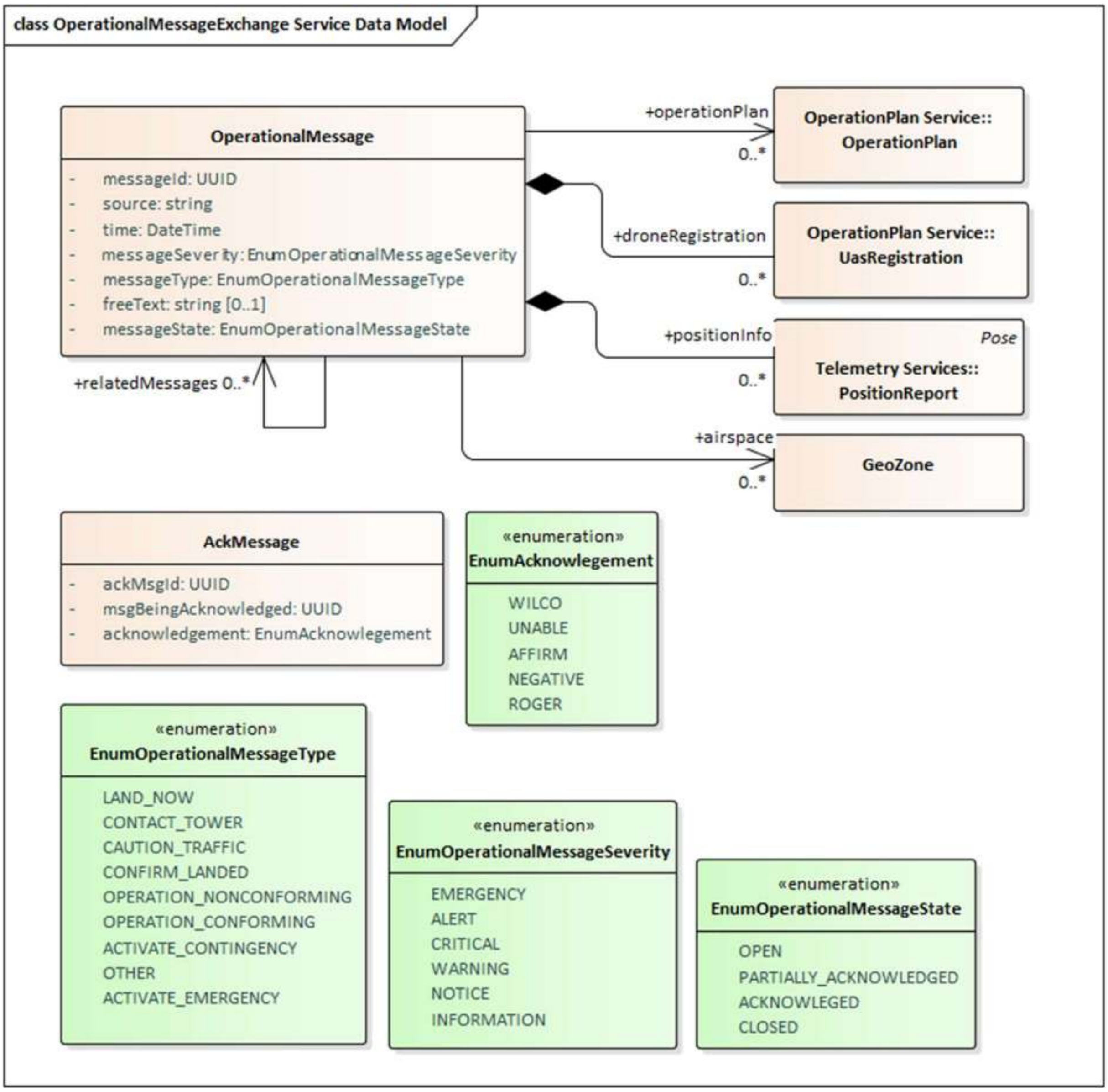


**Figure 6: Operational Message Exchange Model**

## E.2 Embedded document

D2.4-E GOF2.0 VLD Service Specification

# Appendix F Traffic Conformance Monitoring (not validated)

## F.1 Data Model

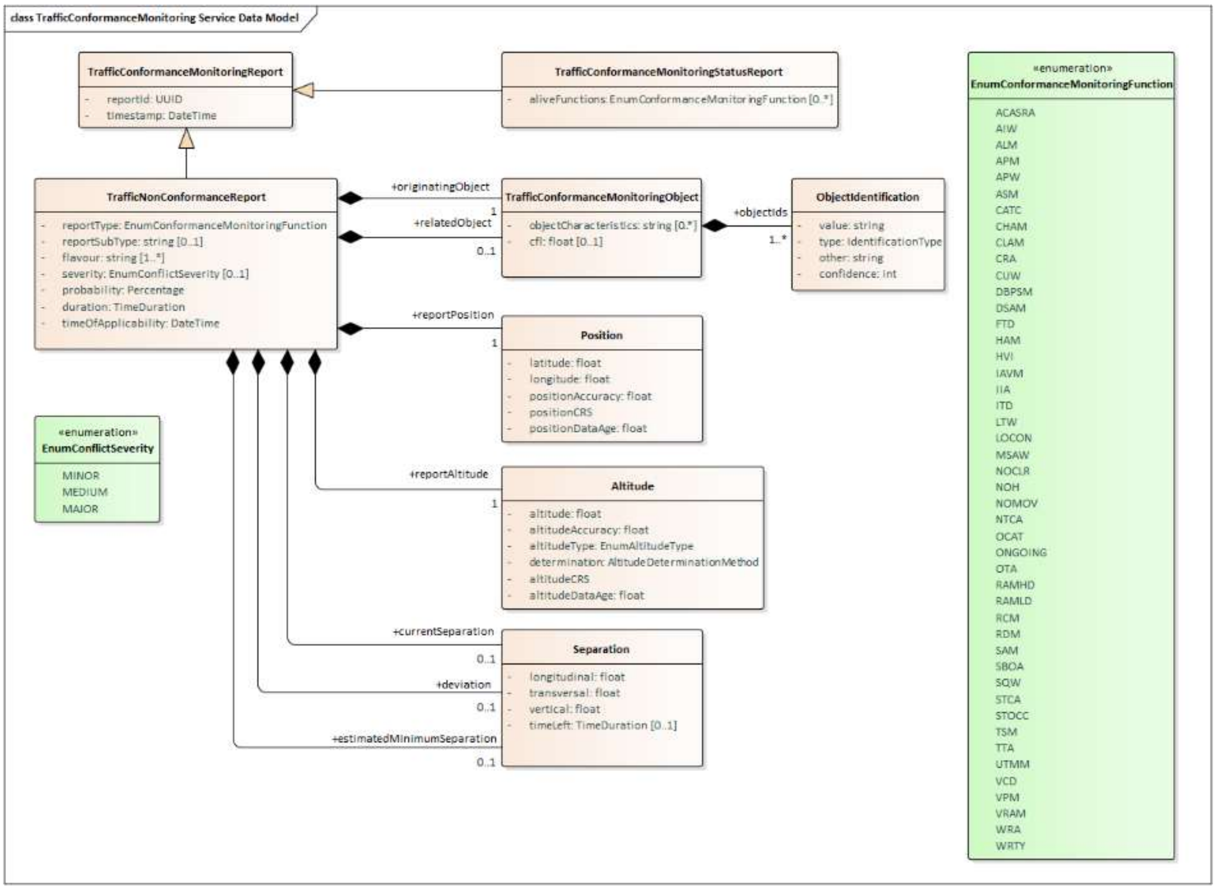


**Figure 7: Traffic Conformance Monitoring Exchange Model**

## F.2 Embedded document

D2.4-F GOF2.0 VLD
Service Specification

# Appendix G Network Data

## G.1 Data Model

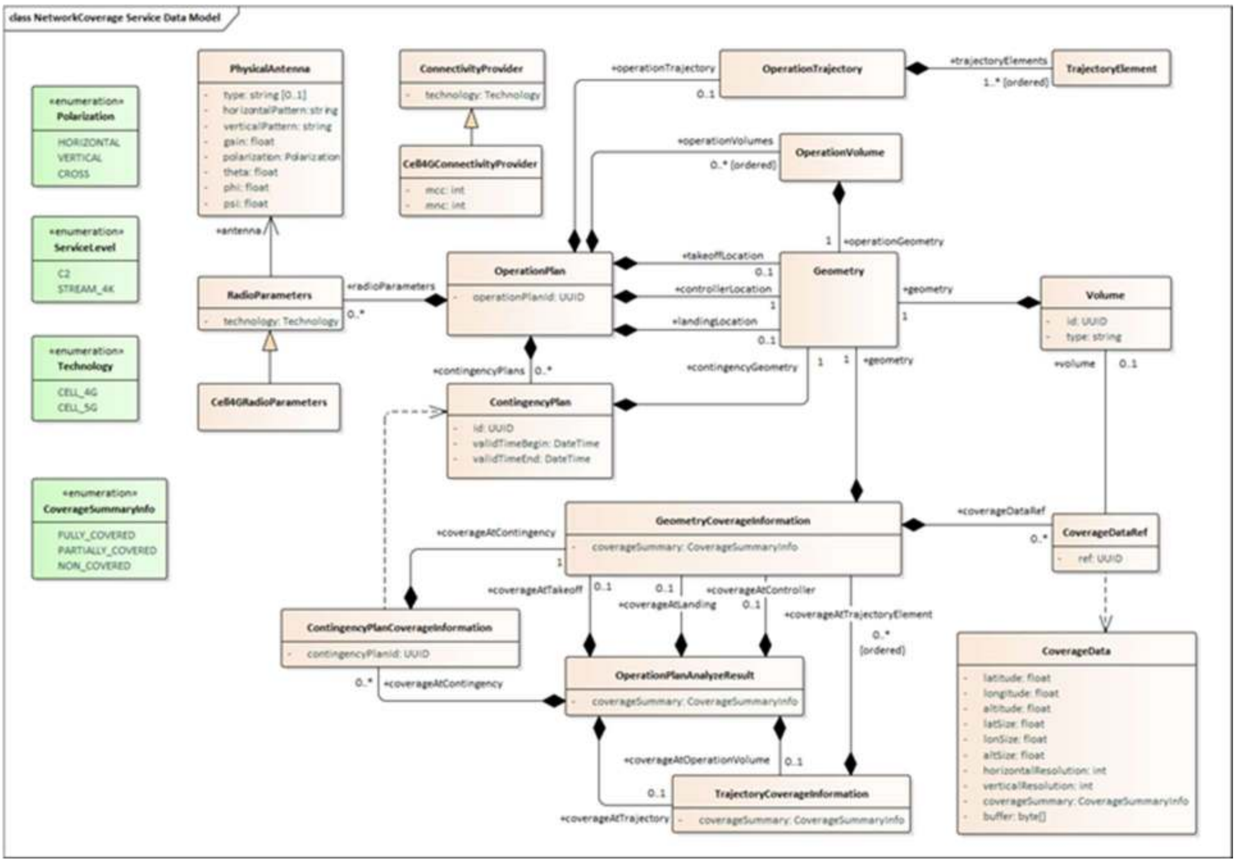


**Figure 8: Network Coverage Exchange Model**

## G.2 Embedded document

D2.4-G GOF2.0 VLD Service Specification

# Appendix H Ground Control Integration

## H.1 Data Model

Where feasible, the information services described in the other appendices have been used in the integration phase approaching the first GOF2.0 trials. GOF 2.0 consortium did not need a specific ground control integration specification based on the operational scenarios run in the trials.

## H.2 .Embedded document

Please refer to the other appendices.



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# Appendix I Drone flight (proposed)

## I.1 Data Model

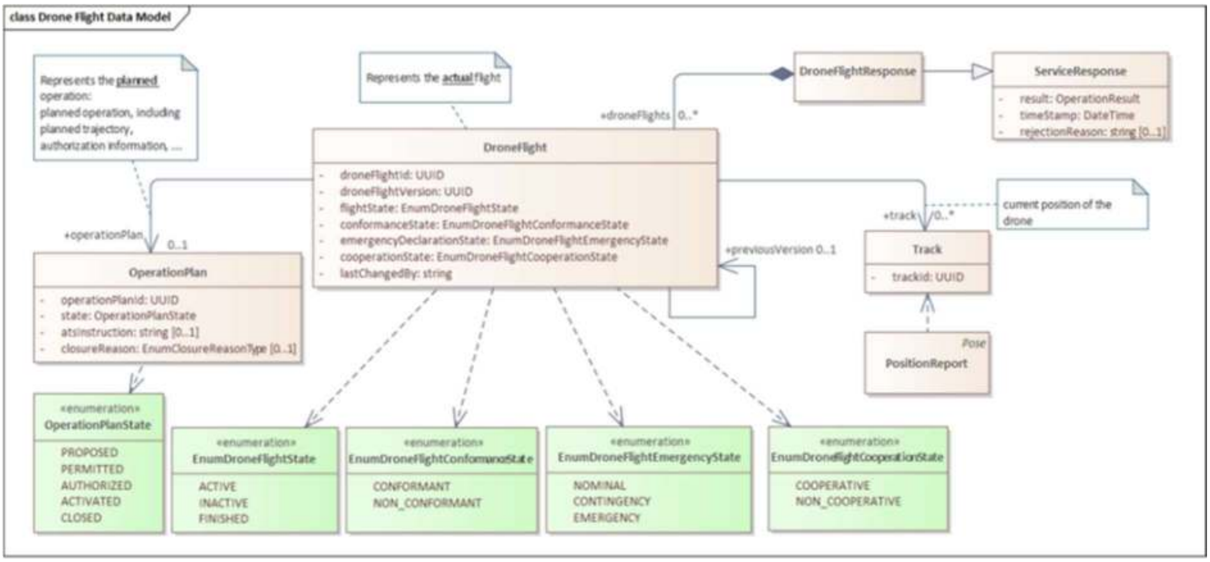


**Figure 9: Drone flight exchange model**

## I.2 Embedded document

D2.4-I GOF2.0 VLD Service Specification

# Appendix J Weather

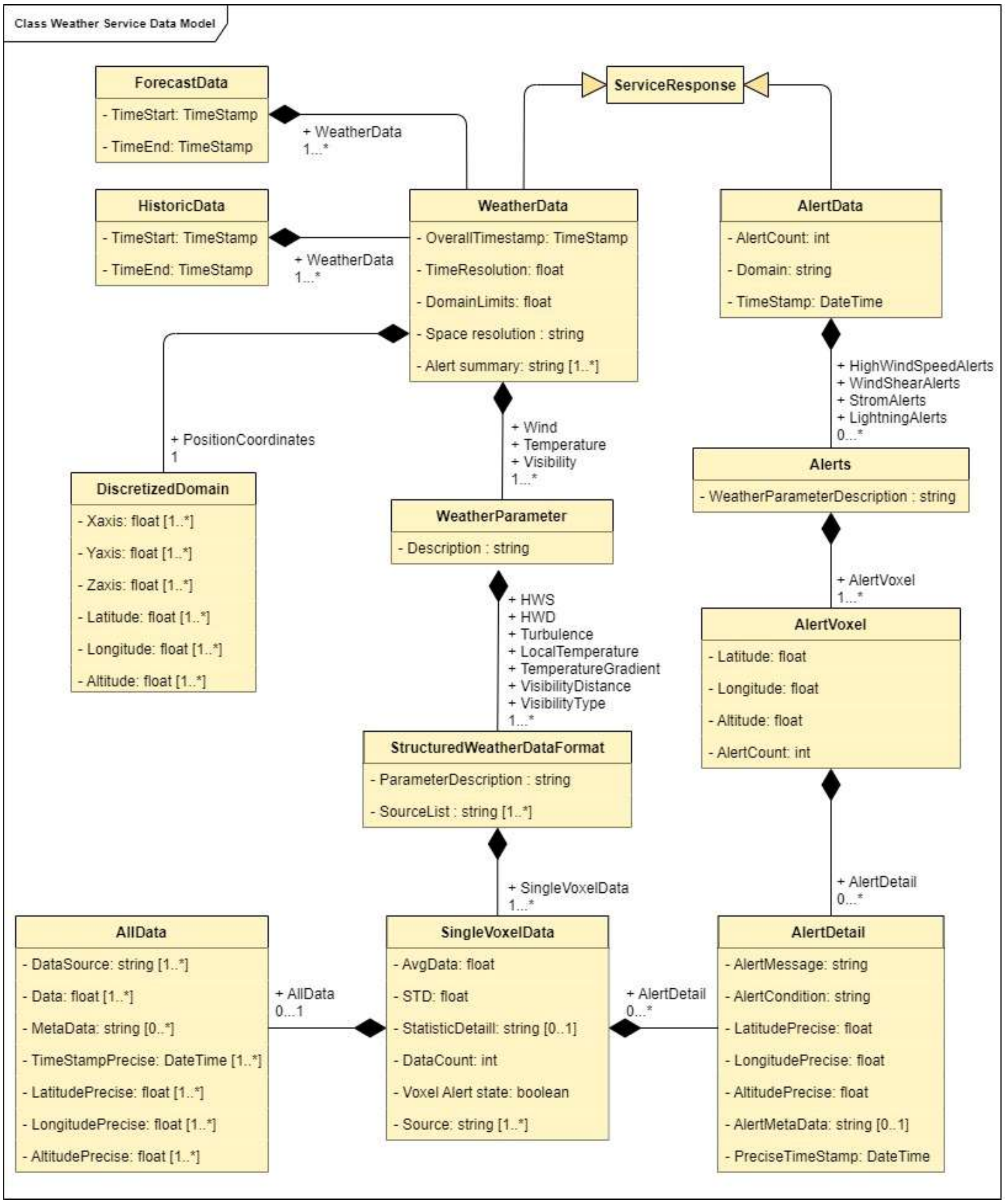


**Figure 10: Weather exchange model**

## J.1 Embedded Document

D2.4-J GOF2.0 VLD
Service Specification

VERY LARGE-SCALE DEMONSTRATION

# D2.4 Appendix A Traffic/Telemetry Service Specification

| | |
|---|---|
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| Consortium Coordinator: | Lennuliiklusteeninduse Aktsiaselts (EANS) |
| Edition Date: | 4 November 2022 |
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## Authoring & Approval

### Authors of the document

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Gregor Mogeritsch / Frequentis | WP2 | 26.10.2022 |
| Hubert Künig / Frequentis | WP2 | 26.10.2022 |
| Peter Cornelius / Frequentis | WP2 | 26.10.2022 |
| Thomas Lutz / Frequentis | WP2 Lead | 26.10.2022 |

### Reviewers internal to the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Jonas Stjernberg / Robots Expert | WP3 Lead | 1.11.2022 |
| Maria Tamm / EANS | Project coordinator | 3.11.2022 |
| Tanel Järvet / CAFA | WP4 Lead | 3.11.2022 |
| Damian Soliwoda / PSNC | WP2 member | 2.11.2022 |
| Lukasz Gorny-Zajac / DRR | WP2 member | 2.11.2022 |
| Parmentier Remy / VAI | WP2 member | 2.11.2022 |
| Pawel Korzec / DRR | WP2 member | 2.11.2022 |
| Piotr Dybiec / DRR | WP2 member | 2.11.2022 |
| Piotr Luboński / PSNC | WP2 member | 31.10.2022 |
| Piotr Szymaniak / PSNC | WP2 member | 31.10.2022 |
| Sven Jürgenson / Threod | WP3 member | 3.11.2022 |
| Leopoldo Tejada/UML | WP2 member | 2.11.2022 |
| Thomas Wana / DIME | WP2 member | 31.10.2022 |
| Yuhang Yun / EHANG | WP3 member | 30.10.2022 |
| Iris Roehrich / FRQ | WP1 member | 3.11.2022 |

### Approved for submission to the SJU By - Representatives of beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Sami Alkula/FANS | Project Management Group | 3.11.2022 |
| Thomas Neubauer/DIME | Project Management Group | 3.11.2022 |
| Pawel Korzec/DRR | Project Management Group | 3.11.2022 |
| Yuhang Yun/EHE | Project Management Group | 3.11.2022 |
| Damini Gera/AIRB | Project Management Group | 3.11.2022 |



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| | | |
|---|---|---|
| Piotr Szymaniak/PSNC | Project Management Group | 3.11.2022 |
| Sven Jürgenson/THREOD | Project Management Group | 3.11.2022 |
| Leopoldo Tejada/UML | Project Management Group | 3.11.2022 |
| Tapio Haarlaa/VAI | Project Management Group | 3.11.2022 |
| Iris Röhrich/FRQ | Project Management Group | 3.11.2022 |
| Juha Lindstedt/AVIA | Project Management Group | 3.11.2022 |
| Piotr Bratek/PANSA | Project Management Group | 3.11.2022 |
| Tanel Järvet/CAFA | Project Management Group | 3.11.2022 |
| Maria Tamm/EANS | Project Management Group | 3.11.2022 |

**Rejected By - Representatives of beneficiaries involved in the project**

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| | | |

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|---|---|---|---|---|
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| 00.00.02 | 18.03.2021 | draft | WP2 Partners | Update or GOF2.0 D2.2 |
| 00.00.03 | 30.04.2021 | Release | WP2 Partners | As GOF2.0 D2.2 |
| 00.00.04 | 26.04.2022 | draft | WP2 Partners | Revised and updated draft |
| 01.00.00 | 04.11.2022 | Released | Coordinator | Submit deliverable |

## Copyright Statement

# GOF 2.0

GOF2.0 INTEGRATED URBAN AIRSPACE VLD

This Updated Service Specification is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 101017689 under European Union's Horizon 2020 research and innovation programme.

## Abstract

This specification introduces a service of a Common Information Service (CIS) which ensures interoperability and hence transparent and reliable information flow between the stakeholders in an operational U-space environment. In accordance with ICAO SWIM, represents an Information Exchange Service.

Specifically, this document describes, in a logical, technology-independent manner, the Traffic/Telemetry service, a Position report Submission Sub-Service and Surveillance Data Service which accepts and carries surveillance data from a number of data sources to a Tracking Service which, in turn, provides a common situational picture to its consumers via this service.

Sources include, but are not limited to, primary and secondary radar and other drone detection services, on-board position telemetry services, and tracking service,

Consumers include, but are not limited to monitoring and traffic information services, tracking services, and display systems.

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# 1 Abstract

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Specifically, this document describes, in a logical, technology-independent manner, the Traffic/Telemetry service, a **Position report Submission Sub-Service** and **Surveillance Data Service** which accepts and carries surveillance data from a number of data sources to a Tracking Service which, in turn, provides a common situational picture to its consumers via this service.

Sources include, but are not limited to, primary and secondary radar and other drone detection services, on-board position telemetry services, and tracking service,

Consumers include, but are not limited to monitoring and traffic information services, tracking services, and display systems.



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# 2 Introduction

## 2.1 Purpose of the document

Based on the guidelines given in [3], this document describes the Traffic/Telemetry bridge service of a Common Information Service (CIS) in a logical technology-independent manner, that is:

- the operational and business context of the service
  - requirements for the service (e.g., information exchange requirements)
  - involved nodes: which operational components provide/consume the service
  - operational activities supported by the service
  - relation of the service to other services
- the service description
  - service interface definitions
  - service interface operations
  - service payload definition
  - service dynamic behaviour description
- service provision and validation aspects

Furthermore, this document clearly defines the version of the service.

## 2.2 Scope

This document describes the Traffic/Telemetry service for a CIS.

The Traffic/Telemetry service provides a means for the operational nodes of the U-space to share their position reports and make them available for further processing.

The Traffic/Telemetry service furthermore provides a means for the operational nodes of the U-space to consume position reports from the U-space participants for further processing.

## 2.3 Intended readership

This service specification is intended to be read by service architects, system engineers and developers in charge of designing and developing an instance of the Traffic/Telemetry service.

Furthermore, this service specification is intended to be read by enterprise architects, service architects, information architects, system engineers and developers in pursuing architecting, design and development activities of other related services.

## 2.4 Background

### 2.4.1 EUROCONTROL Concept of Operations for U-space (CORUS)



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EUROCONTROL CORUS [4] Vol. 2 elaborates in 5.1.1.4 Position reporting submission sub-Service as follows.

***"The Tracking service of U-space (section 5.1.1.5) cannot work unless U-space receives position reports concerning drones. The Position report submission sub-service has been added in this ConOps to allow that. It is not a service on its own but rather an important part of the Tracking service.***

***[…]***

***Position report submission will need to be secure, reliable and low latency. The information in Position Reports is safety critical. The Position report submission sub-service must be deployed in a robust and reliable manner because of its safety criticality.***

***[…]***

***Drone position report submission will be an automatic process (the pilot will not type lat-longs) hence the technical implementation will probably be fed by some software that is running at the drone or remote-piloting station. The feedback that is given is intended for the pilot and may be delivered the same way or through a web or similar interface that the pilot can conveniently consume.***

***Drone position report submission will be an automatic process (the pilot will not type lat-longs) hence the technical implementation will probably be fed by some software that is running at the drone or remote-piloting station. The feedback that is given is intended for the pilot and may be delivered the same way or through a web or similar interface that the pilot can conveniently consume.***

***All drone position reports should be recorded to allow the provision of the Accident and Incident investigation (section 5.1.5.2). Hence the Position report submission service will feed the Legal Recording service (section 5.1.6.3).***

***The Position Reports sent to U-space should include***

***All drone position reports should be recorded to allow the provision of the Accident and Incident investigation (section 5.1.5.2). Hence the Position report submission service will feed the Legal Recording service (section 5.1.6.3).***

***The Position Reports sent to U-space should include***

- ***The current 3D position of the drone, expressed in the agreed measurement system and frame of reference, to the precision expected in the airspace concerned.***
- ***The uncertainty in the reported position (perhaps in the manner of ADS-B)***
- ***The precise time at which the position has been measured, if available***
- ***The means by which the position has been determined, and/or some identifier of the origin of the report – so as to help the tracking service combine multiple sources of reports for the same flight.***
- ***If available the current speed vector of the vehicle, together with its uncertainty***



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- ***The identity of the vehicle, if available, preferably in the form used by Remote Identification see 3.1.4.1***
- ***The identity of the operator of the vehicle, if available***
- ***The identity of the mission plan being executed – if any and if available***
- ***In the absence of the vehicle's identifier, if possible, a temporary identifier for the flight to ease the job of the tracker. "***

## 2.4.2 Global UTM Association (GUTMA) and GUTMA-related

### 2.4.2.1 Flight Logging Protocol

The Flight Logging Protocol [5], section **flight_logging** suggests some data items as follows.

***"For the moment, mandatory fields are timestamp, gps_lon, gps_lat, gps_altitude. speed and battery_voltage are also taken into account, but they are optional. Many types can be added, it will simply not be analysed, just stored.***

- ***Timestamp : number of the seconds elapsed since logging_start_dtg. It is a float, with max 3 decimals (so precision is milliseconds). By extension, the last timestamp will be equal to the duration flight in seconds.***
- ***gps_lon, gps_lat, gps_altitude: GPS coordinates***
- ***speed: ground speed in m/s (float)***
- ***battery_voltage: voltage in volt (float)***
- ***logging_start_dtg: describes the beginning of the flight. It is mandatory.***
- ***altitude_system: indicates the type of altitude reported: "AGL", "MSL" or "WGS84".***

***Event is used for notify events during the flight. It can be take off, gps lost, obstacle detection etc."***

### 2.4.2.2 Air Traffic Protocol

The Air Traffic Protocol has received several suggestions for extension [6]. From the **Objective** and **Data Sources** sections:

***"Therefore the core objective of this reporting standard is the following:***

- ***Identify aircraft with high certainty***
- ***Minimize Latency, reduce bandwidth***
- ***Ensure quality and integrity of the data***
- ***Ability to merge different data sources into a single feed.***

***(…)***

***The following data sources are considered in scope for the purposes of this data feed:***

- ***Aircraft equipped with sensors that detect and produce data (e.g. ADS-B / Mode S / Primary Radar / Mode AC / FLARM / UAT)***
- ***Sensors from private companies / 1st level sensors detecting emitted data (e.g. OEM / Radar manufacturers / Sensor manufacturers)***

- ***UAS / Aircraft itself: In the future all drones will detect neighbouring aircraft and share it (Traffic information service - broadcast (TIS-B) collects information and broadcasts it to any aircraft in the region)"***

### 2.4.3 Federal Aviation Administration (FAA) Concepts of Operations

The FAA defines a messaging service in its **Concepts of Operations v1.0 - Appendix C - UTM Services - Messaging Service** [7] as follows.

***"A service which provides on demand, periodic, or event driven information on UAS operations (e.g. position reports, intent information, and status information) occurring within the subscribed airspace volume and time. Additional filtering may be performed as part of the service."***

### 2.4.4 Swiss Federal Office of Civil Aviation (FOCA)

From the FOCA **Concepts of Operations v1.0** [8], section 3.5.10 - Tracking Service:

***"A service, which tracks position reports of the UAVs in order for other services to operate (deconfliction,flight planning and so on). It fulfils following functions:***

- ***To track UA positions in real-time***
- ***To securely store tracked data***
- ***To provide different access levels to users with different credentials for the tracking data***

***The services will gather positions of the UAS and ensure privacy of its users and their activity. It will benefit the users by allowing the services and the competent authorities to access data while ensuring privacy and data protection of the participants."***

### 2.4.5 International Civil Aviation Organization (ICAO)

In the Global Air Navigation Plan [9], ICAO defines three Aviation System Block Upgrade (ASBU) blocks, B1-RPAS, B2-RPAS, and B3-RPAS, referring to scheduled implementation years of 2019, 2025, 2031, and beyond, and expects increased situational awareness from B1-RPAS onwards.

ICAO Doc 10039 [2] elaborates in section **3.4 INFORMATION EXCHANGE SERVICES** on information exchange services as follow (para. 3.4.2).

***"Within the SWIM Global Interoperability Framework, the Information Exchange layer is instantiated by 'information services' as is further explained. Information services ensure interoperability between ATM applications which consume and provide interoperable information services. Consequently, the concept of information service is a fundamental building block of SWIM which enables interoperability through well-defined information exchanges."***

### 2.4.6 Open Drone ID



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Open Drone ID is a project to provide a low cost and reliable “beacon” capability for drones so that they can be identified when within range of a receiver. Open Drone ID receives support from large companies such as Intel.

The Open Drone ID Message Specification [10] proposes a Location Message in both, a byte and a JSON representation, which permits the transport of

- a position in three space dimensions,
- a velocity, and
- a data age.

The Open Drone ID Message Specification furthermore proposes messages to convey information about

- the type of drone,
- its in-flight status, and
- the location of the drone operator.

### 2.4.7 SESAR-JU

The European Commission identifies an increasing demand for a non-segregated use of airspace which is being driven by a rapidly growing market of Very-Low-Level (VLL) airspace users, most of which are expected to be drones.

Via the Roadmap for the safe integration of drones into all classes of airspace [11], within the European ATM Masterplan [12], the European Commission seeks to ensure that this rapid growth of airspace use happens in a safe and controlled manner.

SESAR develops the required concepts and demonstrations for this process to happen. The roadmap [1], in alignment with ICAO recommendations, identifies three phases for the integration, from which SESAR derives the four U-space service blocks presented in the U-space blueprint [13],

U1 U-space foundation services,
U2 U-space initial services,
U3 U-space advanced services, and
U4 U-space full services.

These stages reflect the anticipated quick growth of demand for U-space services. The state of the art is being validated throughout Europe via several Very Large Demonstrator (VLD) projects such as the GOF USPACE project.

During the U1 phases, SESAR expects drones capable to supply their position via telemetry. The U1 and U2 is anticipated to provide tracking capabilities and services.

### 2.4.8 Efficient, safe and sustainable traffic at sea (EfficienSea2)

The design method and terminology builds on experience from the EfficienSea2 project [14], [15].



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### 2.4.9 ASTM

F3411 - 22a, Standard Specification for Remote ID and Tracking provides a specification on performance requirements for remote identification for unmanned systems. It defines message formats, transmission methods and minimum performance standards for broadcast and network-based remote ID.

Especially, network-based remote ID, as described in F3411 - 22a can be considered a valid implementation of this service specification.

## 2.5 Glossary of terms

| Term | Definition |
|---|---|
| **AIR-REPORT** | A report from an aircraft in flight prepared in conformity with requirements for position, and operational and/or meteorological reporting. |
| **External Data Model** | Describes the semantics of the domain (or a significant part thereof) by defining data structures and their relations. This could be at logical level (e.g., in UML) or at physical level (e.g., in XSD schema definitions), as for example standard data models. |
| **Message Exchange Pattern** | Describes the principles how two different parts of a message passing system (in our case: the service provider and the service consumer) interact and communicate with each other. Examples:<br><br>In the Request/Response MEP, the service consumer sends a request to the service provider in order to obtain certain information; the service provider provides the requested information in a dedicated response.<br><br>In the Publish/Subscribe MEP, the service consumer establishes a subscription with the service provider in order to obtain certain information; the service provider publishes information (either in regular intervals or upon change) to all subscribed service consumers. |
| **Operational Activity** | An activity performed by an operational node. Examples of operational activities are: Route Planning, Route Optimization, Logistics, Safety, Weather Forecast Provision, … |
| **Operational Model** | A structure of operational nodes and associated operational activities and their inter-relations in a process model. |
| **Operational Node** | A logical entity that performs activities. Note: nodes are specified independently of any physical realisation.<br><br>Examples of operational nodes are: Control Center, Authority, Weather Information Provider, … |
| **Service** | The provision of something (a non-physical object), by one, for the use of one or more others, regulated by formal definitions and mutual agreements. Services involve interactions between providers and consumers, which may be performed in a digital form (data exchanges) or through voice communication or written processes and procedures. |

| | |
|---|---|
| **Service Consumer** | A service consumer uses service instances provided by service providers. |
| **Service Data Model** | Formal description of one dedicated service at logical level. The service data model is part of the service specification. Is typically defined in UML and/or XSD. If an external data model exists (e.g., a standard data model), then the service data model shall refer to it: each data item of the service data model shall be mapped to a data item defined in the external data model. |
| **Service Design Description** | Documents the details of a service technical design (most likely documented by the service implementer). The service design description includes (but is not limited to) a service physical data model and describes the used technology, transport mechanism, quality of service, etc. |
| **Service Implementation** | The provider side implementation of a dedicated service technical design (i.e., implementation of a dedicated service in a dedicated technology). |
| **Service Implementer** | Implementers of services from the service provider side and/or the service consumer side. |
| **Service Instance** | One service implementation may be deployed at several places by same or different service providers; each such deployment represents a different service instance, being accessible via different URLs. |
| **Service Instance Description** | Documents the details of a service implementation (most likely documented by the service implementer) and deployment (most likely documented by the service provider). The service instance description includes (but is not limited to) service technical design reference, service provider reference, service access information, service coverage information, etc. |
| **Service Interface** | The communication mechanism of the service, i.e., interaction mechanism between service provider and service consumer. A service interface is characterised by a message exchange pattern and consists of service operations that are either allocated to the provider or the consumer of the service. |
| **Service Operation** | Functions or procedure which enables programmatic communication with a service via a service interface. |
| **Service Physical Data Model** | Describes the realisation of a dedicated service data model in a dedicated technology. This includes a detailed description of the data payload to be exchanged using the chosen technology. The actual format of the service physical data model depends on the chosen technology. Examples may be WSDL and XSD files (e.g., for SOAP services) or swagger (Open API) specifications (e.g., for REST services). If an external data model exists (e.g., a standard data model), then the service physical data model shall refer to it: each data item of the service physical data model shall be mapped to a data item defined in the external data model.<br><br>In order to prove correct implementation of the service specification, there shall exist a mapping between the service physical data model and the service data model. This means, each data item used in the service physical data model shall be mapped to a corresponding data item of the service data model. (In case of existing mappings to a common external (standard) data model from both the service data model and the service physical data model, such a mapping is implicitly given.) |
| **Service Provider** | A service provider provides instances of services according to a service specification and service instance description. All users within the domain can be service providers, e.g., authorities, organizations (e.g., meteorological), commercial service providers, etc. |

| | |
|---|---|
| **Service Specification** | Describes one dedicated service at logical level. The Service Specification is technology-agnostic. The Service Specification includes (but is not limited to) a description of the Service Interfaces and Service Operations with their data payload. The data payload description may be formally defined by a Service Data Model. |
| **Service Specification Producer** | Producers of service specifications in accordance with the service documentation guidelines. |
| **Service Technical Design** | The technical design of a dedicated service in a dedicated technology. One service specification may result in several technical service designs, realising the service with different or same technologies. |
| **Service Technology Catalogue** | List and specifications of allowed technologies for service implementations. Currently, SOAP and REST are envisaged to be allowed service technologies. The service technology catalogue shall describe in detail the allowed service profiles, e.g., by listing communication standards, security standards, stacks, bindings, etc. |
| **Spatial Exclusiveness** | A service specification is characterised as "spatially exclusive", if in any geographical region just one service instance of that specification is allowed to be registered per technology.<br><br>The decision, which service instance (out of a number of available spatially exclusive services) shall be registered for a certain geographical region, is a governance issue. |

**Table 1: Glossary of terms**

## 2.6 List of Acronyms

| Acronym | Definition |
|---|---|
| **API** | Application Programming Interface |
| **CIS** | Common Information Services |
| **MEP** | Message Exchange Pattern |
| **NAF** | NATO Architectural Framework |
| **REST** | Representational State Transfer |
| **SOA** | Service Oriented Architecture |
| **SOAP** | Simple Object Access Protocol |
| **SSD** | Service Specification Document |
| **UML** | Unified Modelling Language |
| **URL** | Uniform Resource Locator |
| **WSDL** | Web Service Definition Language |
| **XML** | Extendible Mark-up Language |
| **XSD** | XML Schema Definition |

**Table 2: List of acronyms**

# 3 Service Identification

The purpose of this chapter is to provide a unique identification of the service and describe where the service is in terms of the engineering lifecycle.

| | |
|---|---|
| **Name** | **Traffic Telemetry Service** |
| **ID** | **urn:frequentis:services:TrafficTelemetryService** |
| **Version** | **2.0.2** |
| **Description** | **A service which provides position reports of objects such as aircraft (manned and unmanned),** |
| **Keywords** | **Position report Submission Sub-Service, Surveillance Data Service, U-space Tracking, UAV Orientation, Speed** |
| **Architect(s)** | **2020-today The Frequentis Group**<br><br>**2018-2020 The GOF U-Space Project Consortium** |
| **Status** | **Provisional** |

**Table 3: Service Identification**

# 4 Operational Context

This section describes the context of the service from an operational perspective.

## 4.1 Functional and Non-functional Requirements

The table below lists applicable existing requirements for the **Traffic/Telemetry** service.

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| [R-1] | Common Situational Awareness | At all times, all U-space participants shall operate on the same common set of data, during pre-flight planning stages as well as during all stages of flight operations. | CORUS [4], 3.1.1.2 Z Volumes; B1-RPAS [9];CEF-SESAR-2018-1 [1], Objective O5 |
| [R-2] | Basis for Open Market | The U-space concept shall be designed such as to ensure a well-established line of authority while at the same time ensuring that an open market for VLL services may develop | SESAR Drone Roadmap [11], Foreword, 4.1 and 4.2;U-space Blueprint [13], Benefits to European society and economy; CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |
| [R-3] | Interoperability | There shall be an implementation of a Flight Information Management System (FIMS) which ensures that, at all times, emerging unmanned traffic management systems and existing technologies from manned operations can exchange any data required to support such common situational awareness, be it for drone operations in areas where established ATC procedures apply, or in zones outside established ATC. | ICAO Doc 10039 [2];[R-2];CEF-SESAR-2018-1 [1], Objective O6; CEF-SESAR-2018-1 [1], Table 8 – Key Challenges<br><br>Note: The term 'Flight Information Management System (FIMS)' has been since replaced by 'Common Information Services (CIS)'. This text hence refers to CIS, rather than FIMS. |
| [R-4] | Standard Protocols | Standard communication protocols shall hence be used where available, and such standard protocols be developed otherwise, in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop. | [R-2];SESAR Drone Roadmap [11], 3.5, section ‘Standards’;C EF-SESAR-2018-1 [1], Table 8 – Key Challenges |
| [R-5] | Open Interfaces | Any interface and protocol hence must be openly defined and its definition be freely accessible in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop. | [R-2];CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |



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| | | | |
|---|---|---|---|
| [R-6] | SWIM | The implementation of a Flight Information Management System (FIMS) shall be based on an ICAO SWIM-compliant architecture. | [R-3];CEF-SESAR-2018-1 [1], 5.3.4 Overall approach and methodology<br><br>Note: The term 'Flight Information Management System (FIMS)' has been since replaced by 'Common Information Services (CIS)'. This text hence refers to CIS, rather than FIMS. |
| [R-7] | Latency | Under no operational circumstance, the processing of position data may add significant latency to the overall detection-to-display latency of position data. In particular,<br><br>The processing latency added by the processing of positional data shall never exceed 10 per cent of the maximum value of the corresponding value permitted for the entire ATM automation system.<br><br>The processing latency and delay added by the processing of positional data should not exceed 1 per cent of the maximum value of the corresponding value permitted for the entire ATM automation system.<br><br>The maximum value for latency and delay is the minimum of the values defined by the ATM system performance requirements by EUROCONTOL and the FAA; for a 3 NM minimal separation, this is 2.2 s, for a 5 NM separation, 2.5 s. | [17], tables in the Executive Summary, [16], 3N_C-R8 and 5N_C-R8 |

**Table 4: Requirements for the Traffic/Telemetry Service**

# 4.2 Other Constraints

## 4.2.1 Relevant Industrial Standards

### 4.2.1.1 ICAO SWIM

The System Wide Information Management (SWIM, [2]) complements human-to-human with machine-to-machine communication, and improves data distribution and accessibility in terms of quality of the data exchanged. The SWIM Concept addresses the challenge of creating an "interoperability environment" which allows the SWIM IT systems to cope with the full complexity of operational information exchanges. The SWIM environment shifts the ATM information architecture paradigm from point-to-point data exchanges to system-wide interoperability.

#### 4.2.1.2 EUROCONTROL ASTERIX

The All-purpose structured EUROCONTROL surveillance information exchange (ASTERIX) [18] is a set of documents defining the low level ("down to the bit") implementation of a data format used for exchanging surveillance-related information and other ATM applications.

EUROCONTROL-SPEC-0149-9 - EUROCONTROL Specification for Surveillance Data Exchange ASTERIX Part 9 Category 062 SDPS Track Messages

EUROCONTROL-SPEC-0149-12 - EUROCONTROL Specification for Surveillance Data Exchange ASTERIX Part 12 Category 21 ADS-B Target Reports

EUROCONTROL-SPEC-0149-14 - EUROCONTROL Specification for Surveillance Data Exchange ASTERIX Part 14 Category 20 Multilateration Target Reports

EUROCONTROL-SPEC-0149-17 - EUROCONTROL Specification for Surveillance Data Exchange ASTERIX Part 17 Category 004 Safety Net Messages

EUROCONTROL-SPEC-0149-28 - EUROCONTROLSpecification for Surveillance Data Exchange – ASTERIX Part 28 - Category 015: INCS System Target Reports

EUROCONTROL-SPEC-0149-29 - EUROCONTROL Specification for Surveillance Data Exchange – ASTERIX Part 29 - Category 129: UAS Identification Reports

EUROCONTROL-SPEC-0149-30 - EUROCONTROL Specification for Surveillance Data Exchange – ASTERIX Part 30 - Category 016: Independent Non-Cooperative Surveillance System Configuration Reports

EUROCONTROL-SPEC-0149-31 - EUROCONTROL Specification for Surveillance Data Exchange – ASTERIX Part 31 - Category 205: Radio Direction Finder Reports

#### 4.2.1.3 EUROCONTROL ATM Automation System Environment Performance Requirements

Eurocontrol defines clear operational requirements and an elaborated assessment methodology for European surveillance in its Specification for ATM Surveillance System Performance [16]. For instance, for a separation of 3 nautical miles:

| Req. # | Quality of service | Mandatory performance |
|---|---|---|
| 3N_C-R8 | Forwarded pressure altitude average data age (see Note 7 in § 3.4.5) | Less than or equal to 2.5 seconds |

**Table 5: Excerpt from EUROCONTROL Specification for ATM Surveillance System Performance [16]**

Further requirements for update rates and error margins apply.

#### 4.2.1.4 FAA ATM Automation System Environment Performance Requirements

In a similar fashion, the Federal Aviation Administration concludes that the time from the determination of a position (measurement) to display (latency of the ATM system) shall not exceed similar values [17]:

| | |
|---|---|
| Latency | 2.2 seconds to display maximum |

The FAA also applies further requirements for update rates and error margins.

### 4.2.2 Operational Nodes

A typical U-space flight goes through several stages, starting strategic-tactically, pre-flight, from Strategic Planning, over to Pre-Tactical Planning, to Tactical Planning. Then, tactical-operationally it enters into the actual in-flight stages from Departure, over to In-Flight, and, finally Arrival. Further post-flight stages may evaluate the results from the data produced during the prior stages.

The Traffic/Telemetry service primarily is relevant during the actual operational in-flight stages of a U-space flight during which the flying device and/or the corresponding ground stations produce the position data which we convey via the Traffic/Telemetry service.

There are several nodes in U-space which could provide position information to the Traffic/Telemetry service.

- An actual aircraft (manned or unmanned), that provides position data to a ground station
- A ground station, relaying or providing position data to a Central Information Service (CIS)
- A CIS to consolidate for consuming applications and services

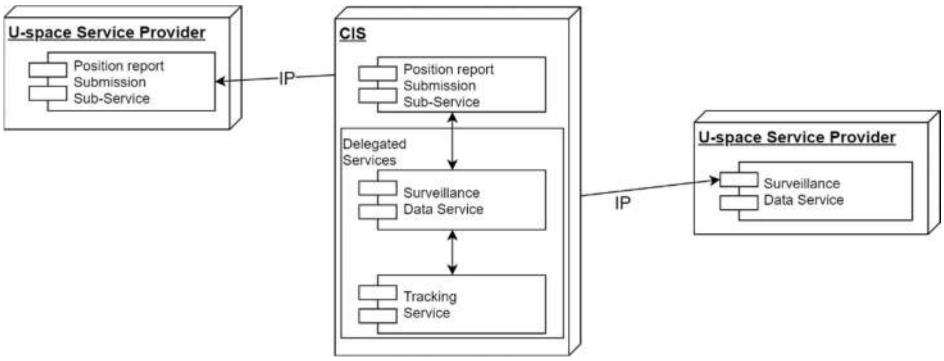


**Figure 1: U-space nodes related to the Traffic/Telemetry service**

Though a simple view on data provided by a Traffic/Telemetry service already could be used for some applications, typically consuming services and applications will utilize the service together with other services like

- Flight Planning Services - to retrieve more information about a flight associated with the position report

- Registration Services - for background on e.g. operator, pilot and flown device
- Geofencing Services – to draw a user's attention to a potential area conflict and to act accordingly, possibly even automatically

Consuming services and applications include the following services and applications.

- Tactical Deconfliction Service
- Tracking Service
- Traffic Alerting Service
- Displays for Situational Overview
- Accident and Incident Reporting Services
- Traffic Monitoring Services
- Traffic Information Services
- Legal Recording Service

Operational nodes which may provide data for the Traffic/Telemetry service include the following ones.

| Operational Node | Remarks |
|---|---|
| Aircraft | Manned, unmanned, and/or autonomous |
| Ground Station | Professional or recreational alike |
| UTM Service Provider | |
| Common Information Service | |

**Table 6: Operational Nodes providing the Traffic/Telemetry service**

Operational nodes which may consume the Traffic/Telemetry service include the following ones.

| Operational Node | Remarks |
|---|---|
| Common Information Service | |
| Information Display | |
| Telemetry Converter | |
| Legal Recorder | |

**Table 7: Operational Nodes consuming the Traffic/Telemetry service**

### 4.2.3 Operational Activities

Operational activities supported by the Traffic/Telemetry service include the following ones.

| Phase | Operational Activity | Remarks |
|---|---|---|
| Pre-flight | Set-up | *(Telemetry likely not operational yet at this stage)* |
| | Plan | *(Telemetry likely not operational yet at this stage)* |

| | | |
|---|---|---|
| | Arm | *(Traffic/telemetry should start to run here)* |
| In-Flight | Depart | Traffic/Telemetry data operational for the flight |
| | Cruise | Traffic/Telemetry data operational for the flight |
| | Arrive | Traffic/Telemetry data operational for the flight |
| Post-Flight | Disarm | *(Traffic/telemetry likely stops here)* |
| | Report | *(Post/flight analysis only)* |

**Table 8: Operational Activities supported by the Traffic/Telemetry service**



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# 5 Service Overview

## 5.1 Service Interfaces

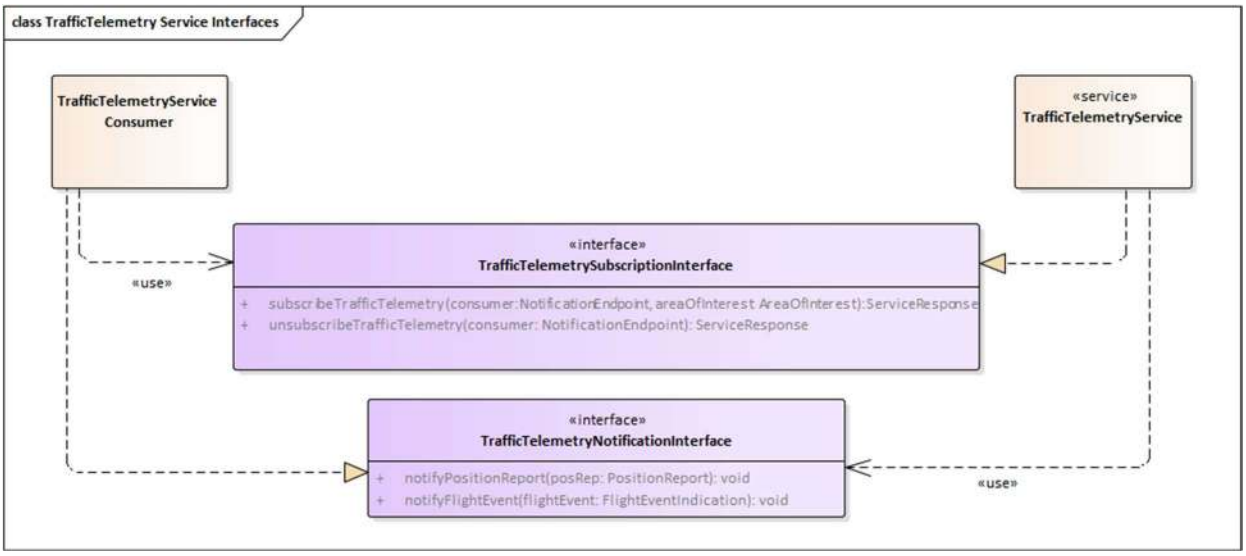


**Figure 2: Traffic/Telemetry Interface Definition diagram**

| ServiceInterface | Role (from service provider point of view) | ServiceOperation |
|---|---|---|
| TrafficTelemetrySubscriptionInterface | Provided | subscribeTrafficTelemetry<br>unsubscribeTrafficTelemetry |
| TrafficTelemetryNotificationInterface | Required | notifyPositionReport<br>notifyFlightEvent |

**Table 9: Service Interfaces**

# 6 Service Data Model

This section describes the information model, i.e., the logical data structures to be exchanged between providers and consumers of the service.

## 6.1 Overview

The Traffic/Telemetry service transfers positional data as **PositionReports**, aggregating **Position** and **Altitude** data, derived from the aggregated **Pose** structure which may carry **Velocity**, **Orientation**, **ObjectIdentification**, and an **ObjectPriority**. Optionally (if supported by the service provider), also **ObjectClassificationInfo** may be included.

The provision of the Position and at least one Altitude data item is mandatory.

There should be at least one **ObjectIdentifiation** data item in each Pose. Data sources should report as many **ObjectIdentification** and **ObjectClassificationInfo** data items as they have data available.

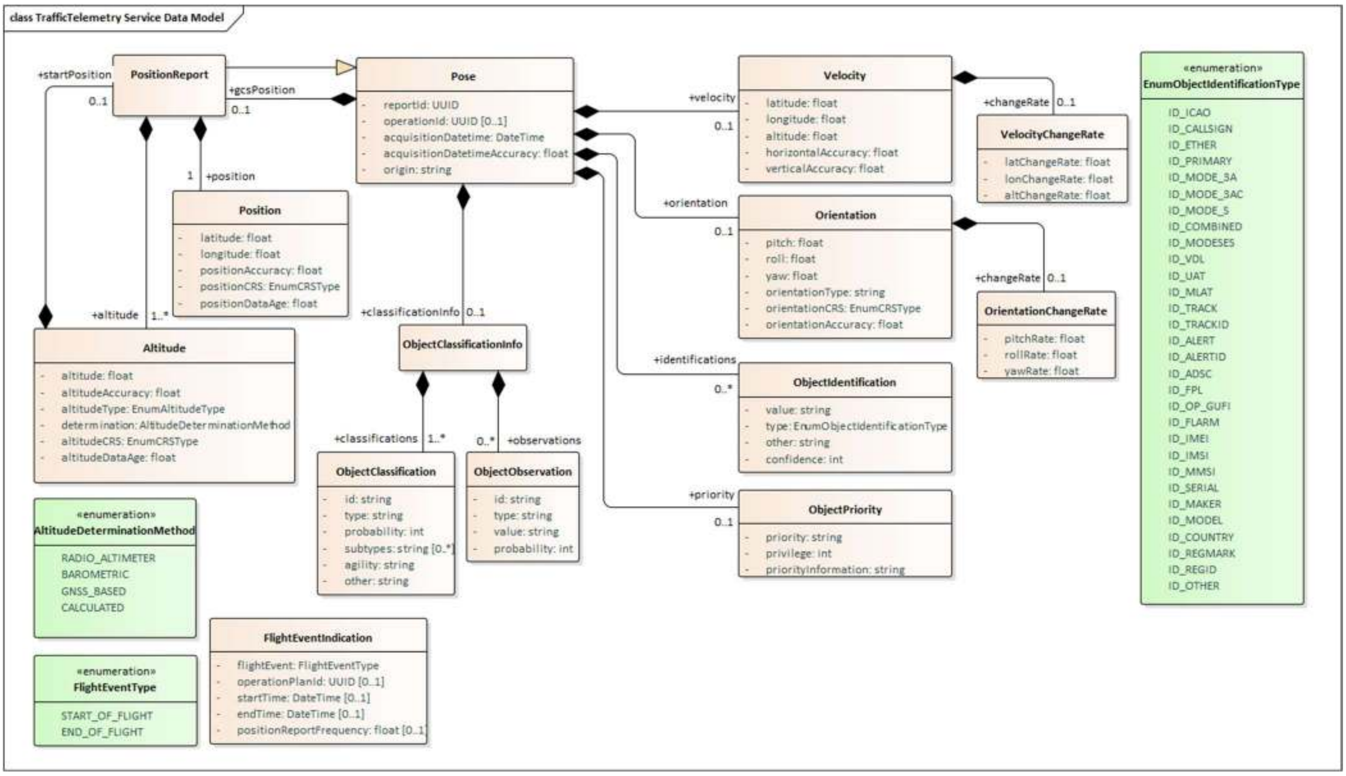


**Figure 3: Data Model diagram of the Traffic/Telemetry Service**

## 6.2 The Pose Data Structure

Pose is a composite of Velocity, Orientation, Object Identification, and Object Priority. This structure builds the base for dedicated Report structures (e.g., the PositionReport). Depending on a service provider's capabilities, only the core attributes of Pose and a (possibly empty) subset of its composing elements may be available on the service interface.

| **Property** | **Type** | **Multiplicity** | **Description** | **Note** |
|---|---|---|---|---|
| reportId | UUID | 1 | A uuid, globally unique to identify the position record | The UUI should be generated by as close as possible to the data originator (e.g. airborne, or by the operator). |
| operationId | UUID | 0..1 | The id of the operation, e. g. a flight_id i. e. a gufi, globally unique identifier referencing the flight producing this position report.<br><br>If no operation plan is known, this element is missing. | More information for an operation may be retrieved using a respective Common Information Service |
| acquisitionDatetime | DateTime | 1 | UTC point in time when the position was measured by the positioning unit of the device in operation | Expressed in UTC using the ISO 8601 date time format |
| acquisitionDatetimeAccuracy | Real | 1 | Accuracy of acquisition time measurement in ms | |
| origin | string | 1 | Indicates the origin of this position record. Can be, e.g., a sensor identification, or a tracker identification. | Two Pose records could be sent from the same aircraft – they would be identified by a different origin. Depending on bandwidth considerations all available sensors should be utiziled and transmit Pose records. |

| | | | | |
|---|---|---|---|---|
| gcsPosition | PositionReport | 0..1 | If provided, carries the Position and Altitude of the Ground Control Station being in control of the drone that is being reported about by this Pose data structure. | |
| velocity | Velocity | 0..1 | If provided, carries the velocity of the object being reported about in this **Pose**.<br><br>There may be none or one **Velocity** data structure provided for every **Pose**, providing all, or a subset, of the data it may carry. | There may be none or one **Velocity** data structure provided for every **Pose**, providing all, or a subset, of the data it may carry. |
| orientation | Orientation | 0..1 | If provided, carries the orientation data of the object being reported about in this **Pose**.<br><br>There may be none or one **Orientation** data structure provided for every **Pose**, providing all, or a subset, of the data it may carry. | There may be none or one **Orientation** data structure provided for every **Pose**, providing all, or a subset, of the data it may carry. |

| | | | | |
|---|---|---|---|---|
| identifications | ObjectIdentification | 0..* | If provided, carries data to assist in identifying the object we report about in this **Pose**. It can be a vehicle registration identifier or any other appropriate identifier.<br><br>There shall be none, one or more complete **ObjectIdentification** data structure(s) provided for every **Pose**, providing the means of identification of the target.<br><br>The first of the **ObjectIdentification** data structures provided shall contain the value which subsequent processing stages may rely on as accurate and binding.<br><br>Per default, this first **ObjectIdentification** data structure should contain the officially registered unique ID as assigned by the registering authority of the country of registration of the vehicle. | Data sources should report as many **ObjectIdentification** data items as they have data available.<br><br>There should be at least one **ObjectIdentifiation** data item in each **Pose**. |
| priority | ObjectPriority | 0..1 | If provided, carries data indicating the priority level of the object being reported about in this **Pose**.<br><br>There shall be none, or one, **ObjectPriority** data structure provided for every **Pose**. | |

| | | | | |
|---|---|---|---|---|
| classificationInfo | ObjectClassificationInfo | 0..1 | Optional information about the classification of the object being reported about. | |

**Table 10: The Pose data structure**

## 6.3 The Velocity Data Structure

The **Velocity** data structure may carry the velocity of the object being reported about. Velocity is represented as vector; it includes information on bearing and inclination.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| latitude | Real | 0..1 | Velocity in latitudinal direction in unit of measurement defined in unit of measurement as defined by Position.positionCrs. | |
| longitude | Real | 0..1 | Velocity in logitudinal direction in unit of measurement defined in unit of measurement as defined by Position.positionCrs. | |
| altitude | Real | 0..1 | Velocity in vertical direction in unit of measurement defined in unit of measurement as defined by Altitude.altitudeCrs. | |
| horizontalAccuracy | Real | 0..1 | Accuracy of horizontal velocity in unit of measurement defined by Position.positionCrs. | |
| verticalAccuracy | Real | 0..1 | Accuracy of vertical velocity in unit of measurement defined in Altitude.altitudeCrs. | |
| changeRate | VelocityChangeRate | 0..1 | Optional information about the change rate of the velocity (i.e., the acceleration). | |

**Table 11: The Velocity data structure**

## 6.4 The VelocityChangeRate Data Structure

The **VelocityChangeRate** data structure describes the speed change rate (acceleration) of the object being reported about.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| latChangeRate | Real | 0..1 | Change rate of the latitudinal velocity per time unit in unit of measurement as defined by Position.positionCrs. | |
| lonChangeRate | Real | 0..1 | Change rate of the longitudinal velocity per time unit in unit of measurement as defined by Position.positionCrs. | |

| | | | | |
|---|---|---|---|---|
| altChangeRate | Real | 0..1 | Change rate of the vertical velocity per time unit in unit of measurement as defined by Altitude.altitudeCrs. | |

**Table 12: The VelocityChangeRate data structure**

## 6.5 The Orientation Data Structure

The **Orientation** data structure may carry the orientation data of the object being reported about.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| pitch | Real | 0..1 | Transverse axis in unit of measurement as defined by orientationCrs | |
| roll | Real | 0..1 | Longitudinal axis in unit of measurement as defined by orientationCrs | |
| yaw | Real | 0..1 | Vertical axis in unit of measurement as defined by orientationCrs | |
| orientationType | OrientationType | 1 | Measured or calculcated | |
| orientationCrs | EnumCRSType | 1 | Coordinate reference system used (e. g., for WGS-84, EPSG:4979) | Enum values: S-UTM Services Common Data Model - Basic Geometry Data Types |
| orientationAccuracy | Real | 0..1 | Accuracy of orientation in unit of measurement defined in orientationCrs | |
| changeRate | OrientationChangeRate | 0..1 | Optional information about the change rate of the Orientation. | |

**Table 13: The Orientation data structure**

## 6.6 The OrientationChangeRate Data Structure

The **OrientationChangeRate** data structure describes the rate of change of the orientation of the object being reported about.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| pitchRate | Real | 0..1 | Change rate of the movement around the transversal axis per time unit in unit of measurement as defined by Orientation.orientationCrs. | |

| | | | | |
|---|---|---|---|---|
| rollRate | Real | 0..1 | Change rate of the movement around the longitudinal axis per time unit in unit of measurement as defined by Orientation.orientationCrs. | |
| yawRate | Real | 0..1 | Change rate of the movement around the vertical axis per time unit in unit of measurement as defined by Orientation.orientationCrs. | |

**Table 14: The OrientationChangeRate data structure**

## 6.7 The ObjectIdentification Data Structure

The **ObjectIdentification** data structure may carry data to assist in identifying the object we report about in this report. It can be a vehicle registration identifier or any other identifier as listed in the IdentificationType property. Data sources should report all **ObjectIdentification** data items they have data about.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| value | String | 1 | The actual value of the identification of the object this report applies to, of type **type**. | |
| type | EnumObjectIdentificationType | 1 | Type of identification conveyed by this **ObjectIdentification** item, as defined by the **EnumObjectIdentificationType**. | |
| other | String | 0..1 | Optional empty item for temporary use until standardization is in place: Unless **type** is set to “ID_OTHER”, do not set this field at all; however, if **type** is set to “ID_OTHER”, set this field to a descriptive string for the type and set **value** to the corresponding value.<br><br>**NOTE:** Use of this field is **discouraged** at any time and permitted for local bilateral temporary deviation of standard only until updated standardization is in place. | |
| confidence | Integer | 0..1 | Optional item with a range from 0 to 100 representing the degree of confidence the emitter of this information has that the object we report about in this report actually can be identified by this particular **value**. | |

**Table 15: ObjectIdentification data structure**

## 6.8 The EnumObjectIdentificationType Enumeration

The **EnumObjectIdentificationType** enumeration type specifies possible ways to identify an object.

| Property | Description | Note |
|---|---|---|
| ID_ICAO | indicating an ICAO 24 bit address | |
| ID_CALLSIGN | indicating a call sign as per [ICAO-DOC-4444] | |
| ID_ETHER | indicating an Ethernet address | |
| ID_PRIMARY | primary surveillance | |
| ID_MODE_3A | secondary surveillance, 2D only, squawk | |
| ID_MODE_3AC | secondary surveillance, 3D, squawk | |
| ID_MODE_S | secondary surveillance, ICAO 24 bit address | |
| ID_COMBINED | ombined primary/secondary surveillance | |
| ID_MODE_SES | dependent surveillance, ICAO 24 bit address | |
| ID_VDL | dependent surveillance, ICAO 24 bit address | |
| ID_UAT | dependent surveillance, ICAO 24 bit address | |
| ID_MLAT | secondary surveillance, ICAO 24 bit address | |
| ID_TRACK | combined surveillance, numeric track id | |
| ID_TRACKID | combined surveillance, track uuid | |
| ID_ALERT | surveillance, numeric alert id | |
| ID_ALERTID | surveillance, alert uuid | |
| ID_ADSC | dependent surveillance, ICAO 24 bit address | |
| ID_FPL | dependent surveillance, squawk or no id, FPL number | |
| ID_GUFI | operation-id, i. e. the uuid of the operation | |
| ID_FLARM | dependent surveillance, FLARM-ID | |
| ID_IMEI | dependent surveillance, IMEI number | |
| ID_IMSI | dependent surveillance, IMSI number | |
| ID_MMSI | dependent surveillance, MMSI number | |
| ID_SERIAL | dependent surveillance, serial number of the vehicle as assigned by its manufacturer | |
| ID_MAKER | dependent surveillance, three letters identifying the manufacturer of the vehicle | |
| ID_MODEL | dependent surveillance, three letters identifying the model of the manufacturer of the vehicle | |
| ID_COUNTRY | dependent surveillance, ISO 3166-1 Alpha 2 code of the country of registration of the vehicle | |
| ID_REGMARK | indicating a registration marking (e. g. [ICAO-ANN-10-IV], [ICAO-ANN-7]) | |
| ID_REGID | indicating a registration (e. g. uuid) from the national (aircraft or drone) registry | |

| Property | Description | Note |
|---|---|---|
| ID_OTHER | **discouraged** | |

**Table 16: EnumObjectIdentificationType enumeration**

## 6.9 The ObjectPriority Data Structure

The **ObjectPriority** data structure may carry information about the status of the object and the priority it requires or requires/requests.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| priority | String | 1 | The status of the object this **ObjectPriority** item reports about, one of:<br><br>NORMAL Generic normal state of operations<br><br>FOLLOWME Normal state of operations, specifically operating as follow-me or marshal<br><br>RUNWAYCHECK Normal state of operations, specifically checking runway or taxiway<br><br>TOWING Normal state of operations, specifically towing vehicle, ship or aircraft<br><br>WIP Normal state of operations, work in progress such as maintenance or sweeping<br><br>TROUBLE Generic state of out-of-order operation such as technical failure<br><br>SAFETY Out-of-order state with safety impact to others (securité)<br><br>URGENCY Out-of-order state with immediate impact on the safety of the object or to human safety or health, or foreseeable distress<br><br>DISTRESS Out-of-order state with immediate danger to human life, on-board, or immediately related to the object | |

| | | | | |
|---|---|---|---|---|
| privilege | String | 1 | The privilege the object which this **ObjectPriority** item reports about requests or requires, one of:<br><br>NORMAL No privilege required nor requested<br><br>LAW Elevated privileges for law enforcement<br><br>EMERGENCY Elevated privileges to avoid danger of life<br><br>STATE Elevated privileges for matters of national security or other public safety, including military operations and diplomatic operations | |
| priorityInformation | String | 0..1 | Optional item which may hold additional information | |

**Table 17: The ObjectPriority data structure**

## 6.10The PositionReport Data Structure

The **PositionReport** data structure provides the actual position data, and one or more altitudes of the object being reported about. Furthermore, it inherits all properties of the **Pose** data structure.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| position | Position | 1 | Carries the position data of the object being reported about in this **PositionReport**. | There shall be one complete **Position** data structure provided for every **PositionReport**. |
| altitudes | Altitude | 1..* | Carries the altitude data of the object being reported about with this **PositionReport**.<br><br>There shall be one or more complete **Altitude** data structure provided for every **PositionReport**. The first of the **Altitude** data structures provided shall contain the value which subsequent processing stages may rely on as accurate and binding. | There shall be at least one complete **Altitude** data structure provided for every **PositionReport**. |
| all attributes inhertited from Pose | | | See Pose Data Structure | |

**Table 18: The PositionReport data structure**

## 6.11The Position Data Structure

The **Position** data structure carries the position data of the object being reported about.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| latitude | Real | 1 | Latitude of position record in unit of measurement as defined by positionCrs | Most commonly used CRSs use degrees as the UoM for the latitude; however, meters are used for Mercator projections. |
| longitude | Real | 1 | Longitude of position record in unit of measurement as defined by positionCrs | Most commonly used CRSs use degrees as the UoM for the longitude; however, meters are used for Mercator projections. |
| positionAccuracy | Real | 1 | Accuracy of **latitude** and **longitude** as the maximum deviation in the unit of measurement as defined by **positionCrs**. This means, for example, a value of **positionAccuracy**=x indicates that the real latitude reported in this position report is expected to be in the range of [**latitude**-x, **latitude**+x]. | The **positionAccuracy** value is mandatory and must be provided in any circumstance. It is the responsibility of the data provider to include an accuracy value into the position report.<br><br>In cases, where the accuracy value is not explicitly given by the data source, the accuracy has to be included according to the best knowledge, taking into account the documented sensor accuracy and the methodology of obtaining the value. |
| positionCrs | EnumCRSType | 1 | Coordinate reference system used (e. g., for WGS-84, EPSG:4979) | Enum values: S-UTM Services Common Data Model - Basic Geometry Data Types |
| positionDataAge | Real | 0..1 | Elapsed time in s since last position data received by the reporter of this **Position** | This attribute shall be provided, if the Position is used in a reporting service (e.g., in a PositionReport); in other cases this attribute may be omitted (e.g., in conversion operations). |

**Table 19: The Position data structure**

## 6.12The Altitude Data Structure

The **Altitude** data structure carries the altitude data of the object being reported about.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| altitude | Real | 1 | Altitude of position record in unit of measurement as defined by **altitudeCrs**. | All currently supported Coordinate Reference Systems use meters as unit of measurement for the altitude. |



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| | | | | |
|---|---|---|---|---|
| altitudeAccuracy | Real | 1 | Spedifies the accuracy of **altitude** as the maximum deviation in the unit of measurement as defined by **altitudeCrs**. This means, for example, a value of **altitudeAccuracy**=x indicates that the real altitude reported in this position report is expected to be in the range of [**altitude**-x, **altitude**+x]. | The **altitudeAccuracy** value is mandatory and must be provided in any circumstance. It is the responsibility of the data provider to include an accuracy value into the position report.<br><br>In cases, where the accuracy value is not explicitly given by the data source, the accuracy has to be included according to the best knowledge, taking into account the documented sensor accuracy and the methodology of obtaining the value.<br><br>For example, in case of barometric altitude determination, the accuracy heavily depends on the current air pressure at the time of measurement. If the data provider is in the possession of up to date pressure data, the resulting accuracy will be |

| | | | | |
|---|---|---|---|---|
| | | | | higher; if no up to date pressure data is available, the data provider shall still add a worst case **altitudeAccuracy** value taking the worst case pressure deviations into account. |
| altitudeType | EnumAltitudeType | 1 | indicates the reference point for altitude measurement, e. g.:<br><br>altitude above mean-sea-level (MSL)<br><br>altitude above take-off location (ATO)<br><br>altitude above ground (AGL/SFC)<br><br>altitude above the WGS-84 ellipsoid; value delivered by GPS. | |
| determinationMethod | AltitudeDeterminationMethod | 1 | Method of determination of altitude, e. g.:<br><br>radio-altimeter<br><br>barometric<br><br>GNSS-based<br><br>calculated against reference point and mean-sea-level | |

| | | | | |
|---|---|---|---|---|
| altitudeCrs | EnumCRSType | 1 | Coordinate reference system used (e. g., for WGS-84, EPSG:4979) | Enum values: S-UTM Services Common Data Model - Basic Geometry Data Types |
| altitudeDataAge | Real | 0..1 | Elapsed time in s since last position data received by the reporter of this **Altitude** | This attribute shall be provided, if the Altitude is used in a reporting service (e.g., in a PositionReport); in other cases this attribute may be omitted (e.g., in conversion operations). |
| startPosition | PositionReport | 0..1 | If provided, contains Position and Altitude of the starting point, where this drone flight has departed. | This information shall be added to the Altitude structure in case that the altitudeType is set to ABOVE_TO. |

**Table 20: The Altitude data structure**

## 6.13The EnumAltitudeType Enumeration

The EnumAltitudeType enumeration type specifies the possible ways to express an altitude/height.

See Common Geometry Data types.

## 6.14The EnumCRSType Enumeration

The EnumCRSType enumeration type specifies the possible ways to express a coordinate reference system.

See Common Geometry Data types.

## 6.15The AltitudeDeterminationMethod Enumeration

The AltitudeDeterminationMethod enumeration type specifies the possible ways to determine an altitude.

| Property | Description | Note |
|---|---|---|
| RADIO_ALTIMETER | Altitude measured via radio altimeter. | |
| BAROMETRIC | Altitude measured via air pressure. | |
| GNSS_BASED | Altitude obtained by satellite navigation system. | |
| CALCULATED | Altitude calculated against reference point. | |

**Table 21: The AltitudeDeterminationMethod enumeration**

## 6.16The FlightEventIndication Data Structure

The **FlightEventIndication** data structure carries information about a flight event, such as a "start of flight" or "end of flight".

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| flightEvent | FlightEventType | 1 | Indicates the type of the flight event being reported about. | |
| operationPlanId | UUID | 0..1 | Reference to the related operation plan, if available. | |
| startTime | DateTime | 0..1 | Indicates the (expected) start time of the flight. To be provided with a START_OF_FLIGHT event indication. | |
| endTime | DateTime | 0..1 | Indicates the end time of the flight. To be provided with an END_OF_FLIGHT event indication. | |
| positionReportFrequency | Float | 0..1 | Expected number of position reports per second for this flight.<br><br>Optionally provided with a START_OF_FLIGHT event indication. | |

**Table 22: The FlightEventIndication data structure**

## 6.17The FlightEventType  Enumeration

The FlightEventType enumeration type specifies the types of flight events.

| Property | Description | Note |
|---|---|---|
| START_OF_FLIGHT | denotes a start-of-flight event. | |
| END_OF_FLIGHT | denotes an end-of-flight event. | |

**Table 23: The FlightEventType enumeration**

## 6.18Common Data Structures Used in UTM Service Specifications

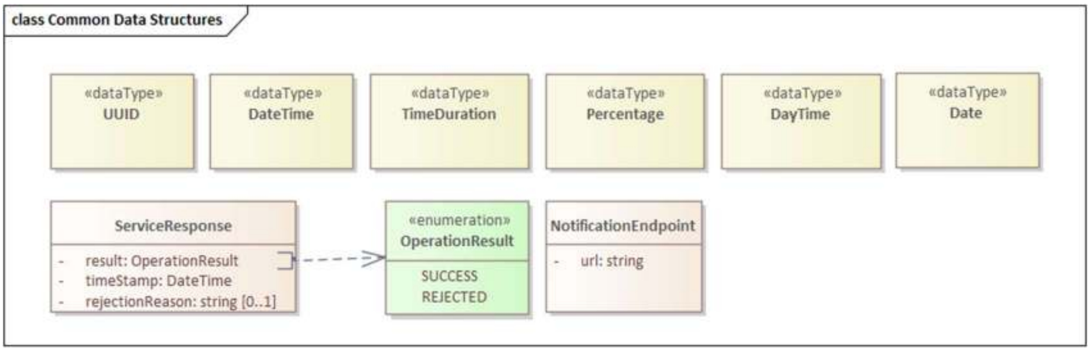


**Figure 4: Common Data Types Used in UTM Service Specifications**

## 6.18.1NotificationEndpoint **Data Structure**

**NotificationEndpoint** is used in subscription and un-subscription operations to show the receiver of notifications as a result of the subscription.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| URL | String | 1 | Endpoint capable of receiving notifications | |

**Table 24: NotificationEndpoint Data Structure**

## 6.18.2ServiceResponse **Data Structure**

ServiceResponse is the generic response provided by each service operation. In some cases, this basic data structure may be extended by inheritance.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| result | OperationResult | 1 | Indicates the result of the request to the service | |
| rejectReason | String | 0..1 | Optional additional information to be provided in case of negative result | |
| timeStamp | DateTime | 1 | | |

**Table 25: ServiceResponse Data Structure**

## 6.18.3OperationResult **Enumeration**

The **OperationResult** enumeration type specifies the possible outcomes of calling an operation.

| Property | Description | Note |
|---|---|---|
| SUCCESS | Operation was successfully executed. | |
| REJECTED | Operation could not be executed. | |

**Table 26: OperationResult Enumeration**

## 6.19Common Geometry Data Structures Used in UTM Service Specifications

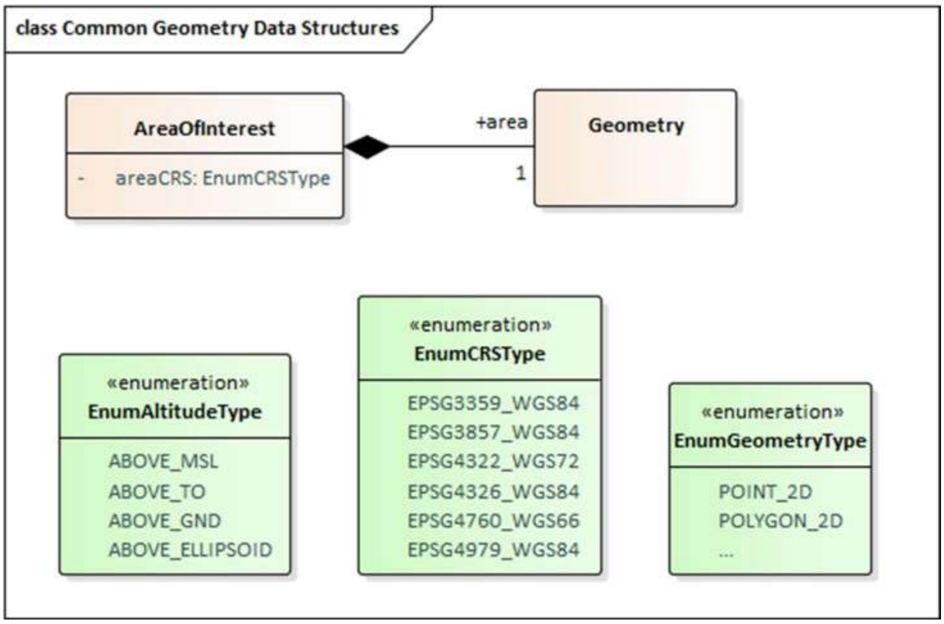


**Figure 5: Common Geometry Data Types Used in UTM Service Specifications**

### 6.19.1AreaOfInterest Data Structure

**AreaOfInterest** is used in subscription operations to provide an indication of the geographic area for which the subscriber is interested to receive notifications.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **area** | **Geometry** | 1 | A geometric description of a geographic area. | Should be a 2-dimensional geometry in this case. |
| **areaCRS** | **EnumCRSType** | 1 | Coordinate reference system used (WGS-84, EPSG:4979) | |

**Table 27: AreaOfInterest Data Structure**

### 6.19.2Geometry Data Structure

**Geometry** describes a geometrical shape of one, two or three dimensions.

The **Geometry** data structure is not further detailed in this service specification. One example of how a generic Geometry structure could be realized is sketched in the table below:

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **coordinates** | **Double** | 2..* | Collection of the coordinates, describing the geometry. | |

| | | | | |
|---|---|---|---|---|
| **geometryType** | **GeometryType** | 1 | Type of geometry being described by the coordinates. | Examples: Point, Polygon, Polyhedron, etc. |

**Table 28: Geometry Data Structure**

## 6.19.3 EnumAltitudeType Enumeration

The **EnumAltitudeType** enumeration type specifies the possible ways to express an altitude/height.

| Property | Description | Note |
|---|---|---|
| **ABOVE_MSL** | Altitude above mean-sea-level.<br><br>Same as orthometric height; same as height above the earth geoid. | |
| ABOVE_TO | Altitude above take-off location. | |
| ABOVE_GND | Height above ground surface. | |
| **ABOVE_ELLIPSOID** | Altitude above the WGS-84 ellipsoid; value delivered by GPS. | |

**Table 29: EnumAltitudeType Enumeration**

## 6.19.4 EnumCRSType Enumeration

The **EnumCRSType** enumeration type specifies the possible ways to express a coordinate reference system. The most common values used are noted in bold letters.

| Property | Description | Note |
|---|---|---|
| EPSG3395_WGS84 | World Mercator<br><br>Geodetic CRS: WGS 84;<br><br>Coordinate System: Cartesian CS.<br><br>Axes: easting, northing (E, N). Orientations: east, north.<br><br>UoM: metre. | Euro-centric view of world excluding polar areas. |

| | | |
|---|---|---|
| EPSG3857_WGS84 | Pseudo-Mercator -- Spherical Mercator, Google Maps, OpenStreetMap, Bing, ArcGIS, ESRI<br><br>Geodetic CRS: WGS 84;<br><br>Coordinate System: Cartesian CS.<br><br>Axes: easting, northing (X, Y). Orientations: east, north.<br><br>UoM: metre. | Uses spherical development of ellipsoidal coordinates. Relative to WGS 84 / World Mercator (CRS code 3395) errors of 0.7 percent in scale and differences in northing of up to 43km in the map (equivalent to 21km on the ground) may arise. |
| **EPSG4322_WGS72** | Geodetic CRS: WGS 72;<br><br>Coordinate System: Ellipsoidal 2D CS.<br><br>Axes: latitude, longitude. Orientations: north, east.<br><br>UoM: degree. | Uses Historic World Geodetic System 1972.<br><br>Horizontal component of 3D system. |
| **EPSG4326_WGS84** | WGS84 - World Geodetic System 1984, used in GPS<br><br>Geodetic CRS: WGS 84;<br><br>Coordinate System: Ellipsoidal 2D CS.<br><br>Axes: latitude, longitude. Orientations: north, east.<br><br>UoM: degree. | Horizontal component of 3D system. Used by the GPS satellite navigation system and for NATO military geodetic surveying. |
| **EPSG4760_WGS66** | Geodetic CRS: WGS 66;<br><br>Coordinate System: Ellipsoidal 2D CS.<br><br>Axes: latitude, longitude. Orientations: north, east.<br><br>UoM: degree. | Uses Historic World Geodetic System 1966.<br><br>Horizontal component of 3D system. |



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| | | |
|---|---|---|
| EPSG4979_WGS84 | Geodetic CRS: WGS 84;<br><br>Coordinate System: Ellipsoidal 3D CS.<br><br>Axes: latitude, longitude, ellipsoidal height. Orientations: north, east, up.<br><br>UoM: degree, degree, metre. | Used by the GPS satellite navigation system. |

**Table 30: EnumCRSType Enumeration**

## **6.19.5**EnumGeometryType **Enumeration**

The **EnumGeometryType** enumeration type specifies possible geometrical shapes.

| **Property** | **Description** | **Note** |
|---|---|---|
| POINT | Single point. | |
| POLYGON | Polygon. | |
| ... | | |

**Table 31: EnumGeometryType Enumeration**

# 7 Service Interface Specifications

This chapter describes the details of each service interface. One sub-chapter is provided for each Service Interface.

The Service Interface specification covers only the static design description while the dynamic design (behaviour) is described later.

## 7.1 Service Interface TrafficTelemetrySubscriptionInterface

### 7.1.1 Operation subscribeForTrafficTelemetry

#### 7.1.1.1 Operation Functionality

A consumer calls this operation to subscribe to position report data.

#### 7.1.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| consumer | Input | NotificationEndpoint | Which endpoint shall be notified in case of new PositionReports (and FlightEvents, if supported). |
| areaOfInterest | Input | AreaOfInterest | Area of interest to the consumer |
| response | Return | ServiceResponse | Provide status information on subscription |

**Table 32: Payload description of subscribeForTrafficTelemetry operation**

### 7.1.2 Operation unSubscribeForTrafficTelemetry

#### 7.1.2.1 Operation Functionality

A consumer calls this operation at the provider to unsubscribe from position report data.

#### 7.1.2.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| consumer | Input | NotificationEndpoint | Which endpoint shall be not be notified (anymore) in case of new PositionReports. |
| response | Return | ServiceResponse | Provide status information on subscription |

**Table 33: Payload description of unSubscribeForTrafficTelemetry operation**

## 7.2 Service Interface TrafficTelemetryNotificationInterface

Consumer provides this interface, allowing the service provider to submit to the consumer position report data (and flight event notifications, if supported).

### 7.2.1 Operation notifyPositionReport

#### 7.2.1.1 Operation Functionality

Once and while subscribed, consumer receives position report data via this operation.

#### 7.2.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| positionReport | Input | PositionReport | A position report matching the area criterium provided with subscription. |

**Table 34: Payload description of notifyPositionReport operation**

### 7.2.2 Operation notifyFlightEvent

#### 7.2.2.1 Operation Functionality

Once and while subscribed, consumer receives flight event notifications via this operation.

#### 7.2.2.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| flightEvent | Input | FlightEventNotification | Indication of a flight event taking place in the area criterium provided with subscription. |

**Table 35: Payload description of notifyFlightEvent operation**



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# 8 Service Dynamic Behaviour

## 8.1 Service Interfaces TrafficTelemetrySubscriptionInterface and TrafficTelemetryNotificationInterface

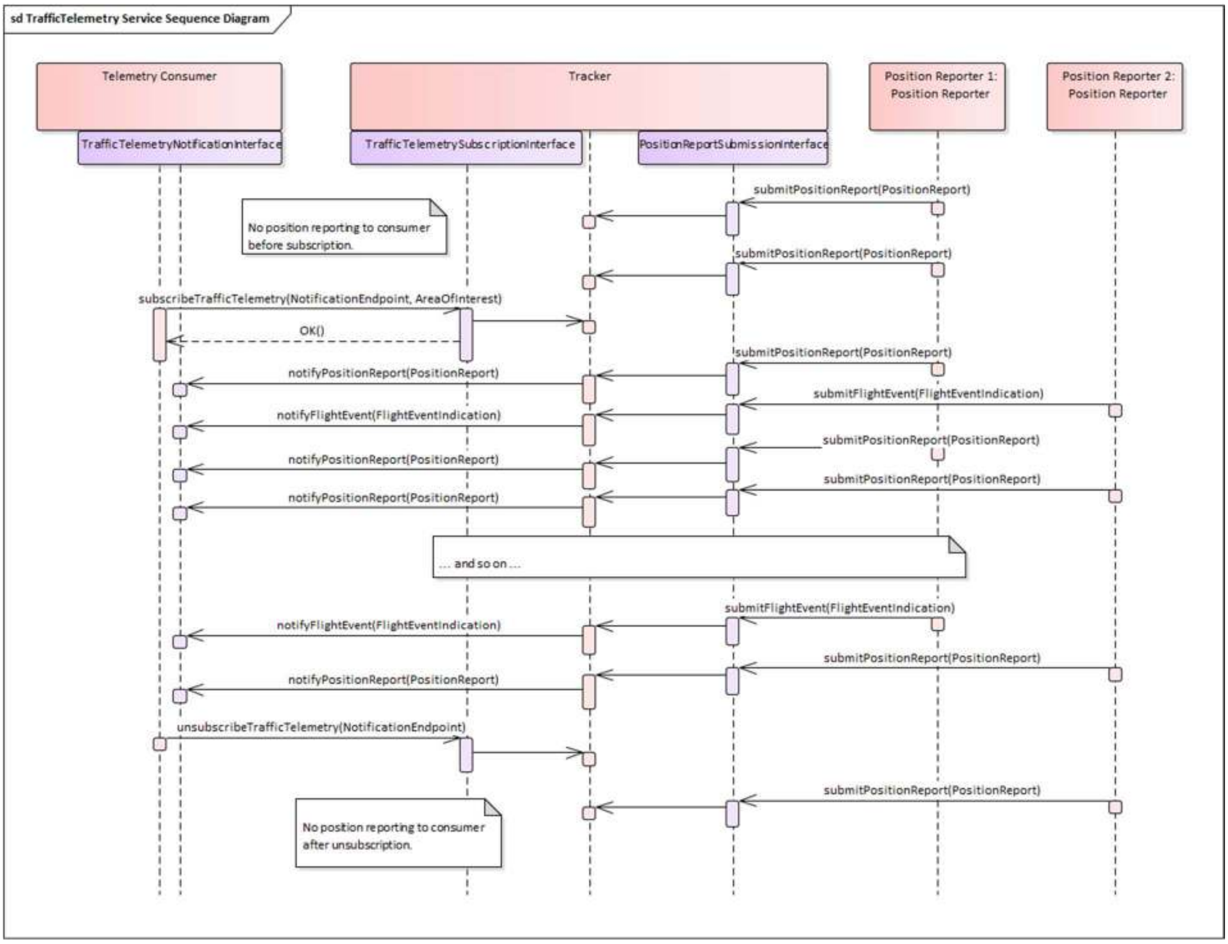


**Figure 6: Traffic/Telemetry Service interface operation sequence diagram**

The figure above provides an example scenario for the TrafficTelemetry service. The scenario assumes a Tracker system providing the TrafficTelemetry service as well as the PositionReportSubmission service. In this example, two different systems are assumed to submit position reports to the tracker. Furthermore, the scenario includes a consumer of the TrafficTelemetry service, subscribing to the Tracker at some point in time and unsubscribing some time later. The consumer, as long as it is subscribed to the Tracker, receives all position reports and flight event notifications matching the area of interest indicated in the subscription.

Note:
In order to illustrate the service operations in a realistic context, this Sequence Diagram contains additional operations from the PositionReportSubmission service, not only TrafficTelemetry service operations.

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| | | |
|---|---|---|
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**Table 36: List of References**



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# D2.4 Appendix B Operation Plan Service Specification

| | |
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## Authoring & Approval

### Authors of the document

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Gregor Mogeritsch / Frequentis | WP2 | 26.10.2022 |
| Hubert Künig / Frequentis | WP2 | 26.10.2022 |
| Peter Cornelius / Frequentis | WP2 | 26.10.2022 |
| Thomas Lutz / Frequentis | WP2 Lead | 26.10.2022 |

### Reviewers internal to the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Jonas Stjernberg / Robots Expert | WP3 Lead | 1.11.2022 |
| Maria Tamm / EANS | Project coordinator | 3.11.2022 |
| Tanel Järvet / CAFA | WP4 Lead | 3.11.2022 |
| Damian Soliwoda / PSNC | WP2 member | 2.11.2022 |
| Lukasz Gorny-Zajac / DRR | WP2 member | 2.11.2022 |
| Parmentier Remy / VAI | WP2 member | 2.11.2022 |
| Pawel Korzec / DRR | WP2 member | 2.11.2022 |
| Piotr Dybiec / DRR | WP2 member | 2.11.2022 |
| Piotr Luboński / PSNC | WP2 member | 31.10.2022 |
| Piotr Szymaniak / PSNC | WP2 member | 31.10.2022 |
| Sven Jürgenson / Threod | WP3 member | 3.11.2022 |
| Leopoldo Tejada/UML | WP2 member | 2.11.2022 |
| Thomas Wana / DIME | WP2 member | 31.10.2022 |
| Yuhang Yun / EHANG | WP3 member | 30.10.2022 |
| Iris Roehrich / FRQ | WP1 member | 3.11.2022 |

### Approved for submission to the SJU By - Representatives of beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Sami Alkula/FANS | Project Management Group | 3.11.2022 |
| Thomas Neubauer/DIME | Project Management Group | 3.11.2022 |
| Pawel Korzec/DRR | Project Management Group | 3.11.2022 |
| Yuhang Yun/EHE | Project Management Group | 3.11.2022 |
| Damini Gera/AIRB | Project Management Group | 3.11.2022 |
| Piotr Szymaniak/PSNC | Project Management Group | 3.11.2022 |
| Sven Jürgenson/THREOD | Project Management Group | 3.11.2022 |



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| | | |
|---|---|---|
| Leopoldo Tejada/UML | Project Management Group | 3.11.2022 |
| Tapio Haarlaa/VAI | Project Management Group | 3.11.2022 |
| Iris Röhrich/FRQ | Project Management Group | 3.11.2022 |
| Juha Lindstedt/AVIA | Project Management Group | 3.11.2022 |
| Piotr Bratek/PANSA | Project Management Group | 3.11.2022 |
| Tanel Järvet/CAFA | Project Management Group | 3.11.2022 |
| Maria Tamm/EANS | Project Management Group | 3.11.2022 |

**Rejected By - Representatives of beneficiaries involved in the project**

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| | | |

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**Copyright Statement**

# GOF 2.0

GOF2.0 INTEGRATED URBAN AIRSPACE VLD

This Updated Service Specification is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 101017689 under European Union's Horizon 2020 research and innovation programme.

## 1.1 Abstract

This specification introduces a service of a Common Information Service (CIS) which ensures interoperability and hence transparent and reliable information flow between the stakeholders in an operational U-space environment. In accordance with ICAO SWIM, represents an Information Exchange Service.

This document describes one of these Bridge Services, the Operation Plan Exchange service in a logical, technology-independent manner.



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# 2 Introduction

## 2.1 Purpose of the document

In accordance with according to the guidelines given in [3], this document describes the Operation Plan Exchange service for the GOF USPACE project on a logical technology-independent manner, that is:

- the operational and business context of the service
    - requirements for the service (e.g., information exchange requirements)
    - involved nodes: which operational components provide/consume the service
    - operational activities supported by the service
    - relation of the service to other services
- the service description
    - service interface definitions
    - service interface operations
    - service payload definition
    - service dynamic behaviour description
- service provision and validation aspects

Furthermore, this document clearly defines the version of the service.

## 2.2 Scope

This document describes the Operation Plan Exchange service for the GOF USPACE project.

The Operation Plan Exchange service provides a means for the operational nodes of the GOF USPACE project to share their UTM operation plans and make them available for further processing.

The Operation Plan Exchange service furthermore provides a means for the operational nodes of the GOF USPACE project to consume UTM operation plans from the U-space participants for further processing.

Finally, the Operation Plan Exchange service provides an interface allowing operational nodes to manipulate drone operation plans by interacting with the service provider in order to request authorization, activation, etc.

## 2.3 Intended readership

This service specification is intended to be read by service architects, system engineers and developers in charge of designing and developing an instance of the Operation Plan Exchange service.



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Furthermore, this service specification is intended to be read by enterprise architects, service architects, information architects, system engineers and developers in pursuing architecting, design and development activities of other related services.

## 2.4 Background

### 2.4.1 EUROCONTROL Concept of Operations for U-space (CORUS)

EUROCONTROL CORUS [4] elaborates in 5.1 Flight planning and derived services reporting as follows.

*"U2 brings flight planning and many derived services. As mentioned in section 4, for airspaces where flight plans are required, the aim is to have a flight plan from every aircraft, drone or manned. This will allow a something like a complete picture to be built in advance. "Something like" because flight plans for drones, like for manned aircraft, will contain some elements of uncertainty, or "flexibility". U2 brings flight planning and many derived services. As mentioned in section 4, for airspaces where flight plans are required, the aim is to have a flight plan from every aircraft, drone or manned. This will allow a something like a complete picture to be built in advance. "Something like" because flight plans for drones, like for manned aircraft, will contain some elements of uncertainty, or "flexibility".*

*[…]*
*Drone flight plans will not be the same as the flight plan defined in ICAO doc 4444 used by manned aviation today. Several factors push for this. There are rules associated with the ICAO flight plan that simply cannot work for small drones, such as a requirement to fly via published points. The ICAO flight plan does a poor job of describing a 4D trajectory and there is no reason to inflict this problem on ourselves in the brave new world of drone flight planning.*
*[…]*
*The basic contents of the drone flight plan will be the same as the ICAO flight plan: who flies what, where and when. Like the ICAO flight plan, the drone flight plan is a legal commitment to fly and stakes a claim on a limited public good – the airspace. Submitting a flight plan is also a commitment by the drone operator to meet the obligations associated with flying, which would include factors like having a safe aircraft and a competent pilot and committing to operate the flight safely, but also committing to meet the costs (if any) associated with flying, to have public liability insurance and so on.*
*There will need to be a nominated actor to whom drone flight plans are sent, probably with a mandate from the civil aviation authority for the country. Flight plans will be sent electronically, ideally from a tool used by a drone operator that makes flight plan creation easy and integrates into the task of creating the plan to be loaded into the drone itself. The basic process will consist in its simplest form as:*

- *Drone operator submits flight plan*
- *Flight plan is checked by U-space*
- *Drone operator gets a response*
- *If valid, the flight plan data is added to the set of current flight plans in the flight planning*

- *system and the operator can load it into the drone*
- *If invalid, the drone operator reads the remarks, changes the plan and resubmits.*

*The 'check' of the flight plan by the U-space includes:*

- *Some parts of Pre-tactical Geo-fencing*
- *Strategic Conflict Resolution*
- *In U3, Dynamic Capacity Management*

*The flight plan management service supports:*

- *Flight plan preparation / optimisation*
- *Pre-tactical Geo-fencing and Tactical Geo-fencing*
- *Strategic Conflict Resolution*
- *Procedural interface with ATC*
- *Collaborative interface with ATC*
- *Tracking*
- *Monitoring*
- *Traffic Information*
- *Emergency Management*
- *Legal Recording*
- *Incident / Accident reporting*
- *Operations Management*
- *Safety Management*
- *Dynamic Capacity Management*
- *Digital Logbook"*

### 2.4.2 SESAR-JU

The European Commission identifies an increasing demand for a non-segregated use of airspace which is being driven by a rapidly growing market of Very-Low-Level (VLL) airspace users, most of which are expected to be drones.

Via the Roadmap for the safe integration of drones into all classes of airspace [11], within the European ATM Masterplan [12], the European Commission seeks to ensure that this rapid growth of airspace use happens in a safe and controlled manner.

SESAR develops the required concepts and demonstrations for this process to happen. The roadmap [1], in alignment with ICAO recommendations, identifies three phases for the integration, from which SESAR derives the four U-space service blocks presented in the U-space blueprint [13],

U1 U-space foundation services,

U2 U-space initial services,

U3 U-space advanced services, and

U4 U-space full services.

These stages reflect the anticipated quick growth of demand for U-space services. The state of the art is being validated throughout Europe via several Very Large Demonstrator (VLD) projects such as the GOF USPACE project.

During the U1 phases, SESAR expects drones capable to supply their position via telemetry. The U1 and U2 is anticipated to provide tracking capabilities and services.

### 2.4.3 1.1.8 Efficient, safe and sustainable traffic at sea (EfficienSea2)

The design method and terminology builds on experience from the EfficienSea2 project [14], [15].

## 2.5 Glossary of terms

| Term | Definition |
|---|---|
| **External Data Model** | Describes the semantics of the domain (or a significant part thereof) by defining data structures and their relations. This could be at logical level (e.g., in UML) or at physical level (e.g., in XSD schema definitions), as for example standard data models. |
| **Message Exchange Pattern** | Describes the principles how two different parts of a message passing system (in our case: the service provider and the service consumer) interact and communicate with each other. Examples:<br><br>In the Request/Response MEP, the service consumer sends a request to the service provider in order to obtain certain information; the service provider provides the requested information in a dedicated response.<br><br>In the Publish/Subscribe MEP, the service consumer establishes a subscription with the service provider in order to obtain certain information; the service provider publishes information (either in regular intervals or upon change) to all subscribed service consumers. |
| **Operational Activity** | An activity performed by an operational node. Examples of operational activities are: Route Planning, Route Optimization, Logistics, Safety, Weather Forecast Provision, … |
| **Operational Model** | A structure of operational nodes and associated operational activities and their inter-relations in a process model. |
| **Operational Node** | A logical entity that performs activities. Note: nodes are specified independently of any physical realisation.<br><br>Examples of operational nodes are: Control Center, Authority, Weather Information Provider, … |

| | |
|---|---|
| **Service** | The provision of something (a non-physical object), by one, for the use of one or more others, regulated by formal definitions and mutual agreements. Services involve interactions between providers and consumers, which may be performed in a digital form (data exchanges) or through voice communication or written processes and procedures. |
| **Service Consumer** | A service consumer uses service instances provided by service providers. |
| **Service Data Model** | Formal description of one dedicated service at logical level. The service data model is part of the service specification. Is typically defined in UML and/or XSD. If an external data model exists (e.g., a standard data model), then the service data model shall refer to it: each data item of the service data model shall be mapped to a data item defined in the external data model. |
| **Service Design Description** | Documents the details of a service technical design (most likely documented by the service implementer). The service design description includes (but is not limited to) a service physical data model and describes the used technology, transport mechanism, quality of service, etc. |
| **Service Implementation** | The provider side implementation of a dedicated service technical design (i.e., implementation of a dedicated service in a dedicated technology). |
| **Service Implementer** | Implementers of services from the service provider side and/or the service consumer side. |
| **Service Instance** | One service implementation may be deployed at several places by same or different service providers; each such deployment represents a different service instance, being accessible via different URLs. |
| **Service Instance Description** | Documents the details of a service implementation (most likely documented by the service implementer) and deployment (most likely documented by the service provider). The service instance description includes (but is not limited to) service technical design reference, service provider reference, service access information, service coverage information, etc. |
| **Service Interface** | The communication mechanism of the service, i.e., interaction mechanism between service provider and service consumer. A service interface is characterised by a message exchange pattern and consists of service operations that are either allocated to the provider or the consumer of the service. |
| **Service Operation** | Functions or procedure which enables programmatic communication with a service via a service interface. |



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| | |
|---|---|
| **Service Physical Data Model** | Describes the realisation of a dedicated service data model in a dedicated technology. This includes a detailed description of the data payload to be exchanged using the chosen technology. The actual format of the service physical data model depends on the chosen technology. Examples may be WSDL and XSD files (e.g., for SOAP services) or swagger (Open API) specifications (e.g., for REST services). If an external data model exists (e.g., a standard data model), then the service physical data model shall refer to it: each data item of the service physical data model shall be mapped to a data item defined in the external data model.<br><br>In order to prove correct implementation of the service specification, there shall exist a mapping between the service physical data model and the service data model. This means, each data item used in the service physical data model shall be mapped to a corresponding data item of the service data model. (In case of existing mappings to a common external (standard) data model from both the service data model and the service physical data model, such a mapping is implicitly given.) |
| **Service Provider** | A service provider provides instances of services according to a service specification and service instance description. All users within the domain can be service providers, e.g., authorities, organizations (e.g., meteorological), commercial service providers, etc. |
| **Service Specification** | Describes one dedicated service at logical level. The Service Specification is technology-agnostic. The Service Specification includes (but is not limited to) a description of the Service Interfaces and Service Operations with their data payload. The data payload description may be formally defined by a Service Data Model. |
| **Service Specification Producer** | Producers of service specifications in accordance with the service documentation guidelines. |
| **Service Technical Design** | The technical design of a dedicated service in a dedicated technology. One service specification may result in several technical service designs, realising the service with different or same technologies. |
| **Service Technology Catalogue** | List and specifications of allowed technologies for service implementations. Currently, SOAP and REST are envisaged to be allowed service technologies. The service technology catalogue shall describe in detail the allowed service profiles, e.g., by listing communication standards, security standards, stacks, bindings, etc. |
| **Spatial Exclusiveness** | A service specification is characterised as "spatially exclusive", if in any geographical region just one service instance of that specification is allowed to be registered per technology.<br><br>The decision, which service instance (out of a number of available spatially exclusive services) shall be registered for a certain geographical region, is a governance issue. |

**Table 1: Glossary of terms**

## 2.6 List of Acronyms

| Acronym | Definition |
|---|---|
| **API** | Application Programming Interface |
| **MEP** | Message Exchange Pattern |
| **NAF** | NATO Architectural Framework |
| **REST** | Representational State Transfer |
| **SOA** | Service Oriented Architecture |
| **SOAP** | Simple Object Access Protocol |
| **SSD** | Service Specification Document |
| **UML** | Unified Modelling Language |
| **URL** | Uniform Resource Locator |
| **WSDL** | Web Service Definition Language |
| **XML** | Extendible Mark-up Language |
| **XSD** | XML Schema Definition |

**Table 2: List of acronyms**



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# 3 Service Identification

The purpose of this chapter is to provide a unique identification of the service and describe where the service is in terms of the engineering lifecycle.

| | |
|---|---|
| **Name** | **OperationPlanExchange Service** |
| **ID** | **urn:gof:services:OperationPlanExchangeService** |
| **Version** | **2.0** |
| **Description** | **An information exchange service which provides operation plan information** |
| **Keywords** | **Operation Plan, Mission Planning, Contingency Plan, Operation Volume, Operation Trajectory** |
| **Architect(s)** | **2021-today The GOF 2.0 Project Consortium**<br><br>**2020-2021 The Frequentis Group**<br><br>**2018-2020 The GOF U-Space Project Consortium** |
| **Status** | **Provisional** |

**Table 3: Service Identification**



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# 4 Operational Context

This section describes the context of the service from an operational perspective.

## 4.1 Functional and Non-functional Requirements

The table below lists applicable existing requirements for the Operation Plan Exchange service.

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| **[R-1]** | Common Situational Awareness | At all times, all U-space participants shall operate on the same common set of data, during pre-flight planning stages as well as during all stages of flight operations. | CORUS [4], 4.1.1.2 Amber airspace;B1-RPAS [9];CEF-SESAR-2018-1 [1], Objective O5 |
| **[R-2]** | Basis for Open Market | The U-space concept shall be designed such as to ensure a well-established line of authority while at the same time ensuring that an open market for VLL services may develop | SESAR Drone Roadmap [11], Foreword, 4.1 and 4.2;U-space Blueprint [13], Benefits to European society and economy;CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |
| **[R-3]** | Interoperability | There shall be an implementation of a Flight Information Management System (FIMS) which ensures that, at all times, emerging unmanned traffic management systems and existing technologies from manned operations can exchange any data required to support such common situational awareness, be it for drone operations in areas where established ATC procedures apply, or in zones outside established ATC. | ICAO Doc 10039 [2];[R-2];CEF-SESAR-2018-1 [1], Objective O6;CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |

| | | | |
|---|---|---|---|
| **[R-4]** | Standard Protocols | Standard communication protocols shall hence be used where available, and such standard protocols be developed otherwise, in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop. | [R-2];SESAR Drone Roadmap [11], 3.5, section 'Standards';CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |
| **[R-5]** | Open Interfaces | Any interface and protocol hence must be openly defined and its definition be freely accessible in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop. | [R-2];CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |
| **[R-6]** | SWIM | The implementation of a Flight Information Management System (FIMS) shall be based on an ICAO SWIM-compliant architecture. | [R-3];CEF-SESAR-2018-1 [1], 5.3.4 Overall approach and methodology |



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| | | | |
|---|---|---|---|
| **[R-7]** | Latency | Under no operational circumstance, the processing of position data may add significant latency to the overall detection-to-display latency of position data. In particular,<br><br>The processing latency added by the processing of positional data shall never exceed 10 per cent of the maximum value of the corresponding value permitted for the entire ATM automation system.<br><br>The processing latency and delay added by the processing of positional data should not exceed 1 per cent of the maximum value of the corresponding value permitted for the entire ATM automation system.<br><br>The maximum value for latency and delay is the minimum of the values defined by the ATM system performance requirements by EUROCONTOL and the FAA; for a 3 NM minimal separation, this is 2.2 s, for a 5 NM separation, 2.5 s. | [17], tables in the Executive Summary, [16], 3N_C-R8 and 5N_C-R8 |

**Table 4: Requirements for the Traffic/Telementry Service**

## 4.2 Other Constraints

### 4.2.1 Relevant Industrial Standards

#### 4.2.1.1 ICAO SWIM

The System Wide Information Management (SWIM, [2]) complements human-to-human with machine-to-machine communication, and improves data distribution and accessibility in terms of quality of the data exchanged. The SWIM Concept addresses the challenge of creating an “interoperability environment” which allows the SWIM IT systems to cope with the full complexity of operational information exchanges. The SWIM environment shifts the ATM information architecture paradigm from point-to-point data exchanges to system-wide interoperability.

### 4.2.2 Operational Nodes

A typical U-space flight goes through several stages, starting strategic-tactically, pre-flight, from Strategic Planning, over to Pre-Tactical Planning, to Tactical Planning. Then, tactical-operationally it enters into the actual in-flight stages from Departure, over to In-Flight, and, finally Arrival. Further post-flight stages may evaluate the results from the data produced during the prior stages.

The Operation Plan Exchange service primarily is relevant during the Pre-Tactical planning stages of a U-space flight during which the relevant stakeholders generate flight planning information data as well as requests for authorization and activation, which we convey via the Operation Plan Exchange service.

Operational nodes which may provide data for the Operation Plan Exchange service include the following ones.

| Operational Node | Remarks |
|---|---|
| USSP | |
| CISP | |
| UTM Service Provider | |
| Flight Information Management System | |

**Table 5: Operational Nodes providing the Operation Plan Exchange service**

Operational nodes which may consume the Operation Plan Exchange service include the following ones.

| Operational Node | Remarks |
|---|---|
| Flight Information Management System | |
| Information Display | |
| Drone Operator | |
| ATM Service Provider | |
| Legal Recorder | |

**Table 6: Operational Nodes consuming the Operation Plan Exchange service**

### 4.2.3 Operational Activities

Operational activities supported by the Operation Plan Exchange service include the following ones.

| Phase | Operational Activity | Remarks |
|---|---|---|

| | | |
|---|---|---|
| Pre-flight | Plan | This is the main phase where the Operation Plan Exchange service is used. |
| In-Flight | Cruise | In the in-flight phase the Operation Plan Exchange service is enhanced by the Drone Flight Exchange service. |
| Post-Flight | Report | |

**Table 7: Operational Activities supported by the Operation Plan Exchange service**

## 4.3 Service Interfaces

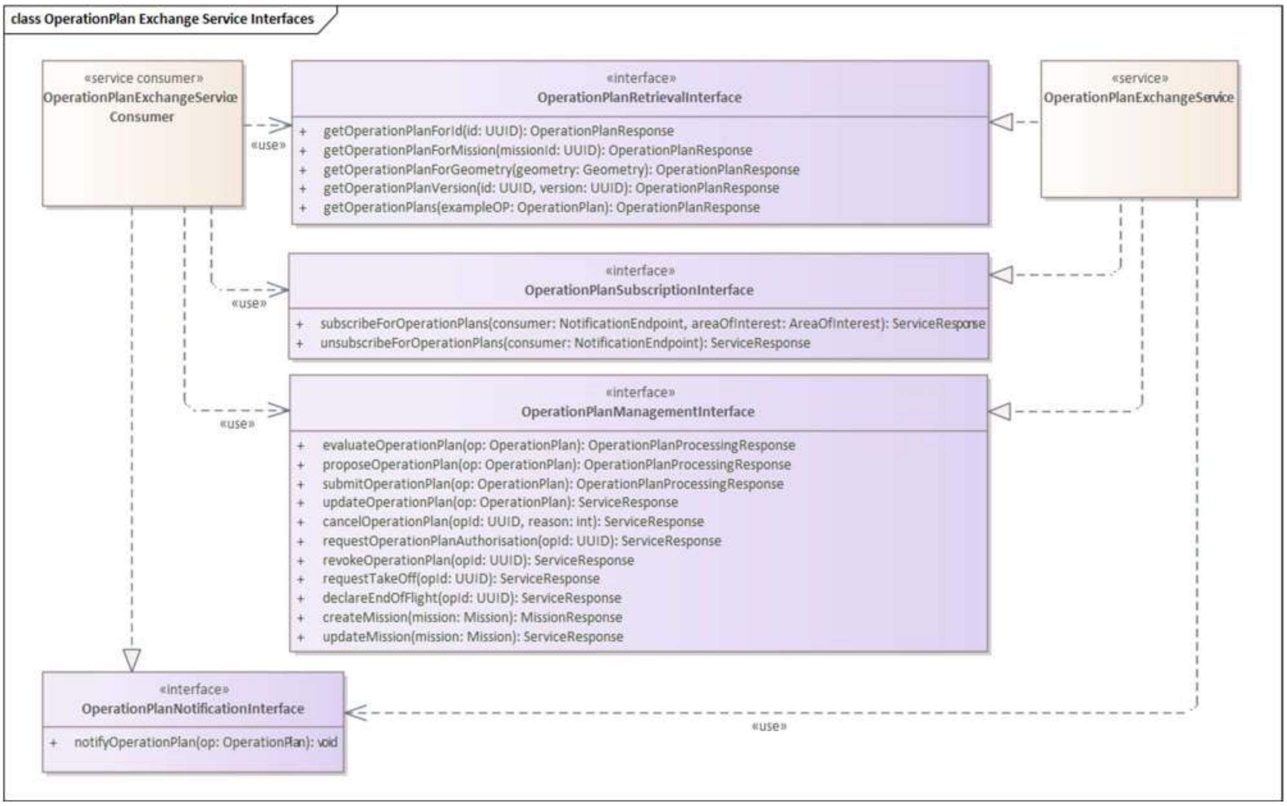


**Figure 1: OperationPlanExchangeService Interface Definition diagram**

| **ServiceInterface** | **Role (from service provider point of view)** | **ServiceOperation** |
|---|---|---|
| OperationPlanRetrievalInterface | Provided | getOperationPlanForId<br>getOperationPlanVersion<br>getOperationPlansForMission<br>getOperationPlansForGeometry<br>getOperationPlans |
| OperationPlanSubscriptionInterface | Provided | subscribeForOperationPlans<br>unSubscribeForOperationPlans |

| | | |
|---|---|---|
| OperationPlanNotificationInterface | Required | notifyOperationPlan |
| OperationPlanManagementInterface | Provided | evaluateOperationPlan<br>proposeOperationPlan<br>submitOperationPlan<br>updateOperationPlan<br>cancelOperationPlan<br>requestOperationPlanAuthorisation<br>revokeOperationPlan<br>requestTakeOff<br>declareEndoOfFlight<br>createMission<br>updateMission |

**Table 8: Service Interfaces**

# 5 Service Data Model

This section describes the information model, i.e., the logical data structures to be exchanged between providers and consumers of the service.

## 5.1 Overview

The OperationPlan exchange service transfers information about Operation Plans and associated data. The central part of the data model for this service is the OperationPlan structure, which collects various data items of various categories:

- identification;
- information about geographical and timely dimension of the operation plan:
  - rough trajectory by a sequence of operation volumes including timely validity of these volumes;
  - optionally a more finegrained 4D trajectory, defined by a list of waypoints (trajectory elements).
- information about contingency plans for the case of unplanned events:
  - alternative actions;
  - alternative landing or loitering areas;
  - alternative volumes for emergency landings;
  - expected endurance
- information about the current state of the operation plan:
  - current state;
- history of the operation plan:
  - history of past updates to the operation plans;
  - history of state transitions.
- priority declarations;
- information about used devices: drone identification and registration information;
- flight related information;
- administrative information, such as contact details, public name and description, comments, etc.;
- additional information about the operation mission.

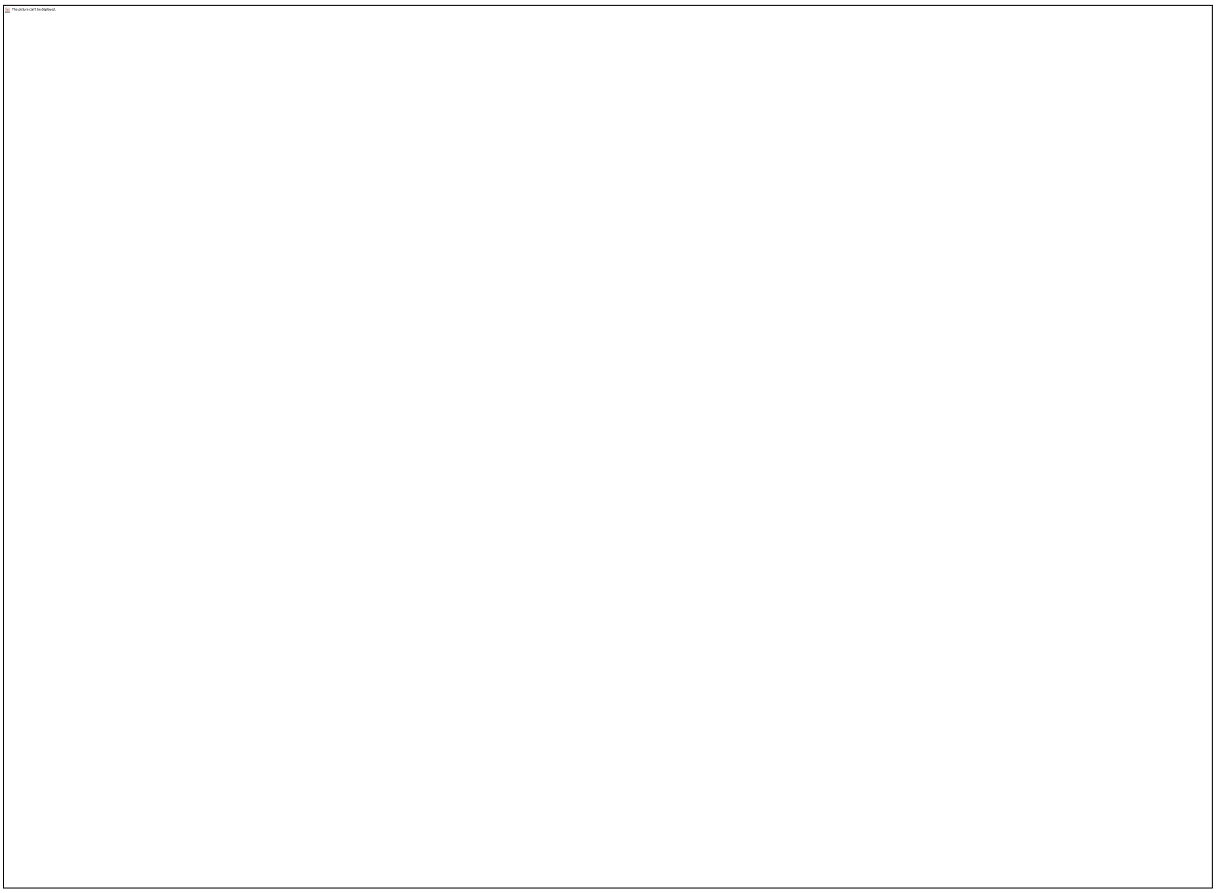

**Figure 2: Operation Plan Services - Base Data Model diagram**

## 5.2 The OperationPlan Data Structure

OperationPlan is the central part of the OperationPlanExchange service data model. As such, it acts as a composite of plenty other structures.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| operationPlanId | UUID | 1 | Globally unique identifier of this operation plan. | |
| version | UUID | 1 | Unique identifier of the version of this operation plan. | This is needed for the history of the OP. See **previousVersion** reference . |

| | | | | |
|---|---|---|---|---|
| previousVersion | Reference to OperationPlan | 0..* | Reference to the previous version of this operation plan. | This reference builds up the history of the OP. Upon every change, a new version of the OP shall be created; this reference points to the previous version.<br><br>This reference can simply be realized by storing the version UUID of the previous version. Alternatively, it could be realized by storing an ordered linked list of UUIDs, including the whole history. |
| aircraftComment | String | 0..1 | Informative text about the aircraft. Not used by the UTM System. Only for human stakeholders. | |
| state | OperationPlanState | 1 | The current state of the operation. Must be maintained by the USS. | |
| operator | String | 1 | Operator identification. | |
| submitTime | DateTime | 1 | Time that this operation plan was first announced to the USS Network in any way. | The submitTime value MUST remain constant for each recipient of the announcement since this value is potentially part of a signature of the operation plan in some cases. |

| | | | | |
|---|---|---|---|---|
| updateTime | DateTime | 1 | A timestamp set by the USS any time the state of the operation plan is updated within the USS Network. An update may be minor or major, but if/when the operation plan is shared in the USS Network, updateTime must reflect the time that update was provided. The updateTime value MUST be constant for each update data exchange.<br><br>This field is set and maintained by the USS managing the operation and is communicated to other USSs. | When the operation plan is announced for the first time, updateTime MUST be equal to submitTime. When an operation plan is modified (updated), updateTime MUST be greater than submitTime. |
| typeOfOperation | OperationType | 1 | Indicates the type of operation. | |

| | | | | |
|---|---|---|---|---|
| swarmSize | int | 1 | Number of drones flying as a swarm.<br><br>If >1, this indicates that this operation plan represents a swarm. | Corus: "U-space considers formation flights and swarms as being collections of aircraft that do not need to be separated by U-space."<br><br>"A swarm is considered by U-space to be a single, solid object. U-space will not attempt to pass another flight through a swarm.... A swarm will have a single operation plan and this plan will include dimensions for the swarm. Swarms may be prohibited in some volumes." |
| formationId | string | 0..1 | Designator for a formation flight. This string is supposed to have the same value for all OPs taking part in a formation flight. | Corus: "Drone formation flights are individual operation plans that are linked, rather than single plans for multiple aircraft. |
| formationOpIds | UUID | 0..* | References to other OPs belonging to the same formation. | Corus: "Drone formation flights are individual operation plans that are linked, rather than single plans for multiple aircraft. |
| minContOpTime | TimeDuration | 0..1 | Minimum continuous operation time. | Minimum acceptable time of the continuous operation to recognize the operation as succesfull. |
| atsInstruction | string | 0..1 | Optional instructions provided by ATS during approval process. | |
| closureReason | EnumClosureReason Type | 0..1 | Indication of the reason for closing the operation plan. | |

| | | | | |
|---|---|---|---|---|
| operationVolumes | OperationVolume | 0..* | The actual geographical information for the operation, defined by at least one operation volume. | Each operation volume MUST have non-zero 4D volume (i.e. each of the 4 dimensions much have a valid value).<br><br>Volume intersection must pass the following checks:<br>a. When ordered by ordinal values, a succeeding operation volume must have a 2D or 3D intersection in 3D space with its immediately preceding operation volume. Note that a 2D intersection in 3D space implies two volumes that "touch" and the intersection has 2D area. Sharing just an edge would not qualify. 3D volumes that don't touch at all would not qualify, even if they would intersect when projected into 2D space (e.g. if "looking down" on the two volumes).<br>b. When ordered by ordinal values, a succeeding operation volume must have a non-negative temporal intersection with its immediately preceding operation volume (Note we'd calculate this by t1-t2 where t1 is the preceding operation volume end time and t2 is the succeeding operation volume start time.).<br>c. When ordered by ordinal values, a succeeding operation volume must have either a non-zero volume (3D) intersection OR a positive temporal intersection. (Note this is a logical "OR" so it may have both intersection types... |

| | | | | |
|---|---|---|---|---|
| | | | | i.e. it is not an "exclusive OR").<br><br>Each spatial dimension of an operation volume's bounding box must have length less than 6000ft (value TBD). This is a sanity check against excessively large volumes. Need to be careful here as there may be legitimate use cases wherein large volumes are required/allowed, but we want to encourage efficient planning and protect against misuse of the shared airspace.<br><br>The planned duration of an operation volume must be less than 120 minutes (value TBD). Again, need to be careful to not damage legitimate use cases, but need to protect against misuse/poor planning. For long duration missions, it may be reasonable to have them replan or to have volumes with the same geography and long time values that slightly intersect.<br><br>The start time of an operation volume other than the first in the array must be greater than or equal to the start time of its immediately preceding operation volume.<br><br>operation volumes may by omitted if an **operationTrajectory** is provided. |
| operationTrajectory | OperationTrajectory | 0..1 | Detailed planned trajectory, including uncertainties. | If no **operationTrajectory** is provided, then the **operationVolumes** are mandatory. |

| | | | | |
|---|---|---|---|---|
| contingencyPlans | ContingencyPlan | 0..* | An array of contingency plans wherein this operation may land if needed/required during operation. Aids in planning and communication during the execution of a contingency. | |
| controllerLocation | Geometry | 1 | Two dimensional location (geographical point) of the controller.<br><br>This is the actual drone pilot location. | |
| gcsLocation | Geometry | 0..1 | Two dimensional location (geographical point) of the ground control station.<br><br>This is the optional control station location for the (potential) cases where the pilot is not co-located with the GCS. | |
| takeoffLocation | Geometry | 0..1 | Two dimensional location (geographical point) of the takeoff point. | |
| landingLocation | Geometry | 0..1 | Two dimensional location (geographical point) of the landing target. | |

| | | | | |
|---|---|---|---|---|
| uasRegistrations | UasRegistration | 1..* | The registration data for the vehicle(s) to be used in this Operation. Note that this is an array to allow for future operations involving multiple vehicles (e.g. 'swarms' or tandem inspections). | The uasRegistrations array MUST NOT be used as a list of potential vehicles for this Operation. If the vehicle data changes prior to an Operation, an update to the plan may be submitted with the updated vehicle information. Providing multiple uasRegistrations in this manner implies that all vehicles will conform to the provided operation volumes. |
| flightDetails | FlightDetails | 0..* | More details related to the flight. | |
| priority | Priority | 1 | describes the priority of this operation operation. | If necessary, this priority may be overruled by a priority definition in the OperationVolume (for example, if the high prio operation is limited to a subset of the OP's OperationVolumes). |
| contactDetails | ContactDetails | 0..1 | Contact information for this operation. | |
| publicInfo | PublicInformation | 0..1 | Additional information for public disclosure. | |
| mission | Mission reference | 0..1 | Reference to a mission. | A mission allows collecting common information for flights related to each other. E.g., a series of flights to be executed for one common goal, e.g., power line inspections flights for one customer at one specific day. |

**Table 9: The OperationPlan data structure**

## 5.3 The OperationPlanResponse Data Structure

OperationPlanResponse is used to carry the result of query-operations asking for o peration plans.

Depending on the operation result, it may contain zero, one or several operation plans.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| operationPlans | OperationPlan | 0..* | Operation plan(s). | |
| **< inherited >** | | | **All properties inherited from ServiceResponse.** | **See common data types.** |

**Table 10: The OperationPlanResponse data structure**

## 5.4 The OperationVolume Data Structure

OperationVolume is used to describe a portion of the actual geographical information for the operation. It includes a definition of the three-dimensional boundaries of a portion of airspace, associated with the time constraints when this portion is planned to be used. Additional flags indicate whether the portion of airspace is beyond the visual line of sight, or if there is a structure (e.g., building) in near vicinity.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| alias | String | 0..1 | Optional descripitve text. | |
| timeBegin | DateTime | 1 | Earliest time the operation will use the operation volume. It must be less than timeEnd. | timeBegin < timeEnd MUST be true. |
| timeEnd | DateTime | 1 | Latest time the operation will done with the operation volume. It must be greater than timeBegin. | timeBegin < timeEnd MUST be true. |

| | | | | |
|---|---|---|---|---|
| actualTimeEnd | DateTime | 0..1 | Time that the operational volume was freed for use by other operations. Should be populated and stored by the USS. | actualTimeEnd MUST satisfy: actualTimeEnd > timeBegin whenever actualTimeEnd is not null. |
| isBVLOS | Boolean | 1 | Describes whether any portion of the operation volume is beyond the visual line of sight of the RPIC. | |
| isNearStructure | Boolean | 0..1 | Is this operation volume within 400' (value TBD) of a structure? | |
| ordinal | Integer | 1 | This integer represents the ordering of the operation volume within the set of operation volumes. | Need not be consecutive integers. |
| operationGeometry | Geometry | 1 | Three-dimensional geometry defining the operation volume. | The type of Geometry, in this case, must be a three-dimensional shape. |



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| | | | | |
|---|---|---|---|---|
| operationGeometryMinimumSeparation | Geometry | 0..1 | Three-dimensional geometry defining minimum separation around the operation volume. | |
| priority | Priority | 0..1 | Priority indication for the operation within this operation volume. | This priority overrules the priority definition in the OperationPlan. |

**Table 11: The OperationVolume data structure**

## 5.5 **The** ContingencyPlan **Data Structure**

ContingencyPlan is the

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| id | UUID | 1 | An identifier unique amongst the set of Contingencies for this operation. | |
| causes | ContingencyCauseType | 1..* | Describes the cause(s) leading to this contingency plan. | |
| locationDescr | ContingenyLocationDescriptionType | 1 | Indication on where the contingency plan is described. | |

| | | | | |
|---|---|---|---|---|
| responseAction | ContingencyResponseType | 1 | The type of contingency response. | LANDING: targeting the contingencyGeography, optionally heading through the contingencyExtraVolume.<br><br>LOITERING: loiter at the contingencyGeography at the specified loiterAltitude.<br><br>RETURN_TO_BASE: return to base as specified by the contingencyGeography, optionally heading through the contingencyExtraVolume. The USS may issue an update to the operation plan to support this maneuver.<br><br>OTHER: details given in freeText property. |
| validTimeBegin | DateTime | 1 | Time that this location is expected to be first available. | |
| validTimeEnd | DateTime | 1 | Time that this location is expected to become unavailable. | |
| freeText | String | 0..1 | To be used for additional comments as needed. | For human use, not for automating any process. |

| | | | | |
|---|---|---|---|---|
| relativePreference | Float | 0..1 | Optional numerical value that can be used in ranking the preference of this Contingency versus any other within the set of Contingency for this operation. | This may be thought of as a ranking of the potential landing sites with all other factors being held equal, though dynamic conditions will likely play a role in adjusting this ranking in real time by the USS or Operator. For example, one Contingency may be significantly further from the operation at a given time and, thus, would be less preferred than it might be otherwise. Further interpretation of this field is left to the operator and USS. |
| relevantOperationVolumes | Integer | 1..* | This is an indicator that this particular ContingencyPlan is valid for use when the operation is active in any of the particular noted OperationVolumes. | In the planning stage of an operation, this array may be populated with ordinals that correspond to the ordinal values supplied with each OperationVolume. |
| endurance | TimeDuration | 1 | Supplementary endurance time. | This is the maximum remaining flight time for this contingency plan. |

| | | | | |
|---|---|---|---|---|
| contingencyGeometry | Geometry | 1 | The geographical area for this contingency. | If responseAction is LANDING or RETURN_TO_BASE, then this is the area on the ground that the UA will be targeting for a landing. The polygon should be large enough to provide high confidence (for some TBD value of "high") that the vehicle will land within it, but hopefully be no larger (for some TBD value of hopefully). If responseAction is LOITERING, this is the 3D-volume the UA will stay within during loitering. |
| contingencyExtraVolume | OperationVolume | 0..* | Describes an extra portion of airspace, which might be needed in the contingecy plan if the emergency landing shall take place outside the original operation trajectory. | This extra 4D-volume shall be adjacent/overlapping to the referred relevantOperationVolumes in the same manner as subsequent OperationVolumes must be adjacient/overlapping (see descriptive Notes on the operationVolumes property of the OperationPlan). |

**Table 12: The ContingencyPlan data structure**

## 5.6 The UasRegistration Data Structure

UasRegistration is the collection of registration data for UAVs.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| droneId | String | 0..1 | Drone identifier. | |

| | | | | |
|---|---|---|---|---|
| registrationId | UUID | 0..1 | Unique identifier referring to a registration. | |
| registrationLocation | String | 1 | An Internet-reachable URL for the registration authority. | More details to come, however, it is thought that this should be an endpoint allowing an unauthenticated GET to obtain metadata about the registrar. |

**Table 13: The UasRegistration data structure**

## 5.7 The FlightDetails Data Structure

FlightDetails provides some flight related data of interest for an operation plan.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| flightNumber | String | 0..1 | Optional. For use by USS for identification purposes. | |
| flightType | String | 0..1 | Optional. Allows to distinguish different types of flight. | |
| flightComment | String | 0..1 | Optional informative text about the operation. | Not used by the UTM System. Only for human stakeholders. |
| maxFlightSpeedKnots | Double | 0..1 | Maximum flight speed in knots. | |

**Table 14: The FlightDetails data structure**

## 5.8 The Priority Data Structure

The Priority data structure describes the priority of an operation plan (or of an operation volume). On of the two optional priorityLevel attributes must be provided.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| priorityText | String | 0..1 | Free text description of the priority classification. | |
| priorityLevelSimple | PriorityLevelSimple | 0..1 | Priority may be expressed in this simple way, allowing to classify the OP as Low-, Medium-, or High-Priority flight. | |

| | | | | |
|---|---|---|---|---|
| priorityLevelCorus | PriorityLevelCorus | 0..1 | Alternatively, the priority may be expressed as one of the 8 priority levels defined in Corus. | |

**Table 15: The Priority data structure**

## 5.9 The OperationTrajectory Data Structure

An OperationTrajectory defines a 4D trajectory to be flown, including the uncertainty.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| positionCRS | EnumCRSType | 1 | Coordinate Reference System used for the horizontal dimensions of the trajectory elements. | |
| altitudeCRS | EnumCRSType | 1 | Coordinate Reference System used for the vertical dimension of the trajectory elements. | |
| positionUncertainty | float | 1 | Maximum allowed horizonal deviation from individual trajectory elements. | |
| altitudeUncertainty | float | 1 | Maximum allowed vertical deviation from individual trajectory elements. | |
| timingUncertainty | Duration | 1 | Maximum allowed timing deviation from individual trajectory elements. | |
| altitudeType | EnumAltitudeType | 1 | Indicates how the vertical dimension is defined in the trajectory elements. | |
| trajectoryElements | TrajectoryElement | 1..* | Ordered list of 4D points | |

**Table 16: The OperationTrajectory data structure**

## 5.10The TrajectoryElement Data Structure

A Trajectoryelement defines a single 4D position to be used in an OperationTrajectory.

Reference coordinate system as well as allowed tolerances (uncertainties) are defined in the OperationTrajectory, valid for all TrajectoryElements.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| latitude | float | 1 | latitude value. | |
| longitude | float | 1 | longitued value. | |

| | | | | |
|---|---|---|---|---|
| altitude | float | 1 | vertical position value. | Altitude or height value, depending on the altitudeType given in the OperationTrajectory. |
| time | DateTime | 1 | time value. | |

**Table 17: The TrajectoryElement data structure**

## 5.11The Mission Data Structure

A Mission is an administrative object, allowing to provide common information about flights that are related to each other, e.g., as they are defined to achieve a common goal.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| missionId | UUID | 1 | Globally unique identification of a mission. | |
| beginTime | DateTime | 0..1 | Time stamp indicating the begin of the mission. | |
| endTime | DateTime | 0..1 | Time stamp indicating the end of the mission. | |
| description | String | 0..1 | Mission description. | |
| contactDetails | ContactDetails | 0..1 | Contact details for the mission. | |
| publicInfo | PublicInformation | 0..1 | Additional descriptive information of the mission. | |
| operationPlans | Reference to OperationPlan | 0..* | Reference to operation plans sharing this mission. | |

**Table 18: The Mission data structure**

## 5.12The PublicInformation Data Structure

PublicInformation allows to provide additional information allowed for public disclosure.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| title | String | 0..1 | Short public title for the operation plan. | |
| description | String | 0..1 | Public description of the operation plan. | |

**Table 19: The PublicInformation data structure**

## 5.13The OperationPlanState Enumeration

The OperationPlanState enumeration type specifies the possible states of an operation plan.

| Property | Description | Note |
|---|---|---|
| PROPOSED | Initial state of the operation plan. | This operation is not yet approved. It may be awaiting information from the operator, it may be in conflict with another operation and undergoing a negotiation process, or for some other reason it is not yet able to be declared PERMITTED. |
| PERMITTED | Authority has given permission to proceed (Certification Processes, SORA, ...) | |
| AUTHORIZED | This operation has been deemed approved by the supporting USS. This implies that the operation meets the requirements for operating in the airspace based on the type of operation submitted. | Authorization of an OP may include the approval by multiple stakeholders. ATM may be one such stakeholder.<br><br>In some cases an OP may be AUTHORIZED without the approval of ATM (in cases where no ATM airspace is involved. |
| ACTIVATED | Operation is cleared for takeoff. | The **OperationPlanState** remains ACTIVATED even when the drone **flight** gets ACTIVE or INACTIVE (this is indicated by the **DroneFlightState**; see DroneFlightExchange service). |
| CLOSED | This operation is closed. It is not airborne and will not become airborne again. | If the UAS and the crew will fly again, it would need to be submitted as a new operation. A USS may announce the closure of any operation, but is not required to announce unless the operation was ROGUE or NONCONFORMING.<br><br>The closure reason is noted in the operation plan attribute closureReason. |

**Table 20: The OperationPlanState enumeration**

## 5.14The EnumClosureReason Enumeration

The EnumClosureReason enumeration type specifies the possible reasons for closing an operation plan

| Property | Description | Note |
|---|---|---|
| NOMINAL | Operation completed nominally. | |

| | | |
|---|---|---|
| REJECTED | OP has been rejected by USSP, CISP or authority. | |
| REVOKED | OP has been revoked by USSP, CISP or authority. | |

**Table 21: The PriorityLevelSimple enumeration**

## 5.15The ContingencyCauseType Enumeration

The ContingencyCauseType enumeration type specifies the possible causes for contingency operations.

| Property | Description | Note |
|---|---|---|
| LOST_C2_UPLINK | Command and control connection from controller to drone was lost. | |
| LOST_C2_DOWNLINK | Command and control connection from drone to controller was lost. | |
| LOST_NAV | Navigation equipment lost. | |
| LOST_SAA | | |
| LOW_FUEL | Not enough energy. | |
| NO_FUEL | Energy lost. | |
| MECHANICAL_PROBLEM | Mechanical problem. | |
| SOFTWARE_PROBLEM | Software problem. | |
| ENVIRONMENTAL | Environmental issues. | |
| SECURITY | Security issues. | |
| TRAFFIC | Other traffic. | |
| LOST_USS | | |
| OTHER | | |
| ANY | | |

**Table 22: The ContingencyCauseType enumeration**

## 5.16The ContingencyLocationDescriptionType Enumeration

The ContingencyLocationDescriptionType enumeration type specifies the possible ways to describe a contingency plan.

| Property | Description | Note |
|---|---|---|
| PREPROGRAMMED | Contingency location that is determined prior to launch and programmed onto the UA. | |
| OPERATOR_UPDATED | Contingency location that is (or will be) updated during operation by operator (e.g., sent to UA). | |
| UA_IDENTIFIED | Contingency location that is identified to be safe to land by the UA itself. | |
| OTHER | Contingency location does not fit any of the defined categories. | |

**Table 23: The ContingencyLocationDescriptionType enumeration**

## 5.17The ContingencyResponseType Enumeration

The ContingencyResponseType enumeration type specifies the possible kinds of contingency response actions.

| Property | Description | Note |
|---|---|---|
| LANDING | The contingency operation will be landing. | |
| LOITERING | The operation will loitering. | |
| RETURN_TO_BASE | The operation will return to base. | |
| OTHER | Additional details should be provided in freeText. | If this gets used often for similar events, Enumeration will be updated with new value. |

**Table 24: The ContingencyResponseType enumeration**

## 5.18The PriorityLevelSimple Enumeration

The PriorityLevelSimple enumeration type specifies three simple priority levels.

| Property | Description | Note |
|---|---|---|
| PRIO_LOW | low priority | |
| PRIO_MEDIUM | medium priority | |
| PRIO_HIGH | high prioroty | |

**Table 25: The PriorityLevelSimple enumeration**

## 5.19The PriorityLevelCorus Enumeration

The PriorityLevelCorus enumeration type specifies priority levels defined in the Corus Conops.

| Property | Description | Note |
|---|---|---|
| PRIO_1_EMERGENCY | | |
| PRIO_2_HOSPITAL | | |
| PRIO_3_AUTHORITIES | | |
| PRIO_4_URGENT_TRANSPORT | | |
| PRIO_5_INDUSTRY | | |
| PRIO_6_TRANSPORT | | |
| PRIO_7_FILMING | | |
| PRIO_8_LEISURE | | |

**Table 26: The PriorityLevelCorus enumeration**

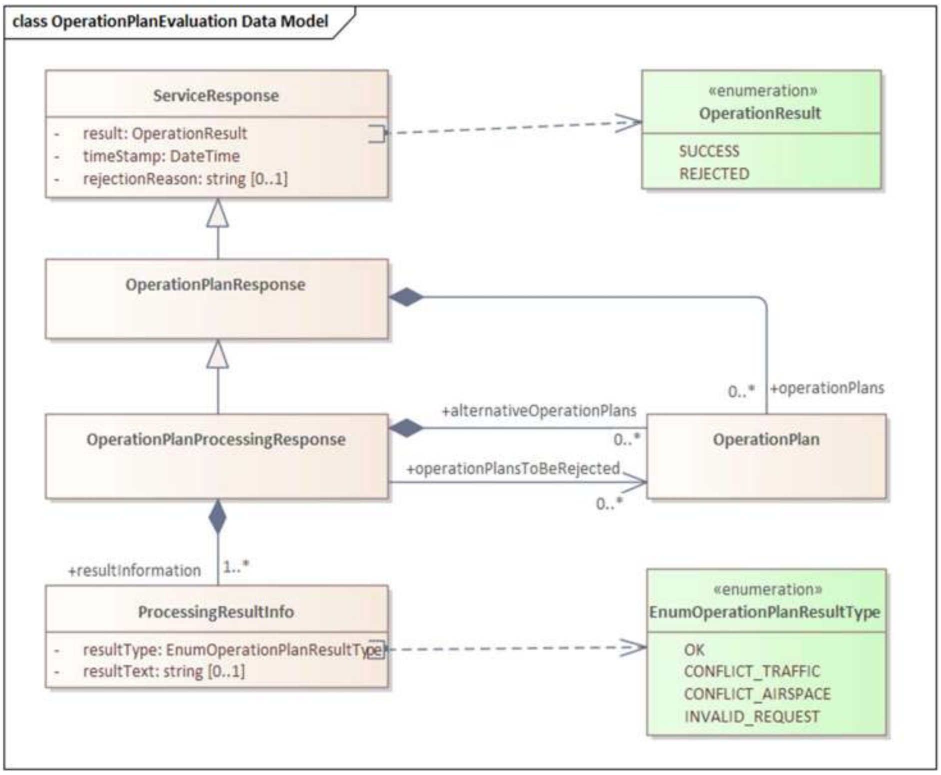

**Figure 3: Operation Plan Services - Operation Plan Processing Response data structure diagram**

## 5.20The OperationPlanProcessingResponse Data Structure

**OperationPlanProcessingResponse** is used to carry the result of evaluation or processing requests for operation plans.

In case of a negative result, it may contain one or several alternative operation plans.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| resultInformation | ProcessingResultInfo | 1..* | Indicates the result of evaluating or processing an operation plan. In case of negative result, more than one **resultInformation** may be added. | |
| alternativeOperationPlans | OperationPlan | 0..* | Optional alternative Operation Plans that may be proposed instead of the evaluated operation plan, in case the resultInformation.resultType is other than OK.<br><br>In case of resultInformation.resultType=OK, this list shall be empty. | see section on Basic Operation Plan data structures for a description of OperationPlan. |
| operationPlansToBeRejected | UUID | 0..* | Operation plans to be rejected in order to be able to accept the given Operation Plan. In case of conflicting operation plans, the service provider may use this property to indicate that the given OP could be accepted, if other OPs (listed in this property) would be rejected. | |
| < **inherited** > operationPlans | OperationPlan | 0..* | In this property, the **OperationPlanProcessingResponse** may contain the OperationPlan for which the evaluation/submission was requested. **(inherited from OperationPlanResponse data structure)** | see section on Basic Operation Plan data structures for a description of **OperationPlanResponse** . |

| | | | | |
|---|---|---|---|---|
| **< inherited > ...** | | | **All properties inherited from ServiceResponse.** | **See common data types.** |

**Table 27: The OperationPlanProcessingResponse data structure**

## 5.21The ProcessingResultInfo Data Structure

**ProcessingResultInfo** is used to carry information about the result of evaluation or processing requests for operation plans.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| resultType | EnumOperationPlanResultType | 1 | Indicates the result of evaluating an operation plan. | |
| resultText | String | 0..1 | Textual description of the reason result. For example, a textual description of the rejection reason.<br><br>In case of a positive resultType, this field may be empty or omitted. | |

**Table 28: The ProcessingResultInfo data structure**

## 5.22The EnumOperationPlanResult Enumeration

The **EnumOperationPlanResult** enumeration type specifies potential results of an Operation Plan processing.

| Property | Description | Note |
|---|---|---|
| OK | The processing result is OK, i.e., the Operation Plan can be accepted. | |
| CONFLICT_TRAFFIC | The Operation Plan cannot be accepted due to conflicting traffic. | |
| CONFLICT_AIRSPACE | The Operation Plan cannot be accepted due to a conflict related to airspace restriction. | |
| INVALID_REQUEST | The Operation plan cannot be accepted due to invalid data. E.g. invalid version, forbidden<br><br>state transfer etc. | |

**Table 29: The EnumOperationPlanResult enumeration**

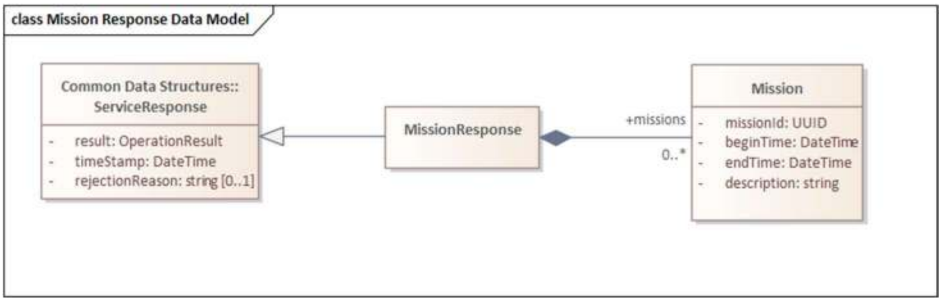


Figure 4: Operation Plan Services - Mission Response data structure diagram

## 5.23The MissionResponse Data Structure

MissionResponse is used to carry the result of query-operations asking for Missions.

Depending on the operation result, it may contain zero, one or several Mission objects.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| missions | Mission | 0..* | Mission data structure(s). | see section on Basic Operation Plan data structures for a description of Mission. |
| **< inherited >** | | | **All properties inherited from ServiceResponse.** | **See common data types.** |

Table 30: The MissionResponse data structure

## 5.24Common Data Structures Used in UTM Service Specifications

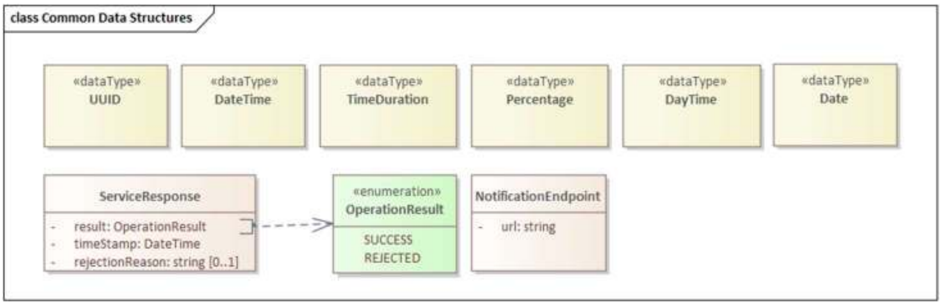


Figure 5: Common Data Types Used in UTM Service Specifications

### 5.24.1NotificationEndpoint Data Structure

**NotificationEndpoint** is used in subscription and un-subscription operations to show the receiver of notifications as a result of the subscription.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **URL** | **String** | 1 | Endpoint capable of receiving notifications | |

**Table 31: NotificationEndpoint Data Structure**

### 5.24.2 ServiceResponse **Data Structure**

ServiceResponse is the generic response provided by each service operation. In some cases, this basic data structure may be extended by inheritance.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **result** | **OperationResult** | 1 | Indicates the result of the request to the service | |
| **rejectReason** | **String** | 0..1 | Optional additional information to be provided in case of negative result | |
| timeStamp | DateTime | 1 | | |

**Table 32: ServiceResponse Data Structure**

### 5.24.3 OperationResult **Enumeration**

The **OperationResult** enumeration type specifies the possible outcomes of calling an operation.

| Property | Description | Note |
|---|---|---|
| **SUCCESS** | Operation was successfully executed. | |
| *REJECTED* | Operation could not be executed. | |

**Table 33: OperationResult Enumeration**

## 5.25 Common Geometry Data Structures Used in UTM Service Specifications

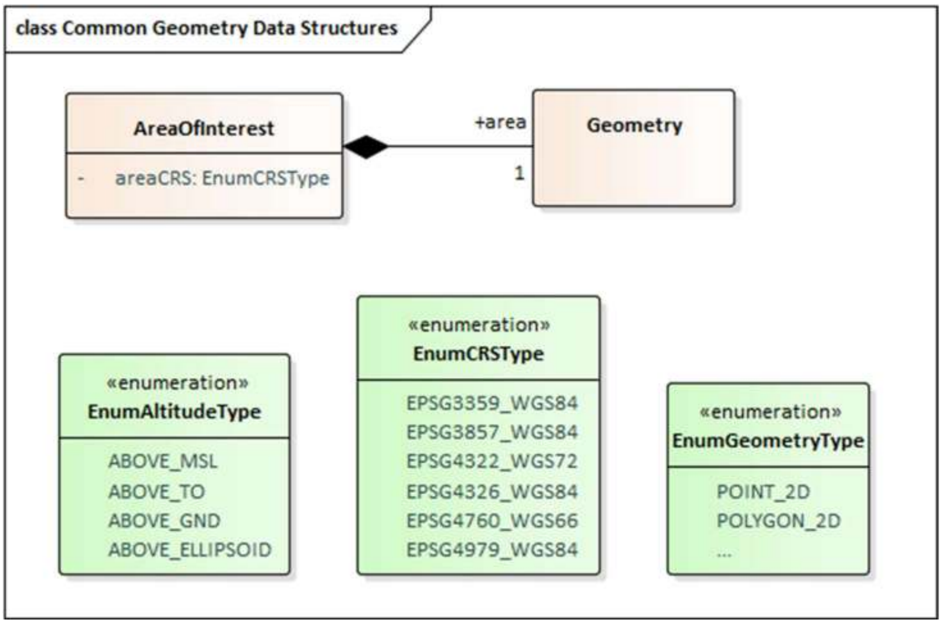


**Figure 6: Common Geometry Data Types Used in UTM Service Specifications**

## 5.25.1AreaOfInterest **Data Structure**

**AreaOfInterest** is used in subscription operations to provide an indication of the geographic area for which the subscriber is interested to receive notifications.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **area** | **Geometry** | 1 | A geometric description of a geographic area. | Should be a 2-dimensional geometry in this case. |
| **areaCRS** | **EnumCRSType** | 1 | Coordinate reference system used (WGS-84, EPSG:4979) | |

**Table 34: AreaOfInterest Data Structure**

## 5.25.2Geometry **Data Structure**

**Geometry** describes a geometrical shape of one, two or three dimensions.

The **Geometry** data structure is not further detailed in this service specification. One example of how a generic Geometry structure could be realized is sketched in the table below:

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **coordinates** | **Double** | 2..* | Collection of the coordinates, describing the geometry. | |
| **geometryType** | **GeometryType** | 1 | Type of geometry being described by the coordinates. | Examples: Point, Polygon, Polyhedron, etc. |

**Table 35: Geometry Data Structure**

### **5.25.3**EnumAltitudeType **Enumeration**

The **EnumAltitudeType** enumeration type specifies the possible ways to express an altitude/height.

| Property | Description | Note |
|---|---|---|
| **ABOVE_MSL** | Altitude above mean-sea-level.<br><br>Same as orthometric height; same as height above the earth geoid. | |
| *ABOVE_TO* | Altitude above take-off location. | |
| *ABOVE_GND* | Height above ground surface. | |
| **ABOVE_ELLIPSOID** | Altitude above the WGS-84 ellipsoid; value delivered by GPS. | |

**Table 36: EnumAltitudeType Enumeration**

### **5.25.4**EnumCRSType **Enumeration**

The **EnumCRSType** enumeration type specifies the possible ways to express a coordinate reference system. The most common values used are noted in bold letters.

| Property | Description | Note |
|---|---|---|
| EPSG3395_WGS84 | World Mercator<br><br>Geodetic CRS: WGS 84;<br><br>Coordinate System: Cartesian CS.<br><br>Axes: easting, northing (E, N). Orientations: east, north.<br><br>UoM: metre. | Euro-centric view of world excluding polar areas. |

| | | |
|---|---|---|
| EPSG3857_WGS84 | Pseudo-Mercator -- Spherical Mercator, Google Maps, OpenStreetMap, Bing, ArcGIS, ESRI<br><br>Geodetic CRS: WGS 84;<br><br>Coordinate System: Cartesian CS.<br><br>Axes: easting, northing (X, Y). Orientations: east, north.<br><br>UoM: metre. | Uses spherical development of ellipsoidal coordinates. Relative to WGS 84 / World Mercator (CRS code 3395) errors of 0.7 percent in scale and differences in northing of up to 43km in the map (equivalent to 21km on the ground) may arise. |
| **EPSG4322_WGS72** | Geodetic CRS: WGS 72;<br><br>Coordinate System: Ellipsoidal 2D CS.<br><br>Axes: latitude, longitude. Orientations: north, east.<br><br>UoM: degree. | Uses Historic World Geodetic System 1972.<br><br>Horizontal component of 3D system. |
| **EPSG4326_WGS84** | WGS84 - World Geodetic System 1984, used in GPS<br><br>Geodetic CRS: WGS 84;<br><br>Coordinate System: Ellipsoidal 2D CS.<br><br>Axes: latitude, longitude. Orientations: north, east.<br><br>UoM: degree. | Horizontal component of 3D system. Used by the GPS satellite navigation system and for NATO military geodetic surveying. |
| **EPSG4760_WGS66** | Geodetic CRS: WGS 66;<br><br>Coordinate System: Ellipsoidal 2D CS.<br><br>Axes: latitude, longitude. Orientations: north, east.<br><br>UoM: degree. | Uses Historic World Geodetic System 1966.<br><br>Horizontal component of 3D system. |

| | | |
|---|---|---|
| *EPSG4979_WGS84* | Geodetic CRS: WGS 84;<br><br>Coordinate System: Ellipsoidal 3D CS.<br><br>Axes: latitude, longitude, ellipsoidal height. Orientations: north, east, up.<br><br>UoM: degree, degree, metre. | Used by the GPS satellite navigation system. |

**Table 37: EnumCRSType Enumeration**

### 5.25.5 EnumGeometryType **Enumeration**

The **EnumGeometryType** enumeration type specifies possible geometrical shapes.

| Property | Description | Note |
|---|---|---|
| **POINT** | Single point. | |
| **POLYGON** | Polygon. | |
| ... | | |

**Table 38: EnumGeometryType Enumeration**

## 5.26 Common Address Data Structures Used in UTM Service Specifications

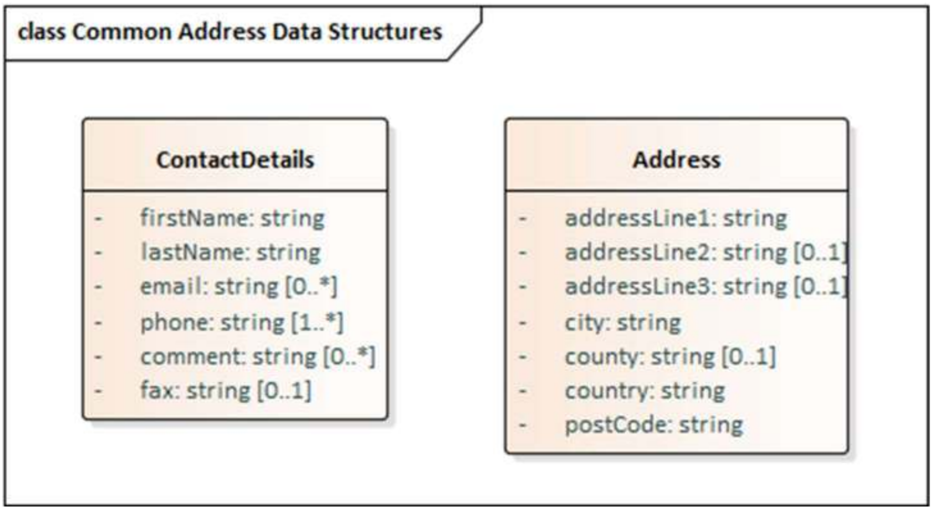

**Figure 7: Common Address Data Types Used in UTM Service Specifications**

## 5.26.1Address **Data Structure**

**Address** is used to represent an address of a person or an organization.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **addressLine1** | **string** | 1 | First address line, typically the street name and house number. | |
| **addressLine2** | **string** | 0..1 | Optional second address line, typically the unit, floor or apartment number. | |
| **addressLine3** | **string** | 0..1 | Optional third address line for country specific information. | |
| **city** | **string** | 1 | The name of the city. | |
| **county** | **string** | 0..1 | Optionally, the name of the county. | |
| **country** | **string** | 1 | The name of the country. | |
| **postCode** | **string** | 1 | Post code. | |

**Table 39: Address Data Structure**

## 5.26.2ContactDetails **Data Structure**

The ContactDetails data structure is used to collect contact information. A contact may be a Person, State, Organisation, Authority, aircraft operating agency, handling agency etc.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **firstName** | **string** | 1 | First name of the contact. | |
| **lastName** | **string** | 1 | Last name of the contact. | |
| **email** | **string** | 0..* | An optional array of email addresses. | To establish best practices, the order of the email addresses in the array should indicate the order that they should be used.<br><br>The responsibility is on the USS providing the email address to ensure it is valid and operational. |

| | | | | |
|---|---|---|---|---|
| **phone** | **string** | 1..* | An array of at least one phone number. | To establish best practices, the order of the phone numbers in the array should indicate the order that they should be used. |
| **fax** | **string** | 0..1 | Optional fax number to reach the contact | |
| **comment** | **string** | 0..* | Any additional comments related to contact information. | |

**Table 40: ContactDetails Data Structure**

# 6 Service Interface Specifications

This chapter describes the details of each service interface. One sub-chapter is provided for each Service Interface.

The Service Interface specification covers only the static design description while the dynamic design (behaviour) is described later.

## 6.1 Service Interface OperationPlanRetrievalInterface

The service provider offers this interface to allow consumers to query operation plan data.

### 6.1.1 Operation getOperationPlanForId

#### 6.1.1.1 Operation Functionality

A consumer calls this operation to explicitly request an operation plan by submitting the known id.

#### 6.1.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| id | Input | UUID | Identifier of an operation plan. |
| response | Return | OperationPlanResponse | Query response, including the operation plan data, if the request was successful. |

**Table 41: Payload description of getOperationPlanForId operation**

### 6.1.2 Operation getOperationPlanVersion

#### 6.1.2.1 Operation Functionality

A consumer calls this operation to explicitly request a certain version of an operation plan by submitting the known ids.

#### 6.1.2.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| id | Input | UUID | Identifier of an operation plan. |
| version | Input | UUID | Version identifier. |
| response | Return | OperationPlanResponse | Query response, including the operation plan data, if the request was successful. |

**Table 42: Payload description of getOperationPlanVersion operation**

### 6.1.3 Operation getOperationPlanForMission

#### 6.1.3.1 Operation Functionality

A consumer calls this operation to explicitly request operation plan data belonging to a certain mission.

#### 6.1.3.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| missionId | Input | UUID | Identifier of a mission. |
| response | Return | OperationPlanResponse | Query response, including the operation plan data, if the request was successful.<br><br>The OperationPlanResponse may contain a list of OperationPlans: all OPs belonging to the mission. |

**Table 43: Payload description of getOperationPlanForMission operation**

### 6.1.4 Operation getOperationPlanForGeometry

#### 6.1.4.1 Operation Functionality

A consumer calls this operation to explicitly request operation plan data for a certain geographical area.

#### 6.1.4.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| geometry | Input | Geometry | Geographical area of interest. |
| response | Return | OperationPlanResponse | Query response, including the operation plan data, if the request was successful.<br><br>The OperationPlanResponse may contain a (potentially empty) list of OperationPlans: all OPs for the area of interest. |

**Table 44: Payload description of getOperationPlanForGeometry operation**

### 6.1.5 Operation getOperationPlans

#### 6.1.5.1 Operation Functionality

A consumer calls this operation to explicitly request operation plan data matching various criteria

#### 6.1.5.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| exampleOP | Input | OperationPlan | Subset of an operation plan.<br>This allows to filter e.g., all OPs with a given contactDetails, or all OPs for a certain drone registration id. |
| response | Return | OperationPlanResponse | Query response, including the operation plan data, if the request was successful.<br><br>The OperationPlanResponse may contain a list of OperationPlans: all OPs matching the data given in the exampleOP. |

**Table 45: Payload description of getOperationPlans operation**

## 6.2 Service Interface OperationPlanSubscriptionInterface

The service provider offers this interface to allow consumers to subscribe/unsubscribe for operation plan data.

### 6.2.1 Operation subscribeForOperationPlan

#### 6.2.1.1 Operation Functionality

A consumer calls this operation to subscribe to receive operation plan data.

#### 6.2.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| consumer | Input | NotificationEndpoint | Which endpoint shall be notified in case of new OperationPlan data. |
| areaOfInterest | Input | AreaOfInterest | Area of interest to the consumer |
| response | Return | ServiceResponse | Provide status information on subscription |

**Table 46: Payload description of subscribeForOperationPlans operation**

### 6.2.2 Operation unsubscribe

#### 6.2.2.1 Operation Functionality

A consumer calls this operation at the provider to unsubscribe from operation plan or no flight zone data.

#### 6.2.2.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| consumer | Input | NotificationEndpoint | Which endpoint shall not be notified (anymore) in case of new OperationPlans or No Flight Zones. |
| response | Return | ServiceResponse | Provide status information on subscription |

**Table 47: Payload description of unsubscribe operation**

## 6.3 Service Interface OperationPlanNotificationInterface

Once and while subscribed, consumer receives operation plan data via this interface.

### 6.3.1 Operation notifyOperationPlan

#### 6.3.1.1 Operation Functionality

The service provider uses this logical operation (implemented by the consumer) to publish operation plan data.

#### 6.3.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| op | Input | OperationPlan | An operation plan matching the filter criteria provided in the subscription |

**Table 48: Payload description of notifyOperationPlan operation**

## 6.4 Service Interface OperationPlanManagementInterface

The service provider offers this interface to allow service consumers to manage operation plans. This includes initial creation as well as modification of operation plans and missions; furthermore it includes the life cycle management for operation plans (request for authorisation, request for takeoff, cancellation, revocation, etc.)

### 6.4.1 Operation evaluateOperationPlan

This operation allows to evaluate an operation plan without actually submitting it for approval.

#### 6.4.1.1 Operation Functionality

The service provider investigates the input operation plan and evaluates whether it can be accepted as is, or whether there exist conflicts with other (planned) operations or with airspace restrictions.

If the operation plan is acceptable, this fact is simply given back as a result to the invoker, but the operation plan is not pre-noted in any way.

If the operation plan is not acceptable, this fact is given back as a result to the invoker, and alternative, acceptable operation plans may be added to the result (e.g., slightly modified in time or space).

#### 6.4.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| op | Input | OperationPlan | The "op" parameter specifies an OperationPlan that shall be evaluated. |
| <none> | Return | OperationPlanProcessingResponse | The return value provides the evaluation result. In case of a negative result, the return value may contain one or several alternative OperationPlans, if the service provider is able to make such proposals. |

**Table 49: Payload description of evaluateOperationPlan operation**

### 6.4.2 Operation proposeOperationPlan

This operation allows to evaluate an operation plan and proposing it (i.e., scheduling it as a proposed plan).

#### 6.4.2.1 Operation Functionality

The service provider investigates the input operation plan and evaluates whether it can be accepted as is, or whether there exist conflicts with other (planned) operations or with airspace restrictions.

If the operation plan is acceptable, this fact is given back as a result to the invoker, and the operation plan is pre-noted and published as a proposed plan to any subscribers.

If the operation plan is not acceptable, this fact is given back as a result to the invoker, and alternative, acceptable operation plans may be added to the result (e.g., slightly modified in time or space). Such alternatives should be pre-noted as proposed plans for a short amount of time.

#### 6.4.2.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| op | Input | OperationPlan | The "op" parameter specifies an OperationPlan that shall be evaluated and proposed. |
| <none> | Return | OperationPlanProcessingResponse | The return value provides the evaluation result. In case of a negative result, the return value may contain one or several alternative OperationPlans, if the service provider is able to make such proposals. |

**Table 50: Payload description of proposeOperationPlan operation**

### 6.4.3 Operation submitOperationPlan

This operation allows to propose an operation plan and submitting it (i.e., requesting for authorisation) in one shot.

#### 6.4.3.1 Operation Functionality

The service provider investigates the input operation plan and evaluates whether it can be accepted as is, or whether there exist conflicts with other (planned) operations or with airspace restrictions. Furthermore, if there are no conflicts, the service provider initiates all necessary approval steps for the operation plan.

If the operation plan is acceptable and can be approved, this fact is given back as a result to the invoker, and the operation plan is published as an approved plan to any subscribers.

If the operation plan is not acceptable or cannot be approved, this fact is given back as a result to the invoker.

#### 6.4.3.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| op | Input | OperationPlan | The "op" parameter specifies an OperationPlan that shall be evaluated and authorised. |
| <none> | Return | OperationPlanProcessingResponse | The return value provides the evaluation result. In case of a negative result, the return value may contain one or several alternative OperationPlans, if the service provider is able to make such proposals. |

**Table 51: Payload description of submitOperationPlan operation**

### 6.4.4 Operation updateOperationPlan

This operation allows to modify an operation plan by providing the updated operation plan data.

#### 6.4.4.1 Operation Functionality

The service provider looks up the operation plans in order to find one which's identifier matches the input operation plan. If there is a matching OP, the service provider tries to create a new version of the OP, taking into account the values given in the input OP.

If the updates to the operation plan are acceptable, this fact is given back as a result to the invoker, and the updated operation plan is published to any subscribers.

If the operation plan is not acceptable, this fact is given back as a result to the invoker, and no publication takes place.

#### 6.4.4.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| op | Input | OperationPlan | The "op" parameter specifies an updated version of an operation plan. |
| <none> | Return | ServiceResponse | The return value provides the operation result. |

**Table 52: Payload description of updateOperationPlan operation**

### 6.4.5 Operation cancelOperationPlan

This operation allows to cancel an operation plan by providing the operation plan identifier.

#### 6.4.5.1 Operation Functionality

The service provider looks up the operation plans in order to find one which's identifier matches the input opId. If there is a matching OP, the service provider changes the state of this OP to "CLOSED" and the closureReason to "CANCELLED".

If the operation was successful, this fact is given back as a result to the invoker, and the cancelled operation plan is published to any subscribers.

If the operation plan is not successful, this fact is given back as a result to the invoker, and no publication takes place.

#### 6.4.5.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| opId | Input | UUID | Identifier of an operation plan that shall be cancelled. |
| <none> | Return | ServiceResponse | The return value provides the operation result. |

**Table 53: Payload description of cancelOperationPlan operation**

### 6.4.6 Operation requestOperationPlanAuthorisation

This operation allows to request the necessary approval steps for a proposed operation plan by providing the operation plan identifier.

#### 6.4.6.1 Operation Functionality

The service provider looks up the operation plans in order to find one which's identifier matches the input opId. If there is a matching OP, the service provider initiates the authorisation process for this OP.

Note that authorisation may include several steps and involvement of several stakeholders and therefore may take some time to compete.

If the operation was successful, this fact is given back as a result to the invoker, and the authorized operation plan is published to any subscribers, as soon as the authorisation is complete.

If the operation is not successful, this fact is given back as a result to the invoker, and no publication takes place.

#### 6.4.6.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| opId | Input | UUID | Identifier of an operation plan that shall be authorised. |
| <none> | Return | ServiceResponse | The return value provides the operation result. |

**Table 54: Payload description of requestOperationPlanAuthorisation operation**

### 6.4.7 Operation revokeOperationPlan

This operation allows to revoke an operation plan by providing the operation plan identifier.

#### 6.4.7.1 Operation Functionality

The service provider looks up the operation plans in order to find one which's identifier matches the input opId. If there is a matching OP, the service provider changes the state of this OP to "CLOSED" and the closureReason to "REVOKED".

If the operation was successful, this fact is given back as a result to the invoker, and the revoked operation plan is published to any subscribers.

If the operation plan is not successful, this fact is given back as a result to the invoker, and no publication takes place.

#### 6.4.7.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| opId | Input | UUID | Identifier of an operation plan that shall be revoked. |
| <none> | Return | ServiceResponse | The return value provides the operation result. |

**Table 55: Payload description of revokeOperationPlan operation**

### 6.4.8 Operation requestTakeOff

This operation allows to request take-off permission for an authorized operation plan by providing the operation plan identifier.

#### 6.4.8.1 Operation Functionality

The service provider looks up the operation plans in order to find one which's identifier matches the input opId. If there is a matching OP, and if the OP is in state AUTHORIZED, the service provider changes the state of this OP to "TAKEOFFGRANTED".

If the operation was successful, this fact is given back as a result to the invoker, and the operation plan is published to any subscribers.

If the operation plan is not successful, this fact is given back as a result to the invoker, and no publication takes place.

#### 6.4.8.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| opId | Input | UUID | Identifier of an operation plan for which takeoff is requested. |
| <none> | Return | ServiceResponse | The return value provides the operation result. |

**Table 56: Payload description of requestTakeOff operation**

### 6.4.9 Operation declareEndOfFlight

This operation allows to declare the end of flight for an active operation plan by providing the operation plan identifier.

#### 6.4.9.1 Operation Functionality

The service provider looks up the operation plans in order to find one which's identifier matches the input opId. If there is a matching OP, and if the OP is in state TAKEOFFGRANTED, the service provider changes the state of this OP to "CLOSED" and the closureReason to "NOMINAL".

If the operation was successful, this fact is given back as a result to the invoker, and the closed operation plan is published to any subscribers.

If the operation plan is not successful, this fact is given back as a result to the invoker, and no publication takes place.

#### 6.4.9.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| opId | Input | UUID | Identifier of an operation plan that shall be declared finished. |
| <none> | Return | ServiceResponse | The return value provides the operation result. |

**Table 57: Payload description of declareEndOfFlight operation**

### 6.4.10 Operation createMission

This operation allows to initiate a mission.

TBD

### 6.4.11 Operation updateMission

This operation allows update a mission.

TBD



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# 7 Service Dynamic Behaviour

## 7.1 Sequence of events, cooperation with other services

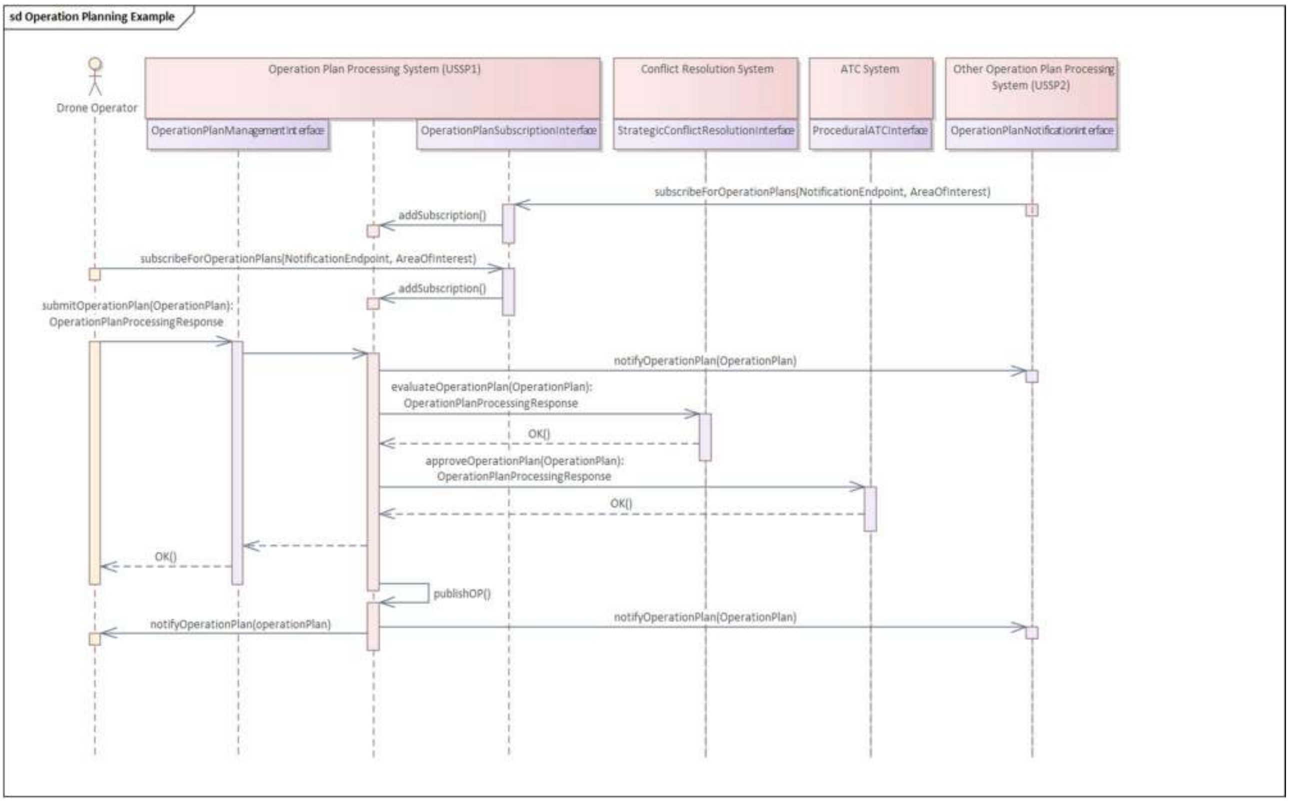


**Figure 8: OperationPlanExchange service operation sequence diagram**

Note:
In order to illustrate the service operations in a realistic context, this Sequence Diagram contains additional operations from other services, not only OperationPlanExchange service operations.

The figure above provides an example scenario for the OperationPlanExchange service. The scenario assumes an Operation Plan Processing system at USSP1 providing the OperationPlanExchange service. Another Operation Plan Processing system at a second USSP2 in this scenario plays the role of a consumer of the OperationPlanExchange service, by subscribing to the first USSP. In addition, the scenario includes a Drone Operator (in the role of a consumer of the OperationPlanExchange service of USSP1). Furthermore, the scenario finally illustrates an example Conflict Resolution system (providing the StrategicConflictResolution service) and an example ATC System (providing the ProceduralATCInterface service).

- The scenario starts with the consumers of the OperationPlanExchange service subscribing for operation plans:

- USSP2 subscribes at USSP1 in order to receive all operation plans (under the assumption that USSP2 provides services in the same or overlapping geographical area as USSP1)
- Drone Operator subscribes at USSP1 in order to get informed about operation plans in a certain area.

- Drone Operator submits a tentative Operation Plan by using the OperationPlanManagmentInterface of the OperationPlanExchange service
- USSP1 immediately publishes the (tentative) operation plan to all subscribers. So the second USSP gets informed about the ongoing planning performed in the first USSP in an early stage.
- USSP1 may need to contact a Conflict Resolution System (via StrategicConflictReslution service) in order to check the requested operation plans for conflicts with existing plans.
- USSP1 may need to contact the ATC System (via ProceduralATCInterface service) in order to get an approval from ATC.
- As soon as all checks are done and the operation plan is approved, USSP1 will provide the response to Drone Operator.
- At the same time, USSP1 will publish the OperationPlan to all subscribers.

## 7.2 Operation Plan State Machine

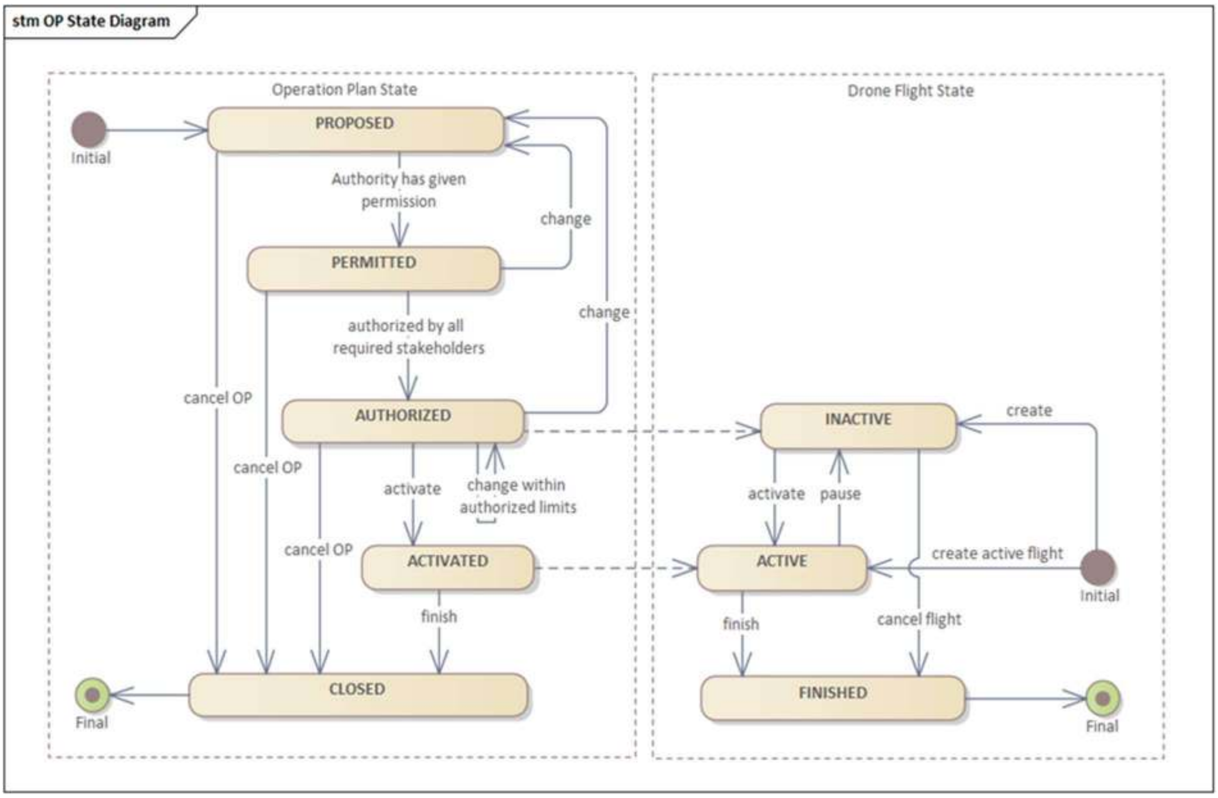


**Figure 9: Operation Plan states - state transition diagram**

# 8 References

This section identifies the documents (name, reference, source project) the Study Plan has **to comply to or to be used as additional inputs.**



| Nr. | Version | Reference |
|---|---|---|
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| [2] | Advanced Edition (unedited) | ICAO Doc 10039, Manual on System Wide Information Management (SWIM) Concept |
| [3] | 00.05.00 | SESAR 2020 GOF USPACE FIMS Design and Architecture, Appendix A Service Description Templates, document SESAR 2020 GOF USPACE Service Documentation Guidelines |
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| [5] | n/a | Global UTM Association (GUTMA) Flight Logging Protocol, https://github.com/gutma-org/flight-logging-protocol/blob/master/Flight_logging_protocol.md |
| [6] | n/a | Global UTM Association (GUTMA) Air Traffic Protocol, https://github.com/hrishiballal/airtraffic-data-protocol-development |
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| | | |
|---|---|---|
| [15] | n/a | IALA specification for e-navigation technical services<br><br>https://www.iala-aism.org/product/g1128-specification-e-navigation-technical-services |
| [16] | Ed. 1.0 | EUROCONTROL Specification for ATM Surveillance System Performance, EUROCONTROL-SPEC-0147, https://www.eurocontrol.int/publications/eurocontrol-specification-atm-surveillance-system-performance |
| [17] | 1 November 2006 | Federal Aviation Administration, Project Report ATC-323, Required Surveillance Performance Accuracy to Support 3-Mile and 5-Mile Separation in the National Airspace System |

**Table 58: List of References**

# D2.4 Appendix C Geographical zones / AIM Exchange Service Specification

| | |
|---|---|
| Deliverable ID: | D2.4-C |
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## Authoring & Approval

### Authors of the document

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Gregor Mogeritsch / Frequentis | WP2 | 26.10.2022 |
| Hubert Künig / Frequentis | WP2 | 26.10.2022 |
| Peter Cornelius / Frequentis | WP2 | 26.10.2022 |
| Thomas Lutz / Frequentis | WP2 Lead | 26.10.2022 |

### Reviewers internal to the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Jonas Stjernberg / Robots Expert | WP3 Lead | 1.11.2022 |
| Maria Tamm / EANS | Project coordinator | 3.11.2022 |
| Tanel Järvet / CAFA | WP4 Lead | 3.11.2022 |
| Damian Soliwoda / PSNC | WP2 member | 2.11.2022 |
| Lukasz Gorny-Zajac / DRR | WP2 member | 2.11.2022 |
| Parmentier Remy / VAI | WP2 member | 2.11.2022 |
| Pawel Korzec / DRR | WP2 member | 2.11.2022 |
| Piotr Dybiec / DRR | WP2 member | 2.11.2022 |
| Piotr Luboński / PSNC | WP2 member | 31.10.2022 |
| Piotr Szymaniak / PSNC | WP2 member | 31.10.2022 |
| Sven Jürgenson / Threod | WP3 member | 3.11.2022 |
| Leopoldo Tejada/UML | WP2 member | 2.11.2022 |
| Thomas Wana / DIME | WP2 member | 31.10.2022 |
| Yuhang Yun / EHANG | WP3 member | 30.10.2022 |
| Iris Roehrich / FRQ | WP1 member | 3.11.2022 |

### Approved for submission to the SJU By - Representatives of beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Sami Alkula/FANS | Project Management Group | 3.11.2022 |
| Thomas Neubauer/DIME | Project Management Group | 3.11.2022 |
| Pawel Korzec/DRR | Project Management Group | 3.11.2022 |
| Yuhang Yun/EHE | Project Management Group | 3.11.2022 |
| Damini Gera/AIRB | Project Management Group | 3.11.2022 |
| Piotr Szymaniak/PSNC | Project Management Group | 3.11.2022 |
| Sven Jürgenson/THREOD | Project Management Group | 3.11.2022 |
| Leopoldo Tejada/UML | Project Management Group | 3.11.2022 |



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| | | |
|---|---|---|
| Tapio Haarlaa/VAI | Project Management Group | 3.11.2022 |
| Iris Röhrich/FRQ | Project Management Group | 3.11.2022 |
| Juha Lindstedt/AVIA | Project Management Group | 3.11.2022 |
| Piotr Bratek/PANSA | Project Management Group | 3.11.2022 |
| Tanel Järvet/CAFA | Project Management Group | 3.11.2022 |
| Maria Tamm/EANS | Project Management Group | 3.11.2022 |

**Rejected By - Representatives of beneficiaries involved in the project**

| Name/Beneficiary | Position/Title | Date |
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| 01.00.00 | 04.11.2022 | Released | Coordinator | Submit deliverable |

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# GOF2.0

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## Abstract

This specification introduces a service of a Common Information Service (CIS) which ensures interoperability and hence transparent and reliable information flow between the stakeholders in an operational U-space environment. In accordance with ICAO SWIM, represents an Information Exchange Service.

This document describes one of these Bridge Services, the Geozones Exchange service in a logical, technology-independent manner.



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# Table of Contents

# 1 Introduction

## 1.1 Purpose of the document

This document describes the Geozones / AIM Service for the GOF2 USPACE project on a logical technology-independent manner, that is:

- the operational and business context of the service
    - requirements for the service (e.g., information exchange requirements)
    - involved nodes: which operational components provide/consume the service
    - operational activities supported by the service
    - relation of the service to other services
- the service description
    - service interface definitions
    - service interface operations
    - service payload definition
    - service dynamic behaviour description
- service provision and validation aspects

Furthermore, this document clearly defines the version of the service.

## 1.2 Scope

This document describes the Geozones / AIM service for the GOF2 USPACE project.

The Geozones / AIM service provides a means for the operational nodes of the GOF2 USPACE project to exchange necessary situational awareness information and make them available for further processing.

The Geozones / AIM service furthermore may be used in official specifications and recommendations.

## 1.3 Intended readership

This service specification is intended to be read by service architects, system engineers and developers in charge of designing and developing an instance of the Geozones / AIM service.

## 1.4 Background

### 1.4.1 EUROCONTROL Concept of Operations for U-space (CORUS)

EUROCONTROL CORUS [4] elaborates in 5.3 Geo-fencing and aeronautical information as follows.

*"Geo-fencing appears in U1, U2 and U3 and is successively refined. It is supported by aeronautical information for drones. This table summarises the different features by level:*

| Service or Capability | Level | Features |
|---|---|---|
| Pre-Tactical Geo-Fencing | U1 | Information provided before flight. The user should have<br><br>access to AIP and NOTAM defined geo-fences in a form that can be used when planning and that can be loaded onto the drone if it has geo-fence fence features in its navigation system |
| On-drone Geo-Fencing | U1 | The ability of the drone to keep itself on the correct side of a geo-fence by having geo-fence definitions (location, time, height) within its navigation system |
| Tactical Geo-Fencing | U2 | This service delivers to the pilot and /or drone operator updates to and new definitions of Geo-Fences occurring at any time, including during flight. The creation of geo-fences with immediate effect may (tbd) require that they are defined outside the AIP. (See below) |
| Drone Aeronautical Information Management | U2 | U2 may (tbd) include a non-AIP repository of Geo-Fences. The Drone Aeronautical Information Management service includes all information coming from such a source, combined with information from the AIP and NOTAMS together with any other drone relevant sources. |
| Dynamic Geo-Fencing | U3 | This service delivers updates and new definitions of geofences directly into the drone, even in flight. This service relies on capabilities of the drone in U3 to receive communications from U-space and to deal with geo-fence updates. |

*Geo-Fences may be defined, even today, using the existing aeronautical information publishing (AIP) mechanism. A geo-fence may be defined as "Restricted Area". The existing aeronautical information publishing mechanism is linked the 'AIRAC' cycle of 28 days. The process is well established but requires that changes, such as the definition of new geo-fences, are known weeks in advance. A "Danger Area" might also be used and has the advantage that it can be defined in advance but left inactive and then activated at short notice by a NOTAM. The Danger Area lacks the Restricted Area's concept of "entry is* *forbidden unless certain conditions are met" which is likely to be a necessary part of using geo-fences to define geo-cages for some operations – as in the red airspace of section 4.1.*

*Creation of Geo-Fences requires accreditation. There needs to be a way for the relevant people or organisations to create geo-fences and there needs to be a way for them to establish that they are the relevant people and should have that ability. U-space will need tools and procedures for geo-fence creation and maintenance.*

*U2 brings the idea of Geo-Fences with immediate, or near-immediate, effect. The authors are not sure how these will be published, whether inside the AIP or outside, but that does not matter here. Immediate effect geo-fences will be used when emergency situations occur, like the need for an air ambulance to land, firefighters operating in an active fire area, or similar. U-space in U2 will have at least one channel to send this information to every drone pilot immediately. Thus we require that the U2 drone pilot is somehow connected to these communication channels and he/she monitors them.*

*The Emergency Management Service should signal to the pilot if an emergency has triggered the creation of a geo-fence with immediate effect in the vicinity of the flight.*

*If the pilot is using a Traffic Information Service for his flight (it may be mandatory, tbd) then that should signal to the pilot that the flight is the wrong side of a newly created Geo-Fence or when the flight approaches a Geo-Fence.*

*If the remote piloting station has a map display, then it should be updated via the Drone Aeronautical Information Management service to show any new Geo-Fence as soon as reasonably possible after its creation.*

*The correct response to finding that the drone is on the wrong side of a newly created geo-fence will probably depend on the exact situation but options might include landing, ditching, returning to base, flying as directly as possible to exit the geo fence or flying in some specific, prearranged way expected to minimise the chance of collision, such flying as at very low speed and very low altitude, or hovering. CORUS awaits the recommendations of the relevant bodies.*

*U3 brings the direct communication of Geo-Fences to the drone. This augments the U2 service by having the drone react without the need for the remote pilot to get involved. There will need to be a way to inhibit this for those drone flights that have permission to cross or be inside any geo-fence. Or for operators / pilots who prefer to maintain manual control. "*

### 1.4.2 Institute of Aeronautics and Astronautics CONOPS

[5] Unmanned Aircraft Concept of Operation of the American Institute of Aeronautics and Astronautics defines ANSP and UAS Operator responsibility as follows.

| Regulator/ANSP Responsibility | UAS Operator /USS Responsibility |
|---|---|
| • Set performance based regulatory environment<br>• Define and update airspace constraints<br>• Foster collaboration among UAS by setting up architecture for data and information exchange<br>• Define data and information exchange specifications for collaboration among multiple stakeholders/operators<br>• Real-time airspace control if demand/capacity imbalance is expected<br>• Provide notifications to UAS operators and public<br>• Set static and dynamic geo-fence areas<br>• Provide flexibility as much as possible and structures (routes, corridors, altitude for direction, crossing restriction) only if necessary<br>• Manage access to controlled airspace and entry/exiting operations | • Register UAS<br>• Training and qualification of operators<br>• Avoid other aircraft, terrain, and obstacles<br>• Don't harm people and animals<br>• Respect airspace constraints<br>• Avoid dangerous and incompatible weather situations<br>• Follow performance based regulation<br>• Broadcast identity – no anonymous flying<br>• Broadcast intent<br>• Provide access to operations plans<br>• Detect, sense and avoid manned aircraft predicated on right of way rules<br>• Status and intent exchange according to ANSP standards<br>• Participate in collaborative decision making<br>• Contingency planning and response (large-scale outages – cell, GPS, security, an unanticipated severe weather) |

*"…The ANSP defines and updates the airspace constraints as necessary in real time, for example if airport configurations change or certain airspaces have to be closed. The interactions between the ANSP and UAS operators/USS will be primarily governed through Interface Control Documents (ICD) and Application Programming Interface (API) based integration of the components. This will create an architecture that will foster collaboration and information exchange among multiple stakeholders. The ANSP may add static or dynamic geo-fences or other means of airspace control and provide notifications to operators and other stakeholders. The regulator/ANSP will also manage access to controlled airspace. …"*

### 1.4.3 Global UTM Association (GUTMA)

Global UTM Association (GUTMA) describes in the first version of the UAS Traffic Management Architecture [6] the UAS Traffic Management System as follows in Figure 1. Aeronautical Info Service is described between UAS Traffic Management System and ATM System(s).

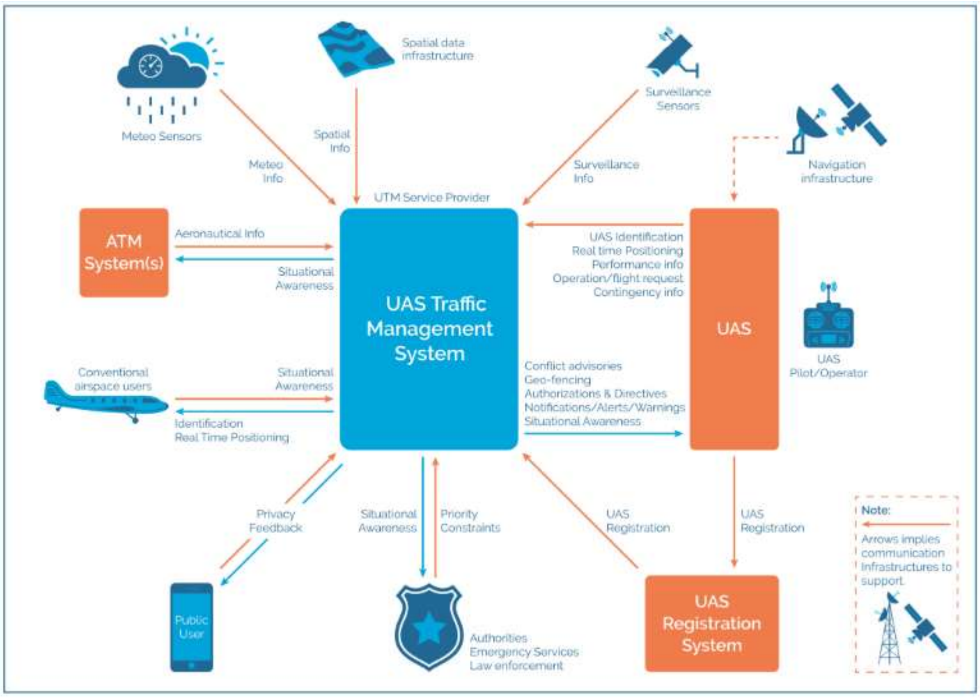


Figure 1: GUTMA UAS TM

### 1.4.4 Federal Aviation Administration (FAA) Concepts of Operations

*"FIMS is a gateway for data exchange between UTM participants and FAA systems, through which the FAA can provide directives and make relevant NAS information available to UAS Operators via the USS Network. The FAA also uses this gateway as an access point for information on operations (as required) and is informed about any situations that could have an impact on the NAS. FIMS provides a mechanism for common situational awareness among all UTM participants and is a central component of the overall UTM ecosystem. FIMS is the UTM component the FAA will build and manage to support UTM operations."*

The FAA defines a messaging service in its *Concepts of Operations v1.0 - Appendix C - UTM Services - Airspace Authorization Service*[7] as follows.

*"A service which provides airspace authorization from the Airspace Authority/Air Navigation Service Provider to a UAS Operator."*

### 1.4.5 Swiss Federal Office of Civil Aviation (FOCA)

From the FOCA *Concepts of Operations v1.0* [8], section 3.5.5 – Airspace Authorization Service:

*"A service, which provides the needed authorizations to fly from the Airspace Authority/ANSP to a UAS Operator. It fulfils following functions:*

- *To provide the opportunity for the pilot and/or the Operator to request an authorization.*
- *To automatically approve requests when possible*
- *To transmit authorization requests to competent authorities when automatic approval is not possible*

- *To support the Air Traffic Control (ATC) or other relevant stakeholders in managing the authorization requests*
- *To notify other relevant parties of issued authorizations*

*This service benefits the UAS Operator, the pilot, as well as the competent authorities. Airspace Authorization will be managed digitally with efficiency gains for all actors involved."*

### 1.4.6 International Civil Aviation Organization (ICAO)

ICAO Doc 10039 [2] elaborates in section *3.4 INFORMATION EXCHANGE SERVICES* on information exchange services as follow (para. 3.4.2).

*"Within the SWIM Global Interoperability Framework, the Information Exchange layer is instantiated by 'information services' as is further explained. Information services ensure interoperability between ATM applications which consume and provide interoperable information services. Consequently, the concept of information service is a fundamental building block of SWIM which enables interoperability through well-defined information exchanges."*

### 1.4.7 SESAR-JU

The European Commission identifies an increasing demand for a non-segregated use of airspace which is being driven by a rapidly growing market of Very-Low-Level (VLL) airspace users, most of which are expected to be drones.

Via the Roadmap for the safe integration of drones into all classes of airspace [9], within the European ATM Masterplan [10], the European Commission seeks to ensure that this rapid growth of airspace use happens in a safe and controlled manner.

SESAR develops the required concepts and demonstrations for this process to happen. The roadmap [1], in alignment with ICAO recommendations, identifies three phases for the integration, from which SESAR derives the four U-space service blocks presented in the U-space blueprint [18],

- U-space foundation services,
- U-space initial services,
- U-space advanced services, and
- U-space full services.

These stages reflect the anticipated quick growth of demand for U-space services. The state of the art is being validated throughout Europe via several Very Large Demonstrator (VLD) projects such as the **Error! Reference source not found.** project.

The European ATM Master Plan describes the drone aeronautical information management as part of U2 – U-Space initial services as follows.

*"Drone aeronautical information management.*

*This service provides the operator with relevant aeronautical information for drone operations. It will* *connect to the Aeronautical information service (AIS) to guarantee coherent information provision for manned and unmanned operators."*

### 1.4.8 SESAR-JU DREAMS

The SESAR JU DREAMS U-Space scenarios [11]are describing in Scenario 6, Long range operations, the aeronautical information service as follows.

*"The U–space application requests the Drone aeronautical information management service (Drone AIM) service information about the drones flying in the vicinity. The Drone AIM service updates the information by requesting the Flight planning management service the active flight plans. As a bonus, the U–space application could also provide information about the presence of general aviation traffic to drone users, using the same interface."*

As described in chapter 5.2 Gap analysis of DREAMS Gap Analysis, [12], data comparison between demand and supply was considered for further validation:



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| Information categories | | Information supply | | Information demand | | |
|---|---|---|---|---|---|---|
| | | Manned aviation | UTM service providers | U-Space Services | Survey results | Scenario Identification |
| Flow management | Urban airspace capacity management | | | U3 | | X |
| | High-density traffic management | | | | | X |
| | De-confliction management | FIXM | X | U1/U2 | X | X |
| | Congestion management | FIXM | | | | X |
| | Urban airspace intrinsic and strategic conflict risk reduction | | | | | X |
| | First/Last 50ft operations | | | | | X |
| | Drone delivery hub capacity management | | | | | X |
| | Controlled airspace data | AIXM | X | U1 | X | X |
| | Hyperlocal airspace data | | | | | X |
| | Dynamic geofencing | | X | U3 | X | X |
| | Static geofencing | | X | U1/U2 | X | X |
| Communication | GNSS coverage map | AIXM/XML | | | X | X |
| | 4G/5G coverage map | | | | X | X |
| | ATC-Drone operator/User communication link | | | U2 | X | X |
| | U-Space user chat service | | | | | X |
| | High quality video datalink | | | | | X |
| | Law enforcement | AIXM | | U1 | X | X |
| | Authorities | | | U1 | | |

Figure 2: DREAMS Gap analysis extract [12]

Also within the GOF-U-space project, a thorough use-case centric analysis was brought underway focusing on how to leverage a common data storage and -management for ATM and UTM. This approach is highly important to satisfy needs for interoperability, stakeholder collaboration and data quality. In this context, a strong focus was put on the storage and management of geofences as airspace volume outer shells to convey geospatial restrictions for UTM operations.

Since AIXM (in its 5.1 version) constitutes a current industry standard to store and share aeronautical static and dynamic information within a SWIM enabled environment, the GOF-U-space project did also focus on assessing whether AIXM is suitable format to manage geofenced airspace volumes and properties needed.

**GOF2 Update:**

Although AIXM-based services are still standard in legacy airspace management, moving to UAS airspaces requires additional converters to provide data conforming to new data format.

## 1.5 Operational systems

### 1.5.1 PANSA

#### 1.5.1.1 Geoprahical zones implementation

**Legal background and assumptions**

Airspace structures presented to UAS users on basis of art. 15 of the Regulation 2019/947 are called UAS geographical zones.

***Art. 15 - Operational conditions for UAS geographical zones***

*When defining UAS geographical zones for safety, security, privacy or environmental reasons, Member States may: (a) prohibit certain or all UAS operations, request particular conditions for certain or all UAS operations or request a prior operational authorisation for certain or all UAS operations; (b) subject UAS operations to specified environmental standards; (c) allow access to certain UAS classes only; (d) allow access only to UAS equipped with certain technical features, in particular remote identification systems or geo awareness systems.*

*2. On the basis of a risk assessment carried out by the competent authority, Member States may designate certain geographical zones in which UAS operations are exempt from one or more of the ‘open’ category requirements.*

*3. When pursuant to paragraphs 1 or 2 Member States define UAS geographical zones, for geo awareness purposes they shall ensure that the information on the UAS geographical zones, including their period of validity, is made publicly available in a common unique digital format.*

***Art. 18 – Tasks of Competent Authority***

*(f) making available in a common unique digital format information on UAS geographical zones identified by the Member States and established within the national airspace of its State;*

**Common unique digital format will be published in the AMC to the Regulation 2019/947.**

**COMMISSION IMPLEMENTING REGULATION (EU) …/... of XXX on a regulatory framework for the U-space (U-space regulation)**



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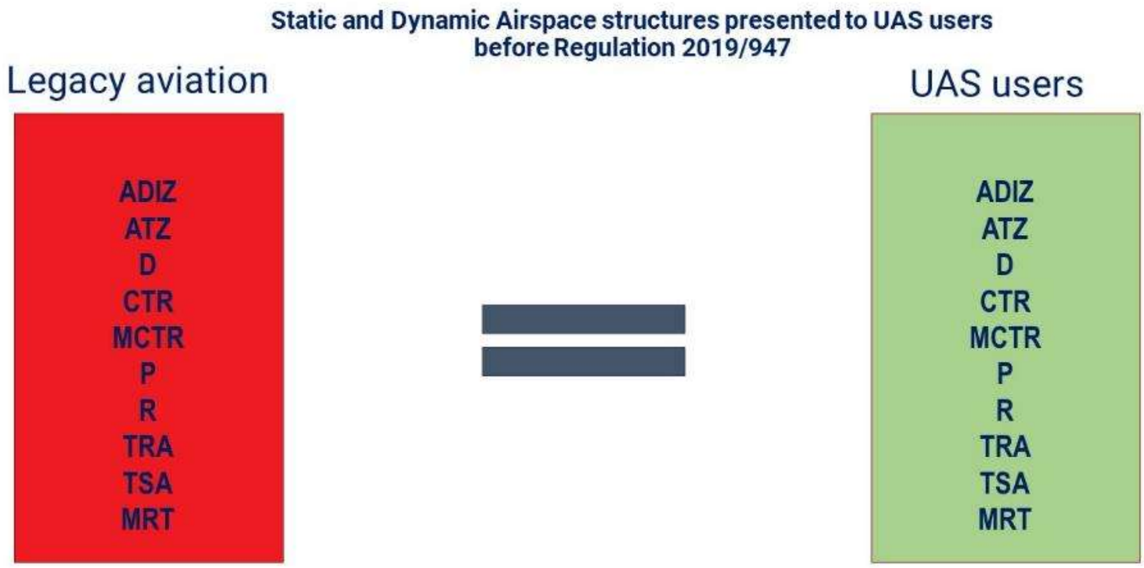
*Art. 2 (1) 'U-space airspace' means a UAS geographical zone designated by Member States, where UAS operations are only allowed to take place with the support of U-space services;*

According to *art. 5 (e) UAS geographical zones relevant to the U-space airspace and published by Member States in accordance with Implementing Regulation (EU) 2019/947;*

*When Member States define UAS geographical zones for safety, security, privacy or environmental reasons as provided for in Implementing Regulation (EU) 2019/947, they may impose specific conditions for certain or all UAS operations or allow access only to UAS equipped with certain technical features.*

**Aeronautical information data publication for UAS operators.**

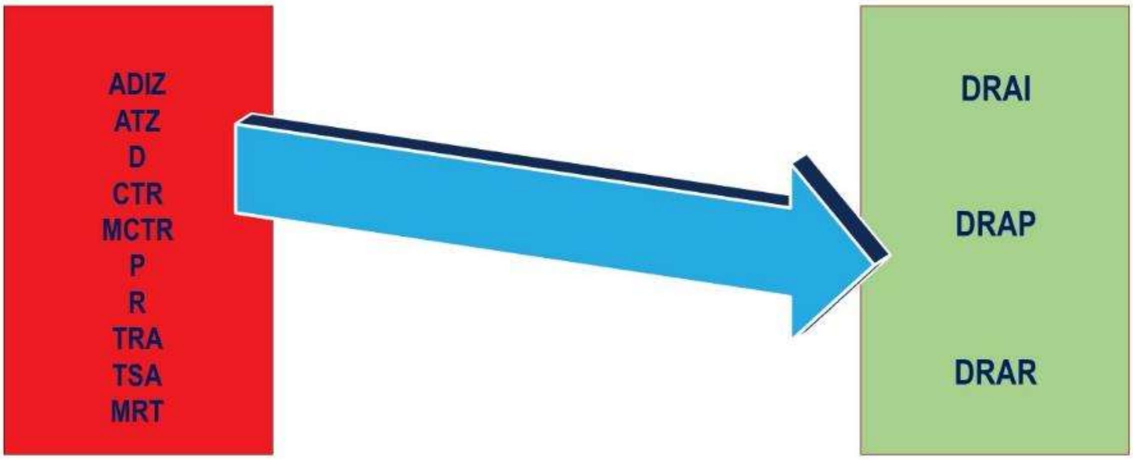
Before entering into force 2019/947 – static and dynamic airspace structures to UAS users. Airspace structures published for legacy aviation were published in the same manner to UAS users.




The regulation 2019/947 changed the way of presenting data to UAS users introducing the concept of geographical zones. In order to create consistency in the aeronautical data presented to the UAS users, the legacy aviation airspace structures should be translated to the language of geographical zones and new characteristics.

Note: The names of the geographical zones presented in this document are official in the certified PansaUTM system and may be used as an example of possible way to tackle them into European legislation.

**Phase 1 Translation of „legacy airspace structures" to geographical zones**




The geographical zones which will be published solely for the purposes of UAS operations will be not connected to existing airspace structures.

**Phase 2 Publishing geographical zones on basis of 2019/947 and U-space regulation**

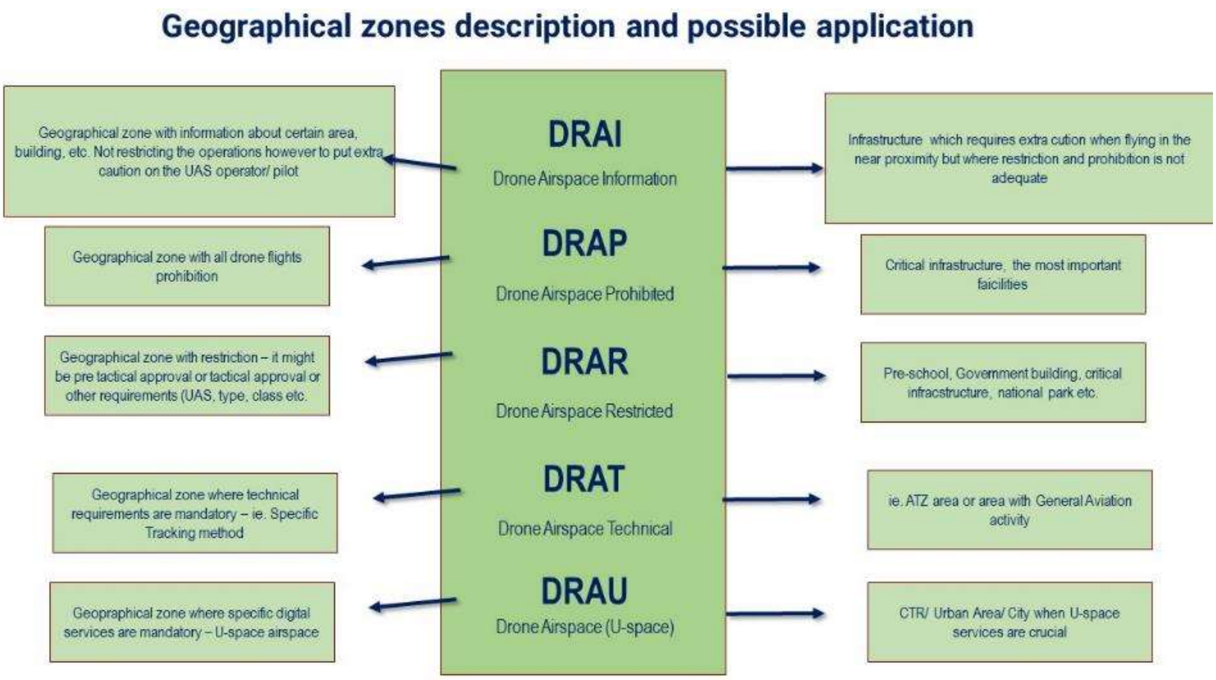

The approach proposed by PANSA also considers the needs of UAS Pilots. Based on the experience gained in managing tactical approvals (more than 10 000), the hereby proposed Geozones concept also includes information about the likelihood (probability) of obtaining approval to fly. Also bearing in mind that there may be a need for an airspace defining only the boundaries of the U-space, the proposal takes this need into account. Different type of geographical zone serve different purposes.

The example of geographical zones types:

| No | Proposed name | Function / Description |
|---|---|---|
| 1 | DRA-RH | restricted area for UAS with a high probability of obtaining approval for the operations |
| 2 | DRA-RM | restricted area for unmanned aerial vehicle systems with average probability of obtaining approval for the operations |
| 3 | DRA-RL | restricted area for UAS with a low probability of obtaining approval for the operations |
| 4 | DRA-RL | restricted area for UAS with a low probability of obtaining approval for the operations |
| 5 | DRA-P | prohibited area for UAS, in which UAS operations cannot be performed |
| 6 | DRA-I | information area for unmanned aerial vehicles, containing information necessary to ensure the safety of operations with the use of unmanned aerial vehicles, including navigational warnings |
| 7 | DRA-T | a restricted area for UAS, in which UAS operations may be performed only with the use of UAS that meet the technical requirements indicated by the Agency and under the conditions specified by the Agency, if such conditions for a given zone have been determined |
| 8 | DRA-U | a geographic zone for UAS where UAS operations can only be performed with the support of specific, verified services provided in this area and under the conditions specified by the Competent Authority, after U-space regulation implementation – the U-space airspace |

restricted area for UAS with a high probability of obtaining approval for the operations

All the proposed geographical zones could be used to address the general reasons for geographical zones publications stated in art. 15 of Regulation 2019/947, namely: safety, security, privacy or environmental reasons. The procedure of geographical zones publication is subject to competent authority.




**Overall Geozones naming convention with activity triggers**

| | 24h | AIRAC | FUA AUP/UUP | NOTAM | Non-aviation timing | Geozone naming convention ACTIVE |
|---|---|---|---|---|---|---|
| CTR | | x | | x | | DRAR |
| CTR1km | | x | | x | | DRAR |
| CTR6km | | x | | x | | DRAR |
| RPA Blue | | x | | x | | DRAR |
| RPA Green | | x | | x | | DRAR |
| RPA Yellow | | x | | x | | DRAR |
| RPA Red | | x | | x | | DRAR |
| MCTR | | x | x | x | | DRAR |
| MCTR2km | x | | | | | DRAR |
| TMA | | x | | x | | DRAP |
| MTMA | | x | x | x | | DRAP |
| RMZ | | x | | x | | DRAR ? |
| TRA | | x | x | x | | DRAR |
| TSA | | x | x | x | | DRAP |
| P | | x | | | | DRAR |
| D | | x | x | x | | DRAR |
| R | | x | x* | x | | DRAR |
| ATZ | | x | x | x | | DRAR |
| ATZ1km | | x | x | x | | DRAR |
| ATZ6km | | x | x | x | | DRAR |
| MRT | | x | x | | | DRAP |
| TFR | | x | x | | | DRAP |
| AAA | | x | | x | | DRAI |
| NW | | x | | x | | DRAI |
| ADIZ | x | | | | | DRAR |
| DRAI | | | | | x | DRAI |
| DRAR | | | | | x | DRAR |
| DRAP | | | | | x | DRAP |
| DRAT | | | | | x | |
| DRAU | | | | | x | |
| *FIS* | x | | | | | |

**Figure 3 Table of proposed PANSA Geozones types mapping**

**It should be taken into account the distinction between the entire volume of aeronautical R airspace and only the protected area, such as e.g. building*

### 1.5.2 AVINOR

In an integrated approach, geo awareness is provided for both UAS Operators and Air Traffic Controllers in daily operations. Aeronautical information is combined with so called NDZ (No Drone Zones) and displayed in map overlays, which are tailored for the user group.

NDZ can be retrieved from authorized sources, or manually created by authorized ATC personnel. They are modelled as 4D volumes, can hold additional information such as labels, reasons, restrictions/permissions, and metadata. For a short term NDZ, providing a 4D volume and very few mandatory attributes are sufficient.

The aim is to reduce workload on controllers and operators. Focus is put on presenting go/no go information, providing more details where relevant or on user request/action (e.g. for AIM data).

The UTM system uses NDZ to assist controllers in operation plan processing, e.g. in approval processes or in case airspace is closed, notifying affected operations.

## 1.6 Glossary of terms

| Term | Definition |
|---|---|
| **Alerting** | The Geoawaraness function shell provide the remote pilot with Geowareness warning alert when a potential or actual breach of airspace restrictions (as defined by the UAS Geozone information) is detected, either in horizontal plane in vertical axis or both.<br><br>The time or threshold to alert shall be defined by the manufacturer, taking into account the subsequent reaction time and trajectory correction manoeuvre span, in order to avoid the UAS penetrating the forbidden zone.<br><br>Margin on limits (meaning additional distance to the border) shall be defined and implemented by the manufacturer, taking into account the accuracy of the UAS position/altitude measurement which is compared to the geographical limit. [25]<br><br>Alerting as described here is a conformance service, which should be combined with telemetry service, not Geozones service. |
| **UAS geographical zone** | *4D* part of airspace defined as geoshape with vertical projection limits and time window, established by the competent authority that facilitates, restricts or excludes UAS operations in order to address risks part [24] |

| | |
|---|---|
| **External Data Model** | Describes the semantics of the domain (or a significant part thereof) by defining data structures and their relations. This could be at logical level (e.g., in UML) or at physical level (e.g., in XSD schema definitions), as for example standard data models. |
| **Geofencing** | The overall Geo-fencing provides the capability to use airspace volumes (geographic fences) to control operations of UAS. [13]<br><br>Old umbrella term for defining airspaces function (it made a sense when only NFZs were used). |
| **Geoshape** | A series of geographical coordinates and dimensions that define a geometrical shape by means of polygons or circles.[25]<br><br>While a term 'circle' is widely used in industry, its mathematical definition - every point on circle is equistand to centre – and projecting it on ellipsoid/geoid causes problems. Implementations of machine intersections/within checks and HMI display usually interpolates curves to lines, and due to lack of standard conversion definition, it may yield different results. |
| **Height/Altitude limits** | The Geozone data format enables to set per zone lower/upper altitude limits (Above Mean Sea Level) or heights (Above Ground Level). The reference and unit of measurement are sent along with the data. [25] |
| **Message Exchange Pattern** | Describes the principles how two different parts of a message passing system (in our case: the service provider and the service consumer) interact and communicate with each other. Examples:<br><br>In the Request/Response MEP, the service consumer sends a request to the service provider in order to obtain certain information; the service provider provides the requested information in a dedicated response.<br><br>In the Publish/Subscribe MEP, the service consumer establishes a subscription with the service provider in order to obtain certain information; the service provider publishes information (either in regular intervals or upon change) to all subscribed service consumers. |
| **Operational Activity** | An activity performed by an operational node. Examples of operational activities are: Route Planning, Route Optimization, Logistics, Safety, Weather Forecast Provision, … |
| **Operational Model** | A structure of operational nodes and associated operational activities and their inter-relations in a process model. |
| **Operational Node** | A logical entity that performs activities. Note: nodes are specified independently of any physical realisation.<br><br>Examples of operational nodes are: Control Center, Authority, Weather Information Provider, … |

| | |
|---|---|
| **Service** | The provision of something (a non-physical object), by one, for the use of one or more others, regulated by formal definitions and mutual agreements. Services involve interactions between providers and consumers, which may be performed in a digital form (data exchanges) or through voice communication or written processes and procedures. |
| **Service Consumer** | A service consumer uses service instances provided by service providers. |
| **Service Data Model** | Formal description of one dedicated service at logical level. The service data model is part of the service specification. Is typically defined in UML and/or XSD. If an external data model exists (e.g., a standard data model), then the service data model shall refer to it: each data item of the service data model shall be mapped to a data item defined in the external data model. |
| **Service Design Description** | Documents the details of a service technical design (most likely documented by the service implementer). The service design description includes (but is not limited to) a service physical data model and describes the used technology, transport mechanism, quality of service, etc. |
| **Service Implementation** | The provider side implementation of a dedicated service technical design (i.e., implementation of a dedicated service in a dedicated technology). |
| **Service Implementer** | Implementers of services from the service provider side and/or the service consumer side. |
| **Service Instance** | One service implementation may be deployed at several places by same or different service providers; each such deployment represents a different service instance, being accessible via different URLs. |
| **Service Instance Description** | Documents the details of a service implementation (most likely documented by the service implementer) and deployment (most likely documented by the service provider). The service instance description includes (but is not limited to) service technical design reference, service provider reference, service access information, service coverage information, etc. |
| **Service Interface** | The communication mechanism of the service, i.e., interaction mechanism between service provider and service consumer. A service interface is characterised by a message exchange pattern and consists of service operations that are either allocated to the provider or the consumer of the service. |
| **Service Operation** | Functions or procedure which enables programmatic communication with a service via a service interface. |
| **Service Physical Data Model** | Describes the realisation of a dedicated service data model in a dedicated technology. This includes a detailed description of the data payload to be exchanged using the chosen technology. The actual format of the service physical data model depends on the chosen technology. Examples may be WSDL and XSD files (e.g., for SOAP services) or swagger (Open API) specifications (e.g., for REST services). If an external data model exists (e.g., a standard data model), then the service physical |

| | |
|---|---|
| | data model shall refer to it: each data item of the service physical data model shall be mapped to a data item defined in the external data model.<br><br>In order to prove correct implementation of the service specification, there shall exist a mapping between the service physical data model and the service data model. This means, each data item used in the service physical data model shall be mapped to a corresponding data item of the service data model. (In case of existing mappings to a common external (standard) data model from both the service data model and the service physical data model, such a mapping is implicitly given.) |
| **Service Provider** | A service provider provides instances of services according to a service specification and service instance description. All users within the domain can be service providers, e.g., authorities, organizations (e.g., meteorological), commercial service providers, etc. |
| **Service Specification** | Describes one dedicated service at logical level. The Service Specification is technology-agnostic. The Service Specification includes (but is not limited to) a description of the Service Interfaces and Service Operations with their data payload. The data payload description may be formally defined by a Service Data Model. |
| **Service Specification Producer** | Producers of service specifications in accordance with the service documentation guidelines. |
| **Service Technical Design** | The technical design of a dedicated service in a dedicated technology. One service specification may result in several technical service designs, realising the service with different or same technologies. |
| **Service Technology Catalogue** | List and specifications of allowed technologies for service implementations. Currently, SOAP and REST are envisaged to be allowed service technologies. The service technology catalogue shall describe in detail the allowed service profiles, e.g., by listing communication standards, security standards, stacks, bindings, etc. |
| **Spatial Exclusiveness** | A service specification is characterised as “spatially exclusive”, if in any geographical region just one service instance of that specification is allowed to be registered per technology.<br><br>The decision, which service instance (out of a number of available spatially exclusive services) shall be registered for a certain geographical region, is a governance issue. |

**Table: Glossary of terms**

## 1.7 List of Acronyms

| Acronym | Definition |
|---|---|
| API | Application Programming Interface |

| | |
|---|---|
| **HMI** | Human Machine Interface |
| **JSON** | JavaScript Object Notation |
| **MEP** | Message Exchange Pattern |
| **NAF** | NATO Architectural Framework |
| **REST** | Representational State Transfer |
| **SOA** | Service Oriented Architecture |
| **SOAP** | Simple Object Access Protocol |
| **SSD** | Service Specification Document |
| **UML** | Unified Modelling Language |
| **URL** | Uniform Resource Locator |
| **WSDL** | Web Service Definition Language |
| **XML** | Extendible Mark-up Language |
| **XSD** | XML Schema Definition |

**Table: List of acronyms**



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# 2 Service Identification

The purpose of this chapter is to provide a unique identification of the service and describe where the service is in terms of the engineering lifecycle.

| | |
|---|---|
| **Name** | *GeozonesExchangeService* |
| **ID** | *urn:gof:services:GeozonesExchangeService* |
| **Version** | *2.0* |
| **Description** | An information exchange service which provides Geozones information |
| **Keywords** | *Airspace, Geozones, AIM* |
| **Architect(s)** | *2021-today The GOF 2.0 Project Consortium*<br>*2020-2021 The Frequentis Group*<br>2020-2021 Droneradar Sp. z o.o.<br>*2018-2020 The GOF U-Space Project Consortium* |
| **Status** | *Provisional* |

**Table: Service Identification**

# 3 Operational Context

This section describes the context of the service from an operational perspective.

## 3.1 Functional and Non-functional Requirements

The table below lists applicable existing requirements for the Geozones service.

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| [R-1] | Common Situational Awareness | At all times, all airspace users as well as ATC shall operate on the same common set of data, during pre-flight planning stages as well as during all stages of flight operations. | CORUS [4], 4.1.1.2 Amber airspace;<br>B1-RPAS [17];<br>CEF-SESAR-2018-1 [1], Objective O5 |
| [R-2] | SWIM | The implementation of a UTM Flight Information Management System (FIMS) shall be based on an ICAO SWIM-compliant architecture. | CEF-SESAR-2018-1 [1], 5.3.4 Overall approach and methodology |
| [R-3] | Interoperability | There shall be an implementation of a Flight Information Management System (FIMS) which ensures that, at all times, emerging unmanned traffic management systems and existing technologies from manned operations can exchange any data required to support such common situational awareness, be it for drone operations in areas where established ATC procedures apply, or in zones outside established ATC. | ICAO Doc 10039 [2];<br>CEF-SESAR-2018-1 [1], Objective O6;<br>CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |
| [R-4] | Regulatory Framework | The U-space concept shall allow regulators to define a framework to pro-actively steer unmanned traffic and declare restricted or closed areas for unmanned aviation. These properties may be permanent or activated according to schedules or following ad-hoc notice. Regulation is desired i.e. for the purpose of protection of critical infrastructure, privacy of residents, noise abatement, natural conservation or security concerns. The regulator may offer a granular | |

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| | | definition of rules and procedures applicable for restricted areas. | |
| [R-5] | Georeferenced volumes | Restrictive airspace is to be defined as georeferenced volumes with altitude thresholds to offer maximal flexibility. | |
| [R-6] | Static Data Usage | There shall be a single source for static aeronautical data provision for pre-flight and inflight operations to be used for both, the U-space as well as legacy aviation. | |
| [R-7] | Static Data Management | Static Data shall be maintained by dedicated local ANSP in close collaboration with the local regulators and other relevant authorities. The Static Data maintenance shall follow the established process of data origination, data management and data provision. | |
| [R-8] | Dynamic Data Usage | There shall be a single source for dynamic aeronautical data provision to be referenced for both, the U-space as well as manned aviation. | |
| [R-9] | Dynamic Data Management for U-Space | Dynamic Data feeds relevant for unmanned aviation only , shall be retrieved by the ANSP as a trusted source input (e.g. a notification input from a public safety control centre) and automatically processed to the data store. | |
| [R-10] | Error Handling in Data Feeds | Dedicated ATM supervisors in the respective responsible area control centres or TMAs shall have access to an error queue to manually manage any inconsistences deriving from ad-hoc restrictions to certain areas for unmanned aviation. | |
| [R-11] | Incident Management | Registered aircraft (trusted source with privilege access) shall be able to trigger automated creations of restricted geofence volumes once they are involved in an incident inspection and transmit a data message with GML and radius information. This will allow a faster notification to other unmanned airspace users. | |
| [R-12] | Alert | In case an area (volume) has been restricted by the regulator or ad-hoc by public safety, etc., an alert shall be sent to all U-space users currently | |

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| | | planning to depart, transit or arrive at the defined and recently restricted geofence. | |
| [R-13] | U-Space Flight Planning | Flight Plans shall be validated against established airspace volumes, their status and other airspace restrictions through which the unmanned aircraft is planning to fly. In case of a regulatory restriction, an alternative routing shall be offered to avoid restricted areas. | |
| [R-14] | Data Quality Assurance | All data consumed by the U-space shall be ADQ grade information (according to EU-Regulation 73/2010), thus ensuring the highest level of data quality for all airspace users regardless of manned or unmanned operations. | *European Regulation 73/2010 & ICAO Annex 15* |
| [R-15] | Basis for Open Market | The U-space concept shall be designed such as to ensure a well-established line of authority while at the same time ensuring that an open market for VLL services may develop. | *SESAR Drone Roadmap [9], Foreword, 4.1 and 4.2;*<br><br>*U-space Blueprint [18], Benefits to European society and economy;*<br><br>*CEF-SESAR-2018-1 [1], Table 8 – Key Challenges* |
| [R-16] | Open Interfaces | Any interface and protocol hence must be openly defined and its definition be freely accessible in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop. | *CEF-SESAR-2018-1 [1], Table 8 – Key Challenges* |
| [R-17] | Latency | The AIXM store shall respond with minimal latency to not delay changes in airspace volume configuration and restrictions changed ad-hoc in daily operations. | |
| [R-18] | UAS Registration | Every unmanned aircraft shall be identifiable by UTM and ATM and relevant State authorities. Next to the unique registration identifier, | |

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| | | information on the type of aircraft shall also be transmitted taccording to EASA specification | |
| [R-19] | Audit Trail | Any creation, update, withdrawal or exchange of data and notifications/alerts shall be logged in a detailed audit trail to be able to allow complete and transparent recovery of the history of actions. | |

**Table 1: Requirements for the Geozones service**

## 3.2 Other Constraints

### 3.2.1 Relevant Industrial Standards

#### 3.2.1.1 ICAO SWIM

The System Wide Information Management (SWIM, [2]) complements human-to-human with machine-to-machine communication, and improves data distribution and accessibility in terms of quality of the data exchanged. The SWIM Concept addresses the challenge of creating an "interoperability environment" which allows the SWIM IT systems to cope with the full complexity of operational information exchanges. The SWIM environment shifts the ATM information architecture paradigm from point-to-point data exchanges to system-wide interoperability.

#### 3.2.1.2 AIXM – Aeronautical Information Exchange Model

To comply with ICAO global and regional requirements for the provision for aeronautical information in the context of the evolution towards SWIM, AIXM is aiming to enable the provision of aeronautical information in digital format. [14][12]

The following main information areas are in the scope of AIXM:

- Aerodrome/Heliport including movement areas, services, facilities, etc.
- Airspace structures
- Organisations and units, including services
- Points and Navaids
- Procedures
- Routes
- Flying restrictions

**AIXM 4.5**

AIXM 4.5 was published in 2005, as an update of an earlier AIXM 3.3 version, which was originally developed by Eurocontrol for the needs of the European AIS Database (EAD) project. It comprises an entity-relationship data model (called "AICM") and an XML Schema.

AIXM 4.5 is still in use in many systems around the world, in particular for the coding of a subset of the static aeronautical data.

**AIXM 5.0**

AIXM 5.0 constituted a significant leap-forward in the evolution of the model. Starting from the experience accumulated with the operational implementation of the earlier versions, in particular AIXM 4.5, the objective was to take advantages of established information engineering standards, in particular Unified Modelling Language (UML) and the ISO-OGC standards for geographical information encoding and provision.

Main differences between AIXM 4.5 and AIXM 5 are given bellow:

| Topic | AIXM 4.5 | AIXM 5 |
|---|---|---|
| Data Scope | Only Static Data | Static and Dynamic Data, enabling Digital NOTAM |
| Geographical Elements | XML | XML/GML<br>(ISO standard for geometry) |
| Temporality | Temporality is a property of the message Supports only static data | Temporality is a property of the aeronautical feature, Supports both static and dynamic data |
| Model Extensibility | Limited extensibility (part of local system) | Defined extensibility concept for the AIXM Schema |

**Current version: AIXM 5.1 /5.1.1**

Followed soon (in 2010) as an updated version of the initial AIXM 5.0. Many existing implementations have made the transition from AIXM 4.5 to AIXM 5.1 and newly developed AIS systems use AIXM 5.1.

#### 3.2.1.3 FIXM – Flight Information Exchange Model

The ICAO Flight and Flow Information for a Collaborative Environment concept provides a globally harmonized process for planning and providing consistent flight information. It is guided by the requirement to eliminate or reduce the limitations of the present Flight Plan and to accommodate the future environment detailed in the Global Air Traffic Management Operational Concept.

FIXM is one component belonging to the Information Exchange Models layer of the SWIM Global Interoperability Framework described by the ICAO SWIM concept (ICAO Doc 10039), which is being refined by the ICAO Information Management Panel (IMP). FIXM therefore monitors the work and conclusions of this panel and will align over time with any relevant recommendations from this panel, as appropriate. [15]

The current version of FIXM format is v4.1.0 and was released in December, 2017.

#### 3.2.1.4 IWXXM – ICAO Weather Information Exchange Model

The Weather Information Exchange Models and Schema are designed to enable a platform independent, harmonized and interoperable meteorological information exchange covering all the needs of the air transport industry.

The WXXM follows the GML object-property model, which requires the properties of objects to be encapsulated by a simple type (domain value). Should a 'property' consist of a complex object or feature, the relationship must be represented through the use of an association. [16]

#### 3.2.1.5 Network Availability Coverage

*New service: Information about Network availability (Coverage) in 4D airspace - DIAMETOR*

In order to enable Beyond Visual Line Of Sight (BVLOS) operations at scale, UAVs need reliable connectivity. To ensure that flight planning can include information on where such connectivity is available, additional data from connectivity providers is required.

In particular, for safety it is necessary to understand where cellular coverage is available to support the needs of the mission. "Coverage" implies a range of requirements such as signal level, interference, dynamic handover/switchover behavior and others to enable a minimum connectivity performance along a flight route in a technology and spectrum independent manner. "Coverage" for a communication service provider (CSP) is also a synonym for "signal availability", whereas in aviation terms it is typically a combination of sufficient availability, continuity, latency and integrity [EUROCAE ER012, RTCA DO 377].

Interfaces are being established to harmonize the data exchange between CSPs and the aviation eco-systems.

#### *3.2.1.6* ASTM UTM Protocol

*Based on publicly available OpenAPI specification, new ASTM protocol draft is similar to ED-269 but more concentrated on American/FAA approach, and little bit less suitable for GOF2*

Source: https://github.com/astm-utm/Protocol

#### 3.2.1.7 ISO/DIS 23629-7

In 2020 new ISO standard for UAS traffic management emerged. Important part for the scope of this document is ISO/DIS 23629-7: Data model for spatial data, (final draft stage at the moment of writing this document).

The standard is rather simple and format-agnostic. Supported airspace attributes are:

- Identifier
- Generate time
- Disappearance time
- Maximum height
- Minimum height
- Type of height

- Shape (polygon or circle)
- Location (centroid)
- Administration contact details
- Conditions for operation
- Availability of UTM services
- Type of airspace

In the light of above requirements, and missing attributes – especially time-related (I.e. missing activation times) - GOF 2.0 Geozones data-model should be a superset of ISO/DIS 23629-7 format.

As a side note: aforementioned standard also defines other important entities, like obstacles, flight routes, take-off and landing areas, CNS coverage and dynamic phenomena, but they are beyond of the scope of this document.

#### 3.2.1.8 ED-269

Another new document is EUROCAE ED-269 - 'Minimum Operational Performance Standard for Geofencing'. It is probably most mature approach, supporting most of the requirements we've met during development of operational systems.

- Most important aspects are:
- Clearly defined format
- Support of multiple airspace volumes per airspace,
- Support of airspace activity periods.
- Services definition: both Pub-Sub and retrieval/updateRetrieval

Although there are some relatively minor issues within the format, we recommend to use it as a base of GOF 2.0 geozones service(s). For more in-depth view see chapters related to Service implementation.

## 3.3 Operational Stakeholders

Aeronautical information comprises both dynamic and static data enabling safe navigation for airspace users.

The data usually designated by the term 'Static Data' is the data known to the aviation world and documented in publications such as AIP, e.g. FIR(s), Aerodromes, Navigation Aids, Areas, Maps, Rules, Subjects to which a NOTAM may be related and other aeronautical information such AIC, etc.

Static data are long-term data and are updated according to AIRAC system that is a stringent and lengthy process involving multiple stakeholders. All data must also undergo a four-eyes principle for manual updates and business rule and CRC checks for structured data uploads. ICAO Annex 15 and the EU Regulation 73/2010 govern the collection, processing and provision of aeronautical data.

Dynamic data is a critically important information distributed at short notice as NOTAM and Pre-Flight Information Bulletin. NOTAM is a notice filed with an aviation authority to alert aircraft pilots of potential hazards along a flight route or at a location that could affect the safety of the flight.

Flight plan, changes thereto and Meteorological information (OPMET) are another type dynamic data. Meteorological reports are related to a specific time and location and shall be updated at specific period. OPMET shall be available at all phases of flight.

Flight plan and its changes are related to specific flight and indicate the status of flight (submitted, modified, current, closed, cancelled).

Different stakeholders are involved in update of OPMET and Flight Plan data at different phase of flight (e.g. Met Office, ATS units, ATC). The way of communication differs at each phase of flight: AFTN (NOTAM, FPL), Web page (PIB), radio (VCS), data-link (CPDLC).

The reporting of static and dynamic aeronautical data involves a stringent origination, maintenance and publication process to ensure data quality and accurate data flow. Information is originated from the following sources:

- Survey Data (Terrain and Obstacle Data) from civil engineers
- Sensors
- Airport Authorities
- Civil Aviation Authorities / Regulating Bodies
- ANSPs (e.g. for Instrument Flight Procedure and Airspace Design)
- Military Data (on no-fly areas, etc.)
- International Organisations (e.g. Eurocontrol Airspace Use Plan, Network Manager, etc.)
- EAD – European AIS Data Base

In the U-space, unmanned aviation must also consume relevant static and dynamic data to gain situational awareness on the aeronautical and physical surroundings along the actual or planned flight path as well as their current operational status and provide safety at area defined by flight plan. Obviously, weather is also an important factor with massive impact on flight performance and safety.

For unmanned aviation static/dynamic data is not limited by airspace volumes, restrictive airspaces. Additional information shall be provided by U-AIM such protected areas (airports, prisons) public areas (schools, stadium, park) etc.

As in manned aviation, drone operators shall validate their flight plans against the actual (real-time) status of the aeronautical and physical entities along the planned trajectory. Obviously not all information used in manned aviation will be relevant for drones. The following data are considered key to allow drones to operate in a unified airspace:

- Obstacle/terrain data
- Airspace reservation/activation (volumes defined by vertical and horizontal limits and Geoshape data) to convey procedures and limitations to manned and unmanned traffic.



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- Points – predefined (published) in U-AIM points that could be used in flight plan, similar with VFR points published in AIP (entry/exit CTR VFR points etc).

- Airspace usage criteria: definition what operation/separation is allowed and what aircraft types (or even aircraft registration) with what type of equipment requirements are established (eg. ADS-B) in the respective airspace

- Flight Information of manned aircraft, particularly GAT aviation in uncontrolled airspace.

- Weather Information: global weather and microclimatic conditions for flight conditions and drift calculations

While obstacles/terrain are considered static data, airspace volumes may have permanent and dynamic nature i.e. some areas are permanently restricted when some are available for drone operations and others are activated ad-hoc or on a pre-defined schedule. Some dedicated drone operators (Police, SAR) shall be able to create ad-hoc geo-fences for special missions. Thus, the U-space users must consider the current operational status of the geofences during pre-flight planning phase (when filing the flight plan) as well as in-flight (so to react on ad-hoc activations of restrictions). Alerts to the drone pilot and/or its FMS is therefore key. It should be possible to obtain airspace status data from U-AIM at post-flight phase when it is required by authority for investigation.

Information needed for drone operations is originated following the standard process for data origination and therefore subject to EU-Regulation 73/2010 and ICAO Annex 15 quality assurance.

However, given the nature of unmanned traffic and its operation in very low altitude, the standard NOTAM process is considered not sufficient to the U-space concept. Ad-hoc airspace reservation and activations shall be possible for drone operators and may include:

- restrictions for volumes representing event arenas (e.g. stadiums during a match),
- incident sites (e.g. a roadside accident, search and rescue activity, etc.)
- public safety announcements (e.g. during demonstrations, etc.)
- and many more

Such creation, change or withdrawal of restricted volumes must be performed by trusted sources outside the usual context of aviation i.e. the public safety control centre, the city government or even sensors in case of a drone accident. This can be achieved by providing a simple, map-based Geofence Creation HMI. Incoming data transmissions to dedicated ANSP FIMS shall be processed automatically unless of a business rule validation error. A fall-back process on ANSP side shall therefore be elaborated to ensure that errors from incoming data origination can be manually corrected at all times to ensure a swift exchange of information to all airspace users. A NOTAM shall only be published in case the originated information is also of use for manned aviation. Otherwise, a notification/alert to the drone operators and/or their FMS is sufficient. Dynamic geofence information is also subject to ICAO Annex 15 and EU Regulation 73/2010 data quality regulations and must therefore pass business rule when provided to the central store.

# 4 Service Overview

This chapter aims at providing an overview of the main elements of the service. Architectural elements applicable for this description are:

- Service: the element representing the service in its entirety.
- Service Interfaces: the mechanisms by which a service communicates. Defined by allocating service operations to either the provider or the consumer of the service.
- Service Operations: describe the logical operations used to access the service.
- Service Operations Parameter Definitions: identify data structures being exchanged via Service Operations.

The above elements may be depicted in one or more diagrams.

## 4.1 Service Data Model

This section describes the information model, i.e., the logical data structures to be exchanged between providers and consumers of the service.



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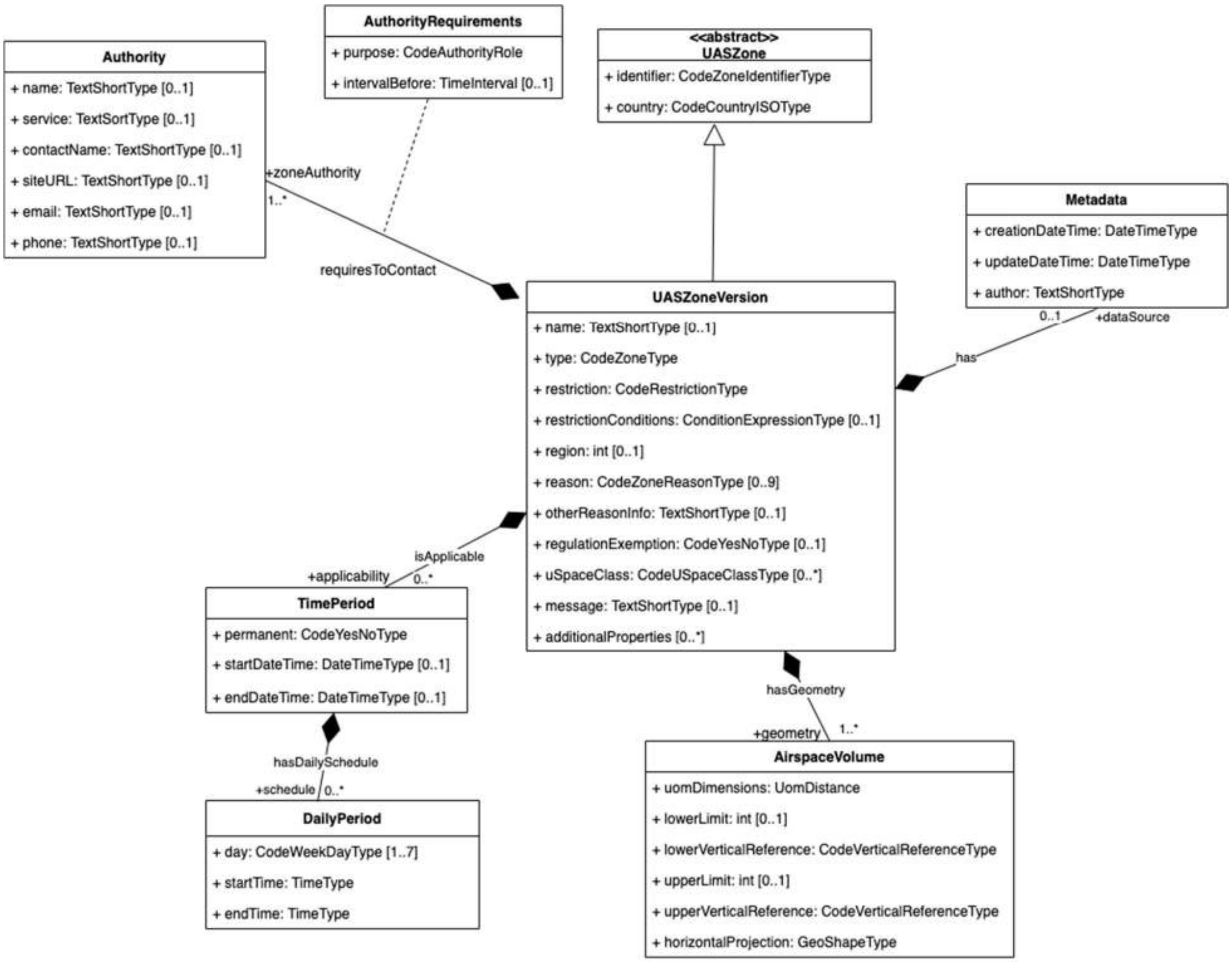


*Figure (x). UAS GEOGRAPHICAL ZONE DATA MODEL (src: ED-269.pdf chapter 8 figure 2)*

ED-269 based data-model supports most of the foreseen GOF 2.0 requirements, like multiple airspace volumes, activity time management and per-zone operational rules. There are still some relatively minor issues to be solved or reported during GOF 2.0 implementation like

- importing/mapping legacy AIXM-based airspaces (different timeslice relation), ED-269 7 chars limit for airspace identifier, AIXM curves support and alike)
- Circle support implementation.
- Polygon with holes implementation
- FUA integration

## 4.2 Service Interface Specifications

**Overview**

Service Interface Specifications should be replaced with new ones, and should follow ED-269 specs, possibly with some changes/extensions due to GOF2.0 scope/implementation.

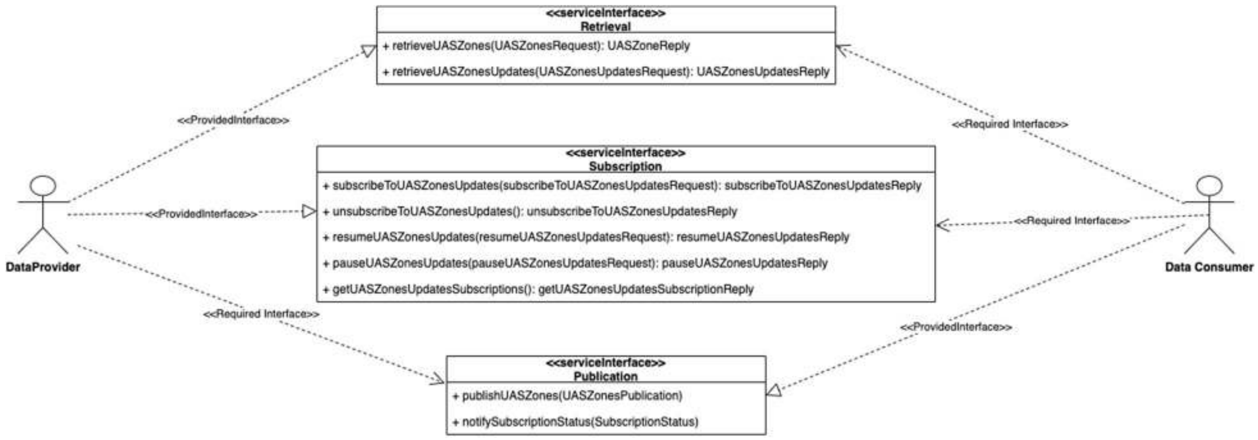


*Figure (x). INTERFACES OVERVIEW (src: ED-269.pdf chapter 9 figure 4)*

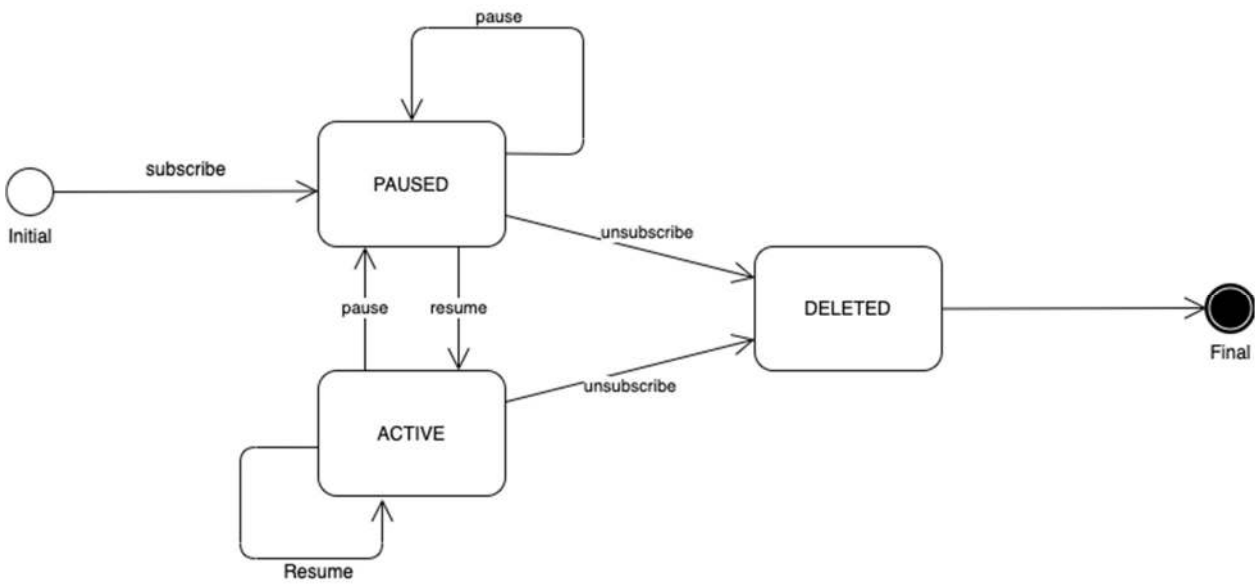


*Figure (x). SUBSCRIPTION STATES (src: ED-269.pdf chapter 9 figure 5)*

ED-269 based interfaces supports most of the foreseen GOF 2.0 requirements, I.e. defines pub-sub mechanism combined with queried retrievals for data sync

During GOF 2.0 implementation we should check if the there are some extra interfaces needed to solve possible issues with implementations

- Batch updates on AIRAC imports, per-type operational rules changes and alike
- Short-term airspace (PANSA 'alerts', FREQUENTIS 'dynamic UVR')
- Optimized queries for operation flight plans support

# 5 Service Provisioning

Left Empty.



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# 6 References

NOTE: The list of references provided hereafter is for guidance. Before the documents are delivered to the SJU, please make sure that you are listing the latest applicable version of the relevant references as in the Programme Library.


| Nr. | Version | Title |
|---|---|---|
| [1] | n/a | CFP Reference CEF-SESAR-2018-1, “Finnish-Estonian "Gulf of Finland" Very Large U-Space Demonstration” |
| [2] | Advanced Edition (unedited) | ICAO Doc 10039, Manual on System Wide Information Management (SWIM) Concept |
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| | | |
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| [24] | C(2021) 2671 final | COMMISSION IMPLEMENTING REGULATION (EU) …/664 of XXX on a regulatory framework for the U-space |
| [25] | June 2020 | ED-269 Minimum Operational Performance Standard for Geofencing |

VERY LARGE-SCALE DEMONSTRATION

sesar JOINT UNDERTAKING

# D2.4 Appendix D Registration Service Specification

| | |
|---|---|
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# Authoring & Approval

## Authors of the document

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Gregor Mogeritsch / Frequentis | WP2 | 26.10.2022 |
| Hubert Künig / Frequentis | WP2 | 26.10.2022 |
| Peter Cornelius / Frequentis | WP2 | 26.10.2022 |
| Thomas Lutz / Frequentis | WP2 Lead | 26.10.2022 |

## Reviewers internal to the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Jonas Stjernberg / Robots Expert | WP3 Lead | 1.11.2022 |
| Maria Tamm / EANS | Project coordinator | 3.11.2022 |
| Tanel Järvet / CAFA | WP4 Lead | 3.11.2022 |
| Damian Soliwoda / PSNC | WP2 member | 2.11.2022 |
| Lukasz Gorny-Zajac / DRR | WP2 member | 2.11.2022 |
| Parmentier Remy / VAI | WP2 member | 2.11.2022 |
| Pawel Korzec / DRR | WP2 member | 2.11.2022 |
| Piotr Dybiec / DRR | WP2 member | 2.11.2022 |
| Piotr Luboński / PSNC | WP2 member | 31.10.2022 |
| Piotr Szymaniak / PSNC | WP2 member | 31.10.2022 |
| Sven Jürgenson / Threod | WP3 member | 3.11.2022 |
| Leopoldo Tejada/UML | WP2 member | 2.11.2022 |
| Thomas Wana / DIME | WP2 member | 31.10.2022 |
| Yuhang Yun / EHANG | WP3 member | 30.10.2022 |
| Iris Röhrich / FRQ | WP1 member | 3.11.2022 |

## Approved for submission to the SJU By - Representatives of beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Sami Alkula/FANS | Project Management Group | 3.11.2022 |
| Thomas Neubauer/DIME | Project Management Group | 3.11.2022 |
| Pawel Korzec/DRR | Project Management Group | 3.11.2022 |
| Yuhang Yun/EHE | Project Management Group | 3.11.2022 |
| Damini Gera/AIRB | Project Management Group | 3.11.2022 |
| Piotr Szymaniak/PSNC | Project Management Group | 3.11.2022 |
| Sven Jürgenson/THREOD | Project Management Group | 3.11.2022 |
| Leopoldo Tejada/UML | Project Management Group | 3.11.2022 |



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|---|---|---|
| Tapio Haarlaa/VAI | Project Management Group | 3.11.2022 |
| Iris Röhrich/FRQ | Project Management Group | 3.11.2022 |
| Juha Lindstedt/AVIA | Project Management Group | 3.11.2022 |
| Piotr Bratek/PANSA | Project Management Group | 3.11.2022 |
| Tanel Järvet/CAFA | Project Management Group | 3.11.2022 |
| Maria Tamm/EANS | Project Management Group | 3.11.2022 |

**Rejected By - Representatives of beneficiaries involved in the project**

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| | | |

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**Copyright Statement**

# GOF2.0

## GOF2.0 INTEGRATED URBAN AIRSPACE VLD

This Updated Service Specification is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 101017689 under European Union's Horizon 2020 research and innovation programme.

### Abstract

This specification introduces a service of a Common Information Service (CIS) which ensures interoperability and hence transparent and reliable information flow between the stakeholders in an operational U-space environment. In accordance with ICAO SWIM, represents an Information Exchange Service.

This document describes one of these Bridge Services, the Registration service in a logical, technology-independent manner.

# Table of Contents

# 1 Introduction

## 1.1 Purpose of the document

The purpose of this service specification document is to provide a holistic overview of the Registration Service and its building blocks in a technology-independent way, according to the guidelines given in [1]. It describes a well-defined baseline of the service by clearly identifying the service version. service and its building blocks in a technology-independent way, according to the guidelines given in [1].

The aim is to document the key aspects of the Registration Service at the logical level:

- the operational and business context of the service
    - requirements for the service (e.g., information exchange requirements)
    - involved nodes: which operational components provide/consume the service
    - operational activities supported by the service
    - relation of the service to other services
- the service description
    - service interface definitions
    - service interface operations
    - service payload definition
    - service dynamic behaviour description
- service provision and validation aspects

Furthermore, this document clearly defines the version of the service.

## 1.2 Scope

This document describes the Registration service.

The Registration service provides a means for the operational nodes to share their intends and make them available for further processing.

## 1.3 Intended readership

This service specification is intended to be read by service architects, system engineers and developers in charge of designing and developing an instance of the Registration Service. Furthermore, this service specification is intended to be read by enterprise architects, service architects, information architects, system engineers and developers in pursuing architecting, design and development activities of other related services.

## 1.4 Background

### 1.4.1 EASA

Due to introduction of the EASA e-Registration service in EU member states, GOF1.0 Services Specification for Registration became outdated. For this reason, it was decided by Consortium Members, to implement at least minimal mock-up of data structures – especially unified pan-European "operator id" in EASA format (i.e. FIN87astrdge12k-xyz-c, see Business Analysis, 3.2.1) for data retrieval and other service layers as described in REPIF documents.

Due to nature of changes, it probably should skip user/drones creation procedures in the scope of GOF 2.0 project.

### 1.4.2 Legal background

As per Article 74 of the Basic Regulation 2018/1139 (BR), "*the Agency, in cooperation with the Commission and the national competent authorities, establish and manage a repository of information necessary to ensure effective cooperation between the Agency and the national competent authorities concerning the exercise of their tasks relation to certification, oversight and enforcement under the Regulation […]*". [13]

### 1.4.3 Regulatory framework for Drones [13]

As per Article 56.7 of the BR: "*Member States shall ensure that information about registration of unmanned aircraft and of operators of unmanned aircraft …/… is stored in digital, harmonised, interoperable national registration systems.*"

Member States have thus the obligation to share data on certified drones and drone operators registered in their register to other member states. This could be ensured through bilateral agreements with each other Member States but this is not considered efficient.

Article 14 of the Implementing Regulation (EU) 2019/947 on rules and procedures for the operation of drones dealing with: "Registration of UAS operators and certified UAS" states:

> "*1. Member States shall establish and maintain accurate registration systems for UAS whose design is subject to certification and for UAS operators whose operation may present a risk to safety, security, privacy, and protection of personal data or the environment.*
>
> *2. The registration systems for UAS operators shall provide the fields for introducing and exchanging the following information:*
>
>> *(a) the full name and the date of birth for natural persons and the name and their identification number for legal persons;*
>>
>> *(b) the address of UAS operators;*
>>
>> *(c) their email address and telephone number;*
>>
>> *(d) an insurance policy number for UAS if required by Union or national law;*

*(e) the confirmation by legal persons of the following statement: 'All personnel directly involved in the operations are competent to perform their tasks, and the UAS will be operated only by remote pilots with the appropriate level of competency';*

*(f) operational authorisations and LUC held and declarations followed by a confirmation in accordance with Article 12(5)(b).*

*3. The registration systems for unmanned aircraft whose design is subject to certification shall provide the fields for introducing and exchanging the following information:*

*(a) manufacturer's name;*

*(b) manufacturer's designation of the unmanned aircraft;*

*(c) unmanned aircraft's serial number;*

*(d) full name, address, email address and telephone number of the natural or legal person under whose name the unmanned aircraft is registered.*

*4. Member States shall ensure that the registration systems are digital and interoperable and allow for mutual access and exchange of information through the repository referred to in Article 74 of Regulation (EU) 2018/1139.*

*5. UAS operators shall register themselves:*

*(a) when operating within the 'open category' any of the following unmanned aircraft:*

*i. with a maximum take-off mass of 250 g or more, or, which in the case of an impact can transfer to a human kinetic energy above 80 Joules;*

*ii. that is equipped with a sensor able to capture personal data , unless it complies with Directive 2009/48/EC.*

*(b) when operating within the 'specific' category an unmanned aircraft of any mass.*

*6. UAS operators shall register themselves in the Member State where they have their residence for natural persons or where they have their principal place of business for legal persons and ensure that their registration information is accurate. A UAS operator cannot be registered in more than one Member State at a time.*

*Member States shall issue a unique digital registration number for UAS operators and for the UAS that require registration, allowing their individual identification.*

*The registration number for UAS operators shall be established on the basis of standards that support the interoperability of the registration systems.*

*7. The owner of an unmanned aircraft whose design is subject to certification shall register the unmanned aircraft.*

*The nationality and registration mark of an unmanned aircraft shall be established in line with ICAO Annex 7. An unmanned aircraft cannot be registered in more than one State at a time.*



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*8. The UAS operators shall display their registration number on every unmanned aircraft meeting the conditions described in paragraph 5.*"

### 1.4.4 Stakeholders [13]

Access to the exchange of information is ruled by Article 74.6 of the BR which states:

> "6. Without prejudice to paragraph 7, the Commission, the Agency, national competent authorities and any competent authority of the Member States entrusted with the investigation of civil aviation accidents and incidents shall, for the exercise of their tasks, have on-line and secure access to all information included in the repository. Where relevant, the Commission and the Agency may disseminate certain information included in the repository, other than information referred to in paragraph 2, to interested parties or make it publicly available."
>
> Note that there is no need identified to make information available to interested parties or to the public for the drones repository at this time.
>
> Note that the term national competent authorities is defined in Article 3(34) of the BR which states: "'national competent authority' means one or more entities designated by a Member State and having the necessary powers and allocated responsibilities for performing the tasks related to certification, oversight and enforcement in accordance with this Regulation and with the delegated and implementing acts adopted on the basis thereof, and with Regulation (EC) No 549/2004."

Table 1 below provides for illustration typical stakeholders which may be given access to the Repository of Information for the Drones domain:

| No | Stakeholder | Internal/ external (related to EASA) |
|---|---|---|
| 1 | European Union Aviation Safety Agency (EASA) | Internal |
| 2 | National Aviation Authorities (NAAs) | External |
| 3 | Law Enforcement Authorities for aviation safety of each Member State (within the scope of the BR) | External |
| 4 | Accident Investigation officers of each Member State | External |
| 5 | ANSP / USSP / Aeronautical Information Service Providers (as "interested parties" per BR Article 74 .6) | External |

**Table** 1**: Example of typical stakeholders [13]**

### 1.4.5 Data Protection

Any activities related to the handling of personal data for the purposes of UAS flights must be at least performed in accordance with generally accepted rules and regulations:

1 Compliance with Regulation (EU) 2018/1725 of the European Parliament and of the Council of 23 October 2018 on the protection of natural persons with regard to the processing of personal

data by the Union institutions, bodies, offices and agencies and on the free movement of such data, and repealing Regulation (EC) No 45/2001 and Decision No 1247/2002/EC.

2 Compliance with Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (GDPR).

### 1.4.6 (EU) 2018/1725

Persons whose personal data are processed by Union institutions and bodies in any context whatsoever, for example, because they are employed by those institutions and bodies, should be protected. [16]

In order to prevent creating a serious risk of circumvention, the protection of natural persons should be technologically neutral and should not depend on the techniques used. [16]

This Regulation should apply to the processing of personal data by all Union institutions, bodies, offices and agencies. It should apply to the processing of personal data wholly or partly by automated means and to the processing other than by automated means of personal data which form part of a filing system or are intended to form part of a filing system. Files or sets of files, as well as their cover pages, which are not structured according to specific criteria should not fall within the scope of this Regulation.[16]

### 1.4.7 GDPR (General Data Protection Regulation)

The protection of natural persons in relation to the processing of personal data is a fundamental right. The principles of, and rules on the protection of natural persons with regard to the processing of their personal data should, whatever their nationality or residence, respect their fundamental rights and freedoms, in particular their right to the protection of personal data. This Regulation is intended to contribute to the accomplishment of an area of freedom, security and justice and of an economic union, to economic and social progress, to the strengthening and the convergence of the economies within the internal market, and to the well-being of natural persons. [15]

### 1.4.8 EASA Registration Broker concept [13]

The diagram below illustrates the EASA broker concept which is based on the existence of national repositories for registration data. At the time of writing this specification, it is known that EASA is establishing a broker, but the technical details are still unknown. The GOF2 consortium accepts this idea, and as soon as the technical specification of the solution is known, it will be integrated into this specification.



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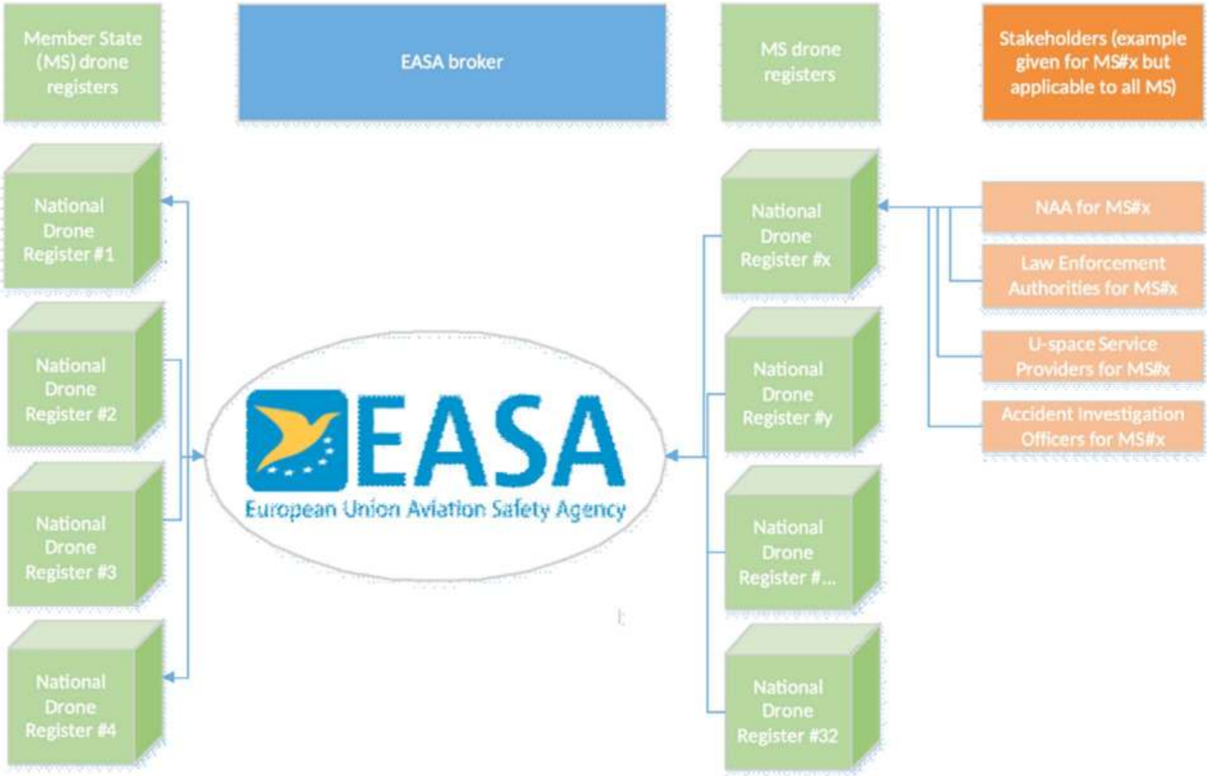


Figure (x): Context diagram (src: REPIF – Business Analisis, Figure 1)

## 1.5 Glossary of terms

| Term | Definition |
|---|---|
| **External Data Model** | Describes the semantics of the domain (or a significant part thereof) by defining data structures and their relations. This could be at logical level (e.g., in UML) or at physical level (e.g., in XSD schema definitions), as for example standard data models. |
| **Message Exchange Pattern** | Describes the principles how two different parts of a message passing system (in our case: the service provider and the service consumer) interact and communicate with each other. Examples:<br><br>In the Request/Response MEP, the service consumer sends a request to the service provider in order to obtain certain information; the service provider provides the requested information in a dedicated response.<br><br>In the Publish/Subscribe MEP, the service consumer establishes a subscription with the service provider in order to obtain certain information; the service provider publishes information (either in regular intervals or upon change) to all subscribed service consumers. |

| | |
|---|---|
| **Operational Activity** | An activity performed by an operational node. Examples of operational activities are: Route Planning, Route Optimization, Logistics, Safety, Weather Forecast Provision, … |
| **Operational Model** | A structure of operational nodes and associated operational activities and their inter-relations in a process model. |
| **Operational Node** | A logical entity that performs activities. Note: nodes are specified independently of any physical realisation.<br>Examples of operational nodes are: Control Center, Authority, Weather Information Provider, … |
| **Service** | The provision of something (a non-physical object), by one, for the use of one or more others, regulated by formal definitions and mutual agreements. Services involve interactions between providers and consumers, which may be performed in a digital form (data exchanges) or through voice communication or written processes and procedures. |
| **Service Consumer** | A service consumer uses service instances provided by service providers. |
| **Service Data Model** | Formal description of one dedicated service at logical level. The service data model is part of the service specification. Is typically defined in UML and/or XSD. If an external data model exists (e.g., a standard data model), then the service data model shall refer to it: each data item of the service data model shall be mapped to a data item defined in the external data model. |
| **Service Design Description** | Documents the details of a service technical design (most likely documented by the service implementer). The service design description includes (but is not limited to) a service physical data model and describes the used technology, transport mechanism, quality of service, etc. |
| **Service Implementation** | The provider side implementation of a dedicated service technical design (i.e., implementation of a dedicated service in a dedicated technology). |
| **Service Implementer** | Implementers of services from the service provider side and/or the service consumer side. |
| **Service Instance** | One service implementation may be deployed at several places by same or different service providers; each such deployment represents a different service instance, being accessible via different URLs. |

| | |
|---|---|
| **Service Instance Description** | Documents the details of a service implementation (most likely documented by the service implementer) and deployment (most likely documented by the service provider). The service instance description includes (but is not limited to) service technical design reference, service provider reference, service access information, service coverage information, etc. |
| **Service Interface** | The communication mechanism of the service, i.e., interaction mechanism between service provider and service consumer. A service interface is characterised by a message exchange pattern and consists of service operations that are either allocated to the provider or the consumer of the service. |
| **Service Operation** | Functions or procedure which enables programmatic communication with a service via a service interface. |
| **Service Physical Data Model** | Describes the realisation of a dedicated service data model in a dedicated technology. This includes a detailed description of the data payload to be exchanged using the chosen technology. The actual format of the service physical data model depends on the chosen technology. Examples may be WSDL and XSD files (e.g., for SOAP services) or swagger (Open API) specifications (e.g., for REST services). If an external data model exists (e.g., a standard data model), then the service physical data model shall refer to it: each data item of the service physical data model shall be mapped to a data item defined in the external data model.<br><br>In order to prove correct implementation of the service specification, there shall exist a mapping between the service physical data model and the service data model. This means, each data item used in the service physical data model shall be mapped to a corresponding data item of the service data model. (In case of existing mappings to a common external (standard) data model from both the service data model and the service physical data model, such a mapping is implicitly given.) |
| **Service Provider** | A service provider provides instances of services according to a service specification and service instance description. All users within the domain can be service providers, e.g., authorities, organizations (e.g., meteorological), commercial service providers, etc. |
| **Service Specification** | Describes one dedicated service at logical level. The Service Specification is technology-agnostic. The Service Specification includes (but is not limited to) a description of the Service Interfaces and Service Operations with their data payload. The data payload description may be formally defined by a Service Data Model. |
| **Service Specification Producer** | Producers of service specifications in accordance with the service documentation guidelines. |



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| | |
|---|---|
| **Service Technical Design** | The technical design of a dedicated service in a dedicated technology. One service specification may result in several technical service designs, realising the service with different or same technologies. |
| **Service Technology Catalogue** | List and specifications of allowed technologies for service implementations. Currently, SOAP and REST are envisaged to be allowed service technologies. The service technology catalogue shall describe in detail the allowed service profiles, e.g., by listing communication standards, security standards, stacks, bindings, etc. |
| **Spatial Exclusiveness** | A service specification is characterised as "spatially exclusive", if in any geographical region just one service instance of that specification is allowed to be registered per technology.<br><br>The decision, which service instance (out of a number of available spatially exclusive services) shall be registered for a certain geographical region, is a governance issue. |

**Table: Glossary of terms**

## 1.6 List of Acronyms

| Acronym | Definition |
|---|---|
| **API** | Application Programming Interface |
| **JSON** | JavaScript Object Notation |
| **MEP** | Message Exchange Pattern |
| **NAF** | NATO Architectural Framework |
| **REST** | Representational State Transfer |
| **SOA** | Service Oriented Architecture |
| **SOAP** | Simple Object Access Protocol |
| **SSD** | Service Specification Document |
| **UML** | Unified Modelling Language |



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| | |
|---|---|
| **URL** | Uniform Resource Locator |
| **WSDL** | Web Service Definition Language |
| **XML** | Extendible Mark-up Language |
| **XSD** | XML Schema Definition |

**Table: List of acronyms**

# 2 Service Identification

The purpose of this chapter is to provide a unique identification of the service and describe where the service is in terms of the engineering lifecycle.

| | |
|---|---|
| **Name** | *Registration Service* |
| **ID** | *urn:gof:services:RegistrationService* |
| **Version** | *2.0.1* |
| **Description** | *A service that allows the registration of the UAS, UAS operators, related persons (crew) and associated data.* |
| **Keywords** | *Registration, eRegistration, Pilot, Operator, UAS, Manufacturer, National Authority, CAA, ANSP, USSP, CIS, Identity, License, Competence* |
| **Architect(s)** | *2021-today The GOF 2.0 Project Consortium*<br>*2020-2021* Droneradar Sp. z o.o.<br>*2018-2020 The GOF U-Space Project Consortium* |
| **Status** | *Provisional* |

**Table: Service Identification**

# 3 Operational Context

## 3.1 Overview

Drone registration is a key part towards commercialization of unmanned air vehicles, and is required by current or upcoming legislation. In most countries, the CAA operates a drone registry which collects data of UTM operators, drone pilots, drones, operational authorizations and verifications of identity.

UAS operators are companies or individuals that operate one or more drones. UAS operators may employ one or more pilots. In the case of private citizens operating drones, they themselves are both UAS operators and the sole pilot.

ID verification systems provide proof of identity of registered pilots and operators. Operators register their drone(s) along with type and id (serial, remoteID, etc.) information, and provide proof of competency as part of their profile in the registry. On December 31, 2020, the registration obligation resulting from the entry into force:

1 **Commission Implementing Regulation (EU) 2019/947 of 24 May 2019** on the rules and procedures for the operation of unmanned aircraft

2 **Commission Delegated Regulation (EU) 2019/945 of 12 March 2019** on unmanned aircraft systems and on third-country operators of unmanned aircraft systems

The registry allows for drone lookup by ID to support other stakeholders, systems or accident investigations.

The operational context description should be based on the description of the operational model, consisting of a structure of operational nodes and operational activities. If such an operational model exists, this section shall provide references to it. If no such operational model exists, then its main aspects shall be described in this section.

The operational context shall be a description of how the service supports interaction among operational nodes. This can be achieved in two different levels of granularity:

- A description of how the service supports the interaction between operational nodes. This basically consists of an overview about which operational nodes shall provide the service and which operational nodes will consume the service.
- A more detailed description that indicates what operational activities the service supports in a process model.

Moreover, the operational context should describe any requirement the service will fulfil or adhere to. This refers to functional as well as non-functional requirements at high level (business/regulatory requirements, system requirements, user requirements). Especially, information exchange requirements are of much interest since the major objective of services is to support interaction between operational nodes.

The source material for the operational context description should ideally be provided by operational



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users and is normally expressed in dedicated requirements documentation. Ensure that the applicable documents are defined in the References section. If no requirements documents are available, then the basic requirements for the service shall be defined in the dedicated sub-section below.

Architectural elements applicable for this description are:

- *Service*
- *Nodes*
- *Operational Activities*
- *Information Exchange Requirements*

## 3.2 Functional and Non-functional Requirements

This section lists (functional and non-functional) requirements applicable to the service being described. A tabular list of requirements shall be added here. If external requirements documents are available, then the tables shall refer to these requirements, otherwise the requirements shall be documented here.

The service MUST be linked to at least one requirement. At least one of the following tables shall be presented in this section. The first table lists references to requirements available from external documents. Make sure you document the sources from where the requirements are coming from. The second table lists new requirements defined for the first time in this service specification document.

The table below lists applicable existing requirements for the Registration Service.

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| | Common Situational Awareness | At all times, all U-space participants shall operate on the same common set of data, during pre-flight planning stages as well as during all stages of flight operations. | CORUS [4], 4.1.1.2 Amber airspace;<br>B1-RPAS [9];<br>CEF-SESAR-2018-1 [1], Objective O5 |

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| | Basis for Open Market | The U-space concept shall be designed such as to ensure a well-established line of authority while at the same time ensuring that an open market for VLL services may develop | SESAR Drone Roadmap [11], Foreword, 4.1 and 4.2;<br><br>U-space Blueprint [13], Benefits to European society and economy;<br><br>CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| | Interoperability | There shall be an implementation of a Flight Information Management System (FIMS) which ensures that, at all times, emerging unmanned traffic management systems and existing technologies from manned operations can exchange any data required to support such common situational awareness, be it for drone operations in areas where established ATC procedures apply, or in zones outside established ATC. | ICAO Doc 10039 [2];<br><br>[R-2];<br><br>CEF-SESAR-2018-1 [1], Objective O6;<br><br>CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| | Standard Protocols | Standard communication protocols shall hence be used where available, and such standard protocols be developed otherwise, in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop. | [R-2]; SESAR Drone Roadmap [11], 3.5, section 'Standards'; CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |
| | Open Interfaces | Any interface and protocol hence must be openly defined, and its definition be freely accessible in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop. | [R-2]; CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| | SWIM | The implementation of a Flight Information Management System (FIMS) shall be based on an ICAO SWIM-compliant architecture. | [R-3]; CEF-SESAR-2018-1 [1], 5.3.4 Overall approach and methodology |

*Tab.: Requirements for the Registration Service*

## 3.3 Other Constraints

### 3.3.1 Relevant Industrial Standards

#### 3.3.1.1 ICAO SWIM

The System Wide Information Management (SWIM, [2]) complements human-to-human with machine-to-machine communication, and improves data distribution and accessibility in terms of quality of the data exchanged. The SWIM Concept addresses the challenge of creating an "interoperability environment" which allows the SWIM IT systems to cope with the full complexity of operational information exchanges. The SWIM environment shifts the ATM information architecture paradigm from point-to-point data exchanges to system-wide interoperability.

# 4 Service Data Model

This section describes the information model, i.e., the logical data structures to be exchanged between providers and consumers of the service.

## 4.1 Overview

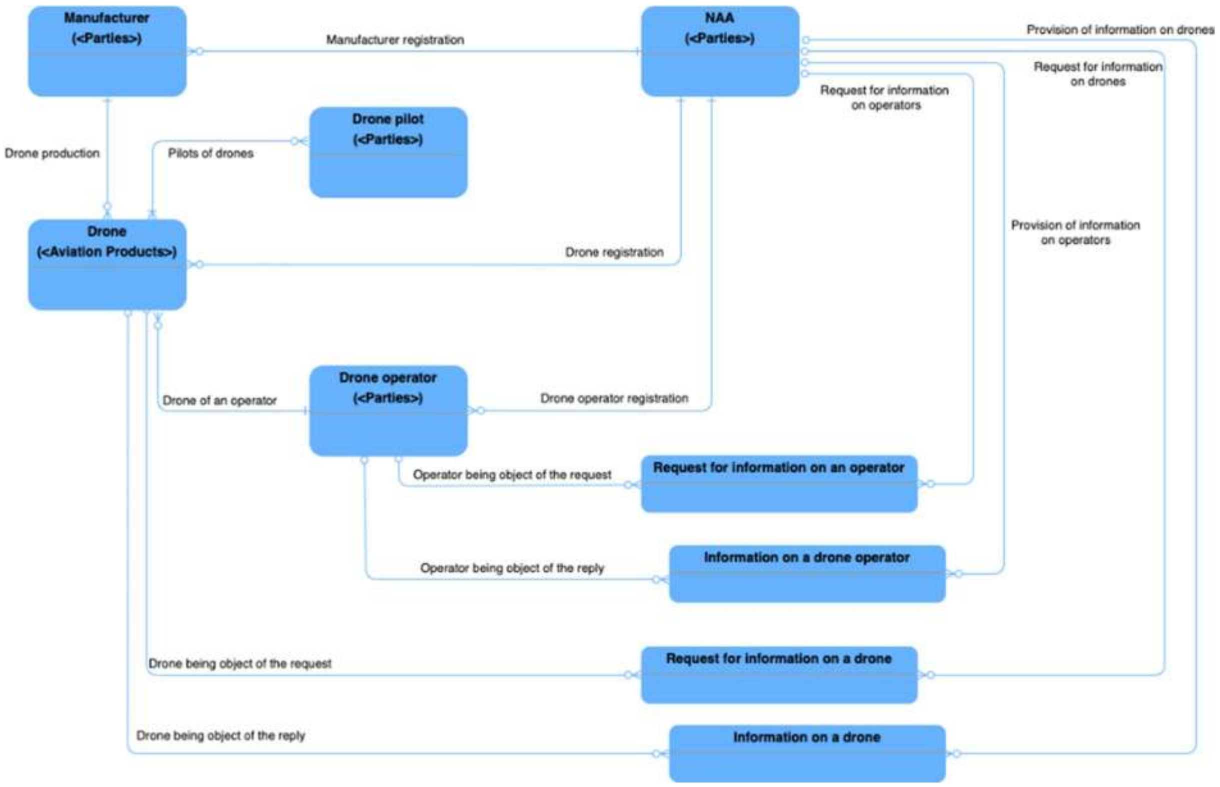


Figure (x+1): Entity-Relations diagram for drones (src: REPIF 0- - Business Analysis, Figure 3)

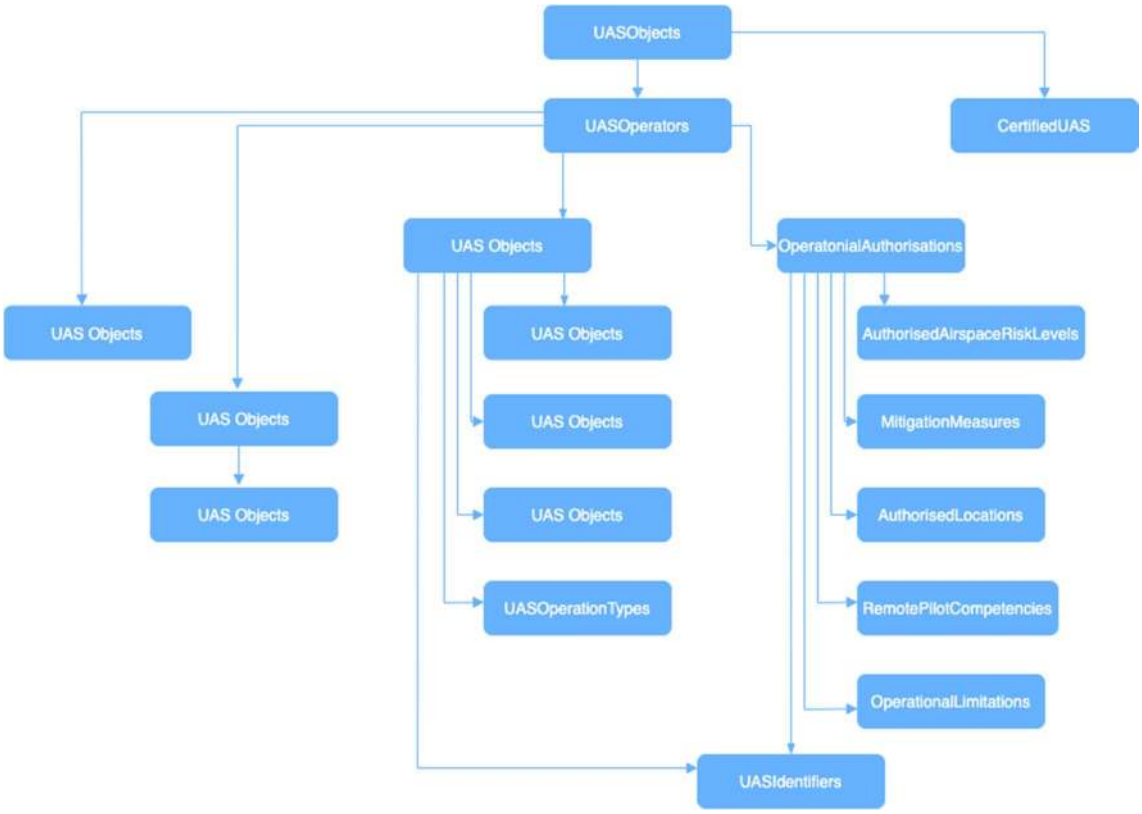


Figure (x+2): Entity Relationships (src: API usage guide)

## 4.2 General comment

Due to the fact that there is no official, approved version of the concept for creating and distributing Registration data, it is at the moment of writing this document, impossible to propose a final, consistent and uniform data model. Given the relatively extensive experience of consortium members represented by technology companies as well as ANSP, the final proposal including best-of-breed practices will be created after the completion of the practical part (trials).

In addition, the conceptual version of the registration as described in EASA official documents appears to be incomplete (API-GUIDE draft status still draft status) and is likely to be modified.

Probably most striking is lack of 'air-worthiness' estimation in certified drone data, which will cause problems with operation plan verification flows. For the purpose of this VLD, the verification process of UAS equipment will be skipped, assuming that it is UAS Operator/Pilot responsibility to use a drone satisfying expected requirements.

Other challenges found include (minor ones):

- concatenate operator names, effectively disabling 'sort/find by surname'
- performance (like mandatory attachment download)

## 4.3 EASA PROTOCOLS

EASA message broker acts as mediating party between the different Member States applications to route a request from a requesting MS to a queried MS. Authentication, integrity and confidentiality on the transport layer are provided using secure TLS connections.


Figure (x+2): Entity Relationships (src: API usage guide, page 5)

### 4.3.1 Methods (src: API usage guide)

#### 4.3.1.1 GET UAS Operator

This method will return the information object of a UAS operator

*GET /registration/{DestinationMS}/v1/uas.svc/UASOperators?$filter={filterparameters}&$expand={expandparameters}*

| Required Query Parameters | How to use | Description |
|---|---|---|
| **DestinationMS** | Provide the ISO3166-1 Alpha 3 country code (See Table 1) | This parameter selects the responder server |
| **filterparameters** | Provide values at least for the mandatory properties. (see table below) | This is a RESTful filter based on ODataV2. Setting the parameters will return the requested information object |
| **expandparameters** | This parameter selects the underlaying structures. All of the parameters defined below should be used to get all the data of the information object (see table below) | This parameter selects the underlaying structures the requester specifies to be included in the response |

| filterparameter | M/O[1] | Description |
|---|---|---|

[1] Mandatory or Optional property

| | | |
|---|---|---|
| **ObjectIDDomain** | M | Value should be always 'UAS' |
| **ObjectIDCountry** | M | Country code of the Member State where the information object is registered. ISO 3166-1 alpha-3 country codes must be used (see Table 1/Chapter 5). |
| **ObjectIDUniqueIDScheme** | M | Select the Scheme.<br><br>Value is "UARM" as the requested linked entity is CertifiedUAS. |
| **ObjectIDUniqueID** | M | As the requested object is CertifiedUAS the value of this attribute is the requested value of the Certified UAS registration mark. |
| **RequesterType** | M | This attribute should contain the code value of the requester type (see Table 4/Chapter 5). |
| **ObjectType** | M | Select the object type.<br><br>As the requested object is CertifiedUAS value '01' should be set. |
| **OriginatingMS** | M | Country code of the MS originating the request. ISO 3166-1 alpha-3 country codes must be used |
| **Timestamp** | M | Provide the request timestamp as datetimeoffset |
| **OriginatingMSReference** | O | Unique id of a request (see 3.1.3.1) |
| **RepositoryID** | O | Attribute not yet in use (attribute should not be provided in request) |
| **RelevantDate** | O | This attribute can be used in case of investigation of a past UAS activity, to indicate a date when the activity was executed. It is therefore not the same as Timestamp |
| **ReplyExpectedDate** | O | Attribute not yet in use |

| **expandparameter** | **M/O** | **Description** |
|---|---|---|
| **UASOperator,** | M | UAS Operator basis information |
| **UASOperator/Attachment,** | M | Binary attachment and properties |
| **UASOperator/OperationalDeclarations,** | M | Operational declaration information |

| | | |
|---|---|---|
| **UASOperator/OperationalDeclarations/UASProducts,** | | |
| **UASOperator/OperationalAuthorisations,**<br><br>**UASOperator/OperationalAuthorisations/AuthorisedAirspaceRiskLevels,**<br><br>**UASOperator/OperationalAuthorisations/AuthorisedLocations,**<br><br>**UASOperator/OperationalAuthorisations/MitigationMeasures,**<br><br>**UASOperator/OperationalAuthorisations/OperationalLimitations,**<br><br>**UASOperator/OperationalAuthorisations/OtherStaffCompetencies,**<br><br>**UASOperator/OperationalAuthorisations/RemotePilotCompetencies,**<br><br>**UASOperator/OperationalAuthorisations/UASIdentifiers,** | M | Operational authorisations information |
| **UASOperator/LUCHeld,**<br><br>**UASOperator/LUCHeld/Privileges,**<br><br>**UASOperator/LUCHeld/SpecialLimitations,**<br><br>**UASOperator/LUCHeld/Specifications,**<br><br>**UASOperator/LUCHeld/UASIdentifiers,**<br><br>**UASOperator/LUCHeld/UASOperationTypes** | M | LUC held information |

*HTTP status codes*

| Code | Description |
|---|---|
| **200** | OK. The responding server has processed the request. Examine the status of ReplyStatus attribute of the UASObject entity provided in the payload. In case of ReplyStatus = “01”, the requested information object exists and is included in the result in payload as part of the expanded Property UASOperator |



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| | |
|---|---|
| | In case of ReplyStatus = “02”, the requested information object was not found |
| **400** | Bad Request. Please verify the request parameters. Contact EASA for further troubleshooting |
| **403** | Forbidden. Request was denied either by the EASA broker or by the responding server. Please verify the credentials used by the client application (client certificate, IP address). Please contact EASA for further troubleshooting |
| **404** | Requested path in URI was not found or the responding server provided the error. Please contact EASA for further troubleshooting |
| **500** | Internal server error. Please retry and if the problem persists please contact EASA for further troubleshooting |
| **501** | Not implemented. Please verify the request parameters. Please contact EASA for further troubleshooting |
| **502** | Bad gateway. Typically this problem indicates a problem in the routing of the request. Please retry and if the problem persists please contact EASA for further troubleshooting |
| **504** | Gateway Timeout. Typically this problem indicates a problem in the routing of the request. Please retry and if the problem persists please contact EASA for further troubleshooting |

Note: The EASA message broker may mask the response of the server when an error occurs and relay only the error code.

Example request URL:

```
https://repif-api-test.easa.europa.eu/registration/ZZZ/v1/uas.svc/UASObjects?

$filter=ObjectIDDomain eq 'UAS' and ObjectIDCountry eq 'ZZZ' and ObjectIDUniqueIDScheme eq 'OPRN' and ObjectIDUniqueID eq 'ZZZ87astrdge12kc' and ObjectType eq '02' and OriginatingMS eq 'ZZA' and RequesterType eq '02' and Timestamp eq datetimeoffset'2020-07-22T10:10:10Z'&

$expand=UASOperator,UASOperator/OperationalDeclarations,UASOperator/OperationalAuthorisations,UASOperator/Attachment,UASOperator/LUCHeld,UASOperator/OperationalDeclarations/UASProducts,UASOperator/OperationalAuthorisations/AuthorisedAirspaceRiskLevels,UASOperator/OperationalAuthorisations/AuthorisedLocations,UASOperator/OperationalAuthorisations/MitigationMeasures,UASOperator/OperationalAuthorisations/OperationalLimitations,UASOperator/OperationalAuthorisations/OtherStaffCompetencies,UASOperator/OperationalAuthorisations/RemotePilotCompetencies,UA
```

```
SOperator/OperationalAuthorisations/UASIdentifiers,UASOperator/LUCHeld/Privileg
es,UASOperator/LUCHeld/SpecialLimitations,UASOperator/LUCHeld/Specifications,UA
SOperator/LUCHeld/UASIdentifiers,UASOperator/LUCHeld/UASOperationTypes
```

Example request URL:

```
https://repif-api-test.easa.europa.eu/registration/ZZZ/v1/uas.svc/UASObjects?


$filter=ObjectIDDomain eq 'UAS' and ObjectIDCountry eq 'ZZZ' and
ObjectIDUniqueIDScheme eq 'OPRN' and ObjectIDUniqueID eq 'ZZZ87astrdge12kc' and
ObjectType eq '02' and OriginatingMS eq 'ZZA' and RequesterType eq '02' and
Timestamp eq datetimeoffset'2020-07-22T10:10:10Z'&


$expand=UASOperator,UASOperator/OperationalDeclarations,UASOperator/Operational
Authorisations,UASOperator/Attachment,UASOperator/LUCHeld,UASOperator/Operation
alDeclarations/UASProducts,UASOperator/OperationalAuthorisations/AuthorisedAirs
paceRiskLevels,UASOperator/OperationalAuthorisations/AuthorisedLocations,UASOpe
rator/OperationalAuthorisations/MitigationMeasures,UASOperator/OperationalAutho
risations/OperationalLimitations,UASOperator/OperationalAuthorisations/OtherSta
ffCompetencies,UASOperator/OperationalAuthorisations/RemotePilotCompetencies,UA
SOperator/OperationalAuthorisations/UASIdentifiers,UASOperator/LUCHeld/Privileg
es,UASOperator/LUCHeld/SpecialLimitations,UASOperator/LUCHeld/Specifications,UA
SOperator/LUCHeld/UASIdentifiers,UASOperator/LUCHeld/UASOperationTypes
```

Example response in HTTP:

Note: this example does not include operational authorisations, declarations, attachment or LUCheld in the content to conserve space in this document

```
HTTP/1.1 200 OK

content-type: application/json; charset=utf-8

dataserviceversion: 2.0


{

  "d": {
```

```
    "results": [
      {
        "__metadata": {
          "id": "https://repif-api-test.easa.europa.eu/registration/ZZZ/v1/uas.svc/UASObjects(ObjectIDDomain='UAS',ObjectIDCountry='ZZZ',ObjectIDUniqueIDScheme='OPRN',ObjectIDUniqueID='ZZZ87astrdge12kc')",
          "uri": "https://repif-api-test.easa.europa.eu/registration/ZZZ/v1/uas.svc/UASObjects(ObjectIDDomain='UAS',ObjectIDCountry='ZZZ',ObjectIDUniqueIDScheme='OPRN',ObjectIDUniqueID='ZZZ87astrdge12kc')",
          "type": "EASA.Repository.UAS.v1.UASObject"
        },
        "OriginatingMS": "ZZA",
        "Timestamp": "/Date(1595412610000+0000)/",
        "OriginatingMSReference": "",
        "RequesterType": "02",
        "ObjectType": "02",
        "ObjectIDDomain": "UAS",
        "ObjectIDCountry": "ZZZ",
        "ObjectIDUniqueIDScheme": "OPRN",
        "ObjectIDUniqueID": "ZZZ87astrdge12kc",
        "RepositoryID": "",
        "RelevantDate": null,
        "ReplyExpectedDate": null,
        "ReplyOriginatingMS": "ZZZ",
        "ReplyDestinationMS": "ZZA",
        "ReplyingMS": "ZZZ",
        "ReplyingMSReference": "8392C57C-33D8-4613-A586-5B2F4AFBCB55",
        "ReplyTimestamp": "/Date(1600876185946+0000)/",
        "Language": "EN",
        "ReplyStatus": "01",
```

```
        "DateOfData": "/Date(1600819200000+0000)/",
        "UASOperator": {
          "__metadata": {
            "id": "https://repif-api-test.easa.europa.eu/registration/ZZZ/v1/uas.svc/UASOperators(RegistrationNumber='ZZZ87astrdge12kc',RegistrationCountry='ZZZ')",
            "uri": "https://repif-api-test.easa.europa.eu/registration/ZZZ/v1/uas.svc/UASOperators(RegistrationNumber='ZZZ87astrdge12kc',RegistrationCountry='ZZZ')",
            "type": "EASA.Repository.UAS.v1.UASOperator"
          },
          "RegistrationNumber": "ZZZ87astrdge12kc",
          "RegistrationCountry": "ZZZ",
          "RepositoryID": "",
          "FullName": "Adam Xxxxx",
          "Address": "Rheinstrasse 3 12345 Koln",
          "Email": "xxxxx@xx.zz",
          "Telephone": "+1234567890",
          "Birthdate": "/Date(976579200000+0000)/",
          "IdentificationNumber": "",
          "Validity": true,
          "RegistrationDate": "/Date(1576108800000+0000)/",
          "Attachment": null,
          "LUCHeld": null,
          "OperationalAuthorisations": {
            "results": []
          },
          "OperationalDeclarations": {
            "results": []
          }
        },
```

```
        "CertifiedUAS": {
          "__deferred": {
            "uri": "https://repif-api-test.easa.europa.eu/registration/ZZZ/v1/uas.svc/UASObjects(ObjectIDDomain='UAS',ObjectIDCountry='ZZZ',ObjectIDUniqueIDScheme='OPRN',ObjectIDUniqueID='ZZZ87astrdge12kc')/CertifiedUAS"
          }
        }
      }
    ]
  }
}
```


| **EntitySet:** | **LUCHeld** | | | | |
|---|---|---|---|---|---|
| **Attribute** | **Description** | **M/O**Error! Bookmark not defined. | **Type (Mutliplicity)** | **Length** | **Notes** |
| LUCNumber | LUC number | M | String | | Approval reference (digital and/or letter code) of the LUC, as issued by the competent authority |
| IssueDate | Issue date | M | Date | | |
| Privileges | Privileges | M | Navigation (1..*) | | |
| UASIdentifiers | Serial number or UA registration mark (for certified UAS) | M | Navigation (1..*) | | |
| UASOperationTypes | Type(s) of UAS operation | M | Navigation (1..*) | | |
| Specifications | Specifications | M | Navigation (1..*) | | |
| SpecialLimitations | Special limitations | M | Navigation (1..*) | | |

| EntitySet: | Attachments | | | | |
|---|---|---|---|---|---|
| **Attribute** | **Description** | **M/O**Error! Bookmark not defined. | **Type (Mutliplicity)** | **Length** | **Notes** |
| AttachmentID | ID of the attachment | M | String | | Technical ID to identify each entity, generated by MS |
| Filename | Name of the file attached | M | String | | |
| ContentType | Type of file / MIME type | M | String | | application/pdf |
| AttachmentData | Base64 encoded file | M | Binary | | |

| EntitySet: | Privileges | | | | |
|---|---|---|---|---|---|
| **Attribute** | **Description** | **M/O**Error! Bookmark not defined. | **Type (Mutliplicity)** | **Length** | **Notes** |
| Privilege | Privileges | M | String | | |

| EntitySet: | UASIdentifiers | | | | |
|---|---|---|---|---|---|
| **Attribute** | **Description** | **M/O**Error! Bookmark not defined. | **Type (Mutliplicity)** | **Length** | **Notes** |
| UASIdentifier | Serial number or UA registration mark (for certified UAS) | M | String | | |

| EntitySet: | UASOperationTypes | | | | |
|---|---|---|---|---|---|
| **Attribute** | **Description** | **M/O**Error! Bookmark | **Type (Mutliplicity)** | **Length** | **Notes** |

| | | | | | |
|---|---|---|---|---|---|
| | | not defined. | | | |
| UASOperationType | Type(s) of UAS operation | M | String | | |

| **EntitySet:** | **Specifications** | | | | |
|---|---|---|---|---|---|
| **Attribute** | **Description** | **M/O**Error! Bookmark not defined. | **Type (Mutliplicity)** | **Length** | **Notes** |
| Specification | Specifications | M | String | | |

| **EntitySet:** | **SpecialLimitations** | | | | |
|---|---|---|---|---|---|
| **Attribute** | **Description** | **M/O**Error! Bookmark not defined. | **Type (Mutliplicity)** | **Length** | **Notes** |
| SpecialLimitation | Special limitations | M | String | | |

| **EntitySet:** | **AuthorisedLocations** | | | | |
|---|---|---|---|---|---|
| **Attribute** | **Description** | **M/O**Error! Bookmark not defined. | **Type (Mutliplicity)** | **Length** | **Notes** |
| AuthorisedLocation | Authorised location(s) | M | String | | Element 4.1 of the form |

| **EntitySet:** | **AuthorisedAirspaceRiskLevels** | | | | |
|---|---|---|---|---|---|
| **Attribute** | **Description** | **M/O**Error! Bookmark not defined. | **Type (Mutliplicity)** | **Length** | **Notes** |
| AuthorisedAirspaceRiskLevel | Authorised airspace risk level | M | String | | Element 4.2 of the form |

| EntitySet: | OperationalLimitations | | | | |
|---|---|---|---|---|---|
| **Attribute** | **Description** | **M/O**Error! Bookmark not defined. | **Type (Mutliplicity)** | **Length** | **Notes** |
| OperationalLimitation | Operational limitations | M | String | | Element 4.3 of the form |

| EntitySet: | MitigationMeasures | | | | |
|---|---|---|---|---|---|
| **Attribute** | **Description** | **M/O**Error! Bookmark not defined. | **Type (Mutliplicity)** | **Length** | **Notes** |
| MitigationMeasure | Mitigation measures | M | String | | Element 4.4 of the form |

| EntitySet: | RemotePilotCompetencies | | | | |
|---|---|---|---|---|---|
| **Attribute** | **Description** | **M/O**Error! Bookmark not defined. | **Type (Mutliplicity)** | **Length** | **Notes** |
| RemotePilotCompetency | Remote pilot competency | M | String | | Element 4.5 of the form |

| EntitySet: | OtherStaffCompetencies | | | | |
|---|---|---|---|---|---|
| **Attribute** | **Description** | **M/O**Error! Bookmark not defined. | **Type (Mutliplicity)** | **Length** | **Notes** |
| OtherStaffCompetency | Competency of other staff essential for the safety of the operation | M | String | | Element 4.6 of the form |

#### 4.3.1.2 GET Certified UAS

This method will return the information object of a Certified UAS

***GET /registration/{DestinationMS}/v1/uas.svc/UASOperators?$filter={filterparameters}&$expand={expandparameters}***

| Required Query Parameters | How to use | Description |
|---|---|---|
| **DestinationMS** | Provide the ISO3166-1 Alpha 3 country code (See Table 1) | This parameter selects the responder server |
| **filterparameters** | Provide values at least for the mandatory properties. (see table below) | This is a RESTful filter based on ODataV2. Setting the parameters will return the requested information object |
| **expandparameters** | This parameter selects the underlaying structures. All of the parameters defined below should be used to get all the data of the information object (see table below) | This parameter selects the underlaying structures the requester specifies to be included in the response |

| filterparameter | M/O[2] | Description |
|---|---|---|
| **ObjectIDDomain** | M | Value should be always 'UAS' |
| **ObjectIDCountry** | M | Country code of the Member State where the information object is registered. ISO 3166-1 alpha-3 country codes must be used (see Table 1/Chapter 5). |
| **ObjectIDUniqueIDScheme** | M | Select the Scheme.<br><br>Value is "UARM" as the requested linked entity is CertifiedUAS. |
| **ObjectIDUniqueID** | M | As the requested object is CertifiedUAS the value of this attribute is the requested value of the Certified UAS registration mark. |
| **RequesterType** | M | This attribute should contain the code value of the requester type (see Table 4/Chapter 5). |

[2] Mandatory or Optional property

| | | |
|---|---|---|
| **ObjectType** | M | Select the object type.<br><br>As the requested object is CertifiedUAS value '01' should be set. |
| **OriginatingMS** | M | Country code of the MS originating the request. ISO 3166-1 alpha-3 country codes must be used |
| **Timestamp** | M | Provide the request timestamp as datetimeoffset |
| **OriginatingMSReference** | O | Unique id of a request (see 3.1.3.1) |
| **RepositoryID** | O | Attribute not yet in use (attribute should not be provided in request) |
| **RelevantDate** | O | This attribute can be used in case of investigation of a past UAS activity, to indicate a date when the activity was executed. It is therefore not the same as Timestamp |
| **ReplyExpectedDate** | O | Attribute not yet in use |

| expandparameter | M/O | Description |
|---|---|---|
| **CertifiedUAS** | M | Certified UAS information |

*HTTP status codes*

| Code | Description |
|---|---|
| **200** | OK. The responding server has processed the request. Examine the status of ReplyStatus attribute of the UASObject entity provided in the payload. In case of ReplyStatus = “01”, the requested information object exists and is included in the result in payload as part of the expanded Property CertifiedUAS<br><br>In case of ReplyStatus = “02”, the requested information object was not found |
| **400** | Bad Request. Please verify the request parameters. Contact EASA for further troubleshooting |
| **403** | Forbidden. Request was denied either by the EASA broker or by the responding server. Please verify the credentials used by the client application (client certificate, IP address). Please contact EASA for further troubleshooting |

| | |
|---|---|
| **404** | Requested path in URI was not found or the responding server provided the error. Please contact EASA for further troubleshooting |
| **500** | Internal server error. Please retry and if the problem persists please contact EASA for further troubleshooting |
| **501** | Not implemented. Please verify the request parameters. Please contact EASA for further troubleshooting |
| **502** | Bad gateway. Typically this problem indicates a problem in the routing of the request. Please retry and if the problem persists please contact EASA for further troubleshooting |
| **504** | Gateway Timeout. Typically this problem indicates a problem in the routing of the request. Please retry and if the problem persists please contact EASA for further troubleshooting |

Note: The EASA message broker may mask the response of the server when an error occurs and relay only the error code.

Example request URL:

```
https://repif-api-test.easa.europa.eu/registration/ZZZ/v1/uas.svc/UASObjects?

$filter=ObjectIDDomain eq 'UAS' and ObjectIDCountry eq 'ZZZ' and ObjectIDUniqueIDScheme eq 'UARM' and ObjectIDUniqueID eq 'ZZZ-S234' and ObjectType eq '01' and OriginatingMS eq 'ZZA' and RequesterType eq '01' and Timestamp eq datetimeoffset'2020-07-22T10:10:10.123Z'&

$expand=CertifiedUAS
```

Example request in HTTP:

```
GET
/registration/ZZZ/v1/uas.svc/UASObjects?$filter=ObjectIDDomain%20eq%20'UAS'%20
and%20ObjectIDCountry%20eq%20'ZZZ'%20and%20ObjectIDUniqueIDScheme%20eq%20'UARM'
%20and%20
ObjectIDUniqueID%20eq%20'ZZZ-S234'%20and%20ObjectType%20eq%20'01'%20and%20
OriginatingMS%20eq%20'ZZA'%20and%20RequesterType%20eq%20'01'%20and%20Timestamp%
20eq%20
datetimeoffset'2020-07-22T10:10:10.123Z'&$expand=CertifiedUASHTTP/1.1

Host: repif-api-test.easa.europa.eu
```

```
Accept: application/json

DataServiceVersion: 2.0
```

Example response in HTTP:

```
HTTP/1.1 200 OK

content-type: application/json; charset=utf-8

dataserviceversion: 2.0
```


```
{

  "d": {

    "results": [

      {

        "__metadata": {

          "id":                                              "https://repif-api-test.easa.europa.eu/registration/ZZZ/v1/uas.svc/UASObjects(ObjectIDDomain='UAS',ObjectIDCountry='ZZZ',ObjectIDUniqueIDScheme='UARM',ObjectIDUniqueID='ZZZ-S234')",

          "uri":                                             "https://repif-api-test.easa.europa.eu/registration/ZZZ/v1/uas.svc/UASObjects(ObjectIDDomain='UAS',ObjectIDCountry='ZZZ',ObjectIDUniqueIDScheme='UARM',ObjectIDUniqueID='ZZZ-S234')",

          "type": "EASA.Repository.UAS.v1.UASObject"

        },

        "OriginatingMS": "ZZA",

        "Timestamp": "/Date(1595412610123+0000)/",

        "OriginatingMSReference": "",

        "RequesterType": "01",

        "ObjectType": "01",

        "ObjectIDDomain": "UAS",

        "ObjectIDCountry": "ZZZ",
```

```
        "ObjectIDUniqueIDScheme": "UARM",

        "ObjectIDUniqueID": "ZZZ-S234",

        "RepositoryID": "",

        "RelevantDate": null,

        "ReplyExpectedDate": null,

        "ReplyOriginatingMS": "ZZZ",

        "ReplyDestinationMS": "ZZA",

        "ReplyingMS": "ZZZ",

        "ReplyingMSReference": "A3B8C48B-20A2-4DA5-BE3B-5CB44B2E7666",

        "ReplyTimestamp": "/Date(1600883169256+0000)/",

        "Language": "EN",

        "ReplyStatus": "01",

        "DateOfData": "/Date(1600819200000+0000)/",

        "UASOperator": {

          "__deferred": {

            "uri":                                          "https://repif-api-
test.easa.europa.eu/registration/ZZZ/v1/uas.svc/UASObjects(ObjectIDDomain='UAS'
,ObjectIDCountry='ZZZ',ObjectIDUniqueIDScheme='UARM',ObjectIDUniqueID='ZZZ-
S234')/UASOperator"

          }

        },

        "CertifiedUAS": {

          "__metadata": {

            "id":                                           "https://repif-api-
test.easa.europa.eu/registration/ZZZ/v1/uas.svc/CertifiedUAS(RegistrationMark='
ZZZ-S234',RegistrationCountry='ZZZ')",

            "uri":                                          "https://repif-api-
test.easa.europa.eu/registration/ZZZ/v1/uas.svc/CertifiedUAS(RegistrationMark='
ZZZ-S234',RegistrationCountry='ZZZ')",

            "type": "EASA.Repository.UAS.v1.CertifiedUAS"

          },

          "CertifiedUASOwner": {
```

```
            "__metadata": {
              "type": "EASA.Repository.UAS.v1.CertifiedUASOwner"
            },
            "RepositoryID": "",
            "FullName": "Barbara Kowalska",
            "Address": "Hoża 22 00-123 Warszawa, Polska",
            "Email": "barbara.kowalska@xxx.com",
            "Telephone": "+123456789",
            "Birthdate": "/Date(788054400000+0000)/",
            "IdentificationNumber": ""
          },
          "RegistrationMark": "ZZZ-S234",
          "RegistrationCountry": "ZZZ",
          "UASManufacturer": "ABC",
          "UASModel": "Super 100",
          "UASSerialNumber": "OK1DGT567YF",
          "RegistrationDate": "/Date(1103673600000+0000)/",
          "Validity": true
        }
      }
    ]
  }
}
```


Example of a response where the requested object was not found:

```
HTTP/1.1 200 OK

content-type: application/json; charset=utf-8

dataserviceversion: 2.0



{

  "d": {

    "results": [

      {

        "__metadata": {

          "id": "https://repif-api-test.easa.europa.eu/registration/ZZZ/v1/uas.svc/UASObjects(ObjectIDDomain='UAS',ObjectIDCountry='ZZZ',ObjectIDUniqueIDScheme='UARM',ObjectIDUniqueID='ZZZ-S235')",

          "uri": "https://repif-api-test.easa.europa.eu/registration/ZZZ/v1/uas.svc/UASObjects(ObjectIDDomain='UAS',ObjectIDCountry='ZZZ',ObjectIDUniqueIDScheme='UARM',ObjectIDUniqueID='ZZZ-S235')",

          "type": "EASA.Repository.UAS.v1.UASObject"

        },

        "OriginatingMS": "ZZA",

        "Timestamp": "/Date(1595412610123+0000)/",

        "OriginatingMSReference": "",

        "RequesterType": "01",

        "ObjectType": "01",

        "ObjectIDDomain": "UAS",

        "ObjectIDCountry": "ZZZ",

        "ObjectIDUniqueIDScheme": "UARM",

        "ObjectIDUniqueID": "ZZZ-S235",

        "RepositoryID": "",

        "RelevantDate": null,

        "ReplyExpectedDate": null,
```

```
        "ReplyOriginatingMS": "ZZZ",
        "ReplyDestinationMS": "ZZA",
        "ReplyingMS": "ZZZ",
        "ReplyingMSReference": "D6CFAAF2-6C69-40D6-A620-B4DF66E6DE79",
        "ReplyTimestamp": "/Date(1600883316641+0000)/",
        "Language": "EN",
        "ReplyStatus": "02",
        "DateOfData": "/Date(1600819200000+0000)/",
        "UASOperator": {
          "__deferred": {
            "uri": "https://repif-api-test.easa.europa.eu/registration/ZZZ/v1/uas.svc/UASObjects(ObjectIDDomain='UAS',ObjectIDCountry='ZZZ',ObjectIDUniqueIDScheme='UARM',ObjectIDUniqueID='ZZZ-S235')/UASOperator"
          }
        },
        "CertifiedUAS": null
      }
    ]
  }
}
```


## 4.4 Reference Data

### 4.4.1 EASA OData EntitySets (source: API_USAGE DOC) – Annex A

| | |
|---|---|
| EntitySet: | UASObjects |

| Attribute | Description | M/O3 | Type (Mutliplicity) | Length | Notes |
|---|---|---|---|---|---|
| ObjectIDDomain | Object identifier domain | M | String | 3 | Please read chapter 3 of this document for details on the values and handling of the attributes of this entityset |
| ObjectIDCountry | Object identifier country | M | String | 3 | |
| ObjectIDUniqueIDScheme | Representation scheme of the Unique ID | M | String | 4 | |
| ObjectIDUniqueID | Certified UAS registration mark / Operator registration number | M | String | | |
| OriginatingMS | Originating MS | M | String | 3 | |
| Timestamp | Request timestamp | M | TimeStamp | | |
| OriginatingMSReference | Originating MS reference | O | String | | |
| RequesterType | Requester type | M | String | | |
| ObjectType | Object type | M | String | | |
| RepositoryID | Repository ID of the registered operator (Placeholder for future use, value should be empty or null) | O | String | | |
| RelevantDate | Relevant date | O | Date | | |
| ReplyExpectedDate | Expected reply date | O | Date | | |
| ReplyOriginatingMS | Originating MS of reply | M | String | 3 | |
| ReplyDestinationMS | Destination MS of reply | M | String | 3 | |
| ReplyingMS | Replying MS | M | String | 3 | |
| ReplyingMSReference | Replying MS reference | M | String | | |
| ReplyTimestamp | Reply timestamp | M | TimeStamp | | |
| Language | Language in which the value of the reply is provided | M | String | | |
| ReplyStatus | Reply status | M | String | | |
| DateOfData | Date of the data | O | Date | | |
| UASOperator | UASOperator linked entity | O | Navigation (0..1) | | |
| CertifiedUAS | CertifiedUAS linked entity | O | Navigation (0..1) | | |

| EntitySet: | CertifiedUAS | | | | |
|---|---|---|---|---|---|
| Attribute | Description | M/O**Error! Bookmark not defined.** | Type (Mutliplicity) | Length | Notes |
| RegistrationMark | UA registration mark | M | String | | |

[3] Mandatory / Optional to provide a value for the attribute

| | | | | | |
|---|---|---|---|---|---|
| RegistrationCountry | Registration country | M | String | 3 | Values from Table 1 of API usage guide |
| UASManufacturer | Manufacturer's name | M | String | | |
| UASModel | Manufacturer's designation of the UAS | M | String | | |
| UASSerialNumber | UAS Serial Number | M | String | | |
| RegistrationDate | Registration date | M | Date | | |
| Validity | Validity of the certified unmanned aircraft registration | M | Boolean | 1 | |
| CertifiedUASOwner | Operator details of the certified UAS | M | Complex | | |

| ComplexType: | CertifiedUASOwner | | | | |
|---|---|---|---|---|---|
| Attribute | Description | M/O**Error! Bookmark not defined.** | Type (Mutliplicity) | Length | Notes |
| RepositoryID | Repository ID of the person under whose name the certified drone is registered | O | String | | Will become mandatory once the technical solution available. Value should be empty or null for now |
| FullName | Full name of the person under whose name the certified drone is registered | M | String | | |
| Address | Address of the person under whose name the certified drone is registered | M | String | | |
| Email | Email of the person under whose name the certified drone is registered | M | String | | |
| Telephone | Tel. number of the person under whose name the | M | String | | |

| | | | | | |
|---|---|---|---|---|---|
| | certified drone is registered | | | | |
| Birthdate | Date of birth of the person under whose name the certified drone is registered in case it is a natural person | O | Date | | |
| IdentificationNumber | Identification number of the person under whose name the certified drone is registered in case it is a legal entity | O | String | | |

| EntitySet: | UASOperators | | | | |
|---|---|---|---|---|---|
| Attribute | Description | M/O**Error! Bookmark not defined.** | Type (Mutliplicity) | Length | Notes |
| RegistrationNumber | Operator registration number | M | String | 16 | Example: FIN87astrdge1 |
| RegistrationCountry | Registration country | M | String | 3 | Values from Table 1 of API usage guide |
| RepositoryID | Repository ID of the registered operator | O | String | | Value should b empty or null f now |
| FullName | Full name of the registered operator | M | String | | |
| Address | Address of the registered operator | M | String | | |
| Email | Email of the registered operator | M | String | | |
| Telephone | Tel. number of the registered operator | M | String | | |
| Birthdate | Date of birth of the registered operator in case it is a natural person | O | Date | | Each of these t attributes is optional but it mandatory to specify one of two, depending the person type (natural or lega |
| IdentificationNumber | Identification number of the registered operator in case it is a legal entity | O | String | | |
| Validity | Validity of the UAS operator registration | M | Boolean | 1 | |
| RegistrationDate | Registration date | M | Date | | |



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| | | | | | |
|---|---|---|---|---|---|
| OperationalAuthorisations | Operational authorisations | O | Navigation (0..*) | | |
| OperationalDeclarations | Operational declarations | O | Navigation (0..*) | | |
| LUCHeld | LUC held | O | Navigation (0..1) | | |
| Attachment | Reply attachment | O | Navigation (0..1) | | MS should provide a copy the operational authorisation a of the LUC 'te of approval' he by the UAS operator registered in th Member State. The copy shou be exchanged through the repository as a unstructured attachment (e.g PDF file) |

| EntitySet: | OperationalAuthorisations | | | | |
|---|---|---|---|---|---|
| Attribute | Description | M/O**Error! Bookmark not defined.** | Type (Mutliplicity) | Length | Notes |
| AuthorisationNumber | Authorisation number | M | String | | Eleme the for elemer form a numbe accord Operat author templa includ AMC1 UAS.S (1) |

| | | | | | |
|---|---|---|---|---|---|
| UASIdentifiers | Serial number or UA registration mark (for certified UAS) | M | Navigation (1..*) | | Eleme the for |
| AuthorisedLocations | Authorised location(s) | M | Navigation (1..*) | | |
| AuthorisedAirspaceRiskLevels | Authorised airspace risk level | M | Navigation (1..*) | | |
| OperationalLimitations | Operational limitations | M | Navigation (1..*) | | |
| MitigationMeasures | Mitigation measures | M | Navigation (1..*) | | |
| RemotePilotCompetencies | Remote pilot competency | M | Navigation (1..*) | | |
| OtherStaffCompetencies | Competency of other staff essential for the safety of the operation | O | Navigation (0..*) | | |
| ExpirationDate | Expiration date | M | Date | | Eleme the for |

| EntitySet: | OperationalDeclarations | | | | |
|---|---|---|---|---|---|
| Attribute | Description | M/O**Error! Bookmark not defined.** | Type (Mutliplicity) | Length | Notes |
| OperationalDeclarationID | Technical ID to identify each entity | M | String | | Techn identif entity, genera MS |
| UASProducts | UAS products | M | Navigation (1..*) | | |
| STSNumber | STS number | M | String | | Values Table usage |
| ExpirationDate | Expiration date | M | Date | | |
| | | | | | |

| EntitySet: | UASProducts | | | | |
|---|---|---|---|---|---|
| Attribute | Description | M/O**Error! Bookmark not defined.** | Type (Mutliplicity) | Length | Notes |
| UASManufacturer | UAS manufacturer | M | String | | |
| UASModel | UAS model | M | String | | |

### 4.4.2 Country Codes

The following table shows the ISO3166-1 alpha-3 country codes (always in CAPITAL) that shall be used for attributes indicating a Member State (eg OriginatingMS, RegistrationCountry). Additionally, for the test environment, the EASA test server will emulate the country code “ZZZ”.

| Member State | Code |
|---|---|
| Austria | AUT |
| Belgium | BEL |
| Bulgaria | BGR |
| Croatia | HRV |
| Cyprus | CYP |
| Czech Republic | CZE |
| Denmark | DNK |
| Estonia | EST |
| Finland | FIN |
| France | FRA |
| Germany | DEU |
| Greece | GRC |
| Hungary | HUN |
| Iceland | ISL |
| Ireland | IRL |
| Italy | ITA |
| Latvia | LVA |
| Liechtenstein | LIE |
| Lithuania | LTU |
| Luxembourg | LUX |
| Malta | MLT |



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| | |
|---|---|
| Netherlands | NLD |
| Norway | NOR |
| Poland | POL |
| Portugal | PRT |
| Romania | ROU |
| Slovakia | SVK |
| Slovenia | SVN |
| Spain | ESP |
| Sweden | SWE |
| Switzerland | CHE |

**Table 2**

### 4.4.3 Language Codes

The following table shows the ISO639-1 language codes (always in CAPITAL) that shall be used for attributes indicating an EU language (Language attribute in UASObject).

| **Language** | **Code** |
|---|---|
| Bulgarian | BG |
| Croatian | HR |
| Czech | CS |
| Danish | DA |
| Dutch | NL |
| English | EN |
| Estonian | ET |
| Finnish | FI |
| French | FR |
| German | DE |
| Greek | EL |
| Hungarian | HU |

| | |
|---|---|
| Irish | GA |
| Italian | IT |
| Latvian | LV |
| Lithuanian | LT |
| Maltese | MT |
| Polish | PL |
| Portuguese | PT |
| Romanian | RO |
| Slovak | SK |
| Slovenian | SL |
| Spanish, Castilian | ES |
| Swedish | SV |

**Table 3**

### 4.4.4 STS Values

| **Value** |
|---|
| STS-01 |
| STS-02 |

**Table 4**

### 4.4.5 Requester Types

| ***Code*** | ***Description*** |
|---|---|
| 01 | Public |
| 02 | Police |
| 03 | Other law enforcement authority |
| 04 | Search & Rescue |
| 05 | Competent authority entrusted with the investigation of civil aviation accidents and incidents |
| 06 | ANSP / U-space Service Providers |

| | |
|---|---|
| 07 | National Aviation/Competent Authority |

**Table 5**

# 5 Service Provisioning

Left Empty.



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# 6 References


| Nr. | Version | Reference |
|---|---|---|
| [1] | | |
| [2] | | |
| [3] | | |
| [4] | | |
| [5] | | |
| [6] | | |
| [7] | | |
| [8] | | https://www.atmmasterplan.eu/ |
| [9] | | https://www.sesarju.eu/u-space-blueprint |
| [10] | | Efficient, safe and sustainable traffic at sea (EfficienSea2), a Horizon 2020 Project, Grant Agreement No 636329<br>https://efficiensea2.orghttps://efficiensea2.org/wp-content/uploads/2018/04/Deliverable-3.6.Standard-proposal-for-Maritime-Cloud-service-specification.pdf |
| [11] | | IALA specification for e-navigation technical services<br>https://www.iala-aism.org/product/g1128-specification-e-navigation-technical-services |
| [12] | | IATA Safety Report 2014 (Issued April 2015)<br>http://www.aviation-accidents.net/report-download.php?id=90003 |
| [13] | | |

| | | |
|---|---|---|
| [14] | | |
| [15] | | *REGULATION (EU) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL*<br><br>*of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation)* |
| [16] | *2018/1725* | |

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# D2.4 Appendix E Operational Message Exchange Service Specification


| | |
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## Authoring & Approval

### Authors of the document

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Gregor Mogeritsch / Frequentis | WP2 | 26.10.2022 |
| Hubert Künig / Frequentis | WP2 | 26.10.2022 |
| Peter Cornelius / Frequentis | WP2 | 26.10.2022 |
| Thomas Lutz / Frequentis | WP2 Lead | 26.10.2022 |

### Reviewers internal to the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Jonas Stjernberg / Robots Expert | WP3 Lead | 1.11.2022 |
| Maria Tamm / EANS | Project coordinator | 3.11.2022 |
| Tanel Järvet / CAFA | WP4 Lead | 3.11.2022 |
| Damian Soliwoda / PSNC | WP2 member | 2.11.2022 |
| Lukasz Gorny-Zajac / DRR | WP2 member | 2.11.2022 |
| Parmentier Remy / VAI | WP2 member | 2.11.2022 |
| Pawel Korzec / DRR | WP2 member | 2.11.2022 |
| Piotr Dybiec / DRR | WP2 member | 2.11.2022 |
| Piotr Luboński / PSNC | WP2 member | 31.10.2022 |
| Piotr Szymaniak / PSNC | WP2 member | 31.10.2022 |
| Sven Jürgenson / Threod | WP3 member | 3.11.2022 |
| Leopoldo Tejada/UML | WP2 member | 2.11.2022 |
| Thomas Wana / DIME | WP2 member | 31.10.2022 |
| Yuhang Yun / EHANG | WP3 member | 30.10.2022 |
| Iris Röhrich / FRQ | WP1 member | 3.11.2022 |

### Approved for submission to the SJU By - Representatives of beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Sami Alkula/FANS | Project Management Group | 3.11.2022 |
| Thomas Neubauer/DIME | Project Management Group | 3.11.2022 |
| Pawel Korzec/DRR | Project Management Group | 3.11.2022 |
| Yuhang Yun/EHE | Project Management Group | 3.11.2022 |
| Damini Gera/AIRB | Project Management Group | 3.11.2022 |
| Piotr Szymaniak/PSNC | Project Management Group | 3.11.2022 |
| Sven Jürgenson/THREOD | Project Management Group | 3.11.2022 |



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| | | |
|---|---|---|
| Leopoldo Tejada/UML | Project Management Group | 3.11.2022 |
| Tapio Haarlaa/VAI | Project Management Group | 3.11.2022 |
| Iris Röhrich/FRQ | Project Management Group | 3.11.2022 |
| Juha Lindstedt/AVIA | Project Management Group | 3.11.2022 |
| Piotr Bratek/PANSA | Project Management Group | 3.11.2022 |
| Tanel Järvet/CAFA | Project Management Group | 3.11.2022 |
| Maria Tamm/EANS | Project Management Group | 3.11.2022 |

**Rejected By - Representatives of beneficiaries involved in the project**

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# GOF2.0

## GOF2.0 INTEGRATED URBAN AIRSPACE VLD

This Updated Service Specification is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 101017689 under European Union's Horizon 2020 research and innovation programme.


## Abstract

This specification introduces an information exchange service which ensures interoperability and hence transparent and reliable information flow between the stakeholders in an operational U-space environment.

In accordance with ICAO SWIM, this document describes one of these Bridge Services, the Operational Message Exchange service in a logical, technology-independent manner.




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# Table of Contents

# 1 Introduction

## 1.1 Purpose of the document

Based on the guidelines given in [GOF1-Arch-AppA], this document describes the OperationalMessage exchange service of a Common Information Service (CIS) in a logical technology-independent manner, that is:

- operational and business context of the service
    - requirements for the service, e.g. information exchange requirements
    - involved nodes: which operational components provide/consume the service
    - operational activities supported by the service
    - relation of the service to other services
- service description
    - service interface definitions
    - service interface operations
    - service payload definition
    - service dynamic behaviour description
- service provision and validation aspects

In addition, this document clearly defines the version of the service.

## 1.2 Scope

This document describes the OperationalMessage Exchange service for a CIS.

The OperationalMessage service provides a means for the operational nodes of the U-space to exchange operational messages, and a corresponding acknowlegement.

## 1.3 Target Group

This service specification is written for:

- service architects,
- system engineers and
- developers in charge of designing and developing an instance of the ConformanceMonitoring service.

In addition, this service specification is written for:

- enterprise architects,
- service architects,
- information architects,
- system engineers and developers in pursuing architecting, design and development activities of other related services.



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## 1.4 Background

### 1.4.1 EU Regulation

The latest EU regulation draft contains requirements for conveying messages between operators, USSPs, and ATSUs involved in a given area whenever a non-conforming operation is detected. [EASA-Commission-Draft], Article 13, Conformance monitoring service refers:

***"1. A conformance monitoring service shall enable the UAS operators to verify whether they comply with the requirements set out in Article 6(1) and the terms of the UAS flight authorisation. To this end, this service shall alert the UAS operator when the flight authorisation deviation thresholds are violated and when the requirements in Article 6(1) are not complied with.***

***2. Where the conformance monitoring service detects a deviation from the flight authorisation, the U-space service provider shall alert the other UAS operators operating in the vicinity of the UAS concerned, other U-space service providers offering services in the same airspace and relevant air traffic services units, which shall acknowledge the alert."***

### 1.4.2 EUROCONTROL Specification for Monitoring Aids (MONA)

EUROCONTROL MONA [EC-MONA] defines conformance monitoring as follows.

***"2.2. Conformance Monitoring***

***The conformance monitoring function compares the system tracks with the corresponding flight clearances in order to warn the controller of any deviation of a flight from its clearance and, where possible, to establish the progress of the flight and to refine the prediction of the remaining trajectory to be flown.***

***Conformance is monitored in three dimensions, though the monitoring performed varies according to the type of clearance issued. In principle, warnings of deviation are generated in cases where the controller might be required to act to re-clear an aircraft that is assumed to be deviating from its clearance or to re-coordinate an aircraft whose boundary estimate changes significantly.***

***The [TP-SPEC] defines a planned trajectory and a tactical trajectory. Where possible, the system recalculates the trajectories that are active for a flight according to the actual behaviour of the aircraft, as described below.***

***..."***

### 1.4.3 EUROCONTROL Concept of Operations for U-space (CORUS)

EUROCONTROL CORUS [CORUS] Vol. 2 elaborates in 5.1.6.1 Monitoring service as follows.

***"5.1.6.1 Monitoring service***

***Subject to appropriate data-quality requirements, this service retrieves data from the tracking service and combines it with information related to non-***

***cooperative obstacles and vehicles to provide an air situation status report for authorities, service providers, and operators, including pilots. This service may include operation plan conformance monitoring, geo-fence compliance monitoring and warnings (see 5.1.2.2), weather limit compliance monitoring, ground risk compliance monitoring, electromagnetic risk monitoring. The geo-fence compliance monitoring and warnings constitute U-space providing Geo-Awareness.***

***..."***

### 1.4.4 International Civil Aviation Organization (ICAO)

ICAO Doc 10039 [ICAO-SWIM] elaborates in section 3.4 INFORMATION EXCHANGE **SERVICES** on information exchange services as follow (para. 3.4.2).

***"Within the SWIM Global Interoperability Framework, the Information Exchange layer is instantiated by 'information services' as is further explained. Information services ensure interoperability between ATM applications which consume and provide interoperable information services. Consequently, the concept of information service is a fundamental building block of SWIM which enables interoperability through well-defined information exchanges."***

### 1.4.5 SESAR-JU

The European Commission identifies an increasing demand for a non-segregated use of airspace which is being driven by a rapidly growing market of EVery-Low-Level (VLL) airspace users, most of which are expected to be drones.

Via the Roadmap for the safe integration of drones into all classes of airspace [EATMP-Drone], within the European ATM Masterplan [EATMP], the European Commission seeks to ensure that this rapid growth of airspace use happens in a safe and controlled manner.

SESAR develops the required concepts and demonstrations for this process to happen. The roadmap [EATMP-Drone], in alignment with ICAO recommendations, identifies three phases for the integration, from which SESAR derives the four U-space service blocks presented in the U-space blueprint [UspaceBlueprint],

U1 U-space foundation services,

U2 U-space initial services,

U3 U-space advanced services, and

U4 U-space full services.

These stages reflect the anticipated quick growth of demand for U-space services. The state of the art has been, and is being, validated throughout Europe via several Very Large Demonstrator (VLD) projects such as the GOF USPACE project.

During the U1 phases, SESAR expects drones capable to supply their position via telemetry. The U1 and U2 blocks are anticipated to provide tracking capabilities and services.

### 1.4.6 Efficient, Safe and Sustainable Traffic at Sea (EfficienSea2)

The design method and terminology builds on experience from the EfficienSea2 project [EfficienSea2], [IALA-ENAV].

## 1.5 Glossary of Terms

| Term | Definition |
|---|---|
| External Data Model | Describes the semantics of the domain (or a significant part thereof) by defining data structures and their relations. This could be at logical level, e.g. in UML or at physical level, e.g. in XSD schema definitions, as for example standard data models. |
| Message Exchange Pattern | Describes the principles how two different parts of a message passing system (in our case: the service provider and the service consumer) interact and communicate with each other. Examples:<br>In the Request/Response MEP, the service consumer sends a request to the service provider in order to obtain certain information; the service provider provides the requested information in a dedicated response.<br>In the Publish/Subscribe MEP, the service consumer establishes a subscription with the service provider in order to obtain certain information; the service provider publishes information (either in regular intervals or upon change) to all subscribed service consumers. |
| Operational Activity | An activity performed by an operational node. Examples of operational activities are: Route Planning, Route Optimization, Logistics, Safety, Weather Forecast Provision, … |
| Operational Model | A structure of operational nodes and associated operational activities and their inter-relations in a process model. |
| Operational Node | A logical entity that performs activities. Note: nodes are specified independently of any physical realisation.<br>Examples of operational nodes are: Control Center, Authority, Weather Information Provider, … |
| Service | The provision of something (a non-physical object), by one, for the use of one or more others, regulated by formal definitions and mutual agreements. Services involve interactions between providers and consumers, which can be performed in a digital form (data exchanges) or through voice communication or written processes and procedures. |
| Service Consumer | A service consumer uses service instances provided by service providers. |
| Service Data Model | Formal description of one dedicated service at logical level. The service data model is part of the service specification. Is typically defined in UML and/or XSD. If an external data model exists, e.g. a standard data model, then the service data model shall refer to it: each data item of the service data model shall be mapped to a data item defined in the external data model. |

| | |
|---|---|
| Service Design Description | Documents the details of a service technical design (most likely documented by the service implementer). The service design description includes (but is not limited to) a service physical data model and describes the used technology, transport mechanism, quality of service, etc. |
| Service Implementation | The provider side implementation of a dedicated service technical design, i.e. implementation of a dedicated service in a dedicated technology. |
| Service Implementer | Implementers of services from the service provider side and/or the service consumer side. |
| Service Instance | One service implementation may be deployed at several places by same or different service providers; each such deployment represents a different service instance, being accessible via different URLs. |
| Service Instance Description | Documents the details of a service implementation (most likely documented by the service implementer) and deployment (most likely documented by the service provider). The service instance description includes (but is not limited to) service technical design reference, service provider reference, service access information, service coverage information, etc. |
| Service Interface | Communication mechanism of the service, i.e., interaction mechanism between service provider and service consumer. A service interface is characterised by a message exchange pattern and consists of service operations that are either allocated to the provider or the consumer of the service. |
| Service Operation | Functions or procedure which enables programmatic communication with a service via a service interface. |
| Service Physical Data Model | Describes the realisation of a dedicated service data model in a dedicated technology. This includes a detailed description of the data payload to be exchanged using the chosen technology. The actual format of the service physical data model depends on the chosen technology. Examples may be WSDL and XSD files (e.g., for SOAP services) or swagger (Open API) specifications (e.g., for REST services). If an external data model exists (e.g., a standard data model), then the service physical data model shall refer to it: each data item of the service physical data model shall be mapped to a data item defined in the external data model.<br>In order to prove correct implementation of the service specification, there shall exist a mapping between the service physical data model and the service data model. This means, each data item used in the service physical data model shall be mapped to a corresponding data item of the service data model. (In case of existing mappings to a common external (standard) data model from both the service data model and the service physical data model, such a mapping is implicitly given.) |
| Service Provider | A service provider provides instances of services according to a service specification and service instance description. All users within the domain can |

| | |
|---|---|
| | be service providers, e.g., authorities, organizations (e.g., meteorological), commercial service providers, etc. |
| Service Specification | Describes one dedicated service at logical level. The Service Specification is technology-agnostic. The Service Specification includes (but is not limited to) a description of the Service Interfaces and Service Operations with their data payload. The data payload description may be formally defined by a Service Data Model. |
| Service Specification Producer | Producers of service specifications in accordance with the service documentation guidelines. |
| Service Technical Design | Technical design of a dedicated service in a dedicated technology. One service specification may result in several technical service designs, realising the service with different or same technologies. |
| Service Technology Catalogue | List and specifications of allowed technologies for service implementations. Currently, SOAP and REST are envisaged to be allowed service technologies. The service technology catalogue shall describe in detail the allowed service profiles, e.g., by listing communication standards, security standards, stacks, bindings, etc. |
| Spatial Exclusiveness | Service specification is characterised as "spatially exclusive", if in any geographical region only one service instance of that specification is allowed to be registered per technology. The decision, which service instance (out of a number of available spatially exclusive services) shall be registered for a certain geographical region, is a governance issue. |

**Tab. 1**: Glossary of Terms

## 1.6 List of Acronyms

| Acronym | Definition |
|---|---|
| API | Application Programming Interface |
| MEP | Message Exchange Pattern |
| NAF | NATO Architectural Framework |
| REST | Representational State Transfer |
| SOA | Service Oriented Architecture |
| SOAP | Simple Object Access Protocol |
| SSD | Service Specification Document |
| UML | Unified Modelling Language |



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| | |
|---|---|
| URL | Uniform Resource Locator |
| WSDL | Web Service Definition Language |
| XML | Extendible Mark-up Language |
| XSD | XML Schema Definition |

**Tab. 2**: List of Acronyms

# 2 Service Identification

This chapter gives a unique identification of the service and describes where the service is in terms of the engineering lifecycle.

| Name | OperationalMessageExchange Service |
|---|---|
| ID | urn:frequentis:services:OperationalMessageExchangeService |
| Version | 1.0 |
| Description | A service which exchanges operational messages between UAS operators, USSPs, or ATSU including such to alert a party about a non-conforming operation, and require a corresponding acknowledgement. |
| Keywords | OperationalMessage Service, U-space, Warning, Alert |
| Architect(s) | 2021-today The Frequentis Group<br><br>2021-2022 The GOF2.0 U-Space Project Consortium |
| Status | Provisional |

**Tab. 3**: Service Identification



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# 3 Operational Context

This section describes the context of the service from an operational perspective

## 3.1 Functional and Non-functional Requirements

The table below lists applicable existing requirements for the OperationalMessageExchange service:

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| [R-1] | Common Situational Awareness | At all times, all U-space participants shall operate on the same common set of data, during pre-flight planning stages as well as during all stages of flight operations. | CORUS [CORUS], 3.1.1.2 Z Volumes; B1-RPAS [ICAO-GANP];CEF-SESAR-2018-1 [GOF1-I-CFP], Objective O5 |
| [R-2] | Basis for Open Market | The U-space concept shall be designed such as to ensure a well-established line of authority while at the same time ensuring that an open market for VLL services may develop | SESAR Drone Roadmap [EATMP-Drone], Foreword, 4.1 and 4.2;U-space Blueprint [UspaceBlueprint], Benefits to European society and economy; CEF-SESAR-2018-1 [GOF1-I-CFP], Table 8 – Key Challenges |
| [R-3] | Interoperability | There shall be an implementation of a Flight Information Management System (FIMS) which ensures that, at all times, emerging unmanned traffic management systems and existing technologies from manned operations can exchange any data required to support such common situational awareness, be it for drone operations in areas where established ATC procedures apply, or in zones outside established ATC. | ICAO Doc 10039 [ICAO-SWIM];[R-2];CEF-SESAR-2018-1 [GOF1-I-CFP], Objective O6; CEF-SESAR-2018-1 [GOF1-I-CFP], Table 8 – Key Challenges<br><br>Note: The term 'Flight Information Management System (FIMS)' in some of these references has been since replaced by 'Common Information Services (CIS)'. This text hence elsewhere refers to CIS, rather than FIMS. |
| [R-4] | Standard Protocols | Standard communication protocols shall hence be used where available, and such standard protocols be | [R-2];SESAR Drone Roadmap [EATMP-Drone], 3.5, section 'Standards'; CEF-SESAR-2018-1 [GOF1-I- |

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|---|---|---|---|
| | | developed otherwise, in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop. | CFP], Table 8 – Key Challenges |
| [R-5] | Open Interfaces | Any interface and protocol hence must be openly defined and its definition be freely accessible in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop. | [R-2];CEF-SESAR-2018-1 [GOF1-I-CFP], Table 8 – Key Challenges |
| [R-6] | SWIM | The implementation of a Flight Information Management System (FIMS) shall be based on an ICAO SWIM-compliant architecture. | [R-3];CEF-SESAR-2018-1 [GOF1-I-CFP], 5.3.4 Overall approach and methodology<br><br>Note: The term 'Flight Information Management System (FIMS)' used therein has been since replaced by 'Common Information Services (CIS)'. This text hence elsewhere refers to CIS, rather than FIMS. |
| [R-7] | Latency | Under no operational circumstance, the processing of position data may add significant latency to the overall detection-to-display latency of position data. In particular,<br><br>The processing latency added by the processing of positional data shall never exceed 10 per cent of the maximum value of the corresponding value permitted for the entire ATM automation system.<br><br>The processing latency and delay added by the processing of positional data should not exceed 1 per cent of the maximum value of the corresponding value permitted for the entire ATM automation system. | [FAA-SUR-PERF], tables in the Executive Summary, [EC-ATM-PERF], 3N_C-R8 and 5N_C-R8 |

| | | | |
|---|---|---|---|
| | | The maximum value for latency and delay is the minimum of the values defined by the ATM system performance requirements by EUROCONTOL and the FAA; for a 3 NM minimal separation, this is 2.2 s, for a 5 NM separation, 2.5 s. | |
| [R-8] | UAS flight authorisation request | The UAS flight authorisation request shall comprise the following information:<br><br>1. the unique serial number of the unmanned aircraft or, if the unmanned aircraft is privately built, the unique serial number of the add-on;<br><br>2. mode of operation;<br><br>3. type of flight (special operations);<br><br>4. category of UAS operation (‘open’, ‘specific’, ‘certified’) and UAS aircraft class or UAS type certificate if applicable;<br><br>5. 4D trajectory;<br><br>6. identification technology;<br><br>7. expected connectivity methods ;<br><br>8. endurance;<br><br>9. applicable emergency procedure in case of a loss of command and control link;<br><br>10. registration number of the UAS operator and, when applicable, of the unmanned aircraft.1. | [EASA-Commission-Draft], Annex IV |
| [R-9] | Non-conformance alerting and acknowlegement | Subject to the airspace type requirements, there shall be continuous oversight about the compliance of U-space operations with the | [EASA-Commission-Draft], Article 13 |

| | | | |
|---|---|---|---|
| | | corresponding flight authorization.<br><br>There must be means to alert the UAS operator conducting an operation about any non-compliance with his flight authorization.<br><br>There must be means to alert other UAS operators operating in the vicinity of the non-compliant operation about this circumstance, other U-space service providers offering services in the same airspace and relevant air traffic services units, all which shall acknowledge the alert. | |

**Tab. 4**: Requirements for the OperationalMessageExchange Service

## 3.2 Other Constraints

### 3.2.1 Relevant Industrial Standards

#### 3.2.1.1 ICAO SWIM

The System Wide Information Management (SWIM, [ICAO-SWIM]) complements human-to-human with machine-to-machine communication, and improves data distribution and accessibility in terms of quality of the data exchanged. The SWIM Concept addresses the challenge of creating an “interoperability environment” which allows the SWIM IT systems to cope with the full complexity of operational information exchanges. The SWIM environment shifts the ATM information architecture paradigm from point-to-point data exchanges to system-wide interoperability.

### 3.2.2 Operational Nodes

The OperationalMessageExchange Service may consume and/or refer to information from a number of other services nodes including the following ones.

| Operational Service Node | Remarks |
|---|---|
| OperationPlan | Operation plans from the OperationPlan service, e. g. of a USSP, or an ATSU/ATSP |
| UasRegistration | Registry data from the UAS Registry service, e. g. of a USSP or an authority |
| TrafficTelemetry | PositionReports from the Traffic/Telemetry service, e. g. of a UAS operator, USSP, a CIS, a SDSP, an aircraft, or an ATSU/ATSP |

| | |
|---|---|
| GeoZone | GeoZone data from the GeoZone service, e. g. of a USSP, an ATSU/ATSP, or an authority |
| TrafficConformanceMonitoring | Traffic/Telemetry-based conformance monitoring service, e. g. of a USSP, an ATSU/ATSP, or an authority |

**Tab. 5**: Operational Services Nodes Providing Data for the OperationalMessageExchange Service

Operational nodes which may consume the service include the following ones:

| Operational Node | Remarks |
|---|---|
| GCS / UAS Operator | Operator ground control station of a UAS operator operating in the same area as this OperationalMessageExchange service |
| USSP | Other USSP(s) operating in the same area as this OperationalMessageExchange service |
| ATSU / ATSP | Air traffic service unit(s) or air traffic services provider operating in the same area as this OperationalMessageExchange service |
| SDSP | Supplementary data service provider(s) operating in the same area as this OperationalMessageExchange service |
| CIS | Common Information Servces operating in the same area as this OperationalMessageExchange service |

**Tab. 6**: Operational Nodes Consuming the OperationalMessageExchange Service

### 3.2.3 Operational Activities

Operational activities supported by the service include the following ones:

| Operational Activity | Remarks |
|---|---|
| Pre-Flight | Short-term communication with other stakeholders possible, e. g. to prevent a pending immediate take-off. |
| Normal flight operations | Communication of traffic advisories, or operational commands such as order to land immediately. |
| Abnormal flight operations | Communication of non-conforming or emergency operational state. |
| Post-flight activities | Evaluation of any message exchange for statistics or conformance evaluation purposes. |

**Tab. 7**: Operational Activities Supported by the OperationalMessageExchange Service

# 4 Service Interfaces

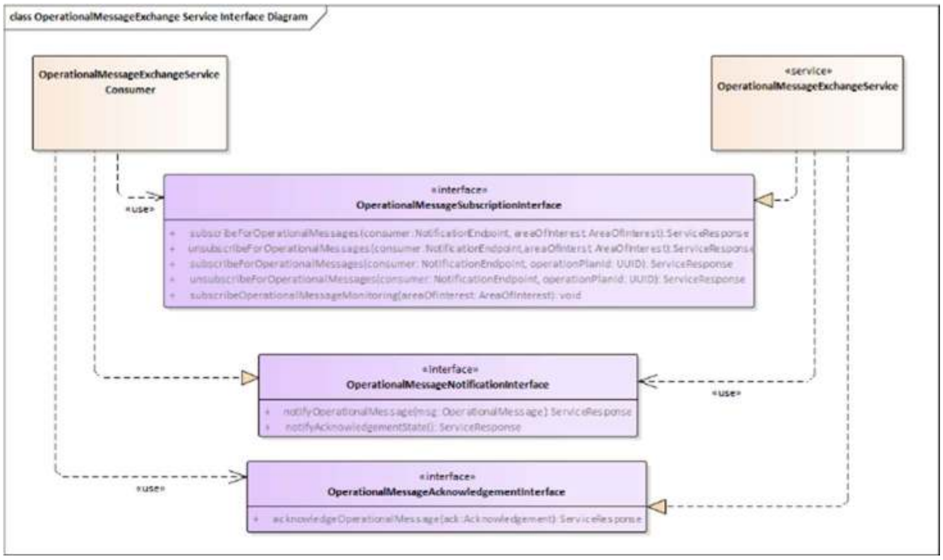


**Figure 1** OperationalMessageExchangeService Interface Definition diagram

An operator subscribes to the **OperationalMessageExchangeSunscriptionInterface** of her USSP for each one of her operationPlanId.

A USSP or ATSU subscribes to the **OperationalMessageExchangeSubscriptionInterface** for its **areaOfInterest** of the other USSPs or ATSUs operating that area, as does a monitoring consumer which **subscribeOperationalMessageMonitoring**.

| ServiceInterface | Role (from service provider point of view) | ServiceOperation |
|---|---|---|
| OperationalMessageSubscriptionInterface | Provided | subscribeForOperationalMessages<br>unsubscribeForOperationalMessages<br>subscribeOperationalMessageMonitoring |
| OperationalMessageAcknowledgementInterface | Provided | acknowlegeOperationalMessage |
| OperationalMessageNotificationInterface | Required | notifyOperationalMessage<br>notifyAcknowledgementState |

**Tab. 8**: Service Interfaces



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# 5 Service Data Model

This section describes the information model, i.e., the logical data structures to be exchanged between providers and consumers of the service.

## 5.1 Overview

The OperationalMessageExchange service transfers operational messages, such as instructions by air traffic control or a UTM service provider (e. g. "Land now!"), and the corresponding acknowledgements via the **OperationalMessage** and **AckMessage** a data structures, respectively.

Such message exchange may take place between an operator and 'her' UTM service provider (USP), or between the involved USPs and/or air traffic services units (ATSU).

Each **OperationalMessage** shall be acknowledged by a corresponding **AckMessage**. Reference to the related **operationPlan**(s) should be provided. Likewise, the corresponding **droneRegistration**(s), positionInfo and reference to **airspace**(s) may be provided as required.

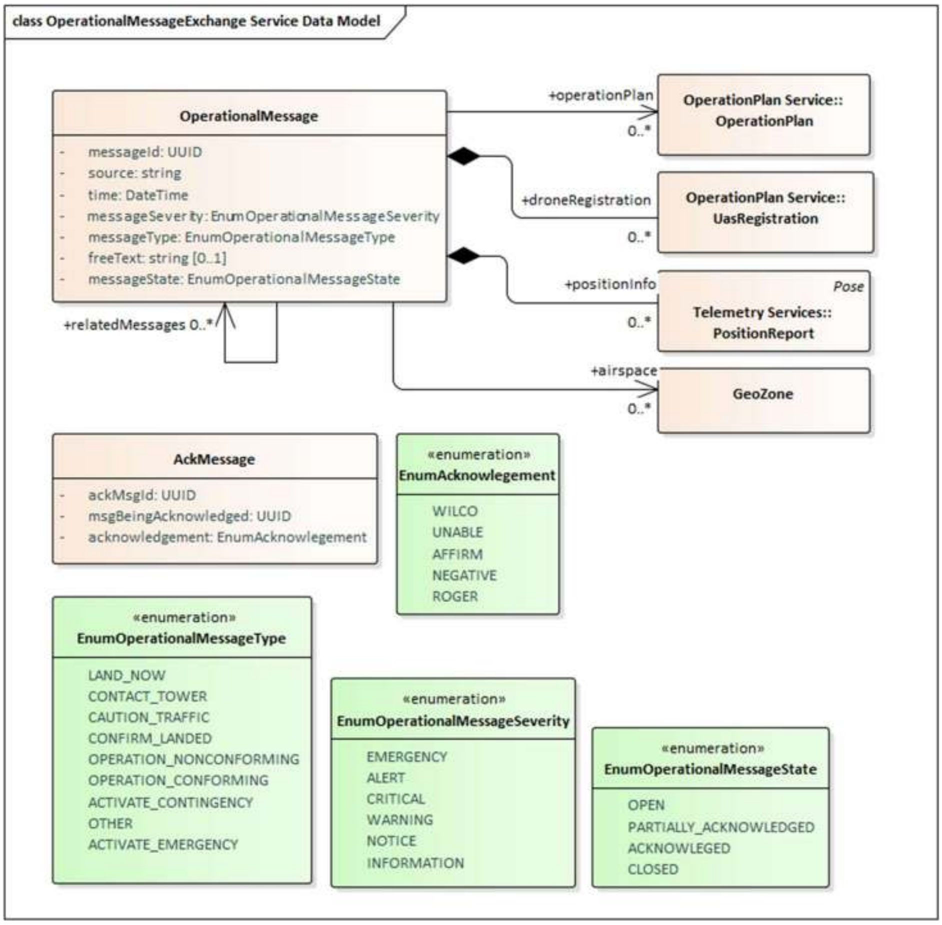


**Figure 2: Data Model diagram of the Identification Service**

## 5.2 OperationalMessage Data Structure

The **OperationalMessage** data structure carries the details of operational information being exchanged.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| messageId | UUID | 1 | Globally unique Operational Message identifier | |
| source | string | 1 | The name of the source of the OperationalMessage | Should be a recognized string by the CIS. |
| time | DateTime | 1 | The time stamp when the OperationalMessage was sent | |
| messageSeverity | EnumOperationalMessageSeverity | 1 | The severity of the OperationalMessage. | |
| messageType | EnumOperationalMessageType | 1 | The type of the OperationalMessage. | |
| freeText | string | 0..1 | Additional textual description of the **OperationalMessage**. | |
| messageState | EnumOperationalMessageState | 1 | The state the **OperationalMessage** is in when it was sent | |
| operationPlan | reference to OperationPlan | 0..* | List of references to OperationPlans the **OperationalMessage** is related to. | May consist of a list of UUIDs, referring to the OperationPlan identifiers. |
| droneRegistration | UasRegistration | 0..* | UAS Registration Information | May be omitted if information is present in the referred OperationPlan. |
| positionInfo | PositionReport | 0..* | Positional indication of the | |

| | | | | |
|---|---|---|---|---|
| | | | **OperationalMessage** . | |
| airspace | GeoZone | 0..1 | Optional reference to an airspace. | |
| relatedMessages | reference to OperationalMessage | 0..* | List of references to other related **OperationalMessage** objects | may consist of a list of UUIDs, referring to the **OperationalMessage** identifiers. |

**Tab. 9**: **The** OperationalMessage **data structure**

## 5.3 AckMessage Data Structure

The **AckMessage** data structure carries the acknowledgements to an **OperationalMessage**.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| ackMsgId | UUID | 1 | Globally unique AckMessage identifier | |
| msgBeingAcknowledged | UUID | 1 | UUID of the OperationalMessage which this AckMessage acknowledges | |
| acknowlegement | EnumAcknowlegement | 1 | The kind of acknowlegement returned by this AckMessage | |

**Tab. 10**: The AckMessage data structure

## 5.4 EnumOperationalMessageSeverity Enumeration

The **EnumOperationalMessageSeveroty** enumeration type specifies the OperationalMessage severtities.

| Property | Description | Note |
|---|---|---|
| EMERGENCY | There is an *immediate* impact to the safety of other air operations, the safety of people, or the safety of structures on the ground. Actions to mitigate required by other operations. | |
| ALERT | There may be an impact to the safety of other air operations, the safety of people, or the safety of structures on the ground. Actions to mitigate required by other operations. | |

| | | |
|---|---|---|
| CRITICAL | Without mitigations by the affected operation, the situation may rise to an emergency in the near future. | |
| WARNING | There is a contained issue in this OperationalMessage that may result in the loss of aircraft. No immediate or likely effect to other operations, people on the ground, or structures. | |
| NOTICE | The information conveyed in this OperationalMessage is provided for situational awareness. Planning by operators and USSs may be affected. | |
| INFORMATION | The information conveyed in this OperationalMessage is provided for situational awareness. | |

**Tab. 11**: EnumOperationalMessageSeverity Enumeration

## 5.5 EnumOperationalMessageType Enumeration

The **EnumOperationalMessageType** enumeration type specifies the OperationalMessage types.

| Property | Description | Note |
|---|---|---|
| LAND_NOW | Instruct the receiver to land the drone immediately. | |
| CONTACT_TOWER | Instruct the receiver to contact the ATC tower. | |
| CAUTION_TRAFFIC | Informs the receiver about nearby traffic. | |
| CONFIRM_LANDED | Informs the receiver that the drone was landed. | |
| OPERATION_CONFORMING | Informs the receiver about a conforming operation. | |
| OPERATION_NONCONFORMING | Informs the receiver about a non-conforming operation. | |
| ACTIVATE_CONTINGENCY | Informs the receiver that the state of Contingency has been entered | |
| ACTIVATE_EMERGENCY | Informs the receiver that the state of Emergency has been entered | |
| OTHER | Any other message as described in the freeText field. | This option should not be used, as it cannot be processed automatically. |

**Tab. 12**: EnumAertType Enumeration

## 5.6 EnumOperationalMessageSeverity Enumeration

The **EnumOperationalMessageSeverity** enumeration type specifies the OperationalMessage severtities.

| Property | Description | Note |
|---|---|---|
| EMERGENCY | There is an *immediate* impact to the safety of other air operations, the safety of people, or the safety of structures on the ground. Actions to mitigate required by other operations. | |
| ALERT | There may be an impact to the safety of other air operations, the safety of people, or the safety of structures on the ground. Actions to mitigate required by other operations. | |
| CRITICAL | Without mitigations by the affected operation, the situation may rise to an emergency in the near future. | |
| WARNING | There is a contained issue in this OperationalMessage that may result in the loss of aircraft. No immediate or likely effect to other operations, people on the ground, or structures. | |
| NOTICE | The information conveyed in this OperationalMessage is provided for situational awareness. Planning by operators and USSs may be affected. | |
| INFORMATION | The information conveyed in this OperationalMessage is provided for situational awareness. | |

**Tab. 13**: EnumOperationalMessageSeverity Enumeration

## 5.7 EnumOperationalMessageState Enumeration

The **EnumOperationalMessageState** enumeration type specifies the possible OperationalMessage states.

| Property | Description | Note |
|---|---|---|
| OPEN | At the time of the transmission of this OperationalMessage, it was in the OPEN state. | |
| PARTIALLY_ACKNOWLEDGED | At the time of the transmission of this **OperationalMessage**, it has been PARTIALLY_ACKNOWLEDGED, i. e., with some acknowlegements received, at least one expected acknowledgement was outstanding. | |
| ACKNOWLEDGED | At the time of the transmission of this **OperationalMessage**, it has been ACKNOWLEDGED from all recipients. | |
| CLOSED | At the time of the transmission of this **OperationalMessage**, it was in the CLOSED state. | |

**Tab. 14**: EnumOperationalMessageState Enumeration



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## 5.8 EnumAcknowlegement Enumeration

The **EnumAcknowlegement** enumeration type specifies the available kinds of **OperationalMessage** acknowlegements available.

| Property | Description | Note |
|---|---|---|
| WILCO | Indicates that the acknowledging party will cooperate and comply with an instruction. | |
| UNABLE | Indicates that the acknowledging party CANNOT cooperate and will NOT comply with an instruction. | |
| AFFIRM | Indicates that the acknowledging party received the information conveyed via the corresponding **OperationalMessage** and confirms it. | |
| NEGATIVE | Indicates that the acknowledging party received the information conveyed via the corresponding **OperationalMessage** but does NOT confirm it. | |
| ROGER | Indicates that the acknowledging party received the information conveyed via the corresponding **OperationalMessage**. | |

**Tab. 15**: EnumAcknowlegement Enumeration

## 5.9 OperationPlan Data Structure

The OperationPlan data structure is defined in the OperationPlanExchange Service data model.

## 5.10 UasRegistration Data Structure

The **UasRegistration** data structure is defined in the OperationPlanExchange Service data model.

## 5.11 PositionReport Data Structure

The **PositionReport data structure is defined in the** TrafficTelemetry Service data model**.**

# 6 Service Interface Specifications

This chapter describes the details of each service interface. Each Service Interface has its own sub-chapter.

The Service Interface specification covers only the static design description while the dynamic design (behaviour) is described later.

## 6.1 Service Interface OperationalMessageSubscriptionInterface

### 6.1.1 Operation subscribeForOperationalMessages

#### 6.1.1.1 Operation Functionality

A consumer calls this operation to subscribe for receiving operational messages related to a certain geographical area of interest, or related to a certain operation plan.

The operation either expects an operationPlanId or an areaOfInterest input parameter.

#### 6.1.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| **consumer** | Input | NotificationEndpoint | Which endpoint shall be notified in case of new OperationalMessages |
| **operationPlanId** | Input | UUID | GUFI of the OperationPlan of interest to the consumer |
| **areaOfInterest** | Input | AreaOfInterest | Area of interest to the consumer |
| **response** | Return | ServiceResponse | Provide status information on subscription |

**Tab. 16**: Payload Description of subscribeForOperationalMessage Operation

### 6.1.2 Operation subscribeForOperationalMessageMonitoring

#### 6.1.2.1 Operation Functionality

A consumer calls this operation to subscribe to monitoring of operational messages related to a certain geographical area of interest.

#### 6.1.2.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| consumer | Input | NotificationEndpoint | Which endpoint shall be notified in case of new OperationalMessages |
| areaOfInterest | Input | AreaOfInterest | Area of interest to the consumer |

| | | | |
|---|---|---|---|
| response | Return | ServiceResponse | Provide status information on subscription |

**Tab. 17**: Payload Description of subscribeForOperationalMessageMonitoring Operation

An operator subscribes to the **OperationalMessageExchangeSunscriptionInterface** of her USSP for each one of her operationPlanId.

A USSP or ATSU subscribes to the **OperationalMessageExchangeSubscriptionInterface** for its **areaOfInterest** of the other USSPs or ATSUs operating that area, as does a monitoring consumer which **subscribeOperationalMessageMonitoring**.

### 6.1.3 Operation unSubscribeForOperationalMessages

#### 6.1.3.1 Operation Functionality

A consumer calls this operation at the provider to unsubscribe from operational messages related to a certain geographical area of interest or related to a certain operation plan.

The operation either expects an operationPlanId or an areaOfInterest input parameter.

#### 6.1.3.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| consumer | Input | NotificationEndpoint | Which endpoint shall be not be notified (anymore) in case of new OperationalMessages |
| operationPlanId | Input | UUID | GUFI of the OperationPlan of interest to the consumer, as given in the subscription |
| areaOfInterest | Input | AreaOfInterest | Area of interest to the consumer, as given in the subscription |
| response | Return | ServiceResponse | Provide status information on subscription |

**Tab. 18**: Payload Description of unSubscribeForOperationalMessages Operation

## 6.2 Service Interface OperationalMessageNotificationInterface

Consumer provides this interface, allowing the service provider to submit to the consumer operational messages.

### 6.2.1 Operation notifyOperationalMessage

#### 6.2.1.1 Operation Functionality

Once and while subscribed, consumer receives operational messages via this operation.

#### 6.2.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|

| | | | |
|---|---|---|---|
| operationalMessage | Input | OperationalMessage | An operational message that matches the OperationPlan UUID or area criterium provided with the subscription |
| Response | Return | ServiceResponse | Technical confirmation that the notification was delivered. |

**Tab. 19**: Payload Description of notifyOperationalMessage Operation

### 6.2.2 Operation notifyOperationalMessageState

#### 6.2.2.1 Operation Functionality

Once and while subscribed, consumer receives state changes of the operational message via this operation.

#### 6.2.2.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| messageId | Input | UUID | Unique identifier of the message for which a state change is notified. |
| operationalMessageState | Input | EnumOperationalMessageState | The state of the operational message that matches the OperationPlan UUID or area criterium provided with the subscription |
| Response | Return | ServiceResponse | Technical confirmation that the notification was delivered. |

**Tab. 20**: Payload Description of notifyOperationalMessageState Operation

## 6.3 Service Interface OperationalMessageAcknowledgementInterface

### 6.3.1 Operation acknowledgeOperationalMessage

#### 6.3.1.1 Operation Functionality

A consumer calls this operation to acknowledge an operational message.

#### 6.3.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| acknowledgeOperationalMessage | Input | AckMessage | Acknowledgment to operational message as requested by the OperationPlan |

| | | | |
|---|---|---|---|
| | | | UUID or area criterium provided with the subscription |
| Response | Return | ServiceResponse | Technical confirmation that the acknowledgement was delivered. |

**Tab. 21**: Payload Description of acknowledgeOperationalMessage Operation

# 7 Service Dynamic Behaviour

## 7.1 Sequence of events, cooperation with other services

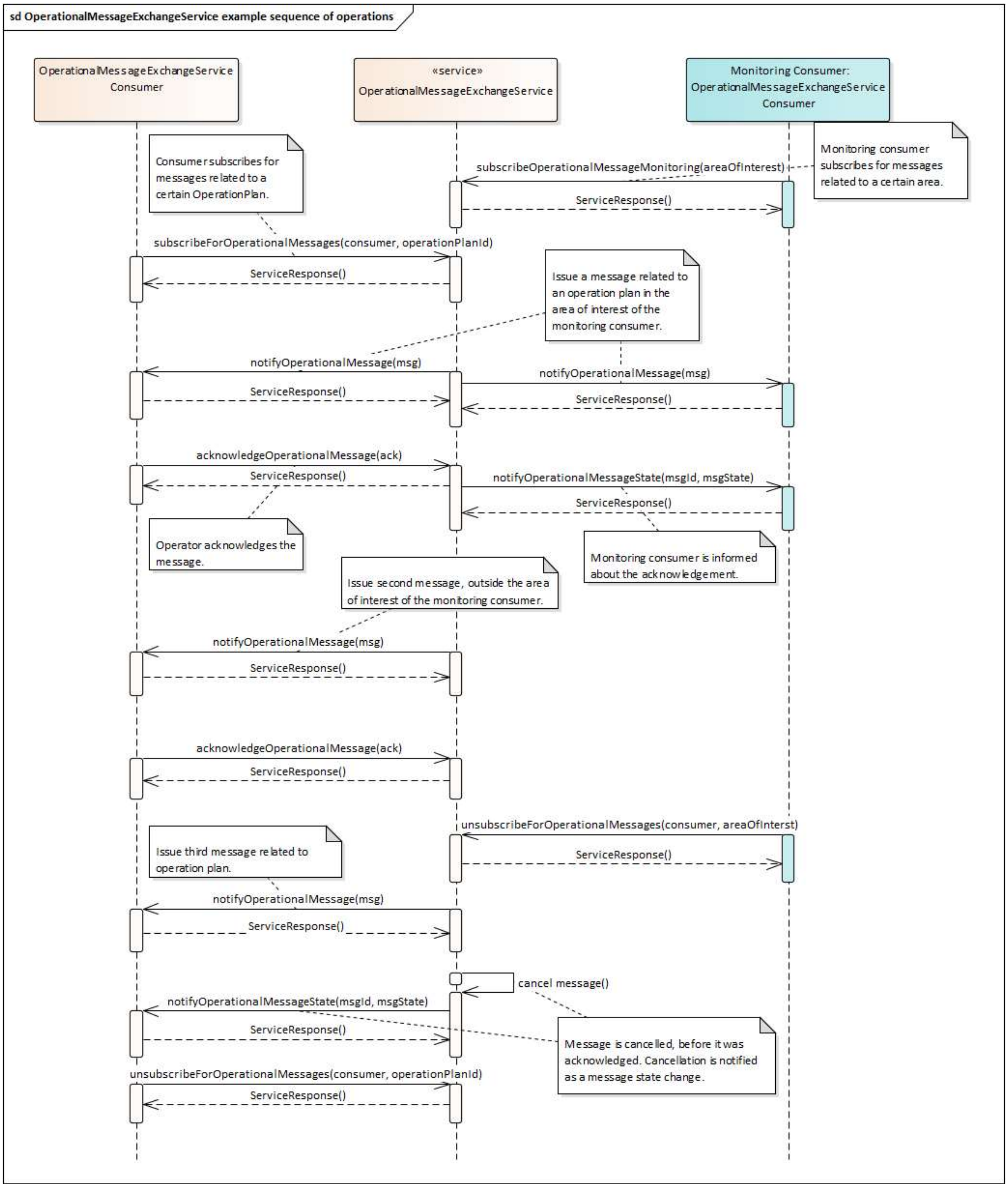


**Figure 3:** OperationalMessageExchange service operation sequence diagram

## 7.2 OperationalMessage State Machine

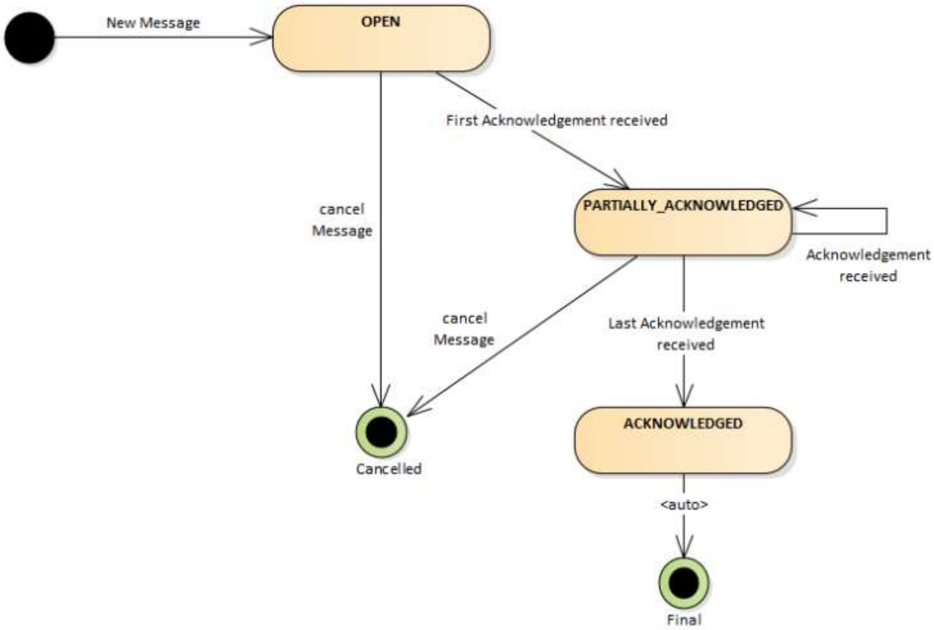


**Figure 4** OperationalMessage states - state transition diagram

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| [ICAO-SWIM] | Advanced Edition (unedited) | ICAO Doc 10039, Manual on System Wide Information Management (SWIM) Concept |
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**Tab. 22**: List of References

VERY LARGE-SCALE DEMONSTRATION

SESAR JOINT UNDERTAKING

# D2.4 Appendix F Traffic Conformance Monitoring Exchange Service Specification

| | |
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# Authoring & Approval

## Authors of the document

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Gregor Mogeritsch / Frequentis | WP2 | 26.10.2022 |
| Hubert Künig / Frequentis | WP2 | 26.10.2022 |
| Peter Cornelius / Frequentis | WP2 | 26.10.2022 |
| Thomas Lutz / Frequentis | WP2 Lead | 26.10.2022 |

## Reviewers internal to the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Jonas Stjernberg / Robots Expert | WP3 Lead | 1.11.2022 |
| Maria Tamm / EANS | Project coordinator | 3.11.2022 |
| Tanel Järvet / CAFA | WP4 Lead | 3.11.2022 |
| Damian Soliwoda / PSNC | WP2 member | 2.11.2022 |
| Lukasz Gorny-Zajac / DRR | WP2 member | 2.11.2022 |
| Parmentier Remy / VAI | WP2 member | 2.11.2022 |
| Pawel Korzec / DRR | WP2 member | 2.11.2022 |
| Piotr Dybiec / DRR | WP2 member | 2.11.2022 |
| Piotr Luboński / PSNC | WP2 member | 31.10.2022 |
| Piotr Szymaniak / PSNC | WP2 member | 31.10.2022 |
| Sven Jürgenson / Threod | WP3 member | 3.11.2022 |
| Leopoldo Tejada/UML | WP2 member | 2.11.2022 |
| Thomas Wana / DIME | WP2 member | 31.10.2022 |
| Yuhang Yun / EHANG | WP3 member | 30.10.2022 |
| Iris Röhrich / FRQ | WP1 member | 3.11.2022 |

## Approved for submission to the SJU By - Representatives of beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Sami Alkula/FANS | Project Management Group | 3.11.2022 |
| Thomas Neubauer/DIME | Project Management Group | 3.11.2022 |
| Pawel Korzec/DRR | Project Management Group | 3.11.2022 |
| Yuhang Yun/EHE | Project Management Group | 3.11.2022 |
| Damini Gera/AIRB | Project Management Group | 3.11.2022 |
| Piotr Szymaniak/PSNC | Project Management Group | 3.11.2022 |
| Sven Jürgenson/THREOD | Project Management Group | 3.11.2022 |



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| | | |
|---|---|---|
| Leopoldo Tejada/UML | Project Management Group | 3.11.2022 |
| Tapio Haarlaa/VAI | Project Management Group | 3.11.2022 |
| Iris Röhrich/FRQ | Project Management Group | 3.11.2022 |
| Juha Lindstedt/AVIA | Project Management Group | 3.11.2022 |
| Piotr Bratek/PANSA | Project Management Group | 3.11.2022 |
| Tanel Järvet/CAFA | Project Management Group | 3.11.2022 |
| Maria Tamm/EANS | Project Management Group | 3.11.2022 |

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# GOF2.0

## GOF2.0 INTEGRATED URBAN AIRSPACE VLD

This Updated Service Specification is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 101017689 under European Union's Horizon 2020 research and innovation programme.

**Figure 1**

## Abstract

This specification introduces a service of a Common Information Service (CIS) which ensures interoperability and hence transparent and reliable information flow between the stakeholders in an operational U-space environment. In accordance with ICAO SWIM, represents an Information Exchange Service.

This document describes one of these Bridge Services, the Traffic Conformance Monitoring Exchange service in a logical, technology-independent manner.

# Table of Contents

# 1 Introduction

## 1.1 Purpose of the document

Based on the guidelines given in [GOF1-Arch-AppA], this document describes the TrafficConformanceMonitoring exchange service of a Common Information Service (CIS) in a logical technology-independent manner, that is:

- operational and business context of the service
  - requirements for the service, e.g. information exchange requirements
  - involved nodes: which operational components provide/consume the service
  - operational activities supported by the service
  - relation of the service to other services
- service description
  - service interface definitions
  - service interface operations
  - service payload definition
  - service dynamic behaviour description
- service provision and validation aspects

In addition, this document clearly defines the version of the service.

## 1.2 Scope

This document describes the TrafficConformanceMonitoring Exchange service for a CIS.

The TrafficConformanceMonitoring service provides a means for the operational nodes of the U-space to exchange conformance-related target information and make it available for further processing.

## 1.3 Target Group

This service specification is written for:

- service architects,
- system engineers and
- developers in charge of designing and developing an instance of the TrafficConformanceMonitoring service.

In addition, this service specification is written for:

- enterprise architects,
- service architects,
- information architects,
- system engineers and developers in pursuing architecting, design and development activities of other related services.

## 1.4 Background

### 1.4.1 EUROCONTROL Specification for Monitoring Aids (MONA)

EUROCONTROL MONA [EC-MONA] defines conformance monitoring as follows.

***"2.2. Conformance Monitoring***

***The conformance monitoring function compares the system tracks with the corresponding flight clearances in order to warn the controller of any deviation of a flight from its clearance and, where possible, to establish the progress of the flight and to refine the prediction of the remaining trajectory to be flown.***

***Conformance is monitored in three dimensions, though the monitoring performed varies according to the type of clearance issued. In principle, warnings of deviation are generated in cases where the controller might be required to act to re-clear an aircraft that is assumed to be deviating from its clearance or to re-coordinate an aircraft whose boundary estimate changes significantly.***

***The [TP-SPEC] defines a planned trajectory and a tactical trajectory. Where possible, the system recalculates the trajectories that are active for a flight according to the actual behaviour of the aircraft, as described below.***

***..."***

### 1.4.2 EUROCONTROL Safety Nets, A Guide for Ensuring Effectiveness

To ATM automation systems, EUROCONTROL applies such conformance monitoring aids in the form of so-called ground-based safety nets which have been shown to very significantly improve ATM safety [EC-SN-Guide]:

***"What are safety nets?***

***Even the safest systems fail. Safety nets help prevent imminent or actual hazardous situations from developing into major incidents or even accidents. In doing so, they provide additional safety barriers in the overall system. In addition, they help keep the societal outcome of aviation operations within acceptable limits.***

***In Professor James Reason's Swiss Cheese Model, safety nets are the last system safety defences against accidents. They are intended to provide timely alerts to air traffic controllers or pilots of an increased risk to flight safety. As the impact of accidents in aviation is high, multiple system safety defences are provided, including redundant safety nets.***

***Safety nets are either ground-based or airborne:***

***Ground-based safety nets are an integral part of the ATM system. Primarily using ATS surveillance data, they provide warning times of up to two minutes. Upon receiving an alert, air traffic controllers are expected to immediately assess the situation and take appropriate action.***



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***Airborne safety nets provide alerts and resolution advisories directly to the pilots. Warning times are generally shorter, up to about 40 seconds. Pilots are expected to immediately take appropriate avoiding action.***

***Airborne safety nets are covered only in terms of their interactions with ground systems. ..."***

***"... Safety nets are there to provide an additional safety margin on top of the inherently safe provision of ATS and aviation operations. They have been demonstrated to deliver additional risk reduction of up to a factor of ten if implemented and operated appropriately. ..."***

### 1.4.3 EUROCONTROL Concept of Operations for U-space (CORUS)

EUROCONTROL CORUS [CORUS] Vol. 2 elaborates in 5.1.6.1 Monitoring service as follows.

***"5.1.6.1 Monitoring service***

***Subject to appropriate data-quality requirements, this service retrieves data from the tracking service and combines it with information related to non-cooperative obstacles and vehicles to provide an air situation status report for authorities, service providers, and operators, including pilots. This service may include operation plan*** *conformance monitoring*, ***geo-fence compliance monitoring and warnings (see 5.1.2.2), weather limit compliance monitoring, ground risk compliance monitoring, electromagnetic risk monitoring. The geo-fence compliance monitoring and warnings constitute U-space providing Geo-Awareness.***

***..."***

### 1.4.4 International Civil Aviation Organization (ICAO)

ICAO Doc 10039 [ICAO-SWIM] elaborates in section **3.4 INFORMATION EXCHANGE SERVICES** on information exchange services as follow (para. 3.4.2).

***"Within the SWIM Global Interoperability Framework, the Information Exchange layer is instantiated by 'information services' as is further explained. Information services*** **ensure interoperability** ***between ATM applications which consume and*** **provide interoperable information services*****. Consequently, the concept of information service is a fundamental building block of SWIM which enables interoperability through well-defined information exchanges."***

### 1.4.5 Open Drone ID

Open Drone ID is a project to provide a low cost and reliable "beacon" capability for drones so that they can be identified when within range of a receiver. Open Drone ID receives support from large companies such as Intel.

The Open Drone ID Message Specification [INTEL-ODID] proposes a Location Message in both, a byte and a JSON representation, which permits the transport of:

- a position in three space dimensions,

- a velocity, and
- a data age.

The Open Drone ID Message Specification furthermore proposes messages to convey information about:

- the type of drone,
- its in-flight status, and
- the location of the drone operator.

### 1.4.6 SESAR-JU

The European Commission identifies an increasing demand for a non-segregated use of airspace which is being driven by a rapidly growing market of EVery-Low-Level (VLL) airspace users, most of which are expected to be drones.

Via the Roadmap for the safe integration of drones into all classes of airspace [EATMP-Drone], within the European ATM Masterplan [EATMP], the European Commission seeks to ensure that this rapid growth of airspace use happens in a safe and controlled manner.

SESAR develops the required concepts and demonstrations for this process to happen. The roadmap [EATMP-Drone], in alignment with ICAO recommendations, identifies three phases for the integration, from which SESAR derives the four U-space service blocks presented in the U-space blueprint [UspaceBlueprint],

U1 U-space foundation services,

U2 U-space initial services,

U3 U-space advanced services, and

U4 U-space full services.

These stages reflect the anticipated quick growth of demand for U-space services. The state of the art has been, and is being, validated throughout Europe via several Very Large Demonstrator (VLD) projects such as the GOF USPACE project.

During the U1 phases, SESAR expects drones capable to supply their position via telemetry. The U1 and U2 blocks are anticipated to provide tracking capabilities and services.

### 1.4.7 Efficient, Safe and Sustainable Traffic at Sea (EfficienSea2)

The design method and terminology builds on experience from the EfficienSea2 project [EfficienSea2], [IALA-ENAV].

## 1.5 Glossary of Terms

| Term | Definition |
|---|---|
| AIR-REPORT | Report from an aircraft in flight prepared in conformity with requirements for position, and operational and/or meteorological reporting |

| | |
|---|---|
| **External Data Model** | Describes the semantics of the domain (or a significant part thereof) by defining data structures and their relations. This could be at logical level (e.g., in UML) or at physical level (e.g., in XSD schema definitions), as for example standard data models. |
| **Message Exchange Pattern** | Describes the principles how two different parts of a message passing system (in our case: the service provider and the service consumer) interact and communicate with each other. Examples:<br><br>In the Request/Response MEP, the service consumer sends a request to the service provider in order to obtain certain information; the service provider provides the requested information in a dedicated response.<br><br>In the Publish/Subscribe MEP, the service consumer establishes a subscription with the service provider in order to obtain certain information; the service provider publishes information (either in regular intervals or upon change) to all subscribed service consumers. |
| **Operational Activity** | Activity performed by an operational node. Examples of operational activities are: Route Planning, Route Optimization, Logistics, Safety, Weather Forecast Provision, … |
| **Operational Model** | Structure of operational nodes and associated operational activities and their inter-relations in a process model. |
| **Operational Node** | Logical entity that performs activities. Note: nodes are specified independently of any physical realisation.<br><br>Examples of operational nodes are: Control Center, Authority, Weather Information Provider, … |
| **Service** | Provision of something (a non-physical object), by one, for the use of one or more others, regulated by formal definitions and mutual agreements. Services involve interactions between providers and consumers, which may be performed in a digital form (data exchanges) or through voice communication or written processes and procedures. |
| **Service Consumer** | Service consumer uses service instances provided by service providers. |
| **Service Data Model** | Formal description of one dedicated service at logical level. The service data model is part of the service specification. Is typically defined in UML and/or XSD.<br>If an external data model exists (e.g., a standard data model), then the service data model shall refer to it: each data item of the service data model shall be mapped to a data item defined in the external data model. |
| **Service Design Description** | Specifies the details of a service technical design (most likely documented by the service implementer). The service design description includes (but is not limited to) a service physical data model and describes the used technology, transport mechanism, quality of service, etc. |



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| | |
|---|---|
| **Service Implementation** | Provider-side implementation of a dedicated service technical design, i.e. implementation of a dedicated service in a dedicated technology |
| **Service Implementer** | Implementers of services from the service provider side and/or the service consumer side |
| **Service Instance** | One service implementation can be deployed at several places by same or different service providers; each such deployment represents a different service instance, being accessible via different URLs. |
| **Service Instance Description** | Documents the details of a service implementation (most likely documented by the service implementer) and deployment (most likely documented by the service provider). The service instance description includes (but is not limited to) service technical design reference, service provider reference, service access information, service coverage information, etc. |
| **Service Interface** | Communication mechanism of the service, i.e. interaction mechanism between service provider and service consumer. A service interface is characterised by a message exchange pattern and consists of service operations that are either allocated to the provider or the consumer of the service. |
| **Service Operation** | Functions or procedure which enables programmatic communication with a service via a service interface. |
| **Service Physical Data Model** | Describes the realisation of a dedicated service data model in a dedicated technology. This includes a detailed description of the data payload to be exchanged using the chosen technology. The actual format of the service physical data model depends on the chosen technology. Examples may be WSDL and XSD files (e.g., for SOAP services) or swagger (Open API) specifications (e.g., for REST services). If an external data model exists (e.g., a standard data model), then the service physical data model shall refer to it: each data item of the service physical data model shall be mapped to a data item defined in the external data model.<br><br>In order to prove correct implementation of the service specification, there shall exist a mapping between the service physical data model and the service data model. This means, each data item used in the service physical data model shall be mapped to a corresponding data item of the service data model. (In case of existing mappings to a common external (standard) data model from both the service data model and the service physical data model, such a mapping is implicitly given.) |
| **Service Provider** | A service provider gives instances of services according to a service specification and service instance description. All users within the domain can be service providers, e.g., authorities, organizations (e.g., meteorological), commercial service providers, etc. |
| **Service Specification** | Describes one specific service at logical level. The Service Specification is technology-agnostic. The Service Specification includes (but is not limited to) a description of the Service Interfaces and Service Operations with their data |

| | |
|---|---|
| | payload. The data payload description may be formally defined by a Service Data Model. |
| **Service Specification Producer** | Producers of service specifications in accordance with the service documentation guidelines. |
| **Service Technical Design** | Technical design of a dedicated service in a dedicated technology. One service specification may result in several technical service designs, realising the service with different or same technologies. |
| **Service Technology Catalogue** | List and specifications of allowed technologies for service implementations. Currently, SOAP and REST are envisaged to be allowed service technologies. The service technology catalogue shall describe in detail the allowed service profiles, e.g., by listing communication standards, security standards, stacks, bindings, etc. |
| **Spatial Exclusiveness** | A service specification is characterised as "spatially exclusive", if in any geographical region only one service instance of that specification is allowed to be registered per technology.<br><br>The decision, which service instance (out of a number of available spatially exclusive services) shall be registered for a certain geographical region, is a governance issue. |

**Table 1:** Glossary of Terms

## 1.6 List of Acronyms

| Acronym | Definition |
|---|---|
| API | Application Programming Interface |
| CIS | Common Information Services |
| MEP | Message Exchange Pattern |
| NAF | NATO Architectural Framework |
| REST | Representational State Transfer |
| SOA | Service Oriented Architecture |
| SOAP | Simple Object Access Protocol |
| SSD | Service Specification Document |
| UML | Unified Modelling Language |
| URL | Uniform Resource Locator |
| WSDL | Web Service Definition Language |

| | |
|---|---|
| XML | Extendible Mark-up Language |
| **XSD** | XML Schema Definition |

**Table 2:** List of Acronyms



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# 2 Service Identification

This chapter gives a unique identification of the service and describes where the service is in terms of the engineering lifecycle.

| Name | TrafficConformanceMonitoring Exchange Service |
|---|---|
| ID | urn:frequentis:services:TrafficConformanceMonitoringExchangeService |
| Version | 1.0 |
| Description | A service which exchanges Traffic Conformance Monitoring warnings about tracks of objects such as aircraft (manned and unmanned) |
| Keywords | TrafficConformanceMonitoring Service, U-space Tracking, Warning, Alert |
| Architect(s) | 2021-today The Frequentis Group<br><br>2021-2022 The GOF2 U-Space Project Consortium |
| Status | Provisional |

**Table 3:** Service Identification

# 3 Operational Context

This section describes the context of the service from an operational perspective.

## 3.1 Functional and Non-functional Requirements

The table below lists applicable existing requirements for the **TrafficConformanceMonitoring Exchange** service.

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| **[R-1]** | Common Situational Awareness | At all times, all U-space participants shall operate on the same common set of data, during pre-flight planning stages as well as during all stages of flight operations. | CORUS [CORUS], 3.1.1.2 Z Volumes; B1-RPAS [ICAO-GANP];CEF-SESAR-2018-1 [GOF1-I-CFP], Objective O5 |
| **[R-2]** | Basis for Open Market | The U-space concept shall be designed such as to ensure a well-established line of authority while at the same time ensuring that an open market for VLL services may develop | SESAR Drone Roadmap [EATMP-Drone], Foreword, 4.1 and 4.2;U-space Blueprint [UspaceBlueprint], Benefits to European society and economy; CEF-SESAR-2018-1 [GOF1-I-CFP], Table 8 – Key Challenges |
| **[R-3]** | Interoperability | There shall be an implementation of a Flight Information Management System (FIMS) which ensures that, at all times, emerging unmanned traffic management systems and existing technologies from manned operations can exchange any data required to support such common situational awareness, be it for drone operations in areas where established ATC procedures apply, or in zones outside established ATC. | ICAO Doc 10039 [ICAO-SWIM];[R-2];CEF-SESAR-2018-1 [GOF1-I-CFP], Objective O6; CEF-SESAR-2018-1 [GOF1-I-CFP], Table 8 – Key Challenges<br><br>**Note: The term 'Flight Information Management System (FIMS)' in some of these references has been since replaced by 'Common Information Services (CIS)'. This text hence elsewhere refers to CIS, rather than FIMS.** |
| **[R-4]** | Standard Protocols | Standard communication protocols shall hence be used where available, and such standard protocols be developed | [R-2];SESAR Drone Roadmap [EATMP-Drone], 3.5, section 'Standards'; CEF-SESAR- |

| | | | |
|---|---|---|---|
| | | otherwise, in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop. | 2018-1 [GOF1-I-CFP], Table 8 – Key Challenges |
| **[R-5]** | Open Interfaces | Any interface and protocol hence must be openly defined and its definition be freely accessible in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop. | [R-2];CEF-SESAR-2018-1 [GOF1-I-CFP], Table 8 – Key Challenges |
| **[R-6]** | SWIM | The implementation of a Flight Information Management System (FIMS) shall be based on an ICAO SWIM-compliant architecture. | [R-3];CEF-SESAR-2018-1 [GOF1-I-CFP], 5.3.4 Overall approach and methodology<br><br>**Note: The term 'Flight Information Management System (FIMS)' used therein has been since replaced by 'Common Information Services (CIS)'. This text hence elsewhere refers to CIS, rather than FIMS.** |
| **[R-7]** | Latency | Under no operational circumstance, the processing of position data may add significant latency to the overall detection-to-display latency of position data. In particular,<br><br>The processing latency added by the processing of positional data shall never exceed 10 per cent of the maximum value of the corresponding value permitted for the entire ATM automation system.<br><br>The processing latency and delay added by the processing of positional data should not exceed 1 per cent of the maximum value of the corresponding value permitted for the entire ATM automation system.<br><br>The maximum value for latency and delay is the minimum of the | [FAA-SUR-PERF], tables in the Executive Summary, [EC-ATM-PERF], 3N_C-R8 and 5N_C-R8 |

| | | | |
|---|---|---|---|
| | | values defined by the ATM system performance requirements by EUROCONTOL and the FAA; for a 3 NM minimal separation, this is 2.2 s, for a 5 NM separation, 2.5 s. | |

**Table 4:** Requirements for the TrafficConformanceMonitoring Service

## 3.2 Other Constraints

### 3.2.1 Relevant Industrial Standards

#### 3.2.1.1 ICAO SWIM

The System Wide Information Management (SWIM, [ICAO-SWIM]) complements human-to-human with machine-to-machine communication, and improves data distribution and accessibility in terms of quality of the data exchanged. The SWIM Concept addresses the challenge of creating an "interoperability environment" which allows the SWIM IT systems to cope with the full complexity of operational information exchanges. The SWIM environment shifts the ATM information architecture paradigm from point-to-point data exchanges to system-wide interoperability.

#### 3.2.1.2 EUROCONTROL ASTERIX

The All-purpose structured EUROCONTROL surveillance information exchange (ASTERIX) [EC-ASTERIX] is a set of documents defining the low level ("down to the bit") implementation of a data format used for exchanging surveillance-related information and other ATM applications.

EUROCONTROL-SPEC-0149-9 - EUROCONTROL Specification for Surveillance Data Exchange ASTERIX Part 9 Category 062 SDPS Track Messages

EUROCONTROL-SPEC-0149-12 - EUROCONTROL Specification for Surveillance Data Exchange ASTERIX Part 12 Category 21 ADS-B Target Reports

EUROCONTROL-SPEC-0149-14 - EUROCONTROL Specification for Surveillance Data Exchange ASTERIX Part 14 Category 20 Multilateration Target Reports

EUROCONTROL-SPEC-0149-17 - EUROCONTROL Specification for Surveillance Data Exchange ASTERIX Part 17 Category 004 Safety Net Messages

EUROCONTROL-SPEC-0149-28 - EUROCONTROL Specification for Surveillance Data Exchange – ASTERIX Part 28 - Category 015: INCS System Target Reports

EUROCONTROL-SPEC-0149-29 - EUROCONTROL Specification for Surveillance Data Exchange – ASTERIX Part 29 - Category 129: UAS Identification Reports

EUROCONTROL-SPEC-0149-30 - EUROCONTROL Specification for Surveillance Data Exchange – ASTERIX Part 30 - Category 016: Independent Non-Cooperative Surveillance System Configuration Reports

EUROCONTROL-SPEC-0149-31 - EUROCONTROL Specification for Surveillance Data Exchange – ASTERIX Part 31 - Category 205: Radio Direction Finder Reports

#### 3.2.1.3 EUROCONTROL ATM Automation System Environment Performance Requirements

EUROCONTROL defines clear operational requirements and an elaborated assessment methodology for European surveillance in its Specification for ATM Surveillance System Performance [EC-ATM-PERF]. For instance, for a separation of 3 nautical miles:

| Req. # | Quality of Service | Mandatory Performance |
|---|---|---|
| 3N_C-R8 | Forwarded pressure altitude average data age (see Note 7 in § 3.4.5) | Less than or equal to 2.5 seconds |

Table 5: **Excerpt from EUROCONTROL Specification for ATM Surveillance System Performance [EC-ATM-PERF]**

**INFO** More requirements for update rates and error margins apply.

#### 3.2.1.4 FAA ATM Automation System Environment Performance Requirements

In a similar fashion, the Federal Aviation Administration concludes that the time from the determination of a position (measurement) to display (latency of the ATM system) shall not exceed similar values [FAA-SUR-PERF]:

| Latency | 2.2 seconds to display maximum |
|---|---|

The FAA also applies further requirements for update rates and error margins.

#### 3.2.1.5 EUROCONTROL Safety Nets, A Guide for Ensuring Effectiveness

**TrafficConformanceMonitoring** with safety nets constitutes the ultimate safety layer with very short timescales remaining to prevent the occurrence of a serious situation [EC-SN-Guide]:

***"Safety nets are either ground-based or airborne:***

***Ground-based safety nets are an integral part of the ATM system. Primarily using ATS surveillance data, they provide warning times of up to two minutes. Upon receiving an alert, air traffic controllers are expected to immediately assess the situation and take appropriate action.***

***Airborne safety nets provide alerts and resolution advisories directly to the pilots. Warning times are generally shorter, up to about 40 seconds. Pilots are expected to immediately take appropriate avoiding action. ..."***

### 3.2.2 Operational Nodes

A typical U-space flight goes through several stages, starting strategic-tactically, pre-flight, from Strategic Planning, over to Pre-Tactical Planning, to Tactical Planning. Then, tactical-operationally it enters into the actual in-flight stages from Departure, over to In-Flight, and, finally Arrival. Further post-flight stages may evaluate the results from the data produced during the prior stages.

The **TrafficConformanceMonitoring** service primarily is relevant during the actual operational in-flight stages of a U-space flight during which the flying device and/or the corresponding ground stations produce the position data which we convey via the Traffic/Telemetry exchange service.

The operational **TrafficConformanceMonitoring** service consumes position information provided by the authoritative Tracking service of the area of its responsibility.

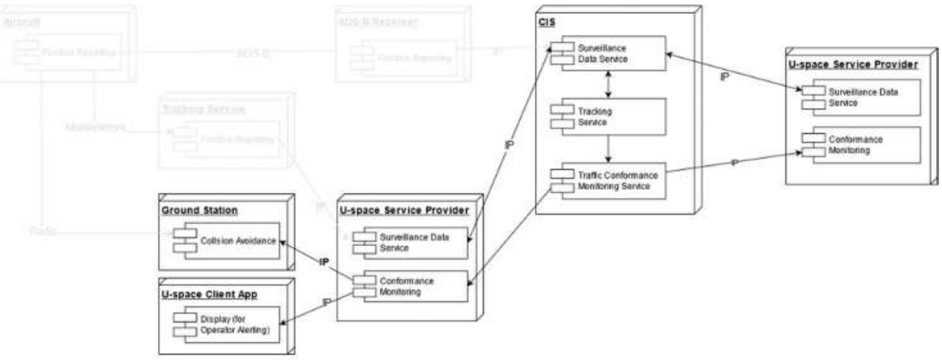


**Figure 2: U-space Nodes Related to the TrafficConformanceMonitoring Service**

Typically, consuming services and applications will utilize the service together with other services like:

- Tracking Services - for reliable, timely traffic information in the area of interest for a reliable situational awareness
- Registration Services - for background on e.g. operator, pilot and flown device
- Geofencing Services – to draw a user's attention to a potential area conflict and to act accordingly, possibly even automatically

Consuming services and applications include the following services and applications:

- Tactical Deconfliction Service
- Traffic Alerting Service, including
    - at an operator's U-space client U-space display for operator alerting, or
    - at an operators ground station, triggering tactical collision avoidance
- Displays for Situational Overview
- Accident and Incident Reporting Services
- Legal Recording Service

Operational nodes which can provide data for the Traffic Conformance Monitoring service include the following ones:

| Operational Node | Remarks |
|---|---|
| Tracking Server | Single Source of Truth for the area of responsibility of the Tracking and the **TrafficConformanceMonitoring** services |

**Table 6:** Operational Nodes Providing to the TrafficConformanceMonitoring Service

Operational nodes which may consume the Traffic Conformance Monitoring service include the following ones.

| Operational Node | Remarks |
|---|---|
| **Common Information Service** | |
| Information Display | |
| Telemetry Converter | |
| Legal Recorder | |

**Table 7:** Operational Nodes Consuming the TrafficConformanceMonitoring Service

### 3.2.3 Operational Activities

Operational activities supported by the Traffic Conformance Monitoring service include the following ones.

| Phase | Operational Activity | Remarks |
|---|---|---|
| Pre-flight | **Set-up** | **(Telemetry input likely not operational yet at this stage)** |
| | **Plan** | **(Telemetry input likely not operational yet at this stage)** |
| | Arm | **(Traffic/telemetry input should start to run here)** |
| In-Flight | Depart | With the availability of Tracking information of the flight, Traffic Conformance Monitoring starts now |
| | Cruise | Traffic Conformance Monitoring operational for the flight |
| | Arrive | Traffic Conformance Monitoring operational for the flight |
| Post-Flight | Disarm | **(Traffic/telemetry likely stops here, so the Traffic Conformance Monitoring for the flight ceases now)** |
| | Report | **(Post/flight analysis only)** |

**Table 8:** Operational Activities Supported by the TrafficConformanceMonitoring Service



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## 3.3 Service Interfaces

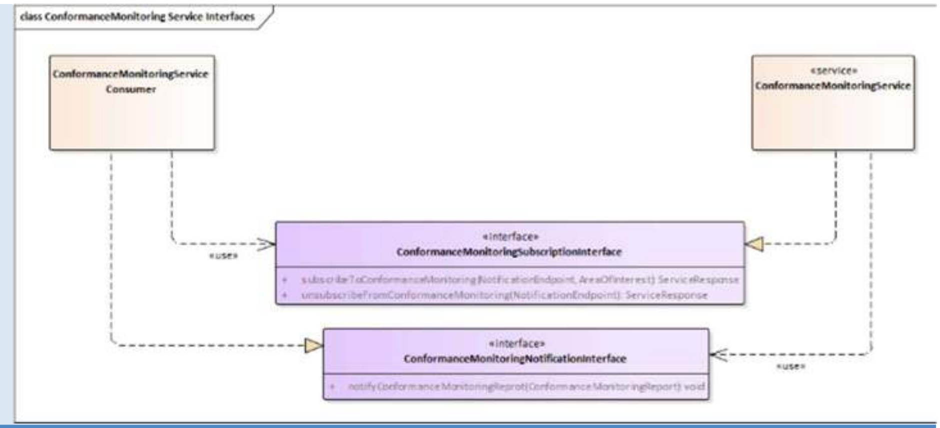


**Figure 3:** TrafficConformanceMonitoring Exchange Interface Definition Diagram

| Service Interface | Role (from service provider point of view) | Service Operation |
|---|---|---|
| **TrafficConformanceMonitoringSubscriptionInterface** | Provided | **subscribeToTrafficConformanceMonitoring**<br><br>**unSubscribeFromTrafficConformanceMonitoring** |
| **TrafficConformanceMonitoringNotificationInterface** | Required | **notifyTrafficConformanceMonitoringReport** |

**Table 9:** Service Interfaces

# 4 Service Data Model

This section describes the information model, i.e., the logical data structures that are exchanged between providers and consumers of the service.

## 4.1 Overview

The Traffic Conformance Monitoring exchange service provides its consumers with TrafficConformanceMonitoringReports. A TrafficConformanceMonitoringReport is one of

- TrafficNonConformanceMonitoringReport, or
- TrafficConformanceMonitoringStatusReport.

A TrafficNonConformanceMonitoringReport informs about a conflict situation reports of conflict situations of one or more **TrafficConformanceMonitoringObject**s. It gives information about the involved objects, characteristics of the conflict, and time and spatial separation.

It is mandatory to provide at least one TrafficConformanceMonitoringObject as the originatingObject data item in each **TrafficNonConformanceMonitoringReport.**Additional TrafficConformanceMonitoringObjects may be added as relatedObjects, if available.

Each **TrafficConformanceMonitoringObject** must include at least one **ObjectIdentifiation** data item which refers to a TRACK. Data sources should report all further **ObjectIdentification** data items they have information about. In fact, this specification relies on it as means to convey essential information.

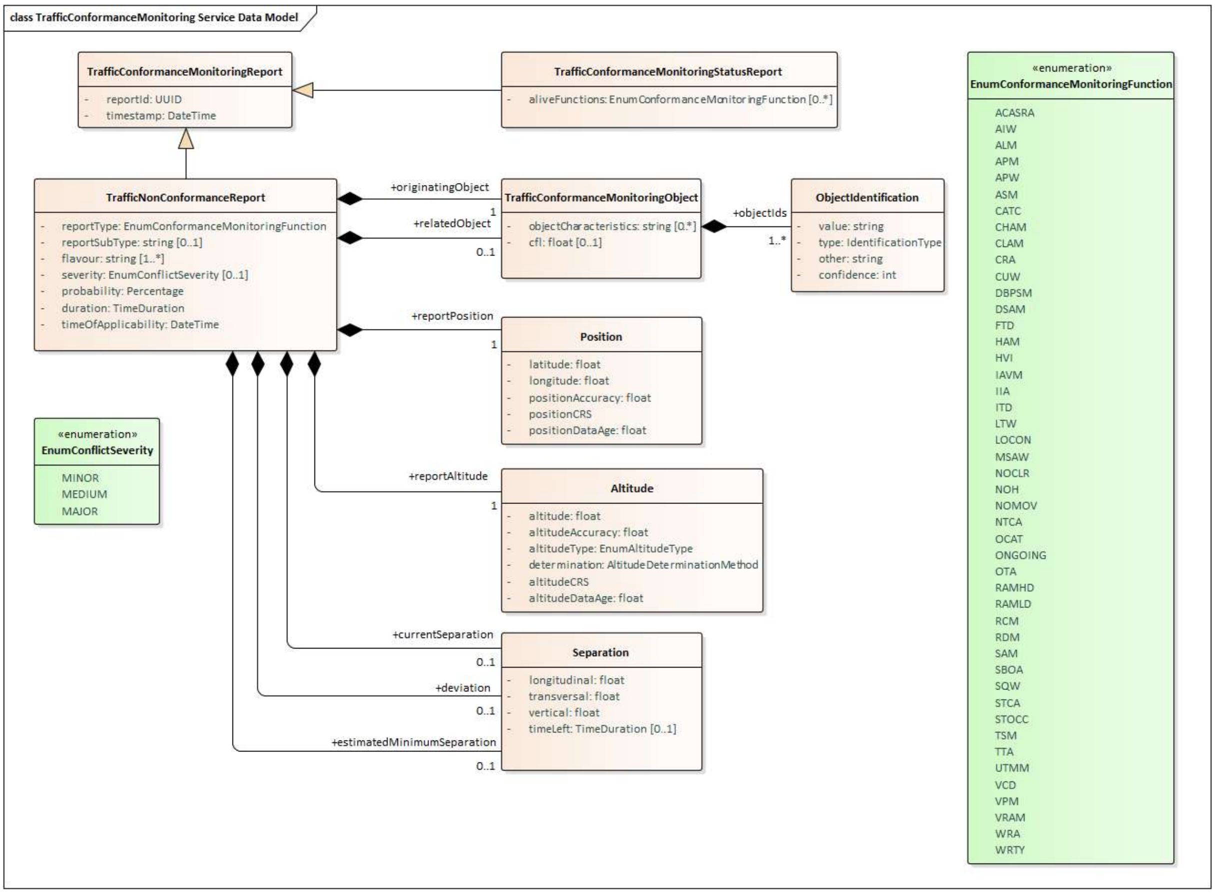


**Figure 4: TrafficConformanceMonitoringReport Data Model Diagram of the Traffic Conformance Monitoring Exchange Service**

## 4.1 TrafficConformanceMonitoringReport Data Structure

The **TrafficConformanceMonitoringReport** data structure is the base report structure being distributed to subscribed service consumers.
Its properties are inherited by both specific report structures TrafficNonConformanceReport and TrafficConformanceMonitoringStatusReport.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| reportId | UUID | 1 | Globally unique identifier of the report. | |
| timestamp | DateTime | 1 | Timestamp of when the report was sent. | |

Tab.: TrafficConformanceMonitoringReport Data Structure

## 4.2 TrafficNonConformanceReport Data Structure

The **TrafficNonConformanceReport** data structure carries the data describing a traffic non-conformance situation.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| originatingObject | TrafficConformanceMonitoringObject | 1 | The TrafficConformanceMonitoringObject structure holds the object originating the Traffic Conformance Monitoring report. | |
| relatedObject | TrafficConformanceMonitoringObject | 0..* | The TrafficConformanceMonitoringObject structure holds an object involved in the Traffic Conformance Monitoring report. | This can be another aircraft but also an area, or other. |
| reportPosition | Position | 1 | The Position structure holds the anticipated or actual position of the issue conveyed with this Traffic Conformance Monitoring report. | |
| reportAltitude | Altitude | 1 | The corresponding Altitude structure holds the altitude of the issue conveyed with this Traffic Conformance Monitoring report. | |
| currentSeparation | Separation | 1 | The Separation structure holds the current separation from the conflict, plus the estimated time left until the conflict. | |
| estimatedMinimumSeparation | Separation | 1 | The Separation structure holds the estimated minimum separation, plus the estimated time left until the minimum separation occurs. | |

| | | | | |
|---|---|---|---|---|
| deviation | Separation | 1 | The Separation structure holds the current deviation from the agreed operation plan. | |
| reportType | EnumConformanceMonitoringFunction | 1 | The type of non-conformance carried inthe report. | |
| reportSubType | String | 0..1 | If required, the subtype of the report may be set as follows.<br><br>For reportType = RIMCAS alerts, one of: RRC Runway/Runway crossing RTC Runway/Taxiway crossing RAS1 Alert stage one RAS2 Alert stage two<br><br>For reportType = UTMM, one of: WrongDirection Object travelling in direction it is not cleared to travel WrongTaxiway Object on wrong taxiway Speeding Object travelling faster than permitted<br><br>For reportType = MSAW: MRVA Minimum radar vector altitude alert<br><br>For reportType = VRAM, one of: CRM Cleared rate monitor alert VRM Vertical rate monitor alert VTM Vertical tracker monitor alert FastClimb Object climbing fast SlowClimb Object climbing slowly | |





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| | | | | |
|---|---|---|---|---|
| | | | FastDescent Object descending fast<br>SlowDescent Object descending slowly<br><br>For reportType = HAM, one of:<br>HD Heading deviation alert<br>RD Rate deviation alert<br>VD Vertical deviation alert<br>FastClimb Object climbing fast<br>SlowClimb Object climbing slowly<br>FastDescent Object descending fast<br>SlowDescent Object descending slowly<br>Above Object above cleared level<br>Below Object below cleared level<br><br>For reportType = DBPSM, one of:<br>ARR Alert upon arrival<br>DEP Alert upon departure<br>TL Alert above transition level<br><br>For reportType = AIW:<br>pAIW AIW relies on primary surveillance only<br><br>For reportType = STCA, one of:<br>LPF Linear Prediction Filter set<br>CPF Current Proximity Filter set<br>MHF Maneouvere Hazard Filter set<br><br>For reportType = DSAM, one of:<br>EarlyVManeouvre Vertical maneouvre of object | |

| | | | |
|---|---|---|---|
| | | | comes early LateVManeouvre Vertical maneouvre of object comes late<br><br>For reportType = FTD, ITD and IIA, one of: (Real number) Separation value in m MRS1 Minimum radar separation on arrival (single RWY) ROT1 Separation based on runway separation occupancy time (single RWY) GAP1 Separation based on manually entered ATCO gap (single RWY) MRS2 Minimum radar separation on arrival (parallel RWY) ROT2 Separation based on runway separation occupancy time (parallel RWY) GAP2 Separation based on manually entered ATCO gap (parallel RWY)<br><br>For reportType = CATC, one of:<br>LineUpVsLineUp Line-Up vs. Line-Up LineUpVsCrossEnter Line-Up vs. Cross or Enter LineUpVsTakeoff Line-Up vs. Takeoff LineUpVsLanding Line-Up vs. Landing CrossEnterVsLineUp Cross or Enter vs. Line-Up CrossEnterVsCrossEnter Cross or Enter vs. Cross or Enter CrossEnterVsTakeoff Cross or Enter vs. Takeoff CrossEnterVsLanding Cross or Enter vs. Landing TakeoffVsLineUp Ta |

| | | | | |
|---|---|---|---|---|
| | | | ke-Off vs. Line-Up TakeoffVsCrossEnter Take-Off vs. Cross or Enter TakeoffVsTakeoff Take-Off vs. Takeoff TakeoffVsLanding Take-Off vs. Landing LandingVsLineUp Landing vs. Line-Up LandingVsCrossEnter Landing vs. Cross or Enter LandingVsTakeoff Landing vs. Takeoff LandingVsLanding Landing vs. Landing PushBackVsPushBack Push-back vs. Push-back PushBackVsTaxi Push-back vs. Taxi TaxiVsPushBack Taxi vs. Push-back TaxiVsTaxi Taxi vs. Taxi<br><br>For reportType = NOCLR, one of: NoPushBackClearance Object moving without clearance to push back NoTaxiClearance Object on taxiway without clearance NoLineUpClearance Object lining up without clearance NoCrossingClearance Object crossing runway without clearance NoEnterClearance Object entering runway without clearance NoTakeoffClearance Object taking off without clearance NoLandingClearance Object Landing without clearance<br><br>For reportType = NOMOV, one of: | |

| | | | | |
|---|---|---|---|---|
| | | | AfterPushBackClearance Object stationary despite push-back clearance<br>AfterTaxiClearance Object stationary despite taxi clearance<br>AfterLineUpClearance Object lining up too late<br>AfterCrossingClearance Object crossing runway too clearance<br>AfterEnterClearance Object entering runway too late<br>AfterTakeoffClearance Object too late for take-off<br>StationaryOnRWY Object stationary on runway<br>StationaryOnTWY Object stationary on taxiway<br><br>For reportType = NOH, one of:<br>NoContact No contact made, as seen from the receiving ATSU side<br>NoTransfer No transfer made, as seen from the leaving ATSU side | |
| flavour | String | 1..* | The flavour of the report, one or more of:<br><br>Military Conflict location in military airspace<br>Civil Conflict location in civil airspace<br>StateReserved Conflict location in reserved airspace<br>FastLateralDivergence Objects are fast diverging laterally at current time<br>FastVerticalDivergence Objects are fast diverging vertically at current time<br>Crossed Objects have crossed at starting time of conflict | |

| | | | | |
|---|---|---|---|---|
| | | | Diverging Objects diverging at starting time of conflict<br>Opposing Objects in opposing direction | |
| severity | EnumConflictSeverity | 0..1 | The severity assigned to the reported conflict. | |
| probability | Percentage | 1 | The probability of the reported situation to occur. Range: 0...100 | |
| duration | TimeDuration | 1 | The duration, in seconds, since the report is being raised. | |
| timeOfApplicability | DateTime | 1 | The time of applicability of this report | |
| ... | | | All properties inherited from TrafficConformanceMonitoringReport. | |

**Table 10:** TrafficNonConformanceReport Data Structure

## 4.3 TrafficConformanceMonitoringStatus Data Structure

The TrafficConformanceMonitoringStatusReport data structure carries the data describing the current status of the TrafficConformanceMonitoring service provider.

It is expected that such TrafficConformanceMonitoringStatusReports are published periodically over the same channel as non-conformance reports are published, so subscribed consumers get informed about active service provision.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| aliveFunctions | EnumConformanceMonitoringFunction | 0..1 | The list of currently provided monitoring functions. | |
| ... | | | All properties inherited from TrafficConformanceMonitoringReport. | |

Tab.: TrafficConformanceMonitoringStatusReport Data Structure

## 4.4 EnumConformanceMonitoringFunction Enumeration

The EnumConformanceMonitoringFunction enumeration type specifies the available monitoring functions .

| Property | Description | Note |
|---|---|---|
| ACASRA | ACAS Resolution Advisory | |
| AIW | Airspace Infringement Warning | |
| ALM | RIMCAS – Arrival / Landing Monitor | |
| APM | Approach Path Monitor | |
| APW | Area Proximity Warning | |
| ASM | RIMCAS – Arrival/Departure Aircraft Separation Monitor | |
| CATC | Conflicting ATC Clearances | |
| CHAM | Cleared Heading Adherence Monitor | |
| CLAM | Clearance Level Adherence Monitor | |
| CRA | RIMCAS – Arrival/Departure Close Runway Alert | |
| CUW | Catch-Up Warning | |
| DBPSM | Downlinked Barometric Pressure Setting Monitor | |
| DSAM | Downlinked Selected Altitude Monitor | |
| FTD | Final Target Distance Indicator | |
| HAM | Holding Adherence Monitor | |
| HVI | Holding Volume Infringement | |
| IAVM | RIMCAS – ILS Area Violation Monitor | |
| IIA | Wake Vortex Indicator Infringement Alert | |
| ITD | Initial Target Distance Indicator | |
| LTW | Lost Track Warning | |
| LOCON | Loss of Control warning | |
| MSAW | Minimum Safe Altitude Warning | |
| NOCLR | No ATC Clearance | |
| NOH | Aircraft Leaving/Entering Aerodrome Area without Handover | |
| NOMOV | Aircraft not moving despite ATC Clearance | |
| NTCA | Near Term Conflict Alert | |

| | | |
|---|---|---|
| OCAT | Outside Controlled Airspace Tool | |
| ONGOING | Ongoing Alert | |
| OTA | RIMCAS – Arrival / Departure Opposite Traffic Alert | |
| RAMHD | Route Adherence Monitor Heading Deviation | |
| RAMLD | Route Adherence Monitor Longitudinal Deviation | |
| RCM | RIMCAS – Runway / Taxiway Crossing Monitor | |
| RDM | RIMCAS – Departure Monitor | |
| SAM | Speed Adherence Monitor | |
| SBOA | RIMCAS – Stop Bar Overrun Alert | |
| SQW | Sequence Warning on Final Approach | |
| STCA | Short Term Conflict Alert | |
| STOCC | Stand Occupied | |
| TSM | RIMCAS – Taxiway Separation Monitor | |
| TTA | RIMCAS – Taxiway Traffic Alert | |
| UTMM | RIMCAS – Unauthorized Taxiway Movement Monitor | |
| VCD | Vertical Conflict Detection | |
| VPM | Vertical Path Monitor | |
| VRAM | Vertical Rate Adherence Monitor | |
| WRA | RIMCAS – Arrival / Departure Wrong Runway Alert | |
| WRTY | Wrong Runway or Taxiway Type | |

Tab.: EnumConformanceMonitoringFunction Enumeration

## 4.5 EnumConflictSeverity Enumeration

The EnumConflictSeverity enumeration type specifies levels of severity of a non-conformance.

| Property | Description | Note |
|---|---|---|
| MINOR | minor severity | |
| MEDIUM | medium severity | |
| MAJOR | major severity | |

Tab.: EnumConflictSeverity Enumeration

## 4.6 TrafficConformanceMonitoringObject Data Structure

The **TrafficConformanceMonitoringObject** data structure defines the structure which may carry the required information about an object involved with this Traffic Conformance Monitoring report.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **objectCharacteristics** | **String Array** | 0..* | Additional classification flags regarding this **TrafficConformanceMonitoringObject**, one or more of:<br><br>GAT Indicates General Air Traffic<br>OAT Indicates Operational Air Traffic<br>IFR Indicates Instrumental Flight Rules<br>VFR Indicates Visual Flight Rules<br>CVFR Indicates Controlled Visual Flight Rules<br>RVSM-OK Indicates approved RVSM operation<br>RVSM-NO Indicates exemption from RVSM<br>RVSM-EX Indicates NOT approved RVSM<br>HPR Indicates High Priority operation<br>CDM-UP Indicates climbing operation<br>CDM-DOWN Indicates descending operation<br>CDM-LEVEL Indicates operation maintaining flight level<br>GV Indicates a ground vehicle | The **objectCharacteristics** can be empty under some circumstances, or hold multiple entries.<br><br>This item is there primarily to ensure immediate forwarding of resolution advisories without delay of at least a minimum of information without delay.<br><br>Data originators shall make use of the **ObjectIdentification** structure to the most complete extent as possible but also should fill this item as appropriate. |
| **cfl** | **Real** | 0..1 | Cleared flight level | |

**Table 11:** TrafficConformanceMonitoringObject Data Structure

There shall be at least one **TrafficConformanceMonitoringObject** type **originatingObject** data structure provided for every **TrafficNonConformanceReport** which holds the information of the object originating the Traffic Conformance Monitoring report. The Position shall be set to the position of the expected report situation. In most cases, there will be a **TrafficConformanceMonitoringObject** type **relatedObject** data structure containing the corresponding information of the related object which may be, for instance, another aircraft, a restricted area, or a gate.

## 4.7 ObjectIdentification Data Structure

The **ObjectIdentification** data structure can carry data to assist in identifying the object we report about in this report. It can be a vehicle registration identifier, or any other identifier as listed in the **IdentificationType** property.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **object_identification_value** | **String** | 1 | The actual value of the identification of the object this report applies to, of type **object_identification_type.** | |
| **object_identification_type** | **IdentificationType** | 1 | Type of identification conveyed by this **ObjectIdentification** item, one of:<br><br>ICAO indicating an ICAO 24 bit address<br><br>CALLSIGN indicating an (ITU) call sign as designated by the country of registration<br><br>ETHER indicating an Ethernet address<br><br>Primary (primary surveillance)<br><br>Mode3A (secondary surveillance, 2D only, squawk)<br><br>Mode3AC (secondary surveillance, 3D, squawk)<br><br>ModeS (secondary surveillance, ICAO 24 bit address) | |

| | | | | |
|---|---|---|---|---|
| | | | Combined (combined primary/secondary surveillance)<br><br>ModeSES (dependent surveillance, ICAO 24 bit address)<br><br>VDL (dependent surveillance, ICAO 24 bit address)<br><br>UAT (dependent surveillance, ICAO 24 bit address)<br><br>MLAT (secondary surveillance, ICAO 24 bit address)<br><br>TRACK (combined surveillance, numeric track id)<br><br>TRACKID (combined surveillance, track uuid)<br><br>ALERT (surveillance , numeric alert id)<br><br>ALERTID (surveillanc e, alert uuid)<br><br>ADSC (dependent surveillance, ICAO 24 bit address)<br><br>FPL (dependent surveillance, squawk or no id)<br><br>GUFI (operation-id, i. e. the uuid of the operation)<br><br>FLARM (dependent surveillance, FLARM-ID)<br><br>IMEI (dependent surveillance, IMEI number) | |

| | | | | |
|---|---|---|---|---|
| | | | IMSI (dependent surveillance, IMSI number)<br><br>MMSI (dependent surveillance, MMSI number)<br><br>SERIAL (dependent surveillance, serial number of the vehicle as assigned by its manufacturer)<br><br>MAKER (dependent surveillance, three letters identifying the manufacturer of the vehicle)<br><br>MODEL (dependent surveillance, three letters identifying the model of the manufacturer of the vehicle)<br><br>COUNTRY (dependent surveillance, ISO 3166-1 Alpha 2 code of the country of registration of the vehicle)<br><br>AREA (name of an area)<br><br>AREAID (uuid of an area)<br><br>CROSS_AREA (name of a crossing area)<br><br>CROSS_AREAID (uuid of a crossing area)<br><br>GATE (designator of a gate)<br><br>GATEID (uuid of a gate) | |

| | | | | |
|---|---|---|---|---|
| | | | RWY (designator of a runway)<br><br>RWYID (uuid of a runway)<br><br>TWY (designator of a taxiway)<br><br>TWYID (uuid of a taxiway)<br><br>SECTOR (designator of a control sector)<br><br>SECTORID (uuid of a control sector)<br><br>STBAR (designator of a stop bar)<br><br>STBARID (uuid of a stop bar)<br><br>OTHER **discouraged**, referring to **object_identification_other** below | |
| **object_identification_other** | **String** | 0..1 | Optional empty item for temporary use until standardization is in place: Unless **object_identification_type** is set to "OTHER", do not set this field at all; however, if **object_identification_type** is set to "OTHER", set this field to a descriptive string for the type and set **object_identification_value** to the corresponding value.<br><br>**INFO** Use of this field is **discouraged** at any time and permitted for local bilateral temporary deviation of standard only | |

| | | | | |
|---|---|---|---|---|
| | | | until updated standardization is in place. | |
| **object_identification_confidence** | **Integer** | 0..1 | Optional item with a range from 0 to 100 representing the degree of confidence the emitter of this information has that the object we report about in this report actually can be identified by this particular **object_identification_value**. | |

**Table 12:** ObjectIdentification Data Structure

Data sources should report all **ObjectIdentification** data items they have data about.

There shall be at least one **ObjectIdentification** data structure present, carrying a data item of **object_identification_type=TRACK**. Data sources should provide as many **ObjectIdentification** data structures as they have data available for a given **TrafficConformanceMonitoringObject**.

## 4.8 The Position Data Structure

The **Position** data structure carries the position data of the object being reported about.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| latitude | Real | 1 | Latitude of position record in unit of measurement as defined by positionCrs | |
| longitude | Real | 1 | Longitude of position record in unit of measurement as defined by positionCrs | |
| positionAccuracy | Real | 1 | Accuracy of latitude and longitude in unit of measurement as defined by positionCrs | |
| positionCrs | Reference | 1 | Coordinate reference system | |

| | | | | |
|---|---|---|---|---|
| | | | used (e. g., for WGS-84, EPSG:4979) | |
| positionDataAge | Real | 0..1 | Elapsed time in s since last position data received by the reporter of this **Position** | This attribute shall be provided, if the Position is used in a reporting service (e.g., in a PositionReport); in other cases this attribute may be omitted (e.g., in conversion operations). |

**Table 13: The** Position **data structure**

There shall be exactly one **reportPosition** for each **TrafficNonConformanceReport**.

## 4.9 The Altitude Data Structure

The Altitude data structure carries the altitude data of the object being reported about.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| altitude | Real | 1 | Altitude of position record in m unit of measurement as defined by altitudeCrs. | |
| altitudeAccuracy | Real | 1 | Accuracy of altitude in in unit of measurement as defined by altitudeCrs | |
| altitudeType | EnumAltitudeType | 1 | indicates the reference point for altitude measurement, e. g.:<br><br>altitude above mean- | |

| | | | | |
|---|---|---|---|---|
| | | | sea-level (MSL)<br><br>altitude above take-off location (ATO)<br><br>altitude above ground (AGL/SFC) | |
| determinationMethod | AltitudeDeterminationMethod | 1 | Method of determination of altitude, e. g.:<br><br>radio-altimeter<br><br>barometric<br><br>GNSS-based<br><br>calculated against reference point and mean-sea-level | |
| altitudeCrs | EnumCRSType | 1 | Coordinate reference system used (e. g., for WGS-84, EPSG:4979) | |
| altitudeDataAge | Real | 0..1 | Elapsed time in s since last position data received by the reporter of this **Altitude** | This attribute shall be provided, if the Altitude is used in a reporting service (e.g., in a PositionReport); in other cases this attribute may be omitted |

| | | | | |
|---|---|---|---|---|
| | | | | (e.g., in conversion operations). |

**Table 14: The** Altitude **data structure**

## 4.10 The EnumAltitudeType Enumeration

The EnumAltitudeType enumeration type specifies the possible ways to express an altitude/height.

See Common Geometry Data types.

## 4.11 The EnumCRSType Enumeration

The EnumCRSType enumeration type specifies the possible ways to express a coordinate reference system.

See Common Geometry Data types.

## 4.12 The AltitudeDeterminationMethod Enumeration

The AltitudeDeterminationMethod enumeration type specifies the possible ways to determine an altitude.

| Property | Description | Note |
|---|---|---|
| RADIO_ALTIMETER | Altitude measured via radio altimeter. | |
| BAROMETRIC | Altitude measured via air pressure. | |
| GNSS_BASED | Altitude obtained by satellite navigation system. | |
| CALCULATED | Altitude calculated against reference point. | |

**Table 15: The AltitudeDeterminationMethod enumeration**

There shall be exactly one **reportAltitude** for each **TrafficNonConformanceReport**.

## 4.13 Separation Data Structure

The **Separation** data structure provides a means to carry spatial separation information of the objects considered.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **longitudinal** | **Real** | 1 | The separation, in metres, in the direction of movement, of this object to the other object involved. | A deviation 'ahead' of the planned position should be annotated as a positive figure, or as a negative figure if 'behind' the planned position. |

| | | | | |
|---|---|---|---|---|
| **transversal** | **Real** | 1 | The separation, in metres, transversal to the direction of movement, of this object to the other object involved. | A deviation 'to the right' (in the sense of movement) of the planned position should be annotated as a positive figure, or as a negative figure if 'to the left'. |
| **vertical** | **Real** | 1 | The vertical separation, in metres, in the direction of movement, of this object to the other object involved | A deviation 'above' of the planned position should be annotated as a positive figure, or as a negative figure if 'below'. |
| **timeLeft** | **TimeDuration** | 0..1 | The time left, in s, until the reported conflict occurs, or is expected to occur. | A deviation has no **timeLeft**. |

**Table 16:** Separation Data Structure

## 4.14 Common Data Structures Used in UTM Service Specifications

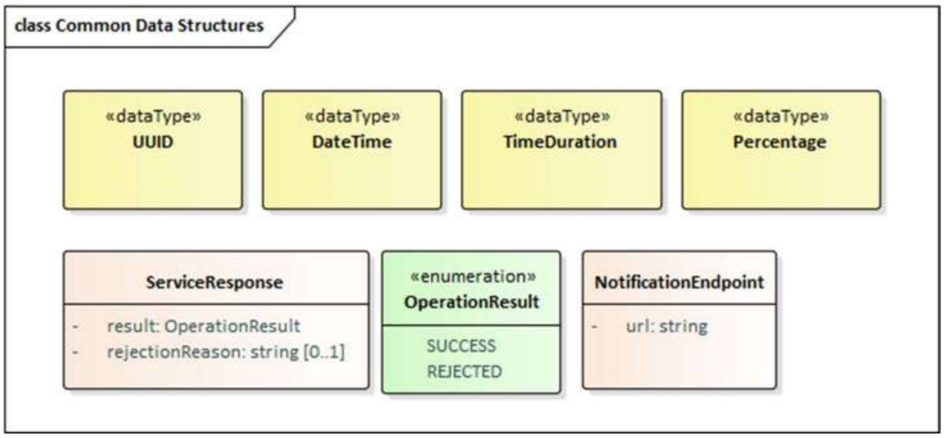


**Figure 5: Common Data Types Used in UTM Service Specifications**

### 4.14.1 NotificationEndpoint Data Structure

**NotificationEndpoint** is used in subscription and un-subscription operations to show the receiver of notifications as a result of the subscription.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **URL** | **String** | 1 | Endpoint capable of receiving notifications | |

**Table 17:** NotificationEndpoint Data Structure

### 4.14.2 ServiceResponse Data Structure

ServiceResponse is the generic response provided by each service operation. In some cases, this basic data structure may be extended by inheritance.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **result** | **OperationResult** | 1 | Indicates the result of the request to the service | |
| **rejectReason** | **String** | 0..1 | Optional additional information to be provided in case of negative result | |

**Table 18:** ServiceResponse Data Structure

## 4.15 Common Geometry Data Structures Used in UTM Service Specifications

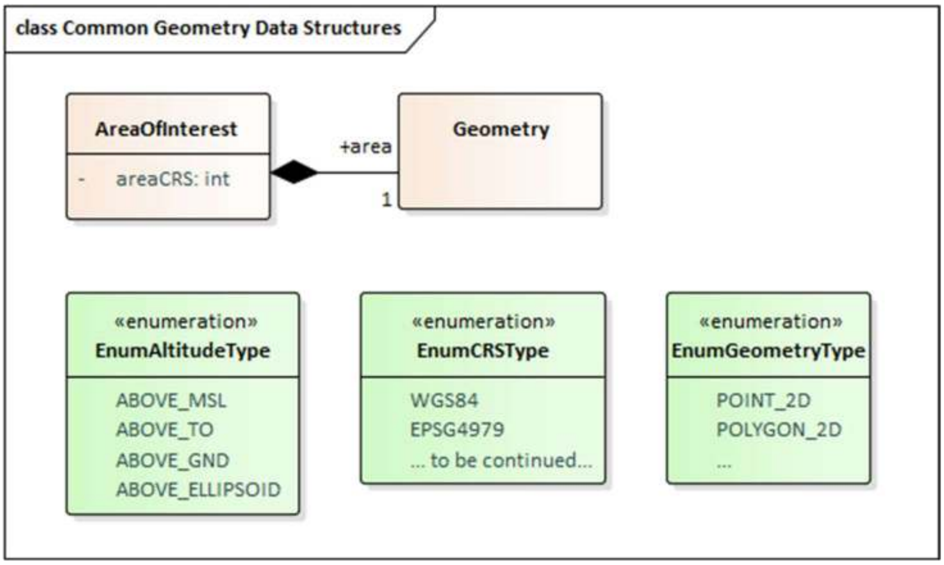


**Figure 6: Common Geometry Data Types Used in UTM Service Specifications**

### 4.15.1 AreaOfInterest Data Structure

**AreaOfInterest** is used in subscription operations to provide an indication of the geographic area for which the subscriber is interested to receive notifications.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **area** | **Geometry** | 1 | A geometric description of a geographic area. | Should be a 2-dimensional geometry in this case. |
| **areaCRS** | **EnumCRSType** | 1 | Coordinate reference system used (WGS-84, EPSG:4979) | |

**Table 19:** AreaOfInterest Data Structure

### 4.15.2 Geometry Data Structure

**Geometry** describes a geometrical shape of one, two or three dimensions.

The **Geometry** data structure is not further detailed in this service specification. One example of how a generic Geometry structure could be realized is sketched in the table below:

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **coordinates** | **Double** | 2..* | Collection of the coordinates, describing the geometry. | |
| **geometryType** | **GeometryType** | 1 | Type of geometry being described by the coordinates. | Examples: Point, Polygon, Polyhedron, etc. |

**Table 20:** Geometry Data Structure

### 4.15.3 EnumAltitudeType Enumeration

The EnumAltitudeType enumeration type specifies the possible ways to express an altitude/height.

| Property | Description | Note |
|---|---|---|
| ABOVE_MSL | Altitude above mean-sea-level.<br><br>Same as orthometric height; same as height above the earth geoid. | |
| ABOVE_TO | Altitude above take-off location. | |
| ABOVE_GND | Height above ground surface. | |
| **ABOVE_ELLIPSOID** | Altitude above the WGS-84 ellipsoid; value delivered by GPS. | |

**Table 21:** EnumAltitudeType Enumeration

### 4.15.4 EnumCRSType Enumeration

The **EnumCRSType** enumeration type specifies the possible ways to express a coordinate reference system.

| Property | Description | Note |
|---|---|---|
| **WGS84** | | |
| EPSG4979 | | |
| ... to be continued ... | | |

**Table 22:** EnumCRSType Enumeration

### 4.15.5 EnumGeometryType Enumeration

The **EnumGeometryType** enumeration type specifies possible geometrical shapes.

| Property | Description | Note |
|---|---|---|
| **POINT** | Single point. | |
| **POLYGON** | Polygon. | |
| ... | | |

**Table 23:** EnumGeometryType Enumeration



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# 5 Service Interface Specifications

This chapter describes the details of each service interface. Each Service Interface has its own sub-chapter.

The Service Interface specification covers only the static design description while the dynamic design (behaviour) is described later.

## 5.1 Service Interface TrafficConformanceMonitoringSubscriptionInterface

### 5.1.1 Operation subscribeForTrafficConformanceMonitoring

#### 5.1.1.1 Operation Functionality

A consumer calls this operation to subscribe to Traffic Conformance Monitoring report data.

#### 5.1.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| **consumer** | Input | **NotificationEndpoint** | Which endpoint shall be notified in case of new **ConformanceReports** |
| **areaOfInterest** | Input | **AreaOfInterest** | Area of interest to the consumer |
| **response** | Return | **ServiceResponse** | Provide status information on subscription |

**Table 24:** Payload Description of subscribeForTrafficConformanceMonitoring Operation

### 5.1.2 Operation unSubscribeForTrafficConformanceMonitoring

#### 5.1.2.1 Operation Functionality

A consumer calls this operation at the provider to unsubscribe from Traffic Conformance Monitoring report data.

#### 5.1.2.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| **consumer** | Input | **NotificationEndpoint** | Which endpoint shall be not be notified (anymore) in case of new **TrafficConformanceMonitoringReports** |
| **response** | Return | **ServiceResponse** | Provide status information on subscription |

**Table 25:** Payload Description of unSubscribeForTrafficConformanceMonitoring Operation

## 5.2 Service Interface TrafficConformanceMonitoringNotificationInterface

Consumer provides this interface, allowing the service provider to submit to the consumer Traffic Conformance Monitoring report data.

### 5.2.1 Operation notifyTrafficConformanceMonitoringReport

#### 5.2.1.1 Operation Functionality

Once and while subscribed, consumer receives Traffic Conformance Monitoring report data via this operation.

#### 5.2.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| **TrafficConformanceMonitoringReport** | Input | **TrafficConformanceMonitoringReport** | A Traffic Conformance Monitoring report that matches the area criterium provided with subscription |

**Table 26:** Payload Description of notifyTrafficConformanceMonitoringReport Operation

# 6 Service Dynamic Behaviour

## 6.1 Service Interfaces TrafficConformanceMonitoringSubscriptionInterface and TrafficConformanceMonitoringNotificationInterface

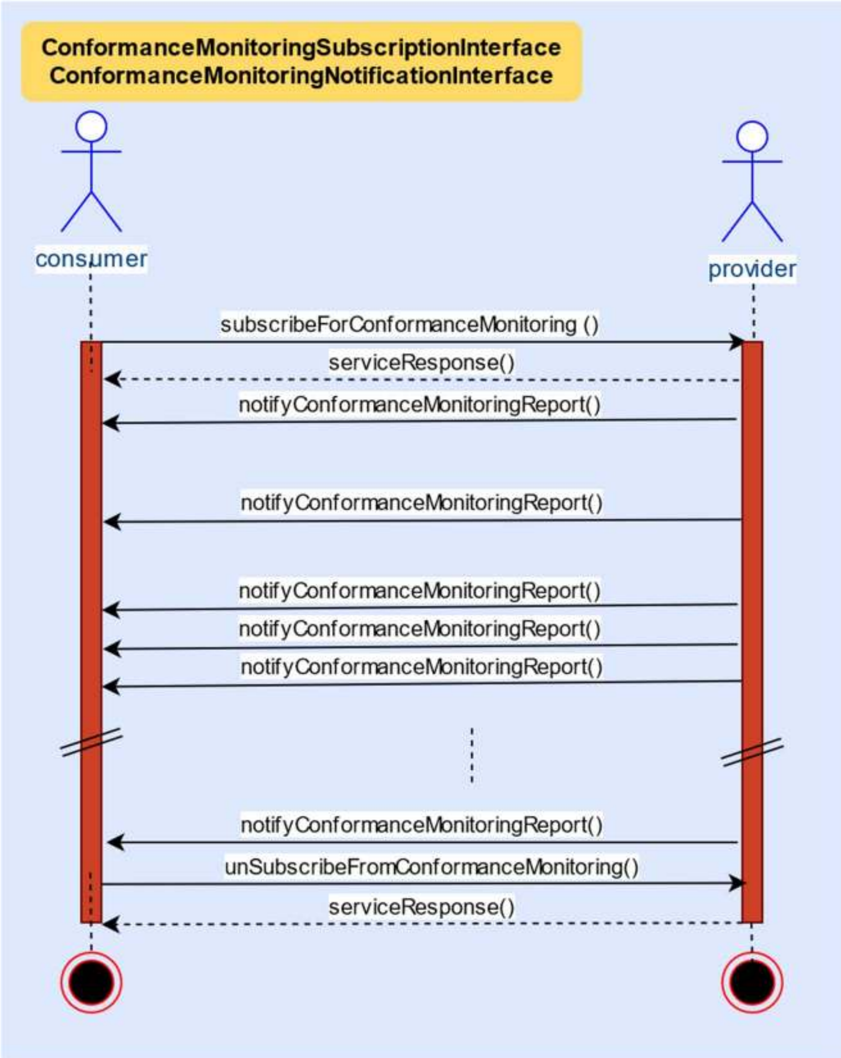


Figure 7: Traffic Conformance Monitoring Exchange Service Interface Operation Sequence Diagram

# 7 Service Provisioning

Not available, left empty.

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**Table 27:** List of References

VERY LARGE-SCALE DEMONSTRATION

# D2.4 Appendix G Network Coverage and Population Density

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# Authoring & Approval

## Authors of the document

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Gregor Mogeritsch / Frequentis | WP2 | 26.10.2022 |
| Hubert Künig / Frequentis | WP2 | 26.10.2022 |
| Peter Cornelius / Frequentis | WP2 | 26.10.2022 |
| Thomas Lutz / Frequentis | WP2 Lead | 26.10.2022 |

## Reviewers internal to the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Jonas Stjernberg / Robots Expert | WP3 Lead | 1.11.2022 |
| Maria Tamm / EANS | Project coordinator | 3.11.2022 |
| Tanel Järvet / CAFA | WP4 Lead | 3.11.2022 |
| Damian Soliwoda / PSNC | WP2 member | 2.11.2022 |
| Lukasz Gorny-Zajac / DRR | WP2 member | 2.11.2022 |
| Parmentier Remy / VAI | WP2 member | 2.11.2022 |
| Pawel Korzec / DRR | WP2 member | 2.11.2022 |
| Piotr Dybiec / DRR | WP2 member | 2.11.2022 |
| Piotr Luboński / PSNC | WP2 member | 31.10.2022 |
| Piotr Szymaniak / PSNC | WP2 member | 31.10.2022 |
| Sven Jürgenson / Threod | WP3 member | 3.11.2022 |
| Leopoldo Tejada/UML | WP2 member | 2.11.2022 |
| Thomas Wana / DIME | WP2 member | 31.10.2022 |
| Yuhang Yun / EHANG | WP3 member | 30.10.2022 |
| Iris Röhrich / FRQ | WP1 member | 3.11.2022 |

## Approved for submission to the SJU By - Representatives of beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Sami Alkula/FANS | Project Management Group | 3.11.2022 |
| Thomas Neubauer/DIME | Project Management Group | 3.11.2022 |
| Pawel Korzec/DRR | Project Management Group | 3.11.2022 |
| Yuhang Yun/EHE | Project Management Group | 3.11.2022 |
| Damini Gera/AIRB | Project Management Group | 3.11.2022 |
| Piotr Szymaniak/PSNC | Project Management Group | 3.11.2022 |
| Sven Jürgenson/THREOD | Project Management Group | 3.11.2022 |



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| | | |
|---|---|---|
| Leopoldo Tejada/UML | Project Management Group | 3.11.2022 |
| Tapio Haarlaa/VAI | Project Management Group | 3.11.2022 |
| Iris Röhrich/FRQ | Project Management Group | 3.11.2022 |
| Juha Lindstedt/AVIA | Project Management Group | 3.11.2022 |
| Piotr Bratek/PANSA | Project Management Group | 3.11.2022 |
| Tanel Järvet/CAFA | Project Management Group | 3.11.2022 |
| Maria Tamm/EANS | Project Management Group | 3.11.2022 |

**Rejected By - Representatives of beneficiaries involved in the project**

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|---|---|---|

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# GOF2.0

GOF2.0 INTEGRATED URBAN AIRSPACE VLD

This Updated Service Specification is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 101017689 under European Union’s Horizon 2020 research and innovation programme.

## Abstract

The Network Coverage service provides information about current and expected data connectivity conditions along a flight route or in a geographical area of interest.

It provides information where connectivity conditions are or are not good enough for safe and reliable data connectivity that adheres to a certain service level, provided by individual communication service providers.

Provided connectivity conditions are provided in terms of quality and performance of network and C2 link data communication between drones and ground stations, as well as coverage information for cellular networks. Targeted service consumers include aviation organisations, drone operators and end users.

# Table of Contents





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## List of Tables

## List of Figures

# 1 Introduction

## 1.1 Purpose of the document

This document describes the Network Coverage Service in a logical technology-independent manner, that is:

- the operational and business context of the service
    - requirements for the service (e.g., information exchange requirements)
    - involved nodes: which operational components provide/consume the service
    - operational activities supported by the service
    - relation of the service to other services
- the service description
    - service interface definitions
    - service interface operations
    - service payload definition
    - service dynamic behaviour description
- service provision and validation aspects

Furthermore, this document clearly defines the version of the service.

## 1.2 Scope

The NetworkCoverage Service described in this document provides a general mechanism between the various stakeholders, interfaces and data models that enable and allow the automated data exchange between the respective parties.

The scope includes the following aspects:

- Operational Context
- Service Interfaces
- Service Interface Definition
- Service Dynamic Behavior
- Service Data Model

There are a number of goals defined that this paper aims to achieve:

1. A goal is to define logical messaging that might be exchanged between a traffic management system (or drone operator, USS/USSP or equivalent) and an MNO.



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2. A goal is to identify architectures that will be amenable to expedient implementation by a variety of MNOs, given that MNOs have various operating procedures and means of managing their networks.
3. A goal is to identify architectures that would support a variety of business models and data sharing models in a technology independent way (i.e. limiting and avoiding exchange of proprietary and/or sensitive data).
4. A goal is to provide coverage information primarily for C2 but also for payload traffic.
5. A goal is to maintain synchronization with other ACJA Work Tasks, such that the entirety provides regulators and users with confidence on performance-based requirements.
6. A goal is to organize those needs that require standards input from ASTM, 3GPP or other standards developing organizations (SDO) to help close the gap between standards orgs. For example, flight plans may come from ASTM but Key Performance Indicator (KPI) analysis methods may come from 3GPP, EUROCAE and RTCA.
7. A goal is to understand what real time metrics, non-real time and aggregated data can come from the MNO, such as, but not limited to, population density, which could be useful in predicting risk and/or performance-based metrics.

The overall objective is to provide a minimum set of descriptions to standardize the way data between MNOs and the UTM ecosystem can be exchanged. The NetworkCoverage Service does not limit any entity, by any means, to deploy or implement other data exchange in addition to the defined service definitions.

This document is not anticipated to be a complete set of functions and definitions for an implementable API.

This service specification is intended to be read by service architects, system engineers and developers in charge of designing and developing an instance of the NetworkCoverage Service.

## 1.3 Intended readership

This service specification is intended to be read by service architects, system engineers and developers in charge of designing and developing an instance of the Network Coverage service.

Furthermore, this service specification is intended to be read by enterprise architects, service architects, information architects, system engineers and developers in pursuing architecting, design and development activities of other related services.

## 1.4 Background

### 1.4.1 EUROCONTROL Concept of Operations for U-space (CORUS)

The fact that ensuring robust communications is essential for safe drone operations is not new. Other projects and papers have been looking into that extensively.

For example, the CORUS Project [2] identifies a so-called Communication Coverage information service (see CORUS ConOps Volume 2, chapter 5.1.7.6).

This service is described there as "The service to provide information about the communication coverage. It can be specialized depending on the communication infrastructure available (e.g. ground or satellite based). This service is used to plan relying on required coverage."

The CORUS consortium and other references [13] depict the service as U-space level 2 service, likely to be available mid-future.

### 1.4.2 General principles and research basis

A key principle of the U-spaces architecture is applying a service-oriented architecture approach, where open, interoperable and standard based interfaces are offered based on SWIM principles .

This document is based on both research and commercial environments outlined in a range of references such as [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [18], [19], [20], [21], [22].

### 1.4.3 Efficient, safe and sustainable traffic at sea (EfficienSea2)

The design method and terminology builds on experience from the EfficienSea2 project [14], [15].

## 1.5 Glossary of terms

| Term | Definition |
|---|---|
| External Data Model | Describes the semantics of the domain (or a significant part thereof) by defining data structures and their relations. This could be at logical level (e.g., in UML) or at physical level (e.g., in XSD schema definitions), as for example standard data models. |
| Message Exchange Pattern | Describes the principles how two different parts of a message passing system (i.e.: the service provider and the service consumer) interact and communicate with each other. Examples:<br>In the Request/Response MEP, the service consumer sends a request to the service provider in order to obtain certain information; the service provider provides the requested information in a dedicated response.<br>In the Publish/Subscribe MEP, the service consumer establishes a subscription with the service provider in order to obtain certain information; the service provider publishes information (either in regular intervals or upon change) to all subscribed service consumers. |
| Operational Activity | An activity performed by an operational node. Examples of operational activities are: Route Planning, Route Optimization, Logistics, Safety, Weather Forecast Provision, … |
| Operational Model | A structure of operational nodes and associated operational activities and their inter-relations in a process model. |
| Operational Node | A logical entity that performs activities. Note: nodes are specified independently of any physical realization.<br>Examples of operational nodes are: Control Center, Authority, Weather Information Provider, … |

| | |
|---|---|
| Service | The provision of something (a non-physical object), by one, for the use of one or more others, regulated by formal definitions and mutual agreements. Services involve interactions between providers and consumers, which may be performed in a digital form (data exchanges) or through voice communication or written processes and procedures. |
| Service Consumer | A service consumer uses service instances provided by service providers. |
| Service Data Model | Formal description of one dedicated service at logical level. The service data model is part of the service specification. Is typically defined in UML and/or XSD. If an external data model exists (e.g., a standard data model), then the service data model shall refer to it: each data item of the service data model shall be mapped to a data item defined in the external data model. |
| Service Design Description | Documents the details of a service technical design (most likely documented by the service implementer). The service design description includes (but is not limited to) a service physical data model and describes the used technology, transport mechanism, quality of service, etc. |
| Service Implementation | The provider side implementation of a dedicated service technical design (i.e., implementation of a dedicated service in a dedicated technology). |
| Service Implementer | Implementers of services from the service provider side and/or the service consumer side. |
| Service Instance | One service implementation may be deployed at several places by same or different service providers; each such deployment represents a different service instance, being accessible via different URLs. |
| Service Instance Description | Documents the details of a service implementation (most likely documented by the service implementer) and deployment (most likely documented by the service provider). The service instance description includes (but is not limited to) service technical design reference, service provider reference, service access information, service coverage information, etc. |
| Service Interface | The communication mechanism of the service, i.e., interaction mechanism between service provider and service consumer. A service interface is characterized by a message exchange pattern and consists of service operations that are either allocated to the provider or the consumer of the service. |
| Service Operation | Functions or procedure that enables programmatic communication with a service via a service interface. |
| Service Physical Data Model | Describes the realization of a dedicated service data model in a dedicated technology. This includes a detailed description of the data payload to be exchanged using the chosen technology. The actual format of the service physical data model depends on the chosen technology. Examples may be WSDL and XSD files (e.g., for SOAP services) or swagger (Open API) specifications (e.g., for REST services). If an external data model exists (e.g., a standard data model), then the service physical data model shall refer to it: each data item of the service physical data model shall be mapped to a data item defined in the external data model.<br>In order to prove correct implementation of the service specification, there shall exist a mapping between the service physical data model and the service data model. This means, each data item used in the service physical data model shall be mapped to a corresponding data item of the service data model. (In case of existing mappings to a common external (standard) data model from both the service data model and the service physical data model, such a mapping is implicitly given.) |

| | |
|---|---|
| Service Provider | A service provider provides instances of services according to a service specification and service instance description. All users within the domain can be service providers, e.g., authorities, organizations (e.g., meteorological), commercial service providers, etc. |
| Service Specification | Describes one dedicated service at logical level. The Service Specification is technology-independent. The Service Specification includes (but is not limited to) a description of the Service Interfaces and Service Operations with their data payload. The data payload description may be formally defined by a Service Data Model. |
| Service Specification Producer | Producers of service specifications in accordance with the service documentation guidelines. |
| Service Technical Design | The technical design of a dedicated service in a dedicated technology. One service specification may result in several technical service designs, realizing the service with different or same technologies. |
| Service Technology Catalogue | List and specifications of allowed technologies for service implementations. Currently, SOAP and REST are envisaged to be allowed service technologies. The service technology catalogue shall describe in detail the allowed service profiles, e.g., by listing communication standards, security standards, stacks, bindings, etc. |
| Spatial Exclusiveness | A service specification is characterized as "spatially exclusive", if in any geographical region just one service instance of that specification is allowed to be registered per technology.<br>The decision, which service instance (out of a number of available spatially exclusive services) shall be registered for a certain geographical region, is a governance issue. |

*Table 1: Glossary of terms*

## 1.6 List of Acronyms

| Acronym | Explanation |
|---|---|
| **3GPP** | 3rd Generation Partnership Project |
| **ACJA** | Aerial Connectivity Joint Activity (by GSMA + GUTMA) |
| **AIXM** | Aeronautical Information Exchange Model |
| **AMQ** | Advanced Message Queuing |
| **API** | Application Programming Interface |
| **ASTM** | American Society for Testing and Materials |
| **ATM** | Air Traffic Management |
| **BVLOS** | Beyond Visual Line of Sight |
| **C2** | Command and Control |
| **CIS** | Common Information Service |
| **CTR** | Controlled Traffic Region |
| **DL** | Downlink connection, data transmission from a base station to a mobile device |
| **DSS** | Discovery and Synchronization Service |
| **EDT** | Estimated Time of Departure |
| **FIXM** | Flight Information Exchange Model |



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| Acronym | Explanation |
|---|---|
| **FPL** | Flight Plan |
| **GSM** | Global System for Mobile Communication |
| **GSMA** | GSM Association |
| **GUTMA** | Global UTM Association |
| **JMG** | Java Message Service |
| **KPI** | Key Performance Indicator |
| **MEP** | Message Exchange Pattern |
| **MNO** | Mobile Network Operator |
| **NAF** | NATO Architectural Framework |
| **NOTAM** | Notice To Air Man |
| **REST** | Representational State Transfer |
| **RF** | Radio Frequency |
| **RSRP** | Reference Signal Received Power |
| **SDO** | Standards Developing Organization |
| **SINR** | Signal to Interference and Noise Ratio (in communication networks) |
| **SOA** | Service Oriented Architecture |
| **SOAP** | Simple Object Access Protocol |
| **SSD** | Service Specification Document |
| **SWIM** | System Wide Information Management |
| **UAM** | Urban Air Mobility |
| **UAS** | Unmanned Aircraft System |
| **UAV** | Unmanned Aerial Vehicle |
| **UL** | Uplink connection, data transmission from a mobile device to a base station |
| **UML** | Unified Modelling Language |
| **URL** | Uniform Resource Locator |
| **URN** | Uniform Resource Name |
| **USS** | UAS Service Supplier |
| **UTM** | UAV Traffic Management |
| **UUID** | Universally Unique Identifier |
| **WXDM** | Weather Information Exchange Model |
| **WSDL** | Web Service Definition Language |
| **XML** | Extensible Mark-up Language |
| **XSD** | XML Schema Definition |

*Table 2: List of acronyms*



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# 2 Service Identification

The purpose of this chapter is to provide a unique identification of the service and describe where the service is in terms of the engineering lifecycle.

| | |
|---|---|
| **Name** | *Traffic Telemetry Service* |
| **ID** | *urn:gof2:services:NetworkCoverageService* |
| **Version** | *1.1* |
| **Description** | The NetworkCoverage Service provides three-dimensional information about data connectivity conditions along a flight route or in an area of interest. It provides information where connectivity conditions are or are not good enough for safe and reliable data connectivity that adheres to a certain service level, provided by individual connectivity providers. |
| **Keywords** | *IP connectivity, data connectivity, data coverage, mobile communication, mobile connectivity, mobile coverage, cell connectivity, cell communication, cell coverage, LTE, 4G, 5G, command and control, C2* |
| **Architect(s)** | *2020-2021 Thomas Neubauer, ACJA ServiceCoverage Definition participants. Service Architects: Thomas Wana, Thomas Lutz, Hubert Kuenig, Josef Jahn*<br><br>*2021 The GOF2 U-Space Project Consortium* |
| **Status** | *Provisional* |

*Table 3: Service identification*

# 3 Operational Context

Safe operation of UAS / UAM may likely require knowledge of expected RF communications link quality (performance) and coverage during planning and flight operation, as well as measurement and monitoring of these parameters during the flight.

Communication coverage is not static information and is subject to continuous change due to a multitude of factors. Consequently, the coverage information comprises real-time and non-real-time data. Real-time data may include live performance indicators, alerts on significant changes, but also real-time network outage information. Non-real-time data for instance could include, but is not limited to, aggregated and historic information as well as planned events (such as planned maintenance outages of the network), which allows connectivity analytics and projections into the future. Both types of data complement each other.

## 3.1 Planning Phase

Before the start of a flight, there may likely be a need to determine how the planned flight path or flight operations area fits into the following geographic areas:

Areas with or without cellular network coverage

Areas where non-cellular RF coverage is bad or non-existent, either due to atmospheric conditions, terrain/building obstruction, or others.

These factors can be determined via network / surveillance coverage maps, RF propagation modeling, as well through public space weather services. Deriving the necessary OK/not-OK information will require automated processing and data exchange.

## 3.2 Flight Phase

During a flight, adherence to the flight plan needs and limitations to be monitored, and any non-conformance outside of pre-established thresholds and safety margins defined in the operational authorization, should trigger appropriate mitigation actions.

In addition, UTM service providers receive data about the link quality between UAV and ground station / pilot, measuring current signal strength, cumulative signal strength, data transmission latency, number of packet retransmissions, network notifications, etc.

This data indicates the real time link quality and may be used to react to possible deterioration of link quality, or even a complete loss of link. Although the safety criticality of the C2 link depends on characteristics of the UA and the contingency procedures proposed by a UAV operator, some UAV may pose a safety risk in case of C2 outage time beyond the expected availability as they are essentially uncooperative drones that do not respond to commands until link is reestablished.

## 3.3 Example Use Case

An example service use is shown in Figure 1 and described in more detail below:

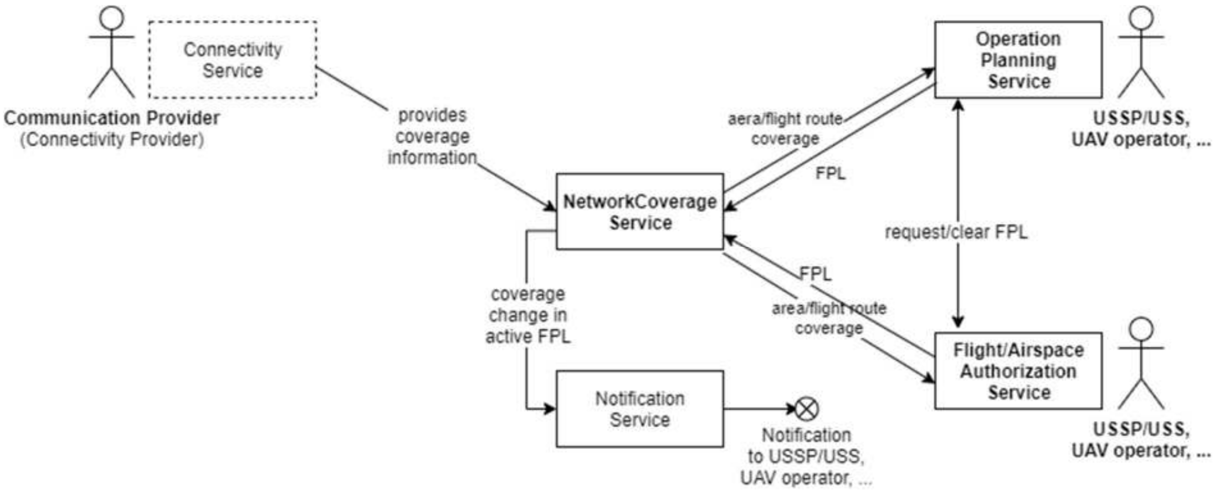


*Figure 1 - Operational model diagram*

A UAV operator wants to fly a mission from A to B.

In order to estimate the general feasibility of the flight, among other things, the connectivity situation in the general area of the flight must be checked by the Operation Planning Service[1]. The Communication Provider provides the area coverage information utilizing the NetworkCoverage Service. Coverage information may also be complemented with measured data.

If the flight is feasible in a given area, a concrete route must be planned. Considering among others the weather, airspace restrictions, aircraft performance, etc., one or more route candidates are created by the drone operator (and/or USS/USSP or equivalent), which are checked with the support of the NetworkCoverage Service whether the minimum service level (for example: continuous C2 availability) is met along the candidate routes. If requested, the NetworkCoverage Service can also propose alternate routes to assure the minimum service level of the connectivity.

The drone operator prepares a flight intent plan ahead of ETD in line with the operational limitations of his/her authorization. The operator can be assisted in this task by the Operation Planning Service which may coordinate with the NetworkCoverage Service if the planned flight route meets the minimum service level requirements.

Shortly before the flight actually commences, the Operation Planning Service may recheck that the connectivity service level requirements are still met (together with meteorology, NOTAMs, etc.), and,

[1] "Operational Planning" is derived from the FAA UTM Conops v2.0 section 2.4.4 [16]: "The Operation Planning service supports the operator to define prior to the operation a four-dimensional (4D) volume of airspace within which the operation is expected to occur, the times and locations of the key events associated with the operation, including launch, recovery, and any other information deemed important (e.g., segmentation of the operation trajectory by time)."

where necessary, alternate routes can be proposed. Then, clearance is requested from Flight/Airspace Authorization Service[2] to commence the flight.

During the flight, due to an outage at the communication provider, a certain segment of the flight planned route ahead of the aircraft loses connectivity. For this the link quality could be used as key performance indicator. A Connectivity Service at the Communication Provider identifies this situation and informs the Notification Service[3] by utilizing the NetworkCoverage Service.

The drone operator may have to re-plan the rest of the flight, and coordinate the changes using the Operation Planning Services, again with the assistance of the NetworkCoverage Service, to stay on a route that meets the connectivity minimum service level requirements, or apply contingency/emergency procedures in line with the approved Concept of Operations.

Providers and actors might / will be different depending on the local legislation/regulations.

## 3.4 Functional and Non-functional Requirements

The table below lists applicable existing requirements for the *Network Coverage* service.

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| REQ-AIRPASS-D31-PACM-0010 | Communication for Procedural ATC Interface | The on-board system should provide a wireless data link and protocol to coordinate procedural directions from ATC services with the UAS ground control station | SESAR U-space requirements |
| REQ-AIRPASS-D31-EACM-0010, REQ-AIRPASS-D31-MNCM-0010, REQ-AIRPASS-D31-TICM-0010, REQ-AIRPASS-D31-DFCM-0010, ... | Communication for Emergency Management, Communication for Monitoring, Communication for Traffic Information, Communication for Dynamic Geofencing, ... | Additional communication requirements like above, but for different use-cases: Emergency Management, Monitoring, Traffic Information, E-Identification, Geofencing, ... | SESAR U-space requirements |

[2] This service is called "Airspace Authorization" service in FAA UTM Conops v2 section 2.4.3 [16] and "Flight Authorisation" in EASA draft Commission U-Space regulation in Europe, Article 12 [17].

[3] The Notification Service may provide such information to the “Constraint Information & Advisories” Service as defined in the FAA ConOps v2.0, Section 2.4.5 [16] or equivalent. Similarly, in the SESAR CORUS “U-Space Concept of Operations” [2] there are services defined in sections 5.1.5.1 and 5.1.6.6 that require “… to provide status information about communication infrastructure. … The service should give warnings of degradation of communications infrastructure”.

| | | | |
|---|---|---|---|
| REQ-DREAMS-D32-OPER.0008 | Definition amendments are proposed to include the U-Space context COM (Communication) | "Two different definitions are proposed:<br>1) ATS COM: 'ATS communication services' means aeronautical fixed and mobile services to enable ground-to-ground, air-to-ground for ATS purposes.<br>2) SWIM-COM: 'SWIM communication services' means fixed and mobile services to enable end systems, either at fixed location, mobiles or in flight, to exchange digital information for ATM/ANS purposes." | SESAR U-space requirements |
| REQ-IMPETUS-D31-INTR.0012 | DTM-UAV Interface | The UAV shall provide continuous information about its position to the DTM, ensuring that at least this direct link with U-Space is not compromised. | SESAR U-space requirements |
| REQ-IMPETUS-D31-DECO.0017 | Legacy networks | Legacy networks such as cellular and GPS networks shall beused to support drone operations and provide communications between different roles. The networks can be used to communicate U-space services needed to carry out safe drone operations. The system will programmatically communicate with these networks for facilitate safe drone operations. | SESAR U-space requirements |
| REQ-TERRA-D32-FPER-0190 | General Communications availability | The selected communication infrastructure shall ensure the connectivity of the ground segment with the external systems with which the system shall interface. | SESAR U-space requirements |
| REQ-TERRA-D32-FPER-0192 | General Communications latency | V2I latency has to be lower than 3 second. | SESAR U-space requirements |
| REQ-TERRA-D32-FPER-020 | Connectivity | The selected communication infrastructure shall provide connectivity between the central system and all nodes. | SESAR U-space requirements |
| REQ-DROC2OM-D21-PERF.0010 | WP2-GENUS-PER-001 | The C2 Link System shall offer, for all addressed data exchanges, an end-to-end availability of provision of at least 99.3% | SESAR U-space requirements |
| REQ-DROC2OM-D21-PERF.0020 | WP2-GENUS-PER-002 | The C2 Link System shall offer, for all addressed data exchanges, an availability of use of at least 99% | SESAR U-space requirements |
| REQ-DROC2OM-D21-PERF.0030 | WP2-GENUS-PER-003 | The C2 Link System shall offer integrity performance in terms of packet error rate measured at the interface between network and logical link layer of at least 10-3 | SESAR U-space requirements |

| | | | |
|---|---|---|---|
| REQ-DROC2OM-D21-FUNC.0050 | WP2-GENUS-FUN-005 | The C2 Link System shall provide communication links for the whole duration of flights as well as prior to take-off and after landing. | SESAR U-space requirements |
| REQ-DROC2OM-D21-FUNC.0080 | WP2-GENUS-FUN-008 | The C2 Link System shall support air-ground communications for drones. | SESAR U-space requirements |
| REQ-DROC2OM-D21-FUNC.0100 | WP2-DATLI-FUN-001 | The C2 Link System shall be compatible with data links which will support all security related countermeasures to prevent identity theft, theft-of-service and eavesdropping threats. | SESAR U-space requirements |
| REQ-DROC2OM-D21-FUNC.0200 | WP2-TERST-FUN-001 | The C2 Link System shall be compatible with a 3GPP LTE/LTE-Advanced or 5G NR terrestrial communication system operating in the 3GPP defined frequency bands. | SESAR U-space requirements |
| REQ-DROC2OM-D21-FUNC.0220 | WP2-TERST-FUN-003 | When using a 3GPP LTE/LTE-Advanced or 5G NR terrestrial communication system, the C2 Link System shall be able to satisfy the baseline traffic profile requirements listed in Section 3.1.* | SESAR U-space requirements |
| REQ-DROC2OM-D21-FUNC.0240 | WP2-INTSE-FUN-001 | The C2 Link System shall define an interface layer for multi-network service integration, including terrestrial and satellite networks relying on the IP protocol for global interconnection. | SESAR U-space requirements |
| REQ-DROC2OM-D21-FUNC.0420 | WP2-MULOP-FUN-001 | The C2 Link System shall allow deployment of competing C2 Link Service providers and operators in samegeographical locations. | SESAR U-space requirements |
| REQ-DROC2OM-D21-FUNC.0450 | WP2-MULOP-FUN-004 | The C2 Link System shall allow Interworking, i.e. having the C2 Link data sent from the drone to ground network through a provider, and reaching the U-Space infrastructure servers through another provider | SESAR U-space requirements |

*Table 4: Functional and Non-functional Requirements*

## 3.5 Operational Nodes

| Operational Node | Remarks |
|---|---|
| Connectivity Provider | A provider of communication services like a Mobile Network Operator or a Satellite Data Communications Provider. |
| Connectivity Service | Service deployed close to mobile network operator infrastructure, providing connectivity data for the Network Coverage Service. |

*Table 5 - Operational Nodes providing the Connectivity Service*

| Operational Node | Remarks |
| --- | --- |
| Operation Planning Service | Service defined in FAA UTM Conops v2.0 section 2.4.4 [16]: "The Operation Planning service supports the operator to define prior to the operation a four-dimensional (4D) volume of airspace within which the operation is expected to occur, the times and locations of the key events associated with the operation, including launch, recovery, and any other information deemed important (e.g., segmentation of the operation trajectory by time).". |
| Flight/Airspace Authorization Service | Service providing authorization for a specific flight. Depending on local regulation this service works with flight trajectories or airspace volumes. |
| Notification Service | Notifies drone operators of relevant changes that occurred typically in-flight, or pre-flight after the initial planning phase.<br>It could consume events from different services, not only the Network Coverage Service. |

*Table 6 - Operational Nodes (directly) consuming the Connectivity Service*

### 3.5.1 Operational Activities

| Operational Activity | Remarks |
| --- | --- |
| Get area and flight route coverage | Returns information about connectivity coverage for a certain area or flight route for a particular technology and communication provider for a particular time period in the future |
| Notify about changes in coverage | For a given area or flight route, get notifications about changes to connectivity. |
| Provide communication services | The communication provider provides its infrastructure to the drone operators for data communication. |

*Table 7 – Operational Activities supported by the NetworkCoverage service*



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# 4 Service Overview

## 4.1 Service Interfaces

The following diagram depicts the Service Interfaces of the NetworkCoverage Service, and their allocations to the Service Provider and the Service Consumers, respectively:

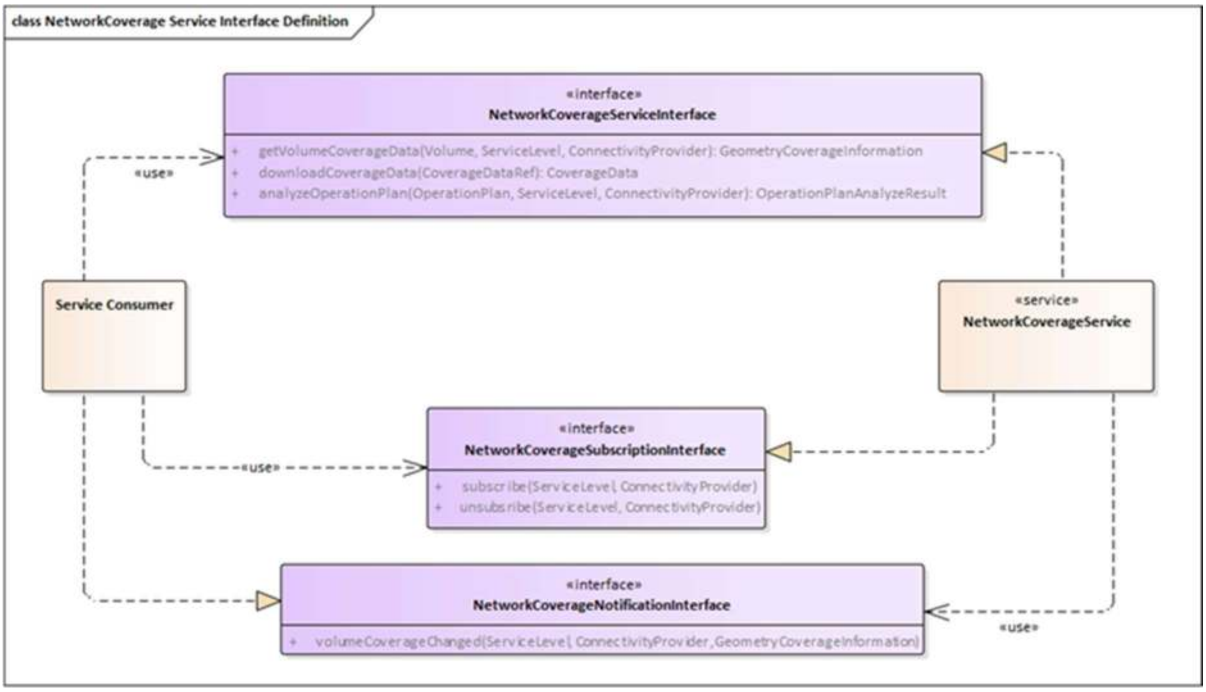


*Figure 2: Network Coverage Service Interface Definition diagram*

| ServiceInterface | Role (from service provider point of view) | ServiceOperation |
|---|---|---|
| NetworkCoverageServiceInterface | Provided | getVolumeCoverage<br>downloadCoverageData<br>analyzeOperationPlan |
| NetworkCoverageSubscriptionInterface | Provided | subscribe<br>unsubscribe |
| NetworkCoverageNotificationInterface | Required | volumeCoverageChanged |

*Table 8: Service Interfaces*

# 5 Service Data Model

This section describes the information model, i.e., the logical data structures to be exchanged between providers and consumers of the service.

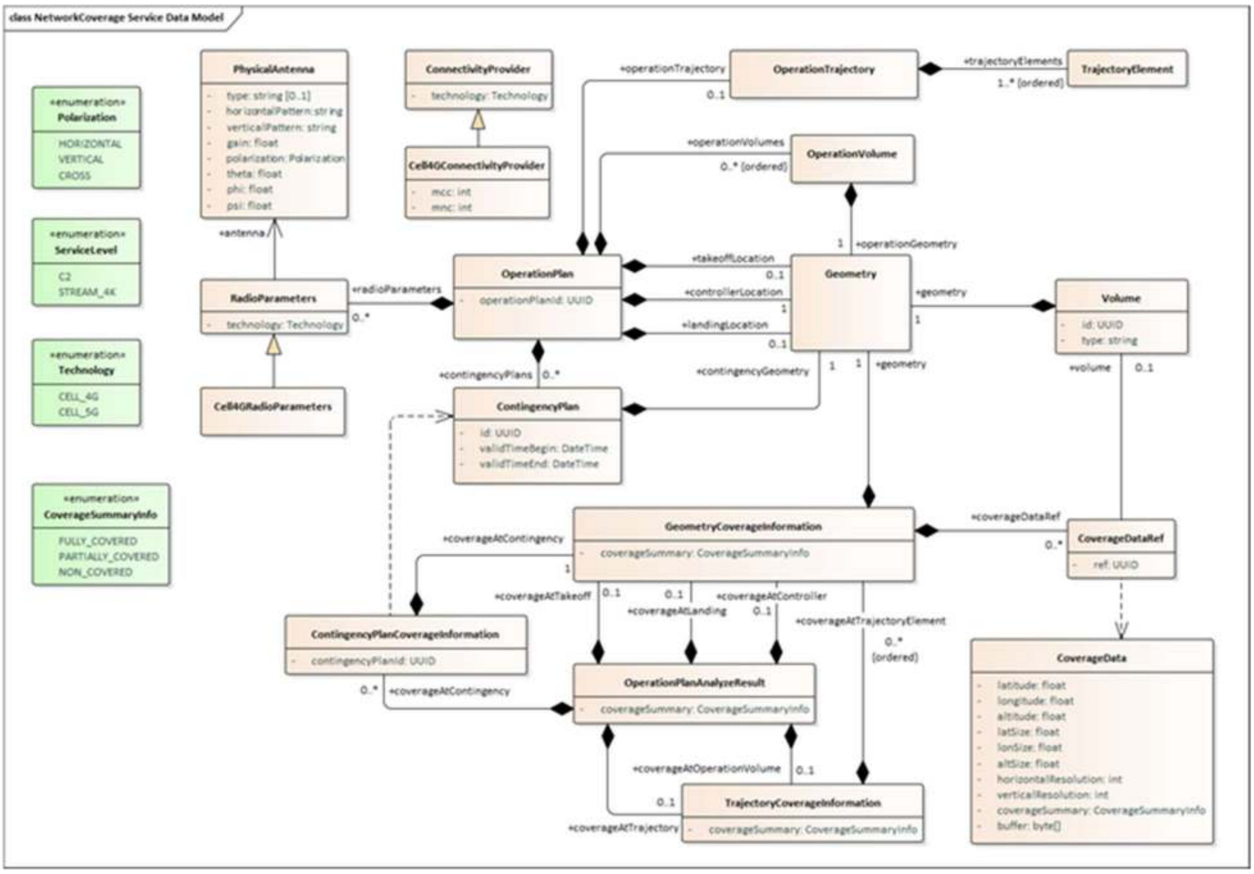


*Figure 3: Data Model diagram of the Network Coverage Service*

The Service Data Model focuses on the core service model and the diagram includes structures (OperationPlan, Volume, Pose), whose detailed specification are out of scope of this document.

The data model supports and is compatible with a number of industry standards, such as ICAO, ASTM F3411-19 [18], EUROCAE ED-269 [20], FIXM, etc. It is important to note that the data model can be extended, for example for future requirements and additional information that may need to be exchanged.

The following tables describe the entities and their attributes in more detail.

## 5.1 The *ConnectivityProvider* Data Structure

The ConnectivityProvider represents a connectivity provider, e.g. a provider of communication services like a Mobile Network Operator or a Satellite Data Communication Provider.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|





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| | | | | |
|---|---|---|---|---|
| technology | Technology | 1 | The technology of the radio parameter. | |

*Table 9: The ConnectivityProvider data structure*

## 5.2 The *Cell4GConnectivityProvider* Data Structure

The Cell4GConnectivityProvider is an example specialization of the ConnectivityProvider class. It contains additional attributes to identify a Mobile Network Operator that offers 4G cellular connectivity services.

It works the same for 5G, while for satellite or other connectivity technology providers the attributes might be different.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| MCC | int | 1 | Mobile Country Code. | |
| MNC | int | 1 | Mobile Network Code. MCC and MNC together uniquely identify the Mobile Network Operator globally. | |

*Table 10: The Cell4GConnectivityProvider data structure*

## 5.3 The *ContingencyPlan* Data Structure

Note: *ContingencyPlan* is fullly described in a separate Operation Plan service specification, selected attributes are listed here to provide context for better understanding.

The *ContingencyPlan* describes an alternative trajectory location for a flight by providing a three-dimensional volume in space together with the applicable time span.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| id | UUID | 1 | Identifier of the contingency plan. | |
| contingencyGeometry | Geometry | 1 | Three-dimensional space fragment, specifying the envelope of contingency trajectory. Can be for example a cube, cylindar, quader, or other geometry. | |
| validTimeBegin | DateTime | 1 | UTC point in time when the flight is expected to enter the given contingency volume. | |
| validTimeEnd | DateTime | 1 | UTC point in time when the flight is expected to leave the given contingency volume. | |

*Table 11: The ContingencyPlan data structure*

## 5.4 The *ContingencyPlanCoverageInformation* Data Structure

The *ContingencyPlanCoverageInformation* holds an analysis in regards to connectivity coverage for a contingecy plan belonging to an operation plan.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| contingencyPlanId | UUID | 1 | Reference to the contingency plan. | |
| coverageAtContingency | GeometryCoverageInformation | 1 | Coverage information corresponding to the contingency plan. | |

*Table 12: The ContingencyPlanCoverageInformation data structure*

## 5.5 The *CoverageData* Data Structure

The CoverageData structure contains 3D aerial coverage information in a raster of a certain resolution. Full capabilities are to be described in an external CoverageData specification document for further processing.

It is essentially a 3D grid where each grid cell has an assigned a value. CoverageData is like a 3D bitmap, where the pixel content represents attributes relevant for exchanging network coverage information, e.g. boolean values true/false to describe whether the requested service level is met at that particular point or not.

In future versions of this data structure, CoverageData could support exchange of numeric values or other types that can be encoded in a byte, allowing to transport e.g. minimum throughput in a grid cell.

How exactly values are encoded in the byte array has to be described in a separate document specific to and available for an implementation of CoverageData.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| latitude | float | 1 | Latitude of the north-west corner of the area covered in WGS84. | |
| longitude | float | 1 | Longitude of the north-west corner of the area covered in WGS84. | |
| altitude | float | 1 | Altitude of the lower boundary of the 3D area. | |
| latSize | float | 1 | Height of the Area, in WGS 84 degrees. Typically 1.0 | |

| | | | | |
|---|---|---|---|---|
| lonSize | float | 1 | Width of the Area, in WGS 84 degrees. Typically 1.0 | |
| altsize | float | 1 | Altitude of the Area, in meters. Typically 500 (?) | |
| horizontalResolution | int | 1 | Horizontal resolution of the raster, in arc seconds (WGS 84). Typically 2. | |
| verticalResolution | int | 1 | Vertical resolution of the raster, in arc meters Typically 15. | |
| coverageSummary | CoverageSummaryInfo | 1 | Overview information about how the requested service level is met for the whole area.<br>If this is FULLY_COVERED or NON_COVERED, then the buffer may be omitted. | |
| buffer | byte | 0..* | The actual 3D array that contains the raster's values. | May be omitted depending on coverageSummary value. |

*Table 13: The CoverageData data structure*

## 5.6 The *CoverageDataRef* Data Structure

The *CoverageDataRef* structure contains a reference to a CoverageData object. Actual coverage data can be downloaded by passing a CoverageDataRef object to the downloadCoverageData method.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| ref | UUID | 1 | Unique reference. | |
| volume | Volume | 0..1 | optional definition of the space volume. | |

*Table 14: The CoverageDataRef data structure*

## 5.7 The *CoverageSummaryInfo* Enumeration

The *CoverageSummaryInfo* enumeration type specifies the level of coverage related to a certain entity or volume.

| Property | Description | Note |
|---|---|---|
| FULLY_COVERED | Network coverage is given for the whole entity/volume. | |
| PARTIALLY_COVERED | Network coverage is given for a part of the entity/volume. | |
| NON_COVERED | Network coverage is not given at all for the whole entity/volume. | |

*Table 15: The CoverageSummaryInfo enumeration*

## 5.8 The *GeometryCoverageInformation* Data Structure

The *GeometryCoverageInformation* holds an analysis in regards to connectivity coverage for certain volume of 3-dimensional space.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| geometry | Geometry | 1 | Describes the volume of space. | |
| coverageSummary | CoverageSummaryInfo | 1 | Overview information about how the requested service level is met for the whole volume.<br>If this is FULLY_COVERED or NON_COVERED, then the coverageDataRef elements may be omitted. | |
| coverageDataRef | CoverageDataRef | 0..* | A series of references to CoverageData structures, describing the coverage of individual cells of a raster of 3D partitions of the volume. | |

*Table 16: The GeometryCoverageInformation data structure*

## 5.9 The *OperationPlan* Data Structure

Note: *OperationPlan* is fullly described in a separate Operation Plan service specification, selected attributes are listed here to provide context for better understanding.

The *OperationPlan* represents a complete flight plan. It refers to Pose instances providing spatial orientation of the aircraft for positions along the planned flight trajectory.

The communication equipment used on the aircraft is provided when requesting a network coverage analysis.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| operationPlanId | UUID | 1 | Unique identifier of the operation plan. A gufi: globally unique flight identifier if form of a UUID | More information for a flight could be retrieved using a respective Flight Information Service |
| operationTrajectory | OperationTrajectory | 0..1 | The OperationTrajectory is an (ordered) list of 3-dimensional points, associated with time span, representing the flight route. | |
| operationVolumes | OperationVolume | 0..* | An ordered list of 3-dimensional space fragments, associated with time span, representing the flight route in a more rough sequence of space voluemes. | |
| contingencyPlans | ContingencyPlan | 0..* | Holds information on preplanned contingency situations, especially regarding volumes and when they are used. | |
| takeoffLocation | Geometry | 0..1 | Explicit indication of the starting point of the flight. | Optional. Redundant with the information given in the first trajectoryElement. |
| landingLocation | Geometry | 0..1 | Explicit indication of the landing point of the flight. | Optional. Redundant with the information given in the last trajectoryElement. |
| controllerLocation | Geometry | 0..1 | Location of controller (e.g. the ground control station). | |
| radioParameters | RadioParameters | 0..1 | Information about the communication equipment used during the flight. | |

*Table 17: The Flight data structure*

## 5.10 The *OperationPlanAnalyzeResult* Data Structure

The *OperationPlanAnalyzeResult* holds an analysis in regards to connectivity coverage for an *OperationPlan*.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| coverageSummary | CoverageSummaryInfo | 1 | Overview information about how the requested service level is met for the whole OperationPlan.<br>If this is FULLY_COVERED or NON_COVERED, then all the other entries of the OperationPlanAnalyzeResult structure may be omitted. | |
| coverageAtTakeoff | GeometryCoverageInformation | 0..1 | Coverage information related to the takeoff location of the operation plan. | This is optional, as it is redundant information also available in the trajectory. |
| coverageAtLanding | GeometryCoverageInformation | 0..1 | Coverage information related to the landing location of the operation plan. | This is optional, as it is redundant information also available in the trajectory. |
| coverageAtController | GeometryCoverageInformation | 0..1 | Coverage information related to the ground controller location of the operation plan. | |

| | | | | |
|---|---|---|---|---|
| coverageAtTrajectory | TrajectoryCoverageInformation | 0..1 | Coverage information related to the trajectory of the operation plan. | |
| coverageAtOperationVolume | TrajectoryCoverageInformation | 0..1 | Coverage information related to the operation volumes of the operation plan. | |
| coverageAtContingencyPlan | ContingencyPlanCoverageInformation | 0..* | Coverage information related to a contingency plan of the operation plan. | |

*Table 18: The OperationPlanAnalyzeResult data structure*

## 5.11 The *PhysicalAntenna* Data Structure

The *PhysicalAntenna* provides information about the physical antenna used for communication on the aircraft. There can be more than one such antennas. The orientation of the antenna on the aircraft is modelled using Euler angles (more specifically, the orientation of the antenna *pattern*).

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| type | string | 0..1 | A type specifier of the antenna. Optional; can be used instead of specifying the pattern, gain and polarization attributes if the antenna type is well-known. | |
| horizontalPattern | string | 1 | Horizontal antenna pattern string. | |
| verticalPattern | string | 1 | Vertical antenna pattern string. | |
| gain | float | 1 | Antenna gain, in dBi. | |
| polarization | Polarization | 1 | Antenna polarization. | |
| theta, phi, psi | float | 1 | Orientation angles of the antenna. | |

*Table 19: The PhysicalAntenna data structure*

## 5.12 The *Polarization* Enumeration

The *Polarization enumeration* type specifies polarization types.

| Property | Description | Note |
|---|---|---|
| HORIZONTAL | Horizontal polarization. | |

| | | |
|---|---|---|
| VERTICAL | Vertical polarization. | |
| CROSS | Cross polarization. | |

Table 20: The Polarization enumeration

## 5.13 The *RadioParameters* Data Structure

The RadioParameters provides communication equipment (physical) and logical communication information. This is an abstract class, needs technology-aware specialized implementation.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| technology | Technology | 1 | The technology of the radio parameters. | |
| antenna | Antenna | 1..* | The used antenna parameters. | |

Table 21: The RadioParameters data structure

## 5.14 The *ServiceLevel* Enumeration

The *ServiceLevel* enumeration type specifies service levels.

| Property | Description | Note |
|---|---|---|
| C2 | | |
| STREAM_4K | | |
| ... | | |

Table 22: The Technology enumeration

## 5.15 The *Technology* Enumeration

The *Technology* enumeration type specifies Communication technologies.

| Property | Description | Note |
|---|---|---|
| CELL_4G | | |
| CELL_5G | | |
| ... | | |

Table 23: The Technology enumeration

## 5.16 The *TrajectoryCoverageInformation* Data Structure

The *TrajectoryCoverageInformation* holds an analysis in regards to connectivity coverage for a flight trajectory belonging to an operation plan.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| coverageSummary | CoverageSummaryInfo | 1 | Overview information about how the requested service level is met for the whole trajectory.<br>If this is FULLY_COVERED or NON_COVERED, then the coverageAtTrjectoryElement elements may be omitted. | |
| coverageAtTrjectoryElement | GeometryCoverageInformation | 0..* | Coverage information corresponding to a certain trajectory element or operation volume. | |

*Table 24: The TrajectoryCoverageInformation data structure*

## 5.17 The *TrajectoryElement* Data Structure

Note: *TrajectoryElement* is fullly described in a separate Operation Plan service specification.

The *TrajectoryElement* describes a segment of a flight trajectory by providing a four-dimensional point in space-time.

## 5.18 The *Volume* Data Structure

The *Volume* structure describes a geographic 3D volume in space. These are covered in greater detail in an external Volume specification. Typical volumes are cylinders with a certain radius and height or polyhedrons.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| id | UUID | 1 | Unique reference. | |
| type | *enum* | 1 | The type of volume | |
| geometry | Geonetry | 1 | The geometry that describes this volume | |

*Table 25: The Volume data structure*

# 6 Service Interface Specifications

This chapter describes the details of each service interface. One sub-chapter is provided for each Service Interface.

The Service Interface specification covers only the static design description while the dynamic design (behaviour) is described in a subsequent chapter.

## 6.1 Network Coverage Service Interface

This Service Interface is the main point of interaction for Service Consumers. It provides methods to fetch volume coverage and conduct operation plan analyzes. It is provided by the Network Coverage Service.

The NetworkCoverageServiceInterface realizes the Request/Response Message Exchange Pattern (MEP), where the Service Consumer calls Operations at the Service Provider and the Service Provider answers synchronously with a result. This MEP is most suitable for the synchronous, 1:1 nature of the included Service Operations.

### 6.1.1 Operation getVolumeCoverage

The getVolumeCoverage operation produces information about three-dimensional area connectivity conditions for a certain Service Level and a certain Connectivity Provider. It basically answers the question where in three-dimensional space can the requested Service Level be provided by the Connectivity Provider right now. Note that this is only a high-level overview on the connectivity conditions as other significant factors like aircraft speed and orientation are conceptually not available at the time of requesting large area coverage.

Coverage information is transported in 3D buffer CoverageData objects. This operation returns references to such objects for the requested volume. The actual coverage data can then be downloaded via the downloadCoverageData operation.

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| volume | Input | Volume | Specifies the 3-dimensional space for which the network coverage shall be determined. |
| serviceLevel | Input | ServiceLevel | Requested service level. |
| connectivityProvider | Input | ConnectivityProvider | Requested connectivity provider. |



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| | | | |
|---|---|---|---|
| <none> | Return | GeometryCoverageInformation | The return value contains a structure with connectivity information for the requested 3D volume.<br>If network connectivity is not homogeneously covered or not covered for the whole volume, then the result contains a list of references to CoverageData elements, comprising a 3D raster of 3D cells with finer graned coverage information. |

*Table 26: Payload description of getVolumeCoverage operation*

### 6.1.2 Operation downloadCoverageData

The download CoverageData operation is used to download the actual coverage data for a given CoverageData reference. CoverageData references can be be obtained from the getVolumeCoverage operation or are reported via the volumeCoverageChanged operation in the NetworkCoverageServiceNotificationInterface.

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| coverageDataRef | Input | CoverageDataRef | CoverageData reference, pointing to the coverage data obtained via a different operation (getVolumeCoverage or volumeCoverageChanged). |
| <none> | Return | CoverateData | The return value contains the detailed coverage information. |

*Table 27: Payload description of downloadCoverageData operation*

### 6.1.3 Operation analyzeOperationPlan

The analyzeOperationPlan operation answers the question “where on the given flight route is the given Service Level met for a particular Connectivity Provider?” It can also help with route planning by providing the option to alter the route in certain limits for locations so that the complete route fulfils the Service Level requirements.

The Network Coverage Service brokers with the Connectivity Provider or connectivity data provider so that the given flight route is evaluated on their premises. The Network Coverage Service then returns the results to the Consumer.

A “service level” in the context of this interface is an abstract name for a combination of connectivity conditions. For example, a “C2” (command & control) service level might require a certain maximum physical layer latency, whereas a “streaming 4K” service level might require a minimum guaranteed throughput in mbit/s. Additionally, depending on the communication technology, other technical thresholds and limits will be in place for the different service levels (in 4G for example, a minimum RSRP and SINR value). These thresholds and limits are configured on the connectivity provider’s side and likely be specified by standardization. The aviation user does not need to know these; she only requests the service levels by name that are relevant for the planned mission.

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| operationPlan | Input | OperationPlan | An operation plan, including four-dimensional trajectory information and optional contingency planning (i.e., alternative flight locations). |
| serviceLevel | Input | ServiceLevel | Requested service level. |
| Connectivity Provider | Input | Connectivity or connectivity data Provider | |
| <none> | Return | OperationPlanAnalyzeResult | The return value contains a structure with connectivity information for the given operation plan.<br>If network connectivity is not homogeneously covered or not covered for the whole operation plan, then the result contains dedicated coverage information structures for individual trajectory elements and for individual contingency planning elements. |

*Table 28: Payload description of analyzeOperationPlan operation*

## 6.2 Network Coverage Subscription Interface

This Service Interface provides Subscribe operations to Service Consumers. It is provided by the Network Coverage Service.

The NetworkCoverageSubscriptionInterface and the NetworkCoverageNotificationInterface together realize the Publisher/Subscriber MEP. As the connectivity information in a certain area constantly changes, the notification for such changes is posted to a Publisher/Subscriber topic. Service Consumers can attach to those topics and get asynchronously notified about changes to areas of their interest.

### 6.2.1 Operation subscribe

The subscribe operation allows a Service Consumer to subscribe to changes in area connectivity coverage.

Whenever the connectivity information for a certain Service Level and Connectivity Provider happens to change, a notification is posted in a dedicated topic. Service Consumers can subscribe to that topic to be notified about those changes.

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| serviceLevel | Input | ServiceLevel | Requested service level. |
| connectivityProvider | Input | ConnectivityProvider | Requested connectivity provider. |

*Table 29: Payload description of subscribe operation*

### 6.2.2 Operation unsubscribe

As the opposite operation of subscribe, this operation allows a Service Consumer to stop receiving notifications about changes for a certain Service Level and Connectivity Provider.

This removes the service consumer from the list of consumers to be notified.

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| serviceLevel | Input | ServiceLevel | Service level for unsubscription. |
| connectivityProvider | Input | ConnectivityProvider | Connectivity provider for unsubscription. |

*Table 30: Payload description of unsubscribe operation*

## 6.3 Network Coverage Notification Interface

This Service Interface is provided by and implemented on the service consumer's side. It is called to notify the service consumer about changes it subscribed to via the operations in the NetworkCoverageSubscriptionInterface.

The NetworkCoverageSubscriptionInterface and the NetworkCoverageNotificationInterface together realize the Publisher/Subscriber MEP. As the connectivity information in a certain area constantly changes, the notification for such changes is posted to a Publisher/Subscriber topic. Service consumers can attach to those topics and get asynchronously notified about changes to areas of their interest.

### 6.3.1 Operation volumeCoverageChanged

This Operation is called on the service consumer's side whenever the coverage information for a certain Service Level and a certain Connectivity Provider changed.

Whenever the connectivity information for a certain Service Level and Connectivity Provider happens to change, a notification is posted in a dedicated topic. If the service consumer subscribed to that topic, it will receive notifications via this operation.

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| serviceLevel | Input | ServiceLevel | Service level for which the coverage changed. |
| connectivityProvider | Input | ConnectivityProvider | Connectivity provider for which the coverage changed. |

| | | | |
|---|---|---|---|
| coverageInfo | Return | GeometryCoverageInformation | Details with connectivity information for the 3D volume in which the connectivity changed.<br>If network connectivity is not homogeneously covered or not covered for the whole volume, then the coverageInfo contains a list of references to CoverageData elements, comprising a 3D raster of 3D cells with finer graned coverage information. |

*Table 31: Payload description of getVolumeCoverage operation*

# 7 Service Dynamic Behaviour

The following diagrams describe examples for the dynamic behavior of the NetworkCoverageService.

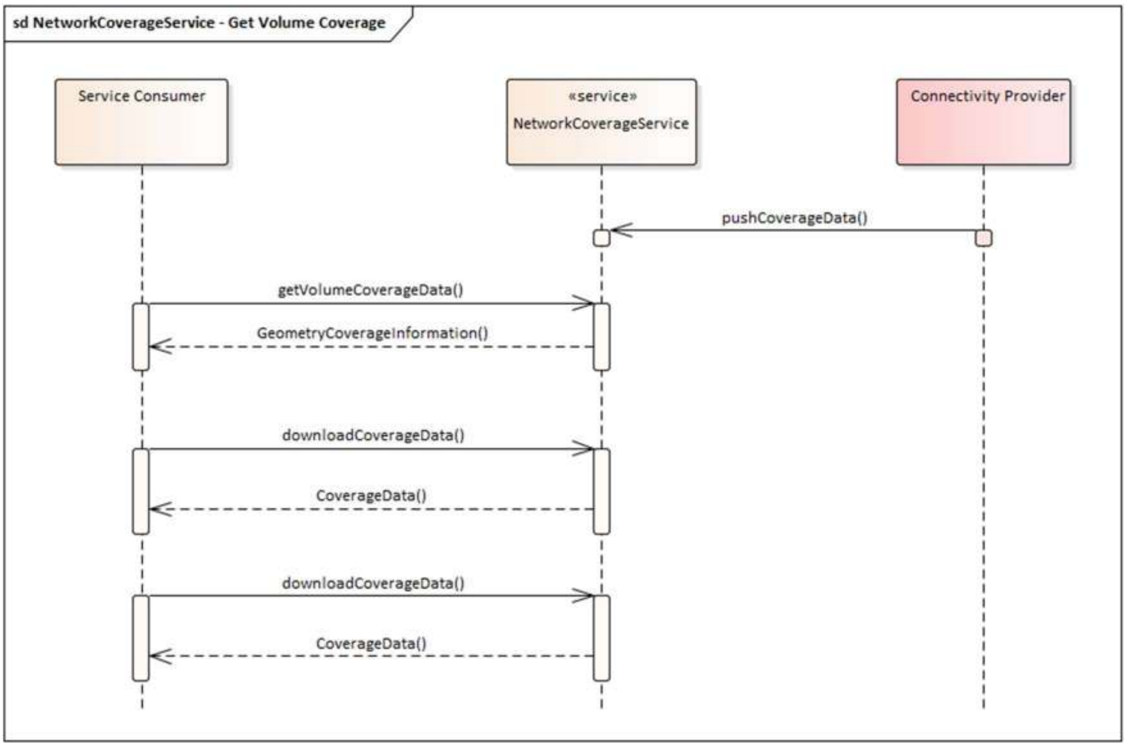


*Figure 4: Network Coverage Service Operation Sequence Diagram – Get area coverage*

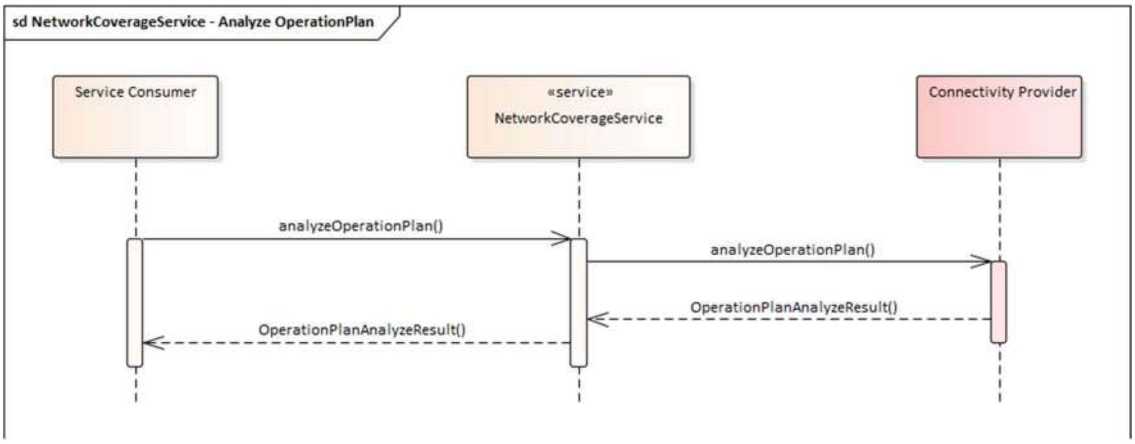


*Figure 5: Network Coverage Service Operation Sequence Diagram – Analyze Operation Plan*

Please note that the interface between the Connectivity Provider and the NetworkCoverage Service are out of scope of this document, however to indicate the dynamic behavior they are shown here.

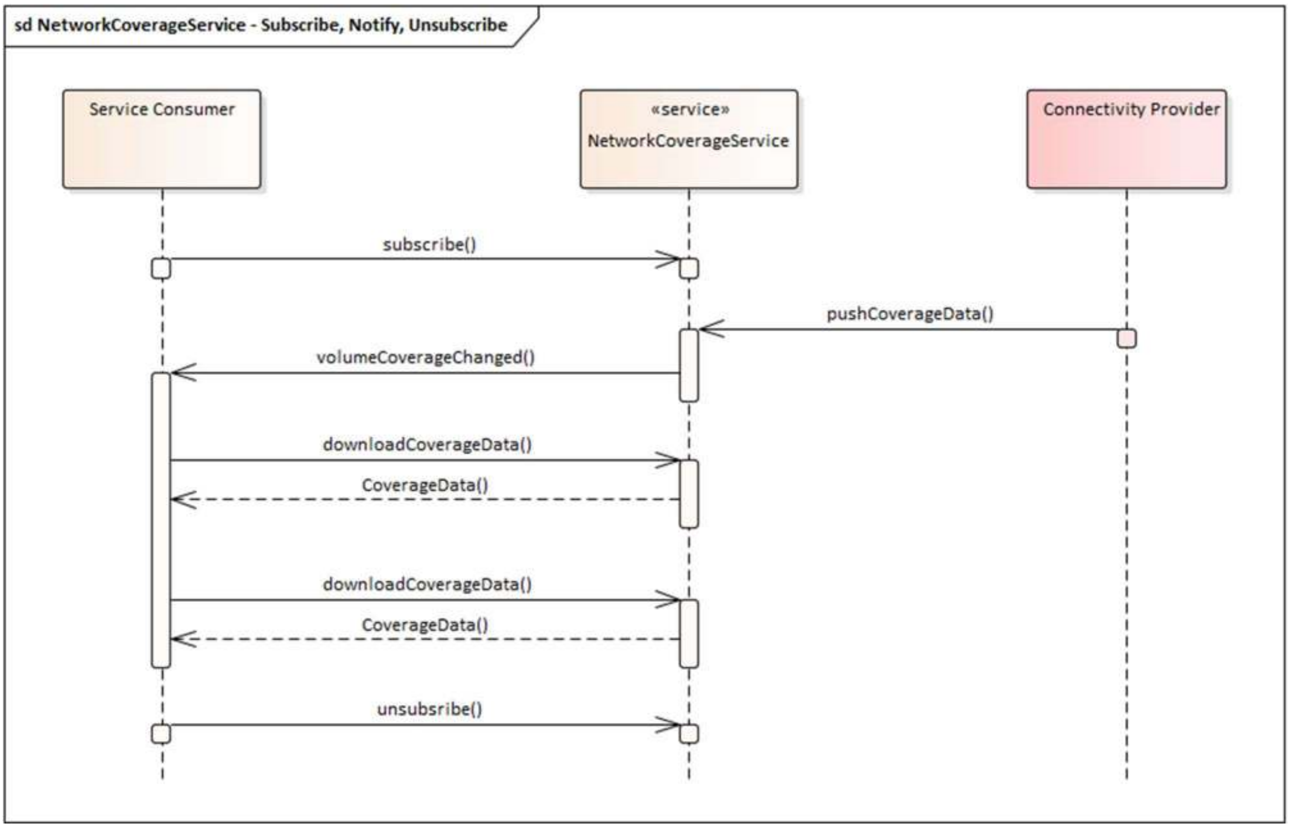


*Figure 6: Network Coverage Service Operation Sequence Diagram – subscription, notification and unsubscription*

# 8 Service Provisioning

Left Empty.

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SESAR JOINT UNDERTAKING

# D2.4 Appendix I Drone Flight Exchange Service Specification


| | |
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## Authoring & Approval

### Authors of the document

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| **Hubert Künig / FRQ** | Scientist | 31.10.2022 |
| **Thomas Lutz / FRQ** | WP2 Lead | 31.10.2022 |
| **Gregor Mogertisch** | WP2 | 31.10.2022 |

### Reviewers internal to the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Lukasz Gorny - Zajac | Solution Architect | 1.11.2022 |
| Pawel Korzec | PM | 1.11.2022 |

### Approved for submission to the SJU By - Representatives of beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Sami Alkula/FANS | Project Management Group | 3.11.2022 |
| Thomas Neubauer/DIME | Project Management Group | 3.11.2022 |
| Pawel Korzec/DRR | Project Management Group | 3.11.2022 |
| Yuhang Yun/EHE | Project Management Group | 3.11.2022 |
| Damini Gera/AIRB | Project Management Group | 3.11.2022 |
| Piotr Szymaniak/PSNC | Project Management Group | 3.11.2022 |
| Sven Jürgenson/THREOD | Project Management Group | 3.11.2022 |
| Leopoldo Tejada/UML | Project Management Group | 3.11.2022 |
| Tapio Haarlaa/VAI | Project Management Group | 3.11.2022 |
| Iris Röhrich/FRQ | Project Management Group | 3.11.2022 |
| Juha Lindstedt/AVIA | Project Management Group | 3.11.2022 |
| Piotr Bratek/PANSA | Project Management Group | 3.11.2022 |
| Tanel Järvet/CAFA | Project Management Group | 3.11.2022 |
| Maria Tamm/EANS | Project Management Group | 3.11.2022 |

### Rejected By - Representatives of beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| | | |

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# GOF 2.0

## GOF2.0 INTEGRATED URBAN AIRSPACE VLD

This Updated Service Specification is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 101017689 under European Union's Horizon 2020 research and innovation programme.

**Abstract**

This specification introduces a service of a Common Information Service (CIS) which ensures interoperability and hence transparent and reliable information flow between the stakeholders in an operational U-space environment. In accordance with ICAO SWIM, represents an Information Exchange Service.

This document describes one of these Bridge Services, the Drone Flight Exchange service in a logical, technology-independent manner.



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## List of Figures

# 1 Introduction

## 1.1 Purpose of the document

In accordance with according to the guidelines given in [3], this document describes the Drone Flight Exchange service for the GOF 2.0 project on a logical technology-independent manner, that is:

- the operational and business context of the service
    - requirements for the service (e.g., information exchange requirements)
    - involved nodes: which operational components provide/consume the service
    - operational activities supported by the service
    - relation of the service to other services
- the service description
    - service interface definitions
    - service interface operations
    - service payload definition
    - service dynamic behaviour description
- service provision and validation aspects

Furthermore, this document clearly defines the version of the service.

## 1.2 Scope

This document describes the Drone Flight Exchange service for the GOF USPACE project.

The Drone Flight Exchange service provides a means for the operational nodes of the GOF USPACE project to share information about drone flights and make them available for further processing.

The Drone Flight Exchange service furthermore provides a means for the operational nodes of the GOF USPACE project to consume information about drone flights from the U-space participants for further processing.

## 1.3 Intended readership

This service specification is intended to be read by service architects, system engineers and developers in charge of designing and developing an instance of the Drone Flight Exchange service as well as of the Operation Plan Information Exchange service.

Furthermore, this service specification is intended to be read by enterprise architects, service architects, information architects, system engineers and developers in pursuing architecting, design and development activities of other related services.

## 1.4 Background

### 1.4.1 EUROCONTROL Concept of Operations for U-space (CORUS)



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EUROCONTROL CORUS [4] elaborates the Operation Plan Processing service as follows:

"*The following can be taken as an approximate list of the steps taken by the Drone operation plan processing service when an operation plan is received.*

- *Syntax check. Does whatever has arrived resemble a flight plan enough to be processed?*
- *Semantic check. Are all the expected pieces of information present?*
- *If OK so far, generate a unique identifier for the operation plan.*
- *Authorisation-check using the e-Registration service. Is there some reason this operator or this pilot or this drone should not be flying?*
- *Construction of a probabilistic 4D model of the flight's likely airspace occupancies, (a trajectory) using the plan, the Weather information service, the flight/performance characteristics of the drone, and any other relevant information. The trajectory will be subject to simple sanity checks.*
- *Weather warning, using the Weather information service. Is there a weather warning for the time and place of the operation*
- *Geo-Fencing, height maxima and other boundary checks, using the Drone aeronautical information service and the probabilistic trajectory. For any geo-fences that are penetrated, is there a corresponding permission in the operation plan? For any conditional access, are the conditions met?*
- *Procedural interface with ATC. If any controlled areas are penetrated by the probabilistic trajectory then the procedural interface with ATC is triggered for each.*
- *The Strategic conflict-management service is invoked.*
- *If available, the Dynamic capacity management service is invoked.*"

In other words, the Operation Plan Processing service deals with the planning aspects of a drone flight. There is no mentioning about the dynamic execution of the drone flight, other than the following:

"*The status of an operation plan also changes when start-of-flight is received or position reports arrive for the flight without start-of-flight. A further status change occurs on receipt of end-of-flight. Hence the Drone operation plan processing service consumes information from the Tracking service.*"

In this document we propose to introduce the Drone Flight Exchange service to bridge the gap between Operation Plan Processing service and Tracking Service.

### 1.4.2 Federal Aviation Administration (FAA) Concepts of Operations

The FAA defines a messaging service in its Concepts of Operations v1.0 - Appendix C - UTM Services - Messaging Service [7] as follows.

*"A service which provides on demand, periodic, or event driven information on UAS operations (e.g. position reports, intent information, and status information) occurring within the subscribed airspace volume and time. Additional filtering may be performed as part of the service."*

### 1.4.3 International Civil Aviation Organization (ICAO)

In the Global Air Navigation Plan [9], ICAO defines three Aviation System Block Upgrade (ASBU) blocks, B1-RPAS, B2-RPAS, and B3-RPAS, referring to scheduled implementation years of 2019, 2025, 2031, and beyond, and expects increased situational awareness from B1-RPAS onwards.

ICAO Doc 10039 [2] elaborates in section 3.4 INFORMATION EXCHANGE SERVICES on information exchange services as follow (para. 3.4.2).

*"Within the SWIM Global Interoperability Framework, the Information Exchange layer is instantiated by 'information services' as is further explained. Information services ensure interoperability between ATM applications which consume and provide interoperable information services. Consequently, the concept of information service is a fundamental building block of SWIM which enables interoperability through well-defined information exchanges."*

### 1.4.4 SESAR-JU

The European Commission identifies an increasing demand for a non-segregated use of airspace which is being driven by a rapidly growing market of Very-Low-Level (VLL) airspace users, most of which are expected to be drones.

Via the Roadmap for the safe integration of drones into all classes of airspace [11], within the European ATM Masterplan [12], the European Commission seeks to ensure that this rapid growth of airspace use happens in a safe and controlled manner.

SESAR develops the required concepts and demonstrations for this process to happen. The roadmap [1], in alignment with ICAO recommendations, identifies three phases for the integration, from which SESAR derives the four U-space service blocks presented in the U-space blueprint [13],

U1 U-space foundation services,

U2 U-space initial services,

U3 U-space advanced services, and

U4 U-space full services.

These stages reflect the anticipated quick growth of demand for U-space services. The state of the art is being validated throughout Europe via several Very Large Demonstrator (VLD) projects such as the GOF USPACE project.

During the U1 phases, SESAR expects drones capable to supply their position via telemetry. The U1 and U2 is anticipated to provide tracking capabilities and services.

### 1.4.5 Efficient, safe and sustainable traffic at sea (EfficienSea2)

The design method and terminology builds on experience from the EfficienSea2 project [14], [15].

## 1.5 Glossary of terms

| Term | Definition |
|---|---|



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| | |
|---|---|
| **AIR-REPORT** | A report from an aircraft in flight prepared in conformity with requirements for position, and operational and/or meteorological reporting. |
| **Drone Flight** | Information about the actual conduction of a drone flight. |
| **External Data Model** | Describes the semantics of the domain (or a significant part thereof) by defining data structures and their relations. This could be at logical level (e.g., in UML) or at physical level (e.g., in XSD schema definitions), as for example standard data models. |
| **Message Exchange Pattern** | Describes the principles how two different parts of a message passing system (in our case: the service provider and the service consumer) interact and communicate with each other. Examples:<br><br>In the Request/Response MEP, the service consumer sends a request to the service provider in order to obtain certain information; the service provider provides the requested information in a dedicated response.<br><br>In the Publish/Subscribe MEP, the service consumer establishes a subscription with the service provider in order to obtain certain information; the service provider publishes information (either in regular intervals or upon change) to all subscribed service consumers. |
| **Operation Plan** | Information about the planning of a drone operation. |
| **Operational Activity** | An activity performed by an operational node. Examples of operational activities are: Route Planning, Route Optimization, Logistics, Safety, Weather Forecast Provision, … |
| **Operational Model** | A structure of operational nodes and associated operational activities and their inter-relations in a process model. |
| **Operational Node** | A logical entity that performs activities. Note: nodes are specified independently of any physical realisation.<br><br>Examples of operational nodes are: Control Center, Authority, Weather Information Provider, … |
| **Service** | The provision of something (a non-physical object), by one, for the use of one or more others, regulated by formal definitions and mutual agreements. Services involve interactions between providers and consumers, which may be performed in a digital form (data exchanges) or through voice communication or written processes and procedures. |
| **Service Consumer** | A service consumer uses service instances provided by service providers. |



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| **Service Data Model** | Formal description of one dedicated service at logical level. The service data model is part of the service specification. Is typically defined in UML and/or XSD. If an external data model exists (e.g., a standard data model), then the service data model shall refer to it: each data item of the service data model shall be mapped to a data item defined in the external data model. |
| **Service Design Description** | Documents the details of a service technical design (most likely documented by the service implementer). The service design description includes (but is not limited to) a service physical data model and describes the used technology, transport mechanism, quality of service, etc. |
| **Service Implementation** | The provider side implementation of a dedicated service technical design (i.e., implementation of a dedicated service in a dedicated technology). |
| **Service Implementer** | Implementers of services from the service provider side and/or the service consumer side. |
| **Service Instance** | One service implementation may be deployed at several places by same or different service providers; each such deployment represents a different service instance, being accessible via different URLs. |
| **Service Instance Description** | Documents the details of a service implementation (most likely documented by the service implementer) and deployment (most likely documented by the service provider). The service instance description includes (but is not limited to) service technical design reference, service provider reference, service access information, service coverage information, etc. |
| **Service Interface** | The communication mechanism of the service, i.e., interaction mechanism between service provider and service consumer. A service interface is characterised by a message exchange pattern and consists of service operations that are either allocated to the provider or the consumer of the service. |
| **Service Operation** | Functions or procedure which enables programmatic communication with a service via a service interface. |



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| | |
|---|---|
| **Service Physical Data Model** | Describes the realisation of a dedicated service data model in a dedicated technology. This includes a detailed description of the data payload to be exchanged using the chosen technology. The actual format of the service physical data model depends on the chosen technology. Examples may be WSDL and XSD files (e.g., for SOAP services) or swagger (Open API) specifications (e.g., for REST services). If an external data model exists (e.g., a standard data model), then the service physical data model shall refer to it: each data item of the service physical data model shall be mapped to a data item defined in the external data model.<br><br>In order to prove correct implementation of the service specification, there shall exist a mapping between the service physical data model and the service data model. This means, each data item used in the service physical data model shall be mapped to a corresponding data item of the service data model. (In case of existing mappings to a common external (standard) data model from both the service data model and the service physical data model, such a mapping is implicitly given.) |
| **Service Provider** | A service provider provides instances of services according to a service specification and service instance description. All users within the domain can be service providers, e.g., authorities, organizations (e.g., meteorological), commercial service providers, etc. |
| **Service Specification** | Describes one dedicated service at logical level. The Service Specification is technology-agnostic. The Service Specification includes (but is not limited to) a description of the Service Interfaces and Service Operations with their data payload. The data payload description may be formally defined by a Service Data Model. |
| **Service Specification Producer** | Producers of service specifications in accordance with the service documentation guidelines. |
| **Service Technical Design** | The technical design of a dedicated service in a dedicated technology. One service specification may result in several technical service designs, realising the service with different or same technologies. |
| **Service Technology Catalogue** | List and specifications of allowed technologies for service implementations. Currently, SOAP and REST are envisaged to be allowed service technologies. The service technology catalogue shall describe in detail the allowed service profiles, e.g., by listing communication standards, security standards, stacks, bindings, etc. |

| | |
|---|---|
| **Spatial Exclusiveness** | A service specification is characterised as “spatially exclusive”, if in any geographical region just one service instance of that specification is allowed to be registered per technology.<br><br>The decision, which service instance (out of a number of available spatially exclusive services) shall be registered for a certain geographical region, is a governance issue. |

**Table 1: Glossary of terms**

## 1.6 List of Acronyms

| Acronym | Definition |
|---|---|
| **API** | Application Programming Interface |
| **CARS** | Common Altitude Reference System |
| **MEP** | Message Exchange Pattern |
| **NAF** | NATO Architectural Framework |
| **OP** | Operation Plan |
| **REST** | Representational State Transfer |
| **SOA** | Service Oriented Architecture |
| **SOAP** | Simple Object Access Protocol |
| **SSD** | Service Specification Document |
| **UML** | Unified Modelling Language |
| **URL** | Uniform Resource Locator |
| **WSDL** | Web Service Definition Language |
| **XML** | Extendible Mark-up Language |
| **XSD** | XML Schema Definition |

**Table 2: List of acronyms**

# 2 Service Identification

The purpose of this chapter is to provide a unique identification of the service and describe where the service is in terms of the engineering lifecycle.

| | |
|---|---|
| **Name** | **DroneFlightExchange Service** |
| **ID** | **urn:gof:services:DroneFlightExchangeService** |
| **Version** | **1.0** |
| **Description** | **An information exchange service which provides drone flight information** |
| **Keywords** | **Operation Plan, Drone Flight execution, Drone Flight States, Correlation between Operation Plan and Position Reporting** |
| **Architect(s)** | **2022 The GOF 2.0 Project Consortium**<br><br>**2022 The Frequentis Group** |
| **Status** | **Provisional** |

**Table 3: Service Identification**

# 3 Operational Context

This section describes the context of the service from an operational perspective.

## 3.1 Functional and Non-functional Requirements

The table below lists applicable existing requirements for the DroneFlightExchange service.

| Requirement Id | Requirement Name | Requirement Text | References |
|---|---|---|---|
| **[R-1]** | Common Situational Awareness | At all times, all U-space participants shall operate on the same common set of data, during pre-flight planning stages as well as during all stages of flight operations. | CORUS [4], 4.1.1.2 Amber airspace;B1-RPAS [9];CEF-SESAR-2018-1 [1], Objective O5 |
| **[R-2]** | Basis for Open Market | The U-space concept shall be designed such as to ensure a well-established line of authority while at the same time ensuring that an open market for VLL services may develop | SESAR Drone Roadmap [11], Foreword, 4.1 and 4.2;U-space Blueprint [13], Benefits to European society and economy;CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |
| **[R-3]** | Interoperability | There shall be an implementation of a Flight Information Management System (FIMS) which ensures that, at all times, emerging unmanned traffic management systems and existing technologies from manned operations can exchange any data required to support such common situational awareness, be it for drone operations in areas where established ATC procedures apply, or in zones outside established ATC. | ICAO Doc 10039 [2];[R-2];CEF-SESAR-2018-1 [1], Objective O6;CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |
| **[R-4]** | Standard Protocols | Standard communication protocols shall hence be used where available, and such standard protocols be developed otherwise, in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop. | [R-2];SESAR Drone Roadmap [11], 3.5, section 'Standards';CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |

| | | | |
|---|---|---|---|
| **[R-5]** | Open Interfaces | Any interface and protocol hence must be openly defined and its definition be freely accessible in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop. | [R-2];CEF-SESAR-2018-1 [1], Table 8 – Key Challenges |
| **[R-6]** | SWIM | The implementation of a Flight Information Management System (FIMS) shall be based on an ICAO SWIM-compliant architecture. | [R-3];CEF-SESAR-2018-1 [1], 5.3.4 Overall approach and methodology |
| **[R-7]** | Latency | Under no operational circumstance, the processing of position data may add significant latency to the overall detection-to-display latency of position data. In particular,<br><br>1. The processing latency added by the processing of positional data shall never exceed 10 per cent of the maximum value of the corresponding value permitted for the entire ATM automation system.<br>2. The processing latency and delay added by the processing of positional data should not exceed 1 per cent of the maximum value of the corresponding value permitted for the entire ATM automation system.<br><br>The maximum value for latency and delay is the minimum of the values defined by the ATM system performance requirements by EUROCONTOL and the FAA; for a 3 NM minimal separation, this is 2.2 s, for a 5 NM separation, 2.5 s. | [17], tables in the Executive Summary, [16], 3N_C-R8 and 5N_C-R8 |

**Table 4: Requirements for the DroneFlightExchange Service**

## 3.2 Other Constraints

### 3.2.1 Relevant Industrial Standards

#### 3.2.1.1 ICAO SWIM

The System Wide Information Management (SWIM, [2]) complements human-to-human with machine-to-machine communication, and improves data distribution and accessibility in terms of quality of the data exchanged. The SWIM Concept addresses the challenge of creating an "interoperability environment" which allows the SWIM IT systems to cope with the full complexity of operational information exchanges. The SWIM environment shifts the ATM information architecture paradigm from point-to-point data exchanges to system-wide interoperability.

### 3.2.2 Operational Nodes

A typical U-space flight goes through several stages, starting strategic-tactically, pre-flight, from Strategic Planning, over to Pre-Tactical Planning, to Tactical Planning. Then, tactical-operationally it enters into the actual in-flight stages from Departure, over to In-Flight, and, finally Arrival. Further post-flight stages may evaluate the results from the data produced during the prior stages.

The DroneFlightExchange service primarily is relevant during the actual operational in-flight stages of a U-space flight during which the flying device and/or the corresponding ground stations produce the position data which we convey via the Traffic/Telemetry service.

The DroneFlightExchange service may be seen as a means of correlation between the position reporting (provided by the Traffic/Telemetry service) on one side and the operation planning (provided by the OperationPlanInformationExchange service) on the other side.

There are several nodes in U-space which could provide position information to the DroneFlightExchange service.

(Figure TBD)

**Figure 1: U-space nodes related to the DroneFlightExchange service**

Operational nodes which may provide data for the DroneFlightExchange service include the following ones.

| Operational Node | Remarks |
|---|---|
| Aircraft | ? |
| Ground Station | ? |
| UTM Service Provider | |
| Flight Information Management System | |

**Table 5: Operational Nodes providing the DroneFlightExchange service**

Operational nodes which may consume the DroneFlightExchange service include the following ones.

| **Operational Node** | **Remarks** |
|---|---|
| **Flight Information Management System** | |
| Information Display | |
| Legal Recorder | |

**Table 6: Operational Nodes consuming the DroneFlightExchange service**

### 3.2.3 Operational Activities

Operational activities supported by the DroneFlightExchange service include the following ones.

| **Phase** | **Operational Activity** | **Remarks** |
|---|---|---|
| Pre-flight | **Set-up** | **(Drone Flight not available yet at this stage)** |
| | **Plan** | **(Drone Flight not available yet at this stage)** |
| | Arm | **(Drone Flight exchange should start to run here)** |
| In-Flight | Depart | Drone Flight data available for the flight |
| | Cruise | Drone Flight data available for the flight |
| | Arrive | Drone Flight data available for the flight |
| Post-Flight | Disarm | **(Drone Flight exchange likely stops here)** |
| | Report | **(Post/flight analysis only)** |

**Table 7: Operational Activities supported by the DroneFlightExchange service**

# 4 Service Interfaces

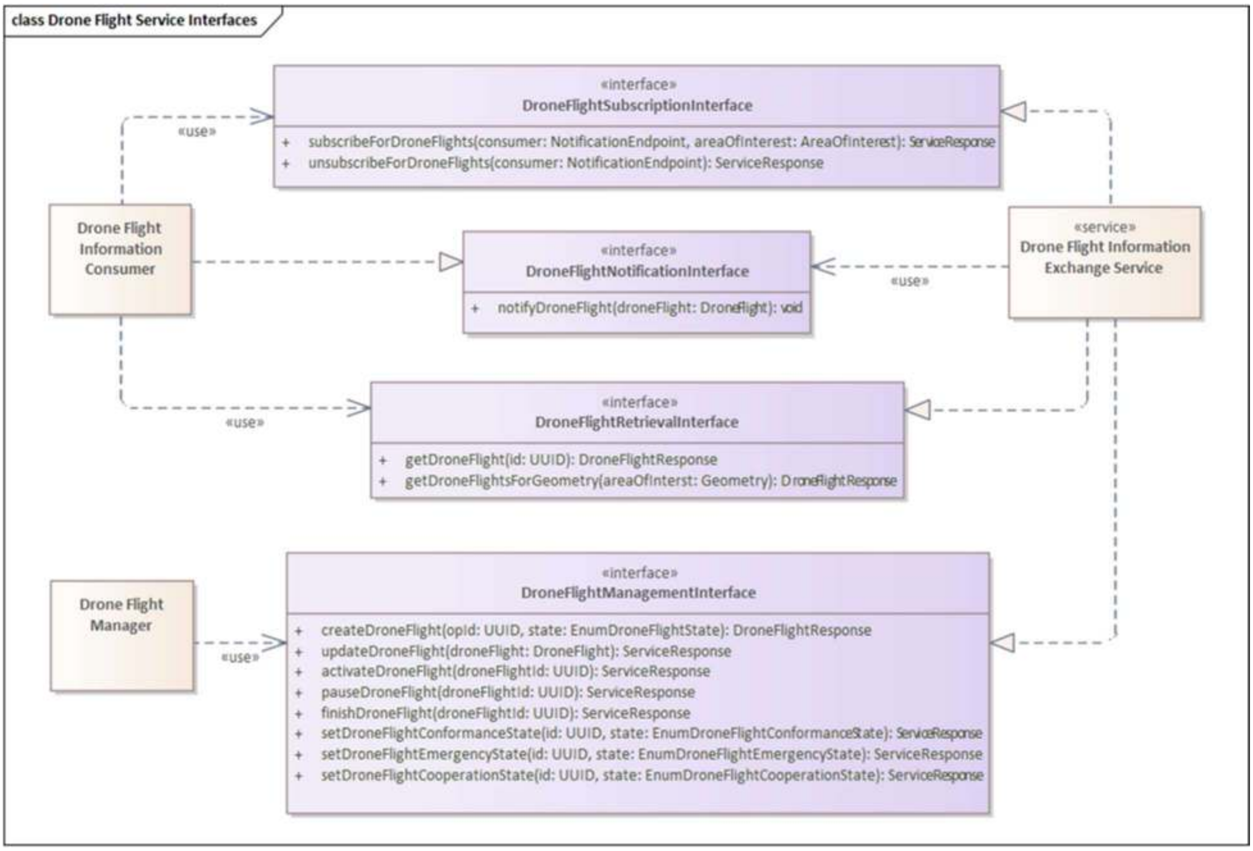


**Figure 2: DroneFlightExchangeService Interface Definition diagram**

| ServiceInterface | Role (from service provider point of view) | ServiceOperation |
|---|---|---|
| DroneFlightManagementInterface | Provided | createDroneFlight<br>updateDroneFlight<br>pauseDroneFlight<br>resumeDroneFlight<br>finishDroneFlight<br>setDroneFlightConformanceState<br>setDroneFlightEmergencyState<br>setDroneFlightCoorperationState |
| DroneFlightSubscriptionInterface | Provided | subscribeForDroneFlights<br>unSubscribeForDroneFlights |
| DroneFlightNotificationInterface | Required | notifyDroneFlight |

| | | |
|---|---|---|
| DroneFlightRetrievalInterface | Provided | getDroneFlight<br>getDroneFlightsForGeometry |

**Table 8: Service Interfaces**



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# 5 Service Data Model

This section describes the information model, i.e., the logical data structures to be exchanged between providers and consumers of the service.

## 5.1 Overview

The DroneFlight exchange service transfers information about an ongoing drone flight and associated data. The central part of the data model for this service is the DroneFlight structure, which includes a summary of the drone flight state information, together with a reference to the related Operation Plan and optionally a reference to tracking information.

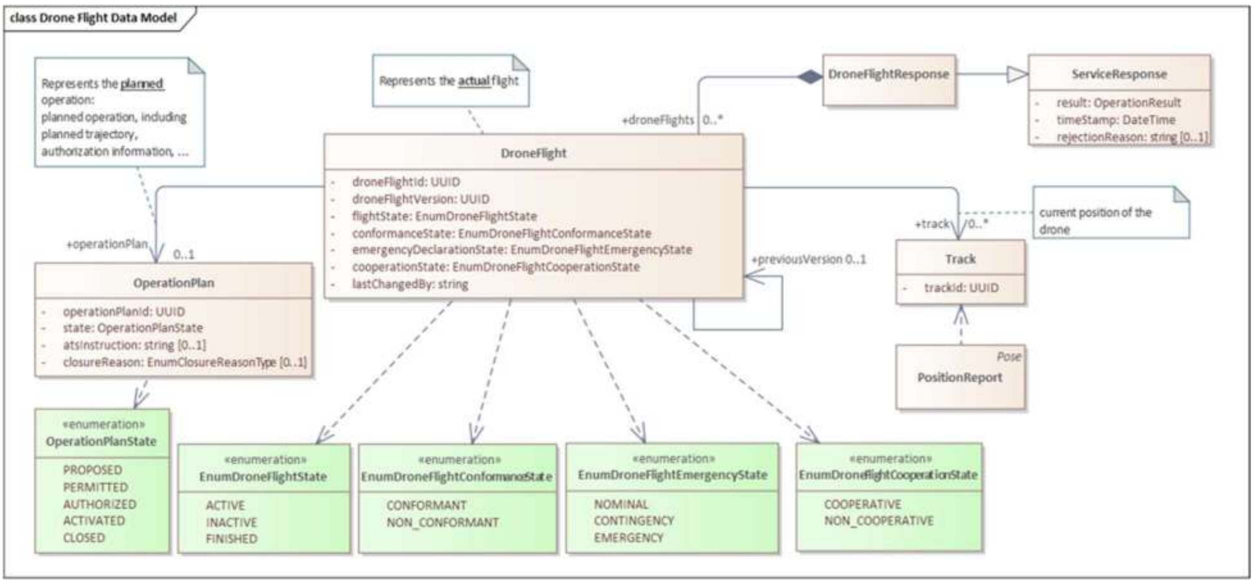


**Figure 3: Drone Flight Service Data Model diagram**

## 5.2 The DroneFlight Data Structure

DroneFlight is the central part of the DroneFlightExchange service data model.

| **Property** | **Type** | **Multiplicity** | **Description** | **Note** |
|---|---|---|---|---|
| droneFlightId | UUID | 1 | Globally unique identifier of this drone flight. | |

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| droneFlightVersion | UUID | 1 | Globally unique identifier of this version of the drone flight. | |
| flightState | DroneFlightState | 1 | The basic life cycle state of the drone flight. | |

| | | | | |
|---|---|---|---|---|
| conformanceState | DroneFlightConformanceState | 1 | The conformance state of the drone flight. It indicates whether the drone flight conforms to the referred, approved Operation Plan. | A drone flight is CONFORMANT if it has a reference to an Operation Plan that is in AUTHORIZED state and if the drone flight behaves as planned, i.e., if the spatial and temporal limitations given in the OP volume (and/or trajectory) are respected.<br><br>Note that a drone flight is still CONFORMANT, even if it is in contingency mode, as long as it follows the contingency plan provided within the Operation Plan.<br><br>A drone flight is considered NON_CONFORMANT if there is no reference to an Operation Plan, or if the referred Operation Plan is not approved, or if the drone is flying outside the approved (spatial and/or temporal) limits. |

| **Property** | **Type** | **Multiplicity** | **Description** | **Note** |
|---|---|---|---|---|
| emergencyDeclarationState | DroneFlightEmergencyDeclarationState | 1 | The emergency declaration state of the drone flight. | This state is to be explicitly declared by the drone operator.<br><br>Note that a drone flight may be in EMERGENCY state while it is still CONFORMANT (e.g., in contingency operation). |
| cooperationState | DroneFlightCooperationState | 1 | The cooperativeness of the drone flight. | A NON_COOPERATIVE NON_CONFORMING drone flight is considered rogue! |
| lastChangedBy | String | 1 | Indicates who did the last update on this object. | |
| operationPlan | Reference to OperationPlan | 0..1 | The reference to the Operation Plan. | This reference is usually given by providing the operationPlanId of the referred Operation Plan. |

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| track | Reference to Track | 0..* | Optional references to Track Identifiers. | By this reference, the DroneFlight is used to transmit correlation information between OperationPlan and Position Reporting. |
| previousVersion | Reference to DroneFlight Object | 0..1 | Refers to the historically previous version of this DroneFlight. | May be realized by simply adding the droneFlightVersion UUID of the previous version. |

**Table 9: The DroneFlight data structure**

## 5.3 The DroneFlightResponse Data Structure

DroneFlightResponse is used to carry the result of query-operations asking for drone flights.

Depending on the operation result, it may contain zero, one or several drone flights.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| droneFlights | DroneFlight | 0..* | Drone flight(s). | |
| < inherited > | | | **All properties inherited from ServiceResponse.** | **See common data types.** |

**Table 10: The DroneFlightResponse data structure**

## 5.4 The OperationPlanState Enumeration

The OperationPlanState enumeration type specifies the possible states of an operation plan.

| Property | Description | Note |
|---|---|---|
| PROPOSED | Initial state of the operation plan.<br><br>This operation is not yet APPROVED. It may be awaiting information from the operator, it may be in conflict with another APPROVED or ACTIVATED operation and undergoing a negotiation process, or for some other reason it is not yet able to be declared APPROVED. | |
| PERMITTED | Authority has given permission to proceed (Certification Processes, SORA, ...) | |
| AUTHORIZED | This operation has been deemed approved by the supporting USS. This implies that the operation meets the requirements for operating in the airspace based on the type of operation submitted. | Authorization of an OP may include the approval by multiple stakeholders. ATM may be one such stakeholder.<br><br>In some cases an OP may be AUTHORIZED without the approval of ATM (in cases where no ATM airspace is involved. |
| ACTIVATED | Operation plan has been activated. Drone is cleared to take off. | |
| CLOSED | This operation is closed. It is not airborne and will not become airborne again. | If the UAS and the crew will fly again, it would need to be as a new operation. A USS may announce the closure of any operation, but is not required to announce unless the operation was ROGUE or NONCONFORMING. |

**Table 11: The OperationPlanState enumeration**

## 5.5 The EnumDroneFlightState Enumeration

The EnumDroneFlightState enumeration type specifies the possible life cycle states of a drone flight.

| Property | Description | Note |
|---|---|---|
| ACTIVE | The drone has potentially taken off and is performing its mission according to the operation plan. | This is the initial state of a drone flight, as the drone flight is created with its activation. |

| Property | Description | Note |
|---|---|---|
| INACTIVE | The drone flight was activated but is currently pausing or has not taken off yet. | |
| FINISHED | The drone flight is completed. | |

**Table 12: The EnumDroneFlightState enumeration**

## 5.6 The EnumDroneFlightConformanceState Enumeration

The EnumDroneFlightConformanceState enumeration type specifies the possible conformance states of a drone flight.

The conformance state indicates whether the drone flight conforms to an approved Operation Plan..

| Property | Description | Note |
|---|---|---|
| CONFORMANT | The drone flight conforms to the referred Operation Plan.<br><br>This means, the drone plan is currently in line with the planned 4D-constraints described by the Operation Plan. | Note that a drone flight is still CONFORMANT, even if it is in contingency mode, as long as it follows the contingency plan provided within the Operation Plan. |
| NON_CONFORMANT | The drone flight is currently not conformant to the referred Operation Plan, or there is no Operation Plan known for the drone flight.<br><br>The Non-Conformance may be a violation of spatial or temporal constraints specified in the Operation Plans Operation Volume or Trajectory or Contingency Plan. Overdue is an example of Non-Conformant state. | |

**Table 13: The EnumDroneFlightConformanceState enumeration**

## 5.7 The EnumDroneFlightEmergencyState Enumeration

The EnumDroneFlightEmergencyState enumeration type specifies the possible kinds of contingency/emergency states that can be declared by the drone operator.

| Property | Description | Note |
|---|---|---|
| NOMINAL | The drone flight is in nominal conditions. | |

| Property | Description | Note |
|---|---|---|
| CONTINGENCY | The drone flight is in contingency conditions. | |
| EMERGENCY | The drone flight is in emergency conditions. | |

**Table 14: The EnumDroneFlightEmergencyState enumeration**

## 5.8 The EnumDroneFlightCooperationState Enumeration

The EnumDroneFlightCooperationState enumeration type specifies whether the drone flight is co-operative or not.

| Property | Description | Note |
|---|---|---|
| CO_OPERATIVE | The drone flight is behaving co-operatively. | If only a flight declaration is possible (without telemetry transmission), the CO_OPERATIVE flight may be a flight reported (submited) to the system. |
| NON_COOPERATIVE | The drone flight is not behaving co-operatively. | A NON_COOPERATIVE NON_CONFORMING drone flight is considered rogue! |

**Table 15: The EnumDroneFlightCooperationState enumeration**

## 5.9 Common Data Structures Used in UTM Service Specifications

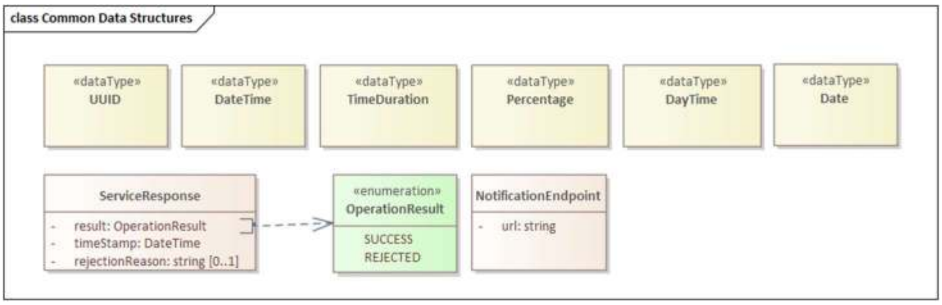


**Figure 4: Common Data Types Used in UTM Service Specifications**

### 5.9.1 NotificationEndpoint Data Structure

**NotificationEndpoint** is used in subscription and un-subscription operations to show the receiver of notifications as a result of the subscription.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| **URL** | **String** | 1 | Endpoint capable of receiving notifications | |

**Table 16: NotificationEndpoint Data Structure**

### 5.9.2 ServiceResponse **Data Structure**

ServiceResponse is the generic response provided by each service operation. In some cases, this basic data structure may be extended by inheritance.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **result** | **OperationResult** | 1 | Indicates the result of the request to the service | |
| **rejectReason** | **String** | 0..1 | Optional additional information to be provided in case of negative result | |
| timeStamp | DateTime | 1 | | |

**Table 17: ServiceResponse Data Structure**

### 5.9.3 OperationResult **Enumeration**

The **OperationResult** enumeration type specifies the possible outcomes of calling an operation.

| Property | Description | Note |
|---|---|---|
| **SUCCESS** | Operation was successfully executed. | |
| *REJECTED* | Operation could not be executed. | |

**Table 18: OperationResult Enumeration**

## 5.10 Common Geometry Data Structures Used in UTM Service Specifications

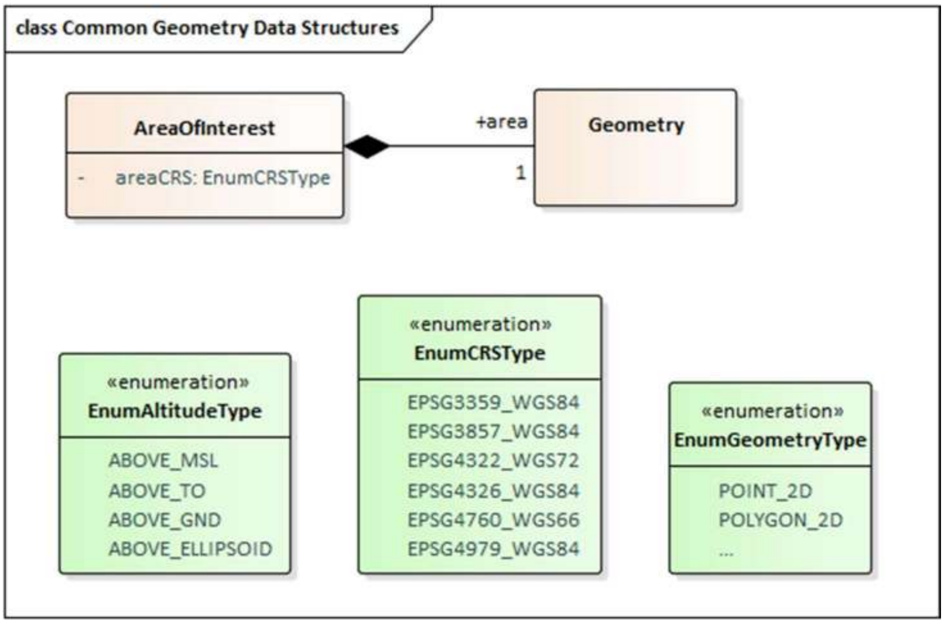


**Figure 5: Common Geometry Data Types Used in UTM Service Specifications**

### **5.10.1**AreaOfInterest **Data Structure**

**AreaOfInterest** is used in subscription operations to provide an indication of the geographic area for which the subscriber is interested to receive notifications.

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **area** | **Geometry** | 1 | A geometric description of a geographic area. | Should be a 2-dimensional geometry in this case. |
| **areaCRS** | **EnumCRSType** | 1 | Coordinate reference system used (WGS-84, EPSG:4979) | |

**Table 19: AreaOfInterest Data Structure**

### **5.10.2**Geometry **Data Structure**

**Geometry** describes a geometrical shape of one, two or three dimensions.

The **Geometry** data structure **is not further detailed in this service specification**. One example of how a generic Geometry structure could be realized is sketched in the table below:

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| **coordinates** | **Double** | 2..* | Collection of the coordinates, describing the geometry. | |

| | | | | |
|---|---|---|---|---|
| **geometryType** | **GeometryType** | 1 | Type of geometry being described by the coordinates. | Examples: Point, Polygon, Polyhedron, etc. |

**Table 20: Geometry Data Structure**

## 5.10.3 EnumAltitudeType **Enumeration**

The **EnumAltitudeType** enumeration type specifies the possible ways to express an altitude/height. The respective values should be measured or converted using CARS system.

| Property | Description | Note |
|---|---|---|
| **ABOVE_MSL** | Altitude above mean-sea-level.<br><br>Same as orthometric height; same as height above the earth geoid. | |
| *ABOVE_TO* | Altitude above take-off location. | |
| *ABOVE_GND* | Height above ground surface. | |
| **ABOVE_ELLIPSOID** | Altitude above the WGS-84 ellipsoid; value delivered by GNSS. | |

**Table 21: EnumAltitudeType Enumeration**

## 5.10.4 EnumCRSType **Enumeration**

The **EnumCRSType** enumeration type specifies the possible ways to express a coordinate reference system. The most common values used are noted in bold letters.

| Property | Description | Note |
|---|---|---|
| *EPSG3395_WGS84* | World Mercator<br><br>Geodetic CRS: WGS 84;<br><br>Coordinate System: Cartesian CS.<br><br>Axes: easting, northing (E, N). Orientations: east, north.<br><br>UoM: metre. | Euro-centric view of world excluding polar areas. |

| | | |
|---|---|---|
| *EPSG3857_WGS84* | Pseudo-Mercator -- Spherical Mercator, Google Maps, OpenStreetMap, Bing, ArcGIS, ESRI<br><br>Geodetic CRS: WGS 84;<br><br>Coordinate System: Cartesian CS.<br><br>Axes: easting, northing (X, Y). Orientations: east, north.<br><br>UoM: metre. | Uses spherical development of ellipsoidal coordinates. Relative to WGS 84 / World Mercator (CRS code 3395) errors of 0.7 percent in scale and differences in northing of up to 43km in the map (equivalent to 21km on the ground) may arise. |
| **EPSG4322_WGS72** | Geodetic CRS: WGS 72;<br><br>Coordinate System: Ellipsoidal 2D CS.<br><br>Axes: latitude, longitude. Orientations: north, east.<br><br>UoM: degree. | Uses Historic World Geodetic System 1972.<br><br>Horizontal component of 3D system. |
| **EPSG4326_WGS84** | WGS84 - World Geodetic System 1984, used in GPS<br><br>Geodetic CRS: WGS 84;<br><br>Coordinate System: Ellipsoidal 2D CS.<br><br>Axes: latitude, longitude. Orientations: north, east.<br><br>UoM: degree. | Horizontal component of 3D system. Used by the GPS satellite navigation system and for NATO military geodetic surveying. |
| **EPSG4760_WGS66** | Geodetic CRS: WGS 66;<br><br>Coordinate System: Ellipsoidal 2D CS.<br><br>Axes: latitude, longitude. Orientations: north, east.<br><br>UoM: degree. | Uses Historic World Geodetic System 1966.<br><br>Horizontal component of 3D system. |



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| | | |
|---|---|---|
| ***EPSG4979_WGS84*** | Geodetic CRS: WGS 84;<br><br>Coordinate System: Ellipsoidal 3D CS.<br><br>Axes: latitude, longitude, ellipsoidal height. Orientations: north, east, up.<br><br>UoM: degree, degree, metre. | Used by the GPS satellite navigation system. |

**Table 22: EnumCRSType Enumeration**

### 5.10.5 EnumGeometryType **Enumeration**

The **EnumGeometryType** enumeration type specifies possible geometrical shapes.

| Property | Description | Note |
|---|---|---|
| **POINT** | Single point. | |
| **POLYGON** | Polygon. | |
| ... | | |

**Table 23: EnumGeometryType Enumeration**

# 6 Service Interface Specifications

This chapter describes the details of each service interface. One sub-chapter is provided for each Service Interface.

The Service Interface specification covers only the static design description while the dynamic design (behaviour) is described later.

## 6.1 Service Interface DroneFlightRetreivalInterface

The service provider offers this interface to allow consumers to retrieve/query drone flight data.

### 6.1.1 Operation getDroneFlight

#### 6.1.1.1 Operation Functionality

A consumer calls this operation to explicitly request a drone flight by submitting the known id.

#### 6.1.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| id | Input | UUID | Identifier of a drone flight. |
| response | Return | DroneFlightResponse | Query response, including the drone flight data, if the request was successful. |

**Table 24: Payload description of getDroneFlight operation**

### 6.1.2 Operation getDroneFlightsForGeometry

#### 6.1.2.1 Operation Functionality

A consumer calls this operation to explicitly request drone flight data for a certain geographical area.

#### 6.1.2.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| areaOfInterest | Input | Geometry | Geographical area of interest. |
| response | Return | DroneFlightResponse | Query response, including the drone flight data, if the request was successful.<br><br>The DroneFlightResponse may contain a list of DroneFlights: all current drone flights for the area of interest. |

**Table 25: Payload description of getDroneFlightForGeometry operation**



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## 6.2 Service Interface DroneFlightSubscriptionInterface

The service provider offers this interface to allow consumers to subscribe/unsubscribe for drone flight data.

### 6.2.1 Operation subscribeForDroneFlights

#### 6.2.1.1 Operation Functionality

A consumer calls this operation to subscribe to receive drone flight data.

#### 6.2.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| consumer | Input | NotificationEndpoint | Which endpoint shall be notified in case of new DroneFlight data. |
| areaOfInterest | Input | AreaOfInterest | Area of interest to the consumer |
| response | Return | ServiceResponse | Provide status information on subscription |

**Table 26: Payload description of subscribeForDroneFlights operation**

### 6.2.2 Operation unsubscribeForDroneFlights

#### 6.2.2.1 Operation Functionality

A consumer calls this operation at the provider to unsubscribe from drone flight data.

#### 6.2.2.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| consumer | Input | NotificationEndpoint | Which endpoint shall not be notified (anymore) in case of new DroneFlights. |
| response | Return | ServiceResponse | Provide status information on subscription |

**Table 27: Payload description of unsubscribeForDroneFlights operation**

## 6.3 Service Interface DroneFlightNotificationInterface

Once and while subscribed, consumer receives drone flight data via this interface.

### 6.3.1 Operation notifyDroneFlight

#### 6.3.1.1 Operation Functionality

The service provider uses this logical operation (implemented by the consumer) to publish drone flight data.

#### 6.3.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| droneFlight | Input | DroneFlight | A drone flight matching the filter criteria provided in the subscription |

**Table 28: Payload description of notifyDroneFlight operation**

## 6.4 Service Interface DroneFlightManagementInterface

The service provider offers this interface to allow consumers to administrate / manipulate drone flights.

### 6.4.1 Operation createDroneFlight

#### 6.4.1.1 Operation Functionality

The service consumer calls this operation to create a drone flight data object.

#### 6.4.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| opId | Input | UUID | Optional reference to an Operation Plan. |
| response | Return | DroneFlightResponse | indicates whether the creation was successful or not. In case of success it also contains the newly created DroneFlight. |

**Table 29: Payload description of createDroneFlight operation**

### 6.4.2 Operation updateDroneFlight

#### 6.4.2.1 Operation Functionality

The service consumer calls this operation to modify a drone flight data object.

#### 6.4.2.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| droneFlight | Input | DroneFlight | An updated version of a drone flight object. |
| response | Return | ServiceResponse | indicates whether the operation was successful or not. |

**Table 30: Payload description of updateDroneFlight operation**

### 6.4.3 Operation pauseDroneFlight

#### 6.4.3.1 Operation Functionality

The service consumer calls this operation to indicate that a drone flight is paused. This results in the drone flight state set to "PAUSED".

#### 6.4.3.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| id | Input | UUID | Identifier of a drone flight object. |
| response | Return | ServiceResponse | indicates whether the operation was successful or not. |

**Table 31: Payload description of pauseDroneFlight operation**

### 6.4.4 Operation resumeDroneFlight

#### 6.4.4.1 Operation Functionality

The service consumer calls this operation to indicate that a drone flight is re-activated. This results in the drone flight state set to "ACTIVE".

#### 6.4.4.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| id | Input | UUID | Identifier of a drone flight object. |
| response | Return | ServiceResponse | indicates whether the operation was successful or not. |

**Table 32: Payload description of resumeDroneFlight operation**

### 6.4.5 Operation finishDroneFlight

#### 6.4.5.1 Operation Functionality

The service consumer calls this operation to terminate a drone flight. This results in the drone flight state set to "FINISHED".

#### 6.4.5.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| id | Input | UUID | Identifier of a drone flight object. |
| response | Return | ServiceResponse | indicates whether the operation was successful or not. |



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**Table 33: Payload description of finishDroneFlight operation**

## 6.4.6 Operation setDroneFlightConformanceState

### 6.4.6.1 Operation Functionality

The service consumer calls this operation to update the conformance state of a drone flight data object.

### 6.4.6.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| id | Input | UUID | Identifier of a drone flight object. |
| state | Input | EnumDroneFlightConformanceState | The new conformance state of the drone flight object. |
| response | Return | ServiceResponse | indicates whether the operation was successful or not. |

**Table 34: Payload description of setDroneFlightConformanceState operation**

## 6.4.7 Operation setDroneFlightEmergencyState

### 6.4.7.1 Operation Functionality

The service consumer calls this operation to update the emergency state of a drone flight data object.

### 6.4.7.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| id | Input | UUID | Identifier of a drone flight object. |
| state | Input | EnumDroneFlightEmergencyState | The new emergency state of the drone flight object. |
| response | Return | ServiceResponse | indicates whether the operation was successful or not. |

**Table 35: Payload description of setDroneFlightEmergencyState operation**

## 6.4.8 Operation setDroneFlightCooperationState

### 6.4.8.1 Operation Functionality

The service consumer calls this operation to update the cooperation state of a drone flight data object.

### 6.4.8.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| id | Input | UUID | Identifier of a drone flight object. |
| state | Input | EnumDroneFlightCooperationState | The new cooperationstate of the drone flight object. |
| response | Return | ServiceResponse | indicates whether the operation was successful or not. |

**Table 36: Payload description of setDroneFlightCooperationState operation**

# 7 Service Dynamic Behaviour

## 7.1 Sequence of events, cooperation with other services

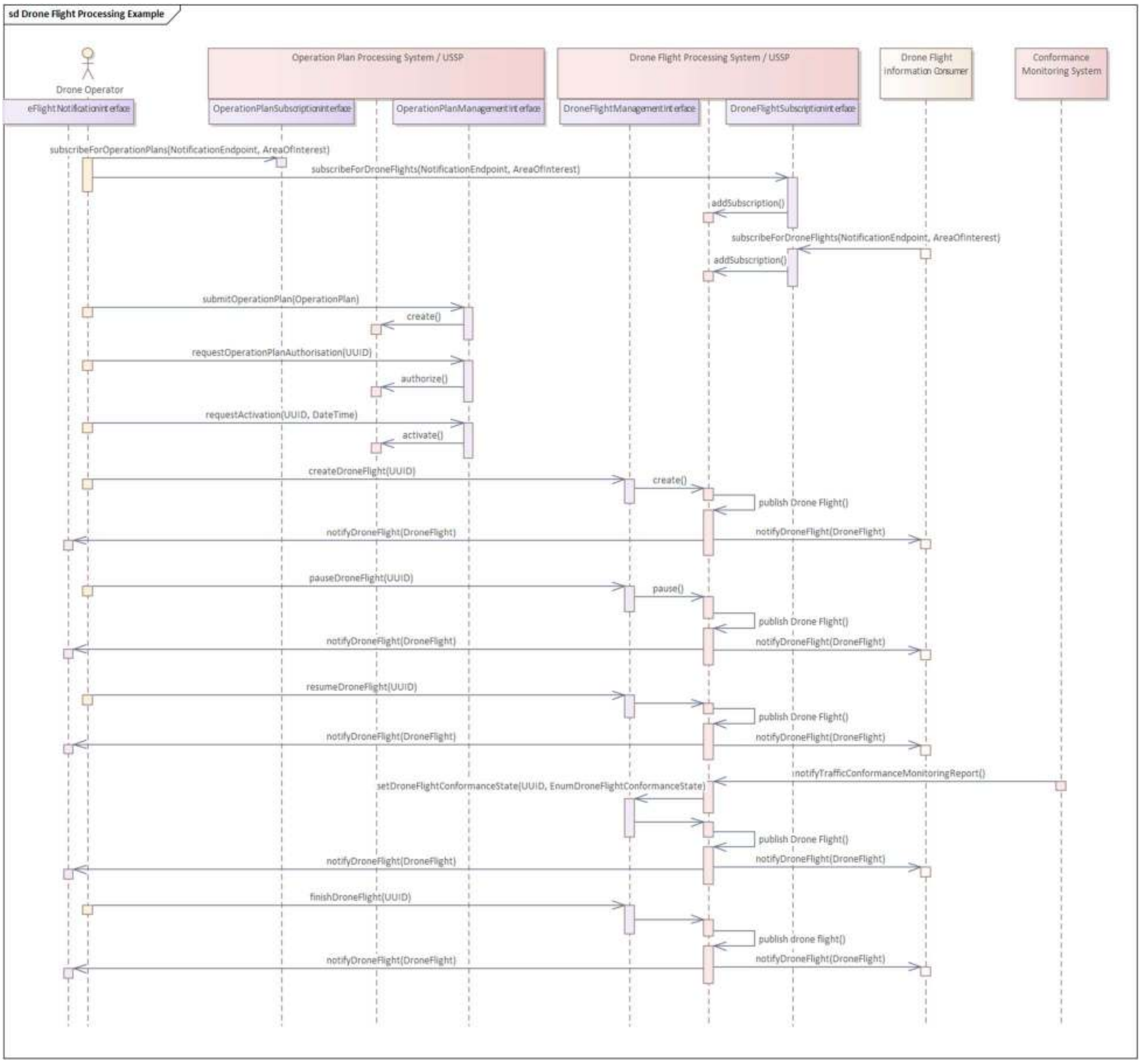


**Figure 6: DroneFlightExchange service example operation sequence diagram**

Note:
In order to illustrate the service operations in a realistic context, this Sequence Diagram contains additional operations (e.g. from OperationPlanExchange service), not only DroneFlightExchange service operations.

The figure above provides an example scenario for the DroneFlightExchange service. The scenario assumes an Operation Plan Processing system providing the OperationPlanExchange service interfaces

(OperationPlanSubscriptionInterface, OperationPlanManagementInterface). Furthermore, a Drone Flight Processing System provides the DroneFlightExchange service interfaces (DroneFlightSubscriptionInterface, DroneFlightManagementInterface). In addition, the scenario includes a Drone Operator (in the role of a consumer of both, the OperationPlanExchange service as well as the DroneFlightExchange service) and a second consumer of DroneFlightExchange service.

- The scenario starts with the service consumers subscribing for operation plans and drone flights:
  - Drone Operator subscribes at OperationPlanExchange service as well as DroneFlightExchange service.
  - Second consumer subscribes at DroneFlightExchange service.
- Drone Operator submits a tentative Operation Plan by using the OperationPlanManagementInterface.
- Drone Operator requests authorization of the OP by using the OperationPlanManagementInterface.
- Drone Operator requests take-off clearance for the Operation Plan by using the OperationPlanManagementInterface.
  - At this point in time, the Drone Flight object shall be created.
  - The DroneFlightManagmentInterface is used to create the Drone Flight.
  - In this example, the Drone Operator is responsible to create the Drone Flight.
  - Creation of the Drone Flight leads to the publication of the Drone Flight to subscribed consumers.
- Drone Operator may request a pause of the flight by using the DroneFlightManagmentInterface .
  - This leads to an update of the Drone Flight State being published to subscribed consumers.
- Drone Operator may request to resume the paused flight by using the DroneFlightManagmentInterface .
  - This leads to an update of the Drone Flight State being published to subscribed consumers.
- Drone flight processing system may be listening to conformance monitoring publications.
  - When receiving a non-conformance report, the drone flight processing system shall update the conformance state of the drone flight
  - The updated conformance state leads to a drone flight publication to subscribed consumers.
- Drone Operator declares the end of flight by using the DroneFlightManagmentInterface .
  - This leads to an update of the Drone Flight State, which is again published to subscribed consumers.

## 7.2 Drone Flight State Machine

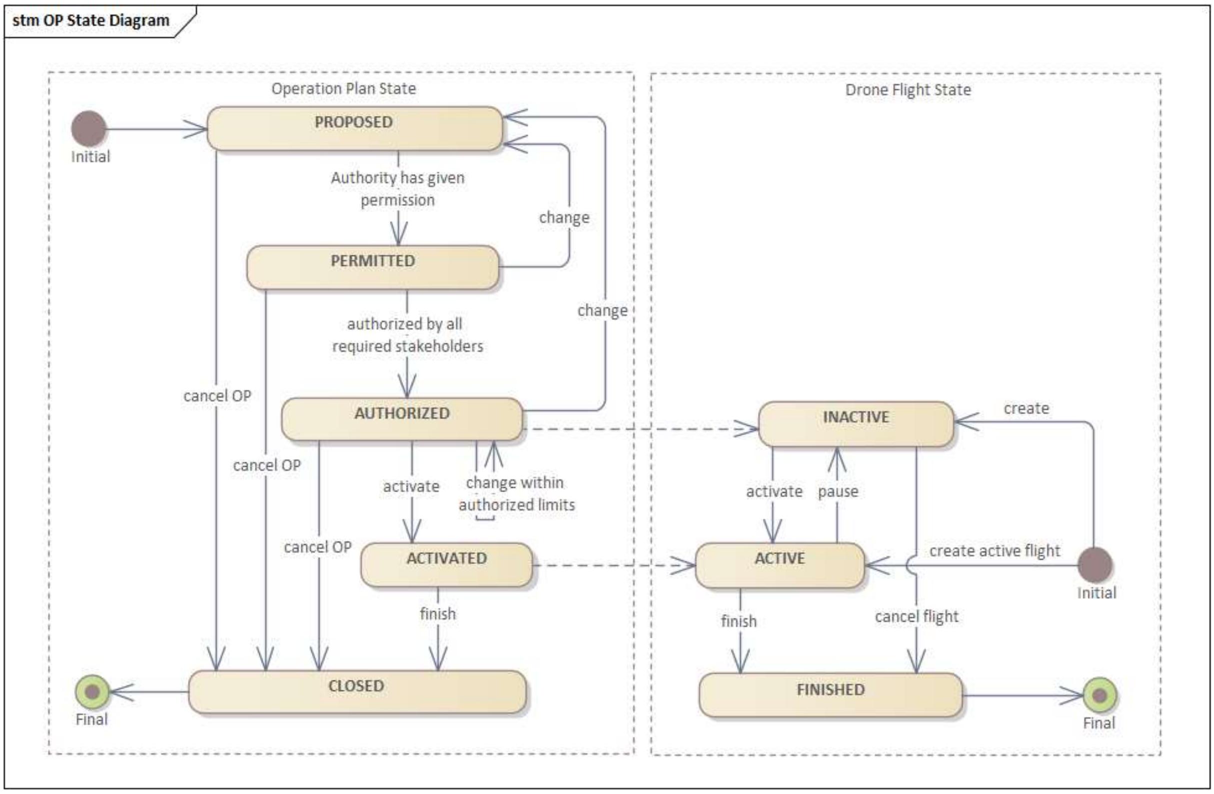


*Figure 7: Drone flight states - state transition diagram in comparison with Operation Plan state machine*

The figure above illustrates the state transitions of Drone Flights graphically aligned with an Operation Plan state diagram. Note that in a nominal life cycle, a Drone Flight usually gets created when the Operation Plan is going to be activated (i.e., the OP is already in state TAKEOFF_GRANTED).

However, there are also cases where a Drone Flight is activated without the existence of an Operation Plan. Imagine the case where an airborne drone flight is detected (e.g., by observation of surveillance tracks), but cannot be correlated to any existing OP. In such a case, a "NON_CONFORMANT" Drone Flight shall be published, indicating that there is an ongoing flight without known Operation Plan.

# 8 References

NOTE: The list of references provided hereafter is for guidance. Before the documents are delivered to the SJU, please make sure that you are listing the latest applicable version of the relevant references as in the Programme Library.


| Nr. | Version | Reference |
|---|---|---|
| [1] | n/a | CFP Reference CEF-SESAR-2018-1, “Finnish-Estonian "Gulf of Finland" Very Large U-Space Demonstration” |
| [2] | Advanced Edition (unedited) | ICAO Doc 10039, Manual on System Wide Information Management (SWIM) Concept |
| [3] | 00.05.00 | SESAR 2020 GOF USPACE FIMS Design and Architecture, Appendix A Service Description Templates, document SESAR 2020 GOF USPACE Service Documentation Guidelines |
| [4] | Ed. 00.02.RC1, 1 March 2019 | EUROCONTROL Concept of Operations for U-space (CORUS), D6.2, Grant Ref. 763551, Call Ref. 2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1), Release Candidate 1 |
| [5] | n/a | Global UTM Association (GUTMA) Flight Logging Protocol, https://github.com/gutma-org/flight-logging-protocol/blob/master/Flight_logging_protocol.md |
| [6] | n/a | Global UTM Association (GUTMA) Air Traffic Protocol, https://github.com/hrishiballal/airtraffic-data-protocol-development |
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| [8] | 1.0 | Federal Office of Civil Aviation (FOCA), Swiss U-Space ConOps, U-Space Program Management, 31.10.2018, FOCA muo / 042.2-00002/00001/00005/00021/00003 |
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| [11] | n/a | SESAR, European ATM Master Plan: Roadmap for the safe integration of drones into all classes of airspace |
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| [15] | n/a | IALA specification for e-navigation technical services<br><br>https://www.iala-aism.org/product/g1128-specification-e-navigation-technical-services |
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| [17] | 1 November 2006 | Federal Aviation Administration, Project Report ATC-323, Required Surveillance Performance Accuracy to Support 3-Mile and 5-Mile Separation in the National Airspace System |
| | | Operation Plan Information Exchange Service Specification |
| | | Traffic/Telemetry Information Exchange Service Specification |

**Table 37: List of References**

# D2.4 Appendix J Weather Service Specification

| | |
|---|---|
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## Authoring & Approval

### Authors of the document

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Darshan Sathiyanarayanan / Vaisala | WP2 | 03.1.2022 |
| Remy Parmentier / Vaisala | WP2 | 3.1.2022 |
| Tapio Haarlaa/ Vaisala | WP2 | 3.1.2022 |

### Reviewers internal to the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Gregor Mogeritsch / Frequentis | WP2 | 1.11.2022 |
| Hubert Künig / Frequentis | WP2 | 1.11.2022 |
| Pawel Korzec / DroneRadar | WP2 | 2.11.2022 |
| Gokul Srinivasan / Robots Expert | WP2 | 2.11.2022 |
| Tanel Järvet / CAFA Tech | WP2 | 2.11.2022 |
| Thomas Lutz / Frequentis | WP2 | 3.11.2022 |

### Approved for submission to the SJU By - Representatives of beneficiaries involved in the project

| Name/Beneficiary | Position/Title | Date |
|---|---|---|
| Sami Alkula/FANS | Project Management Group | 3.11.2022 |
| Thomas Neubauer/DIME | Project Management Group | 3.11.2022 |
| Pawel Korzec/DRR | Project Management Group | 3.11.2022 |
| Yuhang Yun/EHE | Project Management Group | 3.11.2022 |
| Damini Gera/AIRB | Project Management Group | 3.11.2022 |
| Piotr Szymaniak/PSNC | Project Management Group | 3.11.2022 |
| Sven Jürgenson/THREOD | Project Management Group | 3.11.2022 |
| Leopoldo Tejada/UML | Project Management Group | 3.11.2022 |
| Tapio Haarlaa/VAI | Project Management Group | 3.11.2022 |
| Iris Röhrich/FRQ | Project Management Group | 3.11.2022 |
| Juha Lindstedt/AVIA | Project Management Group | 3.11.2022 |
| Piotr Bratek/PANSA | Project Management Group | 3.11.2022 |



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| | | |
|---|---|---|
| Tanel Järvet/CAFA | Project Management Group | 3.11.2022 |
| Maria Tamm/EANS | Project Management Group | 3.11.2022 |

**Rejected By - Representatives of beneficiaries involved in the project**

| Name/Beneficiary | Position/Title | Date |
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## Copyright Statement

# GOF2.0

## GOF2.0 INTEGRATED URBAN AIRSPACE VLD

This Updated Service Specification is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 101017689 under European Union's Horizon 2020 research and innovation programme.

## Abstract

This specification introduces a Supplementary data service which ensures appropriate weather data is accessible in a reliable manner to all stakeholders within the U-space environment.

In accordance with ICAO SWIM, this document describes one of these supplementary data Services, the Weather data service in a logical, technology-independent manner.



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# Table of Contents

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# 1. Introduction

## 1.1. Overview

In order to enable safe and reliable operations at scale, drone operators need an accurate picture of the weather conditions across the airspace before the flight for operations planning, to make a go-no go decision at take-off, all along the flight duration to manage unexpected hazardous weather conditions and post-flight, for a posteriori analysis of flight conditions [1].

Supplementary Weather Data Service[1] [SWDS] is defined and implemented to supply accurate hyperlocal weather data from observations, models and forecasts to SWDS subscribers such as drone operators, USSP, ANSPs, Insurance companies and other interested parties.

SWDS aims at supporting a drone operator’s weather-related risk management and flight optimization. SWDS will be used to make CARS height/altitude transformations, wherever conversion between barometric and GNSS based systems will be required.

In particular, for safety it is necessary to identify and locate areas where weather conditions are not compatible with a given UAV flight envelop and/or do not comply with predefined airspace regulations.

Presently, UAV pilots are checking various sources for regional and local weather information close to the flights’ locations. Weather information sources are for example:

- Weather forecasts provided by the National Weather Service or other Public-domain weather service such as Windy, Skysight, etc.
- Nearby meteorological stations (airports…)
- METAR, TAF
- Hand-held weather station deployed that the take-off location

Such weather data sources poorly represent actual weather conditions that the drone will encounter all along its journey and the responsibility remains on the pilot to make the decision to take-off or not based upon his experience. This is exacerbated for flights inside the urban environment at or below house-roof height.

[1] Third party information provided by a Supplementary Data Service Providers (SDSP) increases knowledge of the operational flight area for a UAV with data and analysis delivered using web services.



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Weather information can arise from multiple sources, it is currently up to the UAV operator / automatic UAV systems to find the weather information from different sources, synthesize and make the call on which information to trust and fly.

Thus, in this work, it is intended to provide a data structure and exchange framework to efficiently synthesize weather data from multiple sources and make them most efficiently available to the relevant entities.

This includes:

- **Construct an adapted data structure model** to provide weather data from different weather sources in a more accessible structure
- **Establish a framework for the exchange protocols** adapted to all relevant weather data types (Wind vector, Turbulence, Shear, Visibility, Temperature, etc)

## 1.2. Scope

The Supplementary Weather Data Service described in this document provides a general mechanism between the various stakeholders, interfaces and data models that enable and allow the automated data exchange and utilization between the respective parties.

The scope includes the following aspects:

- Operational Context
- Service Interfaces
- Service Data Model

There are a number of goals defined that this specification document aims to achieve:

1. A goal is to define the nature of the exchange protocol to communicate between a traffic management system (or drone operator, USSP or equivalent) and a weather information provider.

2. A goal is to identify architectures that will be amenable to expedient implementation by a variety of weather information providers, given that weather information providers have various weather data sources and numerical modelling capabilities.

3. A goal is to identify scalable architectures that would support a variety of business models and data sharing models in a technology independent way (i.e. limiting and avoiding exchange of proprietary and/or sensitive data) but enabling proprietary implementations of a segregated instance of the weather data service that could make use of proprietary weather information.



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The overall objective is to provide a minimum set of descriptions to standardize the way data between Weather Information providers and the UTM ecosystem can be exchanged. The Weather Data Service does not limit any entity, by any means, to deploy or implement other data exchange in addition to the defined service definitions.

## 1.3. Intended readership

This document is intended to be read by all members of the GOF2.0 USPACE project, specifically, technical Point of Contacts (service architects, system engineers and developers) of members involved.

In general, the following entities are intended as readership:

- Air Navigation Service Providers (ANSPs)
- Civil Aviation Authorities (CAAs)
- Administrative Units
- Supplemental Data or Data Service Providers
- Drone Manufacturers
- Drone Operators
- General Aviation Operators
- Authorities
- U-space Service Provides
- U-space Infrastructure Providers

## 1.4. Issue context

The primary issue addressed in this document is to improve the interaction between weather data sources/service providers and UAV stakeholders to facilitate the ingestion of high-quality hyperlocal weather data.

Weather data are produced in multiple formats and sizes. Depending on the weather parameter of interest and the measurement instrument employed, the final weather data files can have varied data types and different update frequencies. This makes it difficult for non-meteorologists to exploit multiple varied sources of high-quality weather data.



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Thus, it is important to explore how the different weather data types and weather service interfaces can be reworked for the benefit of UAV stakeholders.

### 1.4.1. General principles

A key principle of the U-space architecture is applying a service-oriented architecture approach, where open, interoperable and standard based interfaces are offered based on SWIM principles[2].

[2] Note that by SWIM principles the general concept including not only AIXM, FIXM, WIXM via SOAP are meant, but also web services / rest / messaging (JMS, AMQ) as considered in the SWIM Yellow profile [4].



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# 2. Operational context

## 2.1. Overview of operational requirements

Acquiring, interpreting, and making operational decisions based on weather information is essential to safe & efficient UAV operations.

Different stages of a UAV mission will require the appropriate weather information.

- Flight preparation: Weather Forecast
- Pre-flight: Weather Forecast, Current Weather and critical Weather Alerts
- In-flight: Current Weather and critical Weather Alerts
- Post Flight: Historic weather data

The nature of weather data and the weather service interface required will vary depending on the UAV mission phase.



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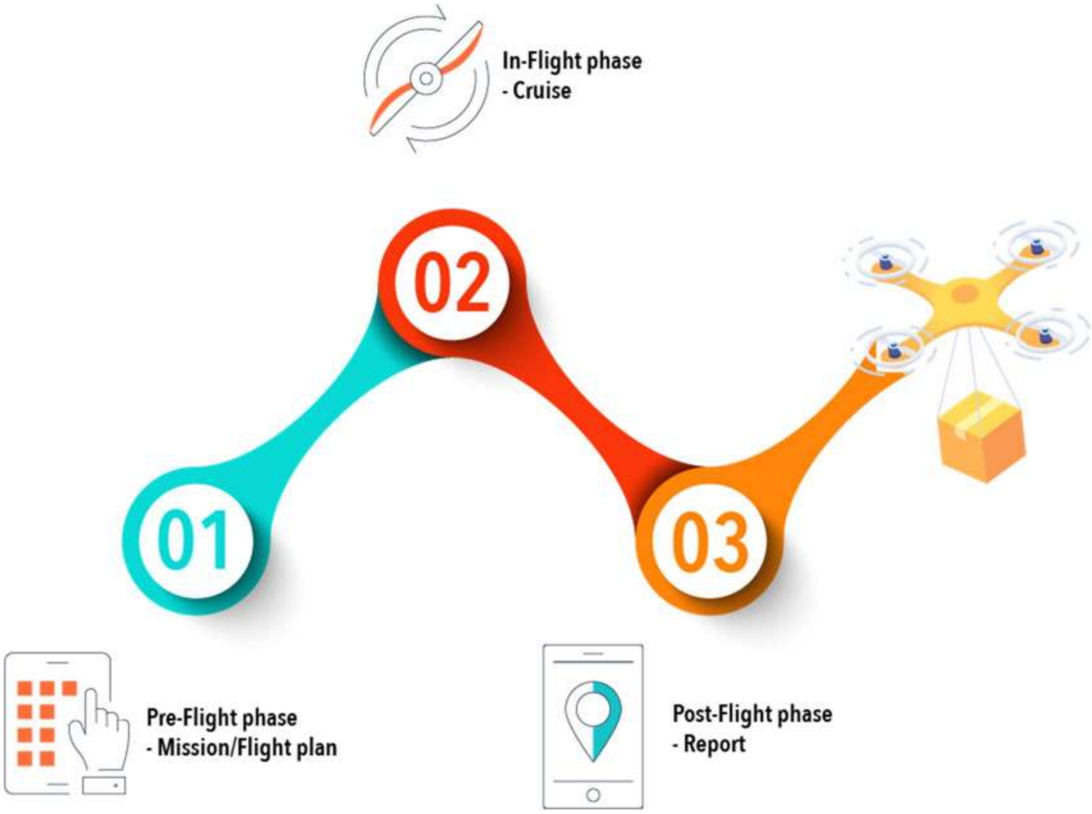


**Figure 1: Operational Phases diagram**

To accommodate for the different weather data and UAV operator interactions at the different UAV mission phases, the Supplementary Weather data service should provide the following capabilities:

- To push weather data
    - A regular update of current weather data in a selected domain at a requested frequency
    - An Irregular update of the current alert state in a selected domain of interest
- To allow for weather data query with input specifications from the user
    - The Historic weather data at the requested time periods
    - The Forecast weather data at the requested time horizons

The operational nature of the supplementary weather service data provider that meets these requirements is detailed in the following two chapters in this section.



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## 2.2. Operational nodes

Operational nodes which may consume the Weather Data service include the following ones.

| Operational Node | Remarks |
|---|---|
| U-space service provider | |
| ANSP | |
| UAV operator | |

**Table 1 : Operational Nodes**

## 2.3. Operational Activities

Operational activities supported by the Weather Data service include the following ones.

| Phase | Operational Activity | Remarks |
|---|---|---|
| Flight preparation | Plan | The consumer will be able to query the weather service for a weather forecast at the required time scale. |
| Pre-flight | Plan | The consumer will be able to query the weather service for a weather forecast at the required time scale.<br><br>The Consumer will be able to get a real-time high-resolution weather data update from the weather service interface at mission critical locations (along the whole Operation Plan including alternative landing sites). |
| In-Flight | Take-Off | The Consumer will be able to get a real-time high-resolution weather data update from the weather service interface at mission critical locations (Take off sites). |

| | | |
|---|---|---|
| | Cruise | The Consumer will be able to get a real time update of the Weather at a requested frequency within a domain covering the flight path, from the weather service. |
| | Land/Arrive | The Consumer will be able to get a real-time high-resolution weather data update from the weather service interface at mission critical locations (Landing sites). |
| Post-Flight | Report | The consumer will be able to query the weather service for historic weather data at given locations. |

**Table 2: Operational Activities supported by the Supplementary Weather Data Service**

# 3. Service Interface overview

The weather data interface will accommodate a data subscription/publication interface and a query-based interface. The former is meant to transfer regular data and weather alerts. The latter serves to transfer weather data that need to be queried at each instance with user specific input parameters (ex: weather forecasts).

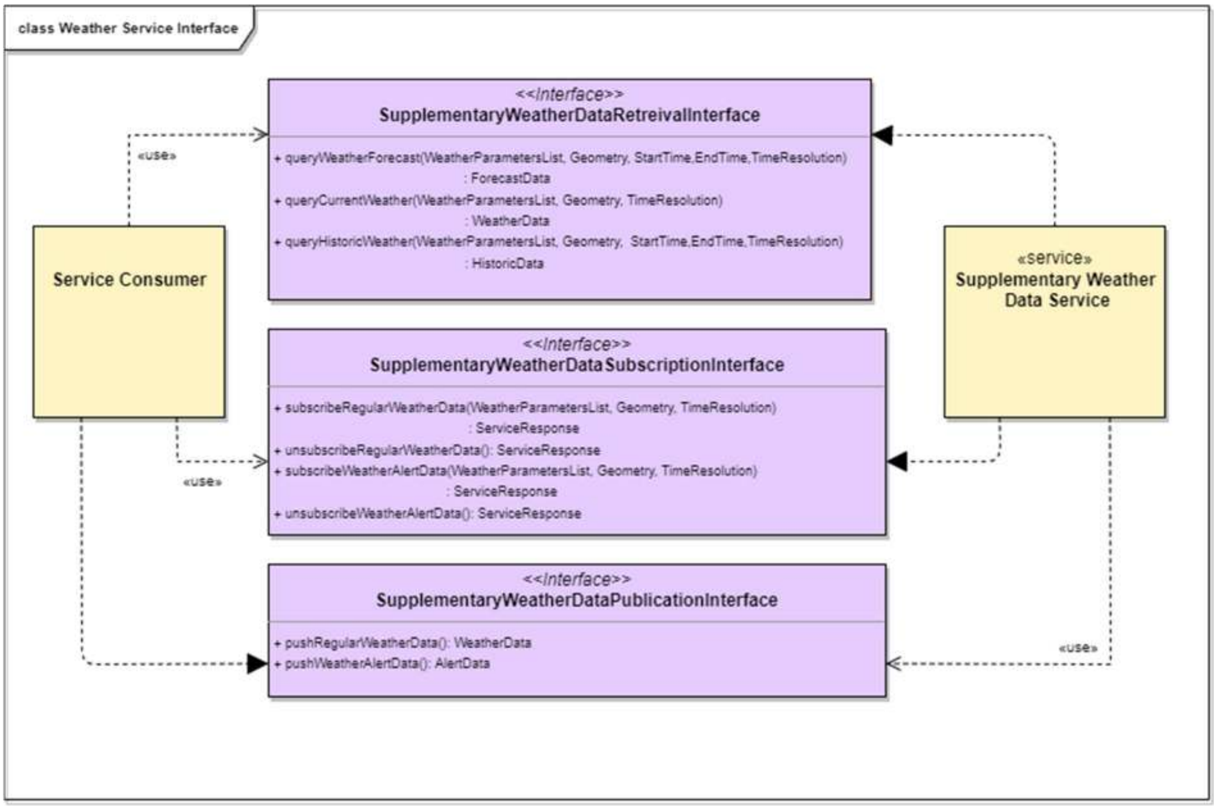


Figure 2: Service Interface Overview

| ServiceInterface | Role (from service provider point of view) | ServiceOperation |
|---|---|---|
| SupplementaryWeatherDataRetrievalInterface | Provided | queryWeatherForecast<br>queryCurrentWeather<br>queryHistoricWeather |
| SupplementaryWeatherDataSubscriptionInterface | Provided | subscribeRegularWeatherData<br>unsubscribeRegularWeatherData<br>subscribeWeatherAlertData<br>unsubscribeWeatherAlertData |
| SupplementaryWeatherDataPublicationInterface | Used | pushRegularWeatherData<br>pushWeatherAlertData |

**Table 3: Service Interfaces**

# 4. Service Data Model

This section describes the information model, i.e., the logical data structures to be exchanged between providers and consumers of the service.

## 4.1. Overview

Weather data comprises of the information pertaining to multiple different parameters of the environment. For example, wind, temperature, visibility, lightning, fog, rain, Humidity, Icing etc.

However, weather data from different sources can vary in terms of spatial and temporal characteristics. Thus, it becomes important to find a way to harmonize at least the spatial indexation of this data, to make it easier to ingest (and appropriately average or regroup weather data points in time).

The wind for example can be measured either by an anemometer -at one location at high frequency- or through a Weather radar – at multiple locations at a lower frequency-. On one hand the high frequency data could be more useful to optimize take-off and landing at the vertiport. And on the other hand, the volumetric measurement of the wind field can be more useful to plan the flight trajectory itself. Thus, a common data structure able to accommodate weather data that is spatially and temporally distributed must be used.

Practically, each data file could be reformatted into a voxel grid format. Thus, each measurement, be it from any instrument at any position can be allocated to a certain voxel in space.

The Weather data will be allocated to a 3D cartesian grid.

This grid will divide the space into cuboids, with a given horizontal dimension and a given vertical dimension. (A parameter that can be varied by the consumer).

Each weather data file received from a different weather source will have to be first formatted to incorporate this spatial referencing (allocated to the corresponding cuboid in which it is placed).

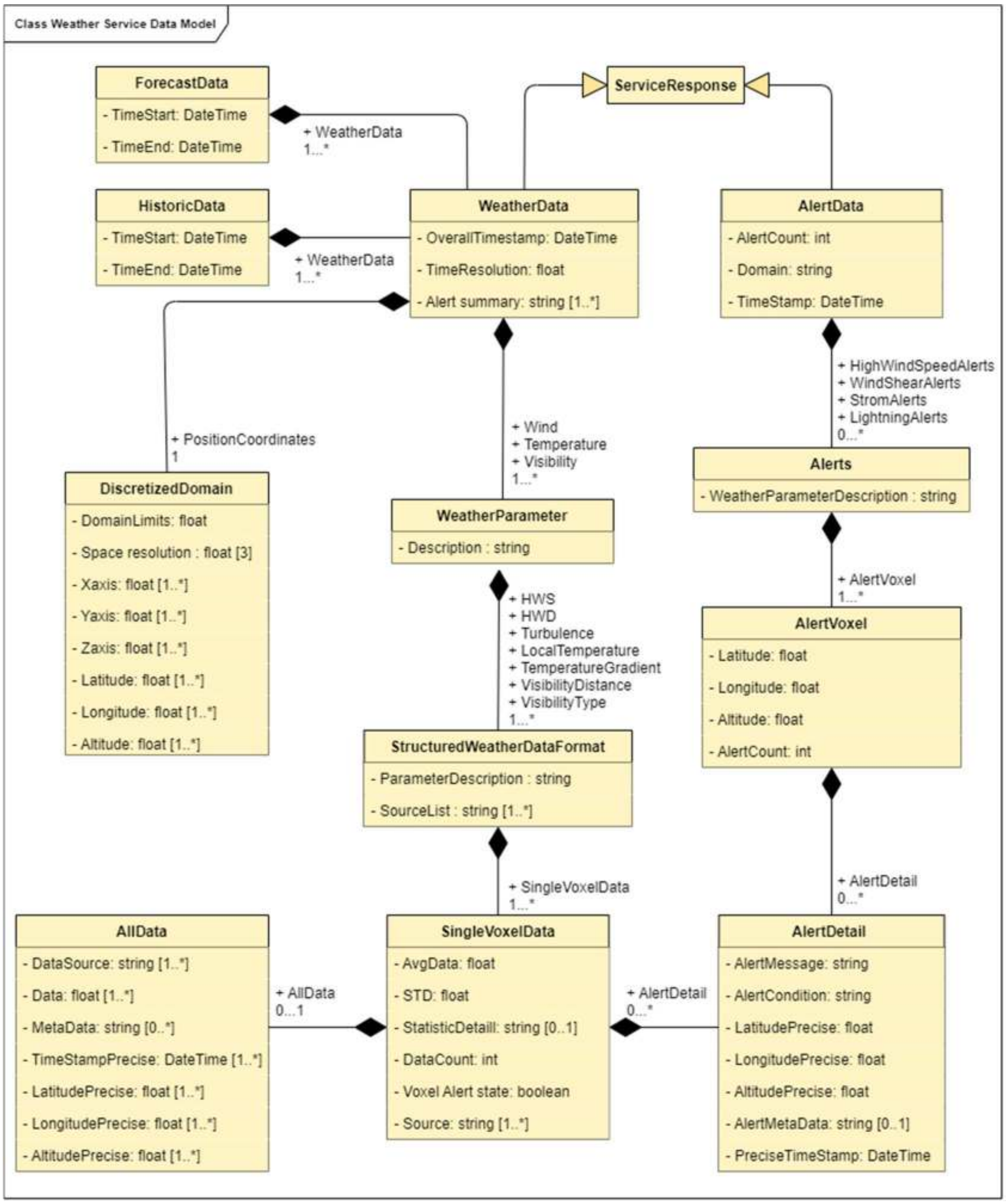


**Figure 3: Data model Overview**

## 4.2. The WeatherData Data Structure

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| OverallTimestamp | DateTime | 1 | A time stamp corresponding to the time period of the provided data. The TimeStamp contains the value of the time at the end of each time period/bin. | The time period used here is given by the TimeResoution. |
| TimeResolution | Float | 1 | The time between two consecutive regular weather updates. | The minimum time resolution is inversely linked to the domain size. (to avoid flooding the receiver with high frequency updates of large files ). |
| AlertSummary | String | 1..* | A sequency of strings containing a summary of the different alerts for each weather parameter chosen. | |
| Wind | WeatherParameter | 0..1 | A Weather parameter containing voxel structured information on the different variables pertaining to Wind. (HorizontalWindSped, HorizontalWindDirection, Turbulence) | Further variables can be added to expand information provided in the wind. |

| | | | | |
|---|---|---|---|---|
| Temperature | WeatherParameter | 0..1 | A Weather parameter containing voxel structured information on the different variables pertaining to Temperature. (LocalTemperature, TemperatureGradient) | Further variables can be added to expand information provided in the temperature. |
| Visibility | WeatherParameter | 0..1 | A Weather parameter containing voxel structured information on the different variables pertaining to Visibility. (VisibilityType, VisibilityDistance) | Further variables can be added to expand information provided in the visibility. |

**Table 4: WeatherData Data Structure**

## 4.3. The HistoricData Data Structure

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| TimeStart | DateTime | 1 | A time stamp corresponding to the start of the historic weather data requested. | |
| TimeEnd | DateTime | 1 | A time stamp corresponding to the end of the historic weather data requested. | The minimum time resolution is inversely linked to the domain size. (to not flood too the bandwidth with high frequency updates of large files ). |

| | | | | |
|---|---|---|---|---|
| WeatherData | WeatherData | 1..* | Multiple WeatherData corresponding each to a time period. | Each of the WeatherData contains all information on the state of the weather for a given time period. |

**Table 5: HistoricData Data Structure**

## 4.4. The ForecastData Data Structure

| **Property** | **Type** | **Multiplicity** | **Description** | **Note** |
|---|---|---|---|---|
| TimeStart | DateTime | 1 | A time stamp corresponding to the start of the forecast weather data requested. | |
| TimeEnd | DateTime | 1 | A time stamp corresponding to the end of the forecast weather data requested. | The minimum time resolution is inversely linked to the domain size. (to not flood too the bandwidth with high frequency updates of large files ). |
| WeatherData | WeatherData | 1..* | Multiple WeatherdData corresponding each to a time period. | Each of the WeatherData contains all information on the state of the weather for a given time period. |

**Table 6: ForecastData Data Structure**

## 4.5. The WeatherParameter Data StructureS

| **Property** | **Type** | **Multiplicity** | **Description** | **Note** |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Description | String | 1 | A description of the group weather parameter: ex: Wind, Temperature, Visibility, etc | It should describe the group weather parameter and not the sub weather parameter. |
| HWS | StructuredWeather Data | 0..1 | The HorizontalWindSpeed provided in a voxel structured format for a given time period. | The HorizontalWindSpeed is provided in the Wind WeatherData structure. |
| HWD | StructuredWeather Data | 0..1 | The HorizontalWindDirection provided in a voxel structured format for a given time period. | The HorizontalWindDirection is provided in the Wind WeatherData structure. |
| Turbulence | StructuredWeather Data | 0..1 | The Turbulence provided in a voxel structured format for a given time period. | The Turbulence is provided in the Wind WeatherData structure. |
| LocalTemperature | StructuredWeather Data | 0..1 | The LocalTepmerature provided in a voxel structured format for a given time period. | The LocalTemperature is provided in the Temperature WeatherData structure. |
| TemperatureGradient | StructuredWeather Data | 0..1 | The TemperatureGradient provided in a voxel structured format for a given time period. | The TemperatureGradient is provided in the Temperature WeatherData structure. |

| | | | | |
|---|---|---|---|---|
| VisibilityType | StructuredWeather Data | 0..1 | The VisibilityType provided in a voxel structured format for a given time period. | The VisibilityType is provided in the Visibility WeatherData structure. |
| VisibilityDistance | StructuredWeather Data | 0..1 | The VisibilityDistance provided in a voxel structured format for a given time period. | The VisibilityDistance is provided in the Visibility WeatherData structure. |

**Table 7: WeatherParameter Data Structure**

## 4.6. The StructuredWeatherData Data Structure

| **Property** | **Type** | **Multiplicity** | **Description** | **Note** |
|---|---|---|---|---|
| ParameterDescription | String | 1 | A description of the weather parameter is provided. This will include the units used. | It should describe the sub weather parameter and not simply the weather group. For example, it should describe the Turbulence and not simply the Wind. |
| SourceList | String | 1..* | A sequence of strings listing the different weather data sources used for the given weather parameter. | The list is unique. |

| | | | | |
|---|---|---|---|---|
| SingleVoxelData | SingleVoxelData | 1..* | A 3D array with each data point providing all weather information within a voxel in the SingleVoxelData structure. | The 3D array indexation should correspond to the indexation used for the domain discretization. This allows to find the position of each voxel using the DiscretisedDomain variable. |

**Table 8: StructuredWeatherData Data Structure**

## 4.7. The SingleVoxelData Data Structure

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| AvgData | float | 1 | Provides the averaged value of a given weather parameter within a voxel during the given time period. | The AvgData in certain cases can also be replaced by the most representative value of a weather parameter within the given voxel. This also allows for quality filters to be applied during the averaging. |
| STD | float | 1 | Provides the StandardDeviation of the averaged data. | |
| StatisticDetail | string | 0..1 | Provides Details on the averaging and Standard Deviation computation. | This allows for transparency in the filtering performed. This information can be opted out to improve file size. |
| DataCount | int | 1 | The number of available data points within a voxel. | |

| | | | | |
|---|---|---|---|---|
| VoxelAlertState | boolean | 1 | The VoxelAlertState shows state 1 if at least one alert is present within the given voxel. And 0 otherwise. | |
| Source | string | [1..*] | A list of data sources used within a given voxel. | This list is unique. |
| AllData | AllData | [0..1] | All data points within a voxel (non-averaged at least in space) are provided. | This data can be opted out, to keep file sizes manageable. This data is useful for certain given locations where it is necessary to have the raw weather data, with least processing.<br>This data can be opted out through a parameter provided in the subscription operation. |
| AlertDetail | AlertData | [0..*] | Detailed Alert information within a voxel during the given time period is provided in the AlertDataStructure. | Each individual Alert will be held in a different AlertDetial variable. |

**Table 9: SingleVoxelData Data Structure**

## 4.8. The AllData Data Structure

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| DataSource | String | [1..*] | An array of strings providing the source of the corresponding individual data point. | The indexation is common with the Data variable within this data structure. Each index along the array corresponds to an individual measurement. |
| Data | Float | [1..*] | An array of float providing the raw data information. | The indexation is common with the Data variable within this data structure. Each index along the array corresponds to an individual measurement. |
| MetaData | String | [0..*] | An array of strings providing meta data for the corresponding individual data point. (This could be instrument specific measurement points) | This variable may be removed depending on the weather parameter used.<br><br>The indexation is common with the Data variable within this data structure. Each index along the array corresponds to an individual measurement. |
| TimeStampPrecise | DateTime | [1..*] | An array of DateTime providing the individual data TimeStamp information. | The indexation is common with the Data variable within this data structure. Each index along the array corresponds to an individual measurement. |
| LatitudePrecise | Float | [1..*] | An array of Float providing the individual data precise latitude position information. | The indexation is common with the Data variable within this data structure. Each index along the array corresponds to an individual measurement. |

| | | | | |
|---|---|---|---|---|
| LongitudePrecise | Float | [1..*] | An array of Float providing the individual data precise longitude position information. | The indexation is common with the Data variable within this data structure. Each index along the array corresponds to an individual measurement. |
| AltitudePrecise | Float | [1..*] | An array of Float providing the individual data precise Altitude position information. | The indexation is common with the Data variable within this data structure. Each index along the array corresponds to an individual measurement. |

**Table 10: AllData Data Structure**

## 4.1. The DiscretizedDomain Data Structure

| **Property** | **Type** | **Multiplicity** | **Description** | **Note** |
|---|---|---|---|---|
| DomainLimits | Float | 1 | The bounds of the domain for the weather data to be provided in. | The Domain limits max size is linked to the space resolution chooses. (to keep the size of each data file manageable) |
| SpaceResolution | Float | 3 | The X, Y and Z resolution corresponding to the size of each voxel within the discretised domain. Unit in Meters. | |
| Xaxis | Float | 1..* | A 3D array containing the Xaxis position of the centre of each voxel. Unit used in meters. | The Xaxis is centred within the chosen domain. |



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| | | | | |
|---|---|---|---|---|
| Yaxis | Float | 1..* | A 3D array containing the Yaxis position of the centre of each voxel. Unit in meters. | The Yaxis is centred within the chosen domain. |
| Zaxis | Float | 1..* | A 3D array containing the Zaxis position of the centre of each voxel. Unit in meters. | The Zaxis is centred within the chosen domain. |
| Latitude | Float | 1..* | A 3D array containing the Latitude position of the centre of each voxel. | The coordinate system used is WGS84. |
| Longitude | Float | 1..* | A 3D array containing the Longitude position of the centre of each voxel. | The coordinate system used is WGS84. |
| Altitude | Float | 1..* | A 3D array containing the Altitude position of the centre of each voxel. Unit in meters. | The coordinate system used is WGS84. And altitude is provided AMSL. |

**Table 11: DiscretizedDomain Data Structure**

## 4.2. The AlertDetail Data Structure

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| AlertMessage | String | 1 | Provides the alert level, with the relevant description. | |
| AlertCondition | String | 1 | Provides the Alert condition met. | This will include the multiple Alert conditions for different alert levels as well. |

| | | | | |
|---|---|---|---|---|
| LatitudePrecise | Float | 1 | A float containing the exact Latitude of the data point corresponding to the alert. | Latitude Precise provides the position of the raw measured data points within a voxel. This is in contrast to Latitude (found in the DiscretisedDomain data structure). |
| LongitudePrecise | Float | 1 | A float containing the exact Longitude of the data point corresponding to the alert. | Longitude Precise provides the position of the raw measured data points within a voxel. This is in contrast to Longitude (found in the DiscretisedDomain data structure). |
| AltitudePrecise | Float | 1 | A float containing the exact Altitude of the data point corresponding to the alert. | Altitude Precise provides the position of the raw measured data points within a voxel. This is in contrast to Altitude (found in the DiscretisedDomain data structure). |
| AlertMetadata | String | 0..1 | A string containing particular metadata relevant to the Alert. | |
| PreciseTimeStamp | DateTime | 1 | A DateTime containing the exact TimeStamp of the data point corresponding to the alert. | The precise Time stamp corresponds to the exact time (high resolution) of alert measurement/occurrence. This is in contrast to the “TimeStamp” provided in the AlertData variable that corresponds to the end of each 1 second bins used as the update frequency. |

**Table 12: AlertDetail Data Structure**

## 4.3. The AlertVoxel Data Structure

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| Latitude | Float | 1 | The Latitude of the Centre of the voxel containing the alert. | |
| Longitude | Float | 1 | The Longitude of the Centre of the voxel containing the alert. | |
| Altitude | Float | 1 | The Altitude of the Centre of the voxel containing the alert. | |
| AlertCount | Int | 1 | Provides the number of alerts within a given voxel. | |
| AlertDetail | AlertDetail | 0..* | Details about each alert in AlertDetail format. | |

**Table 13: AlertVoxel Data Structure**

## 4.4. The Alerts Data Structure

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| WeatherParameterDescription | String | 1 | Describes the weather parameter used to create the alert. | |
| AlertVoxel | AlertVoxel | 1..* | Multiple Alert voxels, containing each information about the alerts within each given voxel. | Only Voxels with an alert are provided. |

**Table 14: Alerts Data Structure**

## 4.5. The AlertData Data Structure

| Property | Type | Multiplicity | Description | Note |
|---|---|---|---|---|
| AlertCount | Int | 1 | The total number of alerts in a given update. | |
| Domain | Float | 3 | The dimensions and spatial resolution of the domain of interest. | |
| TimeStamp | DateTime | 1 | The time stamp of the alerts update. | Provided at 1 second steps. |
| HighWindSpeedAlerts | Alerts | 0..1 | All Alerts at a given instance pertaining to Wind speed going beyond a threshold. | |
| WindShearAlerts | Alerts | 0..1 | All Alerts at a given instance pertaining to Wind shear going beyond a threshold. | |
| StormAlerts | Alerts | 0..1 | All alerts at a given instance about storms in the alerts format. | |
| LightningAlerts | Alerts | 0..1 | All alerts within the given domain providing lightning alerts. | |

**Table 15: AlertData Data Structure**



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## 4.6. Common data structures used in U-space specifications

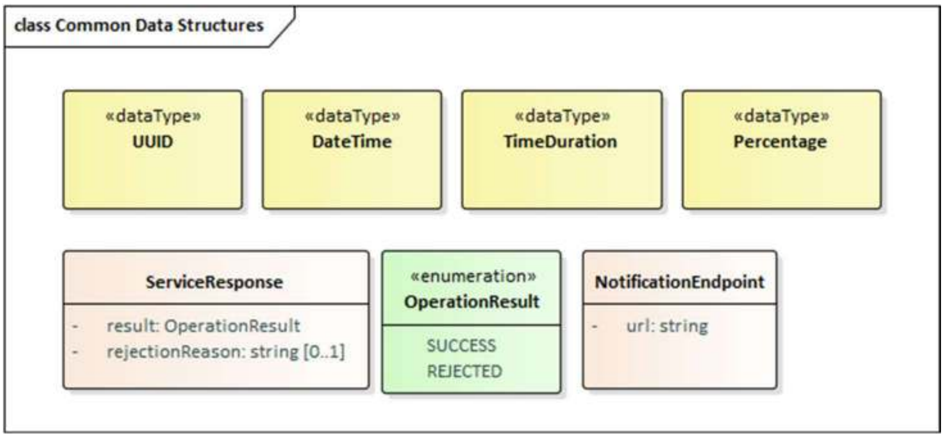


**Figure 4: Common Data Types Used in U-space Service Specifications**

### 4.6.1. *ServiceResponse* Data Structure

ServiceResponse is the generic response provided by each service operation. In some cases, this basic data structure may be extended by inheritance.

| Property | Type | Multi-plicity | Description | Note |
|---|---|---|---|---|
| *result* | *Oper-ation-Result* | 1 | Indicates the result of the request to the service | |
| *rejectReason* | *String* | 0..1 | Optional additional information to be provided in case of negative result | |

**Table 16: ServiceResponse Data Structure**

# 5. Service Interface specifications

This chapter describes the details of each service interface. One sub-chapter is provided for each Service Interface.

The Service Interface specification covers only the static design description while the dynamic design (behaviour) is described later.

## 5.1. Service Interface

## 5.2. SupplementaryWeatherDataretrievalInterface

The supplementary Weather Data Retrieval Interface allows service consumers to retrieve weather data on request. (Historic, Current and Forecast weather data)

### 5.2.1. Operation queryWeatherForecast

#### 1.1.1.1 Operation Functionality

Returns a ForecastData file containing the weather forecast for the time indicated by the input timestamp.

#### 1.1.1.2 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| WeatherParametersList | Input | WeatherParametersList | List of Weather Parameters requested. |
| Geometry | Input | Geometry | The extent of the spatial domain and the spatial resolution of the output data. |
| StartTime | Input | DateTime | The start time of the requested weather data. |

| | | | |
|---|---|---|---|
| EndTime | Input | DateTime | The end time of the requested weather data. |
| TemporalResolution | Input | Float | The temporal resolution of the requested weather data. (in seconds) |
| ForecastData | Return | ForecastData | Query response, including the requested forecast Weather data. |

**Table 17: Operation queryWeatherForecast parameters**

### 5.2.2. Operation queryCurrentWeather

#### 1.1.1.3 Operation Functionality

Returns a WeatherData file containing the current weather data at the time of request.

#### 1.1.1.4 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| WeatherParametersList | Input | WeatherParametersList | List of Weather Parameters requested. |
| Geometry | Input | Geometry | The extent of the spatial domain and the spatial resolution of the output data. |
| WeatherData | Return | WeatherData | Query response, including the requested current Weather data. |

**Table 18: Operation queryCurrentWeather parameters**

### 5.2.3. Operation queryHistoricWeather

The Historic data service interface will allow the UAV operator/USSP to use an API command to query historic weather data from the weather data base. The user will be able to query weather data for past dates /times as per requirement.

#### 1.1.1.5 Operation Functionality

Returns a HistoricData file containing the weather data corresponding to the requested time frame in the past.

#### 1.1.1.6 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| WeatherParametersList | Input | WeatherParametersList | List of Weather Parameters requested. |
| Geometry | Input | Geometry | The extent of the spatial domain and the spatial resolution of the output data. |
| StartTime | Input | DateTime | The start time of the requested weather data. |
| EndTime | Input | DateTime | The end time of the requested weather data. |
| TemporalResolution | Input | Float | The temporal resolution of the requested weather data. (in seconds) |
| HistoricData | Return | HistoricData | Query response, including the requested historic Weather data. |

**Table 19: Operation queryHistoricWeather parameters**

## 5.3. Service Interface SupplementaryWeatherDataSubscriptionInterface

Allows service consumers to subscribe/unsubscribe for reception of weather data publications

### 5.3.1. Operation subscribeRegularWeatherData

#### 1.1.1.7 Operation Functionality

A consumer calls this operation to subscribe to Regular Weather Data.

#### 1.1.1.8 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| WeatherParametersList | Input | WeatherParametersList | List of Weather Parameters requested. |
| Geometry | Input | Geometry | The extent of the spatial domain and the spatial resolution of the output data. |
| TemporalResolution | Input | Float | The temporal resolution of the requested weather data. (in seconds) |
| ServiceResponse | Return | ServiceResponse | Provide status information on subscription. |

**Table 20: Operation subscribeRegularWeatherData parameters**

### 5.3.2. Operation unsubscribeRegularWeatherData

#### 1.1.1.9 Operation Functionality

A consumer calls this operation to unsubscribe to Regular Weather Data.

#### 1.1.1.10 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|

| | | | |
|---|---|---|---|
| ServiceResponse | Return | ServiceResponse | Provide status information on subscription. |

Table 21: Operation unsubscribeRegularWeatherData parameters

### 5.3.3. Operation subscribeWeatherAlertData

#### 1.1.1.11 Operation Functionality

A consumer calls this operation to subscribe to Weather Alert Data.

#### 1.1.1.12 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| WeatherParametersList | Input | WeatherParametersList | List of Weather Parameters requested. |
| Geometry | Input | Geometry | The extent of the spatial domain and the spatial resolution of the output data. |
| TemporalResolution | Input | Float | The temporal resolution of the requested weather data. (in seconds) |
| ServiceResponse | Return | ServiceResponse | Provide status information on subscription. |

Table 22: Operation subscribeWeatherAlertData parameters

### 5.3.4. Operation unsubscribeWeatherAlertData

#### 1.1.1.13 Operation Functionality

A consumer calls this operation to unsubscribe to Weather Alert Data.

#### 1.1.1.14 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| ServiceResponse | Return | ServiceResponse | Provide status information on subscription. |

## 5.4. Service Interface SupplementaryWeatherDataPublicationInterface

Supplementary Weather Data Service to publish (push) real time weather data to subscribed consumers through this interface.

### 5.4.1. Operation pushRegularWeatherData

#### 1.1.1.15 Operation Functionality

Publishes WeatherData file updates at a regular frequency containing current weather information.

#### 1.1.1.16 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| WeatherData | Return | WeatherData | A regular push of the requested weather data corresponding to subscription |

**Table 23: Operation pushRegularWeatherData parameters**

### 5.4.2. Operation pushWeatherAlertData

Certain types of measurements such as wind shear and storms require real time alerts to be communicated with the stakeholders. Thus, there will be made available an irregular data push. The idea is to communicate an alert immediately after an alert grade phenomenon has been observed.

#### 1.1.1.17 Operation Functionality

Publishes Weather AlertData file updates at a regular frequency containing current weather alert information.

### 1.1.1.18 Operation Parameters

| Parameter Name | Direction | Data Type | Description |
|---|---|---|---|
| AlertData | Return | AlertData | A high frequency irregular push of the requested alert data corresponding to subscription. |

**Table 24: Operation pushWeatherAlertData parameters**



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# 6.Service Dynamic Behavior

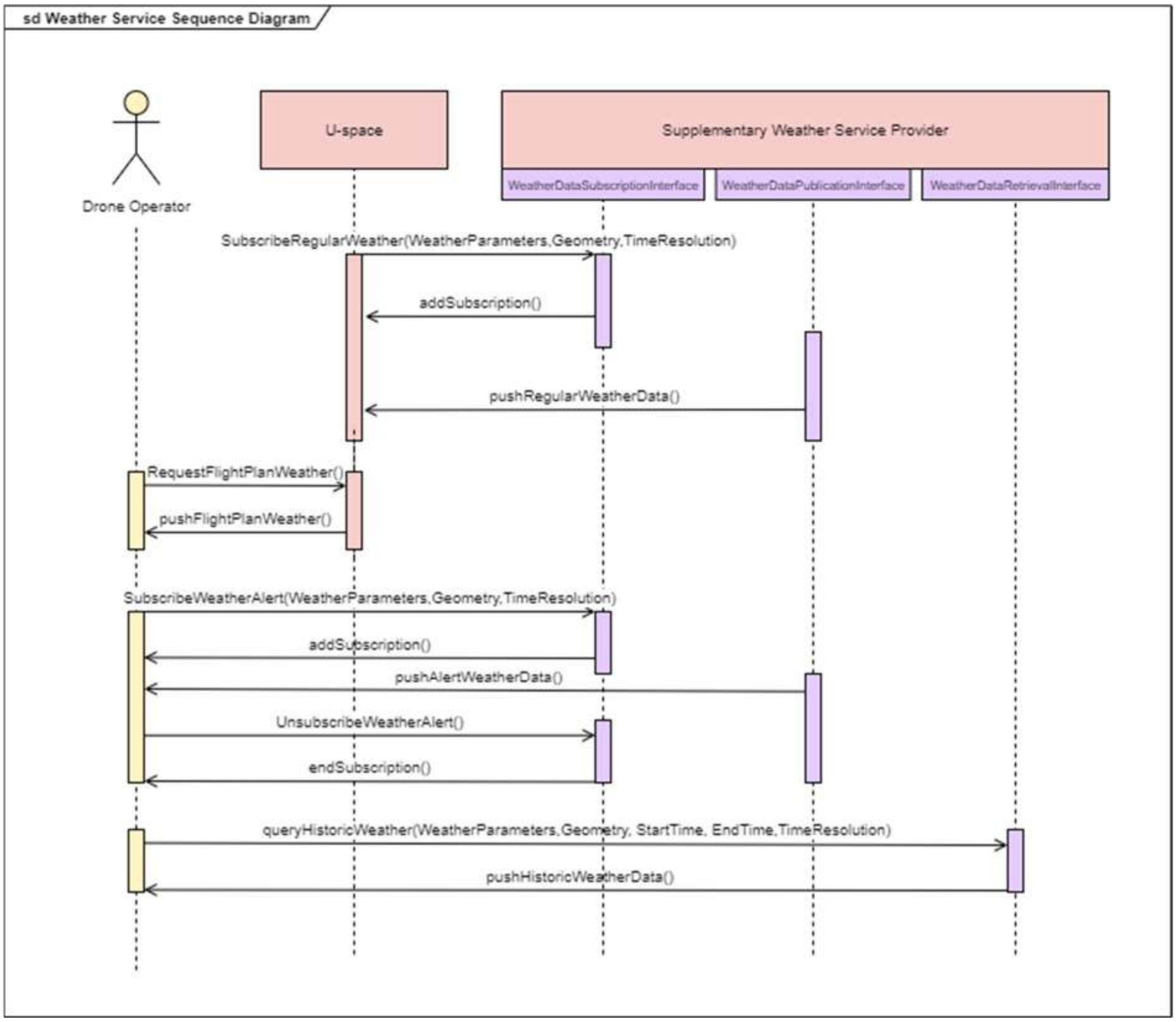


**Figure 5: Service Dynamic Behavior**

The figure above provides an example scenario for the Supplementary Weather data service.

The following three Scenarios are illustrated in the above diagram:

- U-space Regular weather data update and dispatch to UAV operators
- UAV operators subscribe to weather alerts

- UAV operator query for Historic and Forecast data.

# 7. Definitions of Acronyms and Terms

### 7.1.1. List of Acronyms

| Acronym | Explanation |
|---|---|
| **3GPP** | 3rd Generation Partnership Project |
| **ACJA** | Aerial Connectivity Joint Activity (by GSMA + GUTMA) |
| **AIXM** | Aeronautical Information Exchange Model |
| **AMQ** | Advanced Message Queuing |
| **API** | Application Programming Interface |
| **ASTM** | American Society for Testing and Materials |
| **ATM** | Air Traffic Management |
| **BVLOS** | Beyond Visual Line of Sight |
| **CARS** | Common Altitude Reference System |
| **C2** | Command and Control |
| **CIS** | Common Information Service |
| **CTR** | Controlled Traffic Region |
| **EDT** | Estimated Time of Departure |
| **FIXM** | Flight Information Exchange Model |
| **FPL** | Flight Plan |
| **GSMA** | GSM Association |
| **GUTMA** | Global UTM Association |
| **SSD** | Service Specification Document |
| **SWIM** | System Wide Information Management |
| **UAM** | Urban Air Mobility |
| **U-space** | Concept of procedures and services to support unmanned traffic management |
| **UAS** | Unmanned Aircraft System |
| **UAV** | Unmanned Aerial Vehicle |



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| Acronym | Explanation |
|---|---|
| **USSP** | U-space Service Providers |
| **UTM** | UAV Traffic Management |



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# 8. References

| Nr. | Version | Reference |
|---|---|---|
| [1] | | *European ATM Master Plan: Roadmap for the safe integration of drones into all classes of airspace*<br>https://www.sesarju.eu/node/2993 |



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INDUSTRIAL RESEARCH

# U-space ConOps: Interface U-space/ATM (AURA sol.2)

| | |
|---|---|
| Project Acronym: | PJ34 AURA |
| Topic: | Collaborative ATM - U-space Interface |
| Consortium Coordinator: | Indra |
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## Authoring & Approval

### Authors of the document

| Beneficiary | Date |
|---|---|
| Indra | 10/02/2023 |

### Reviewers internal to the project

| Beneficiary | Date |
|---|---|
| Indra | 16/02/2023 |

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| Beneficiary | Date |
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| 01.00.01 | 17/02/2023 | Finished | INDRA | Annex to be introduced in CORUS XUAM ConOps |





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# PJ34-W3-01 AURA

## COLLABORATIVE ATM - U-SPACE INTERFACE

This document aims to provide a summary of the detail regarding PJ34-W3-01 in terms of being introduced as an Annex associated to CORUS-XUAM ConOps documentation.

## Abstract

During CORUS-XUAM ConOps seminars which were held during 2022, several projects were shown in a way of being compared to the current CORUS concept. These seminars aimed to collect all valuable information, concepts, details, systems, etc. which could enrich and give a more complete view of the U-space.

AURA was presented in November 2022. The main issues addressed were:

- AURA General Description.
- AURA volumes of Operation.
- Introduction to solutions 1 and 2.
- Regarding Solution 1 Collaborative ATM-U-space Interface, the following points were discussed:
    - General description.
    - Operational Processes Assessment.
    - Clusters and services validation.
    - Stakeholders.
    - Systems.
    - Standards.
    - Conclusions.

All this material was presented in comparison to the CORUS concept and, following this presentation, the need for the concept to be developed within the ConOps was derived. After several coordinations with the CORUS XUAM team, definition of services is going to be included in the main ConOps documentation and, in order to address additional information and details linked to the services defined, the present document represents an annex that could be considered, pending review and approval.



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# Table of Contents

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# 1 Introduction to the concept

Solution PJ.34-W3-01 goal is the definition of the ATM/U-Space Interface by identifying the data exchanges required between ATM and U-Space systems and by defining the information needed to be shared. This identification leads to the generation of a set of basic services permitting the information exchange through SWIM as middleware of the ATM - U-space systems interface. The information exchange services defined conform the initial ATM-U-Space common interface.

The definition of the U-space/ATM common interface by identifying an initial set of basic services and by considering the relevant information to be exchanged, permits and guarantees the interoperability between both systems, avoiding airspace fragmentation and allowing safe drones' operations into controlled and uncontrolled airspace.

Due to the fact of operations being performed in a High Risk environment (UAS operation to be conducted in CTR airspace whose planned trajectories are interfering with manned aircraft planned trajectories, causing a potential conflict), the role of ATM/ATC Controller is very relevant as participant in the operation flow. For example, in the flight authorization flow, ATC must confirm the FA request and the FA request.

This clarification is done in order to avoid some divergence from the existing regulation. In the flight authorization flow we consider the need for the ATM to approve the authorization when it is not contemplated under EC 664/2021 regulation, because the operations are performed under controlled airspace. The same consideration is applied for the activation request from ATM.

# 2 New Operating Method

The scope of this section is to provide information regarding the proposed "new operating method" for enabling and describing the U-space-ATM Interface interaction.

Focusing on the U-space-ATM Interface and the main services addressed in the solution by the UCs containing information exchanges between the two systems, different topics/services/information-exchanges are impacted and need to be described in the New Operating Method definition in the frame of Solution PJ34-W3-01 Collaborative U-space-ATM interface, which can be summarised as follows:

- Flight Authorization.
- Drone Nominal Operation.
- Dynamic Airspace Reconfiguration (understood as how will work a future service associated to DAR, immediately linked to Solution 2 development).
- Emergency Management.
- Drone Non Nominal Operation.
- Traffic Information:
    - Tracking – From U-space to ATM and vice versa.
    - Alerts – From U-space to ATM (Conformance Monitoring Alerts, Conflicts Alerts).
- Any other Topic/Service/Information-exchange performed via ATM-U-space Interface needed to be considered for the Op. Method definition.

The following views represent in a more understandable way the approach to the new operating methods mentioned. In this way, all of them are represented except from traffic information as not being an operating method itself.

## 2.1 Flight Authorization (and nominal operation)

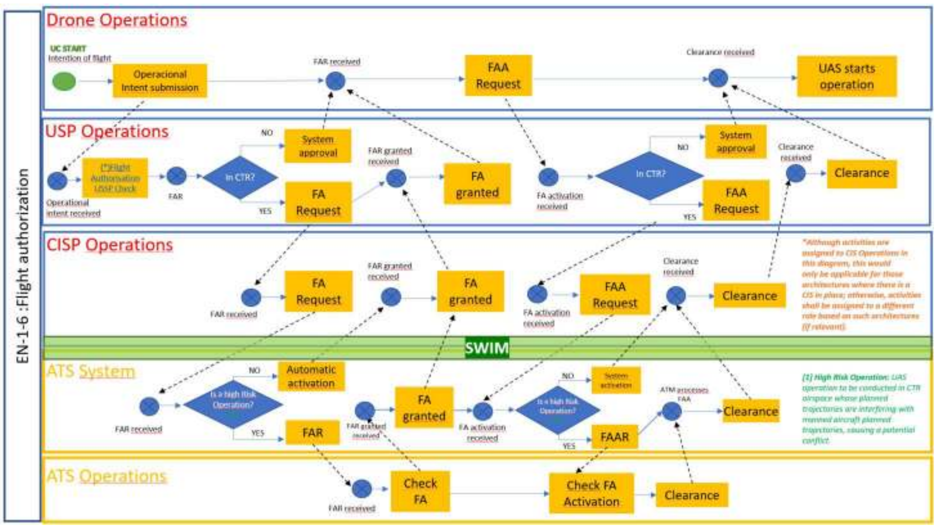


**Figure 1: Flight Authorization**

## 2.2 Dynamic Airspace Reconfiguration

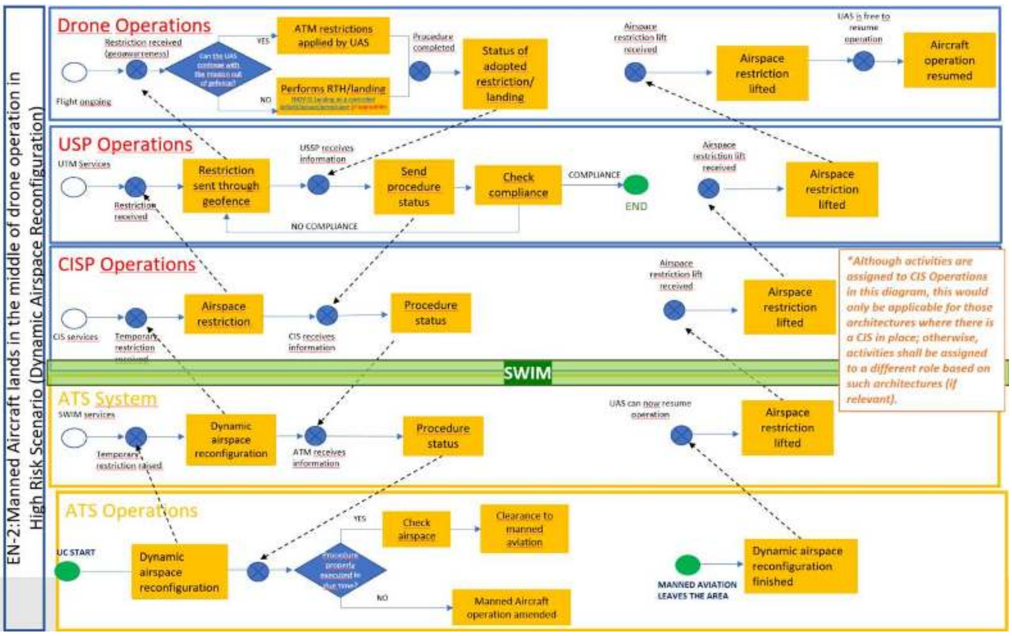


**Figure 2: Dynamic airspace reconfiguration**

## 2.3 Emergency Management

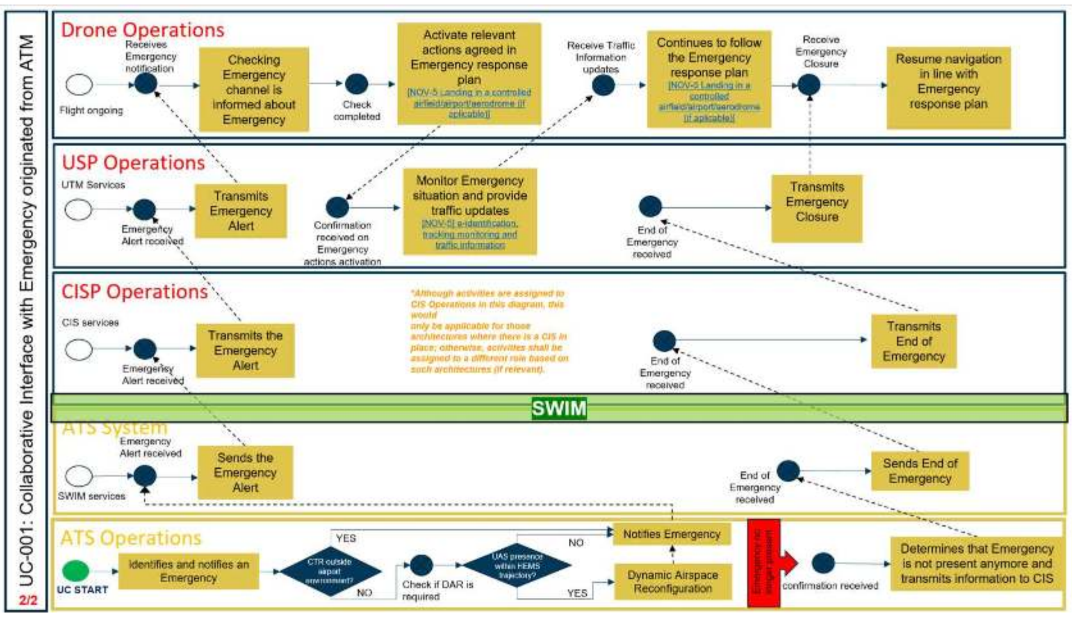


**Figure 3: Emergency management**

## 2.4 Nominal Situation

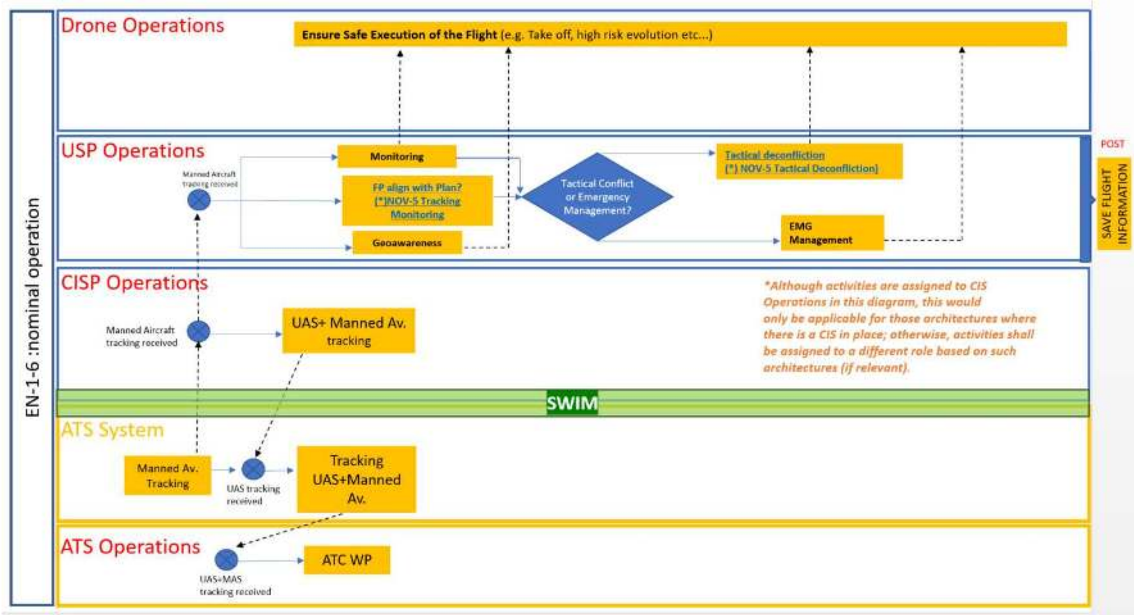


**Figure 4: Nominal situation**

## 2.5 Non Nominal Situation

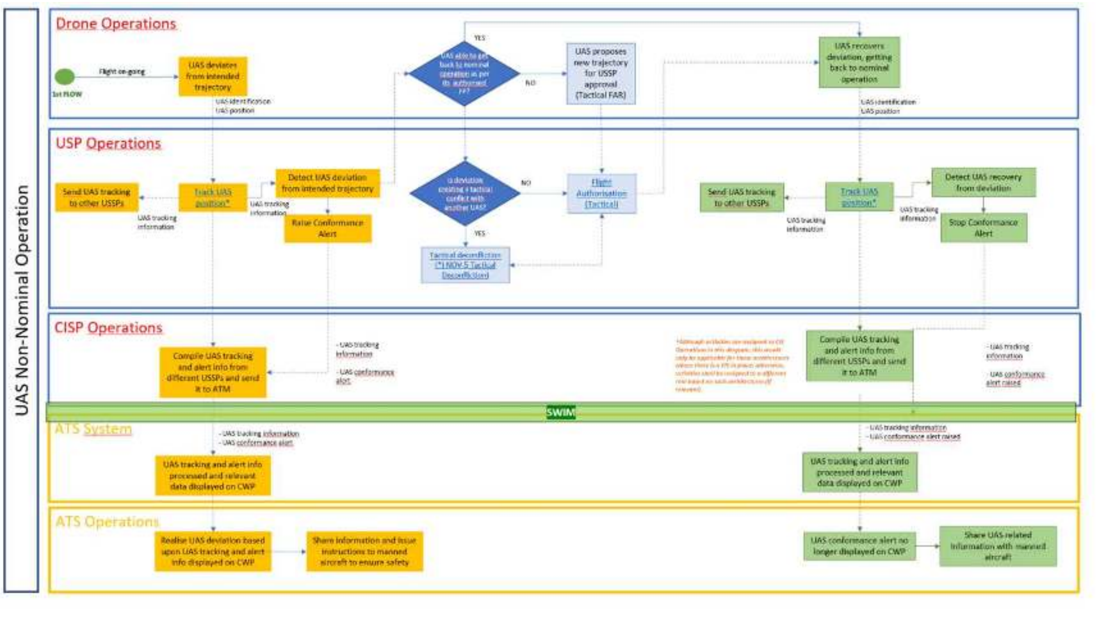


**Figure 5: Non nominal situation**





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# 3 Services description

The main objective of this project is to define an ATM/U-Space common interface and validate the information exchanges of a first set of defined services as part of this interface, using SWIM and further develop the concept of operations for ATM-U-space Collaborative interface. The solution first assess works from SESAR and other international entities and, then, the initial list of U-space U2/U3 services candidates for information exchange will be determined. In particular, the solution determines which services and which specific information is relevant to ATM systems. Therefore, the objective of solution 1 is to validate at V2 and V3 level the exchange of information and interface requirements needed to allow a feasible interoperability between U-space (U-space U2 and U3 services) and ATM.

In this way, the main procedure followed is defined by the following picture:

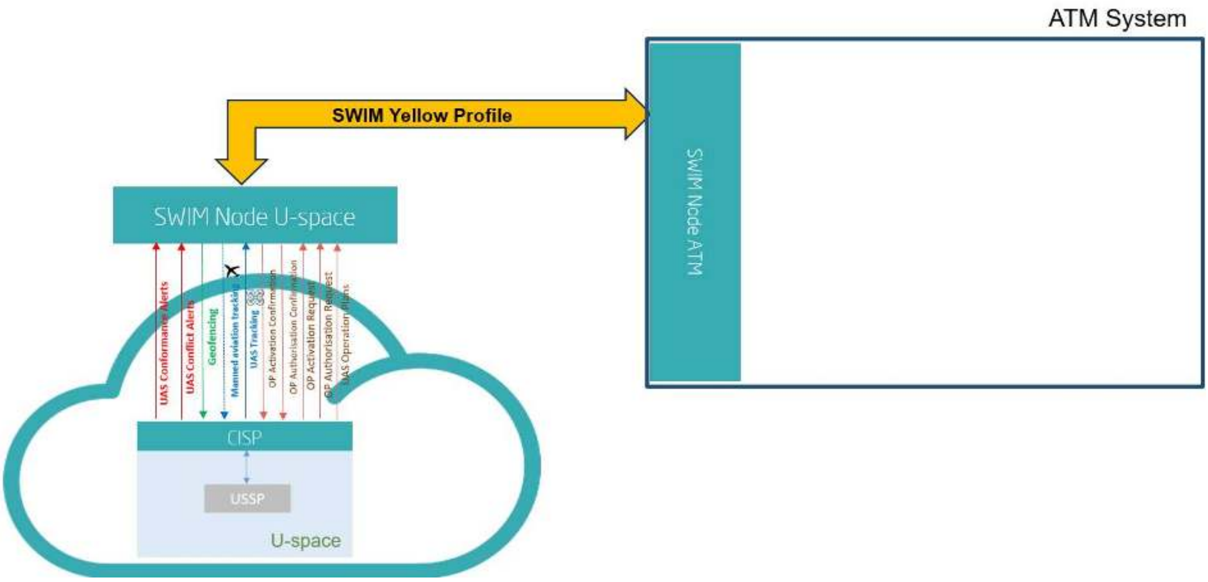


**Figure 6: Solution 1 information exchange procedure**

From now on, focusing on the set of services which are covered by AURA Solution 1, the following subsections give an additional level of information over the already shown in the main ConOps documentation. These sections address the main interfaces involved in the interchange of information required for each one of the services and the payload associated. This information comes from current SDD documentation, which shall be further refined and developed in the subsequent SESAR3 proposals using the different outputs, conclusions and recommendations obtained after Solution 1 validations.



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## 3.1 Operation Plan Information Exchange Service

### 3.1.1 Service interface specifications

(* indicates that the Data Entity has been created for the needs of this service, but is not yet part of AIRM)

#### 3.1.1.1 ActivationProvisionInformationExchangeInterface

The service provider offers this interface to allow consumers to request an activation for an Operation Plan.

##### 3.1.1.1.1 Operation getActivationForAuthorisationId

| Input | Service Payload | Data Entity |
|---|---|---|
| | AuthorizationId | *AuthorizationId |
| **Return** | **Service Payload** | **Data Entity** |
| | ActivationResponse | *ActivationRequestResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * ActivationRequestResponse | | | |
| | rejectReason | P-String | No |
| | result | EnumOperationResult | Yes |
| | activations | Activation | 0..* |
| * AuthorizationId | | | |
| | authorizationId | UUIDType | Yes |

##### 3.1.1.1.2 Operation getActivationForOperationPlanId

The service provider offers this interface to allow consumers to request an authorization for operatioPlan.

| Input | Service Payload | Data Entity |
|---|---|---|
| | UASOperationPlanId | *OperationPlanID |
| **Return** | **Service Payload** | **Data Entity** |
| | ActivationResponse | *ActivationRequestResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * ActivationRequestResponse | | | |
| | rejectReason | P-String | No |



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| | | | |
|---|---|---|---|
| | result | EnumOperationResult | Yes |
| | activations | Activation | 0..* |
| * OperationPlanID | | | |
| | operationPlanID | UUIDType | Yes |

### 3.1.1.2 AuthorizationProvisionInformationExchangeInterface

The service provider offers this interface to allow consumers to request an authorization for operationPlan.

#### 3.1.1.2.1 Operation getAuthorizationForId

A consumer calls this operation to explicitly request an authorization by submitting the known id.

| Input | Service Payload | Data Entity |
|---|---|---|
| | UASOperationPlanId | *OperationPlanID |
| **Return** | **Service Payload** | **Data Entity** |
| | AuthorizationResponse | *AuthorizationRequestResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * AuthorizationRequestResponse | | | |
| | rejectReason | P-String | No |
| | result | EnumOperationResult | Yes |
| | authorizations | Authorization | * |
| * OperationPlanID | | | |
| | operationPlanID | UUIDType | Yes |

### 3.1.1.3 OperationPlanNotificationInformationExchangeInterface

Once and while subscribed, consumer receives operation plan data via this interface.

#### 3.1.1.3.1 Operation notifyMilitaryOperationPlan

The service provider uses this logical operation (implemented by the consumer) to publish military operation plan data.

| Input | Service Payload | Data Entity |
|---|---|---|
| | UASOperationPlan | *OperationPlan |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) |
|---|---|---|---|

| | | | or Multiplicity |
|---|---|---|---|
| * OperationPlan | | | |
| | operationPlanId | UUIDType | Yes |
| | version | UUIDType | Yes |
| | typeOfOperation | CodeOperationType | Yes |
| | state | CodeOperationPlanState | Yes |
| | swarmsize | P-Integer | Yes |
| | submitTime | DateTimeType | Yes |
| | updateTime | DateTimeType | Yes |
| | minContOpTime | P-Integer | No |
| | missionId | UUIDType | Yes |
| | atsInstruction | P-String | No |
| | contactDetails | ContactDetails | 1 |
| | operationTrajectory | OperationTrajectory | 0..1 |
| | operationVolumes | OperationVolume | * |
| | priority | Priority | 1 |
| | uASRegistration | UASRegistration | 1..* |

#### 3.1.1.3.2 Operation notifyOperationPlan

The service provider uses this logical operation (implemented by the consumer) to publish operation plan data.

| Input | Service Payload | Data Entity |
|---|---|---|
| | UASOperationPlan | *OperationPlan |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * OperationPlan | | | |
| | operationPlanId | UUIDType | Yes |
| | version | UUIDType | Yes |
| | typeOfOperation | CodeOperationType | Yes |
| | state | CodeOperationPlanState | Yes |
| | swarmsize | P-Integer | Yes |

| | | | |
|---|---|---|---|
| | submitTime | DateTimeType | Yes |
| | updateTime | DateTimeType | Yes |
| | minContOpTime | P-Integer | No |
| | missionId | UUIDType | Yes |
| | atsInstruction | P-String | No |
| | contactDetails | ContactDetails | 1 |
| | operationTrajectory | OperationTrajectory | 0..1 |
| | operationVolumes | OperationVolume | * |
| | priority | Priority | 1 |
| | uASRegistration | UASRegistration | 1..* |

### 3.1.1.4 OperationPlanProvisionInformationExchangeInterface

The service provider offers this interface to allow consumers to query operation plan data.

#### 3.1.1.4.1 Operation getOperationPlanForGeometry

A consumer calls this operation to explicitly request operation plan data for a certain geographical area.

| Input | Service Payload | Data Entity |
|---|---|---|
| | Geometry | *Geometry |
| **Return** | **Service Payload** | **Data Entity** |
| | OperationPlanResponse | *OperationPlanResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * Geometry | | | |
| | geometryType | EnumGeometryType | Yes |
| | uomDimensions | UomDistance | Yes |
| | lowerLimit | P-Integer | No |
| | lowerVerticalReference | CodeVerticalReferenceType | No |
| | upperLimit | P-Integer | Yes |
| | upperVerticalReference | CodeVerticalReferenceType | Yes |
| * OperationPlanResponse | | | |
| | rejectReason | P-String | No |

| | | | |
|---|---|---|---|
| | result | EnumOperationResult | Yes |
| | operationPlans | OperationPlan | 0..* |

#### 3.1.1.4.2 Operation getOperationPlanForId

A consumer calls this operation to explicitly request an operation plan by submitting the known id.

| Input | Service Payload | Data Entity |
|---|---|---|
| | UASOperationPlanId | *OperationPlanID |
| **Return** | **Service Payload** | **Data Entity** |
| | OperationPlanResponse | *OperationPlanResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * OperationPlanID | | | |
| | operationPlanID | UUIDType | Yes |
| * OperationPlanResponse | | | |
| | rejectReason | P-String | No |
| | result | EnumOperationResult | Yes |
| | operationPlans | OperationPlan | 0..* |

#### 3.1.1.4.3 Operation getOperationPlanForMission

A consumer calls this operation to explicitly request operation plan data belonging to a certain mission.

| Input | Service Payload | Data Entity |
|---|---|---|
| | MissionId | *MissionId |
| **Return** | **Service Payload** | **Data Entity** |
| | OperationPlanResponse | *OperationPlanResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * MissionId | | | |
| | missionId | UUIDType | Yes |
| * OperationPlanResponse | | | |
| | rejectReason | P-String | No |
| | result | EnumOperationResult | Yes |
| | operationPlans | OperationPlan | 0..* |

#### 3.1.1.4.4 Operation getOperationPlans

A consumer calls this operation to explicitly request operation plan data matching various criteria.

| Input | Service Payload | Data Entity |
|---|---|---|
| | UASOperationPlan | *OperationPlan |
| **Return** | **Service Payload** | **Data Entity** |
| | OperationPlanResponse | *OperationPlanResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * OperationPlan | | | |
| | operationPlanId | UUIDType | Yes |
| | version | UUIDType | Yes |
| | typeOfOperation | CodeOperationType | Yes |
| | state | CodeOperationPlanState | Yes |
| | swarmsize | P-Integer | Yes |
| | submitTime | DateTimeType | Yes |
| | updateTime | DateTimeType | Yes |
| | minContOpTime | P-Integer | No |
| | missionId | UUIDType | Yes |
| | atsInstruction | P-String | No |
| | contactDetails | ContactDetails | 1 |
| | operationTrajectory | OperationTrajectory | 0..1 |
| | operationVolumes | OperationVolume | * |
| | priority | Priority | 1 |
| | uASRegistration | UASRegistration | 1..* |
| * OperationPlanResponse | | | |
| | rejectReason | P-String | No |
| | result | EnumOperationResult | Yes |
| | operationPlans | OperationPlan | 0..* |

#### 3.1.1.4.5 Operation getOperationVersion

A consumer calls this operation to explicitly request a certain version of an operation plan by submitting the known ids.

| Input | Service Payload | Data Entity |
|---|---|---|
| | UASOperationPlanId | *OperationPlanID |

| Input | Service Payload | Data Entity |
|---|---|---|
| | UASOperationPlanVersionId | *OperationPlanVersion |
| **Return** | **Service Payload** | **Data Entity** |
| | OperationPlanResponse | *OperationPlanResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * OperationPlanID | | | |
| | operationPlanID | UUIDType | Yes |
| * OperationPlanResponse | | | |
| | rejectReason | P-String | No |
| | result | EnumOperationResult | Yes |
| | operationPlans | OperationPlan | 0..* |
| * OperationPlanVersion | | | |
| | version | UUIDType | Yes |

### 3.1.1.4.6 Operation submitMission

A consumer calls this operation to explicitly submit a mission that contains a serie of operation plans (at least one operation plan).

| Input | Service Payload | Data Entity |
|---|---|---|
| | Mission | *Mission |
| **Return** | **Service Payload** | **Data Entity** |
| | OperationPlanResponse | *OperationPlanResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * Mission | | | |
| | missionId | UUIDType | Yes |
| | beginTime | DateTimeType | No |
| | endTime | DateTimeType | No |
| | description | P-String | No |
| | contactDetails | ContactDetails | 0..1 |

| | | | |
|---|---|---|---|
| | operationsPlans | OperationPlan | 1..* |
| | publicInformation | PublicInformation | 0..1 |
| * OperationPlanResponse | | | |
| | rejectReason | P-String | No |
| | result | EnumOperationResult | Yes |
| | operationPlans | OperationPlan | 0..* |

### 3.1.1.5 OperationPlanSubscriptionExchangeInterface

The service provider offers this interface to allow consumers to subscribe/unsubscribe for operation plan data.

#### 3.1.1.5.1 Operation subscribeForOperationPlan

A consumer calls this operation to subscribe to receive operation plan data.

| Input | Service Payload | Data Entity |
|---|---|---|
| | NotificationEndpoint | *NotificationEndpoint |

| Input | Service Payload | Data Entity |
|---|---|---|
| | AreaOfInterest | *AreaOfInterest |
| **Return** | **Service Payload** | **Data Entity** |
| | ServiceResponse | *ServiceResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * AreaOfInterest | | | |
| | areaCRS | EnumCRSType | Yes |
| | area | P-String | Yes |
| * NotificationEndpoint | | | |
| | URL | P-String | Yes |
| * ServiceResponse | | | |
| | result | EnumOperationResult | Yes |
| | rejectReason | P-String | No |

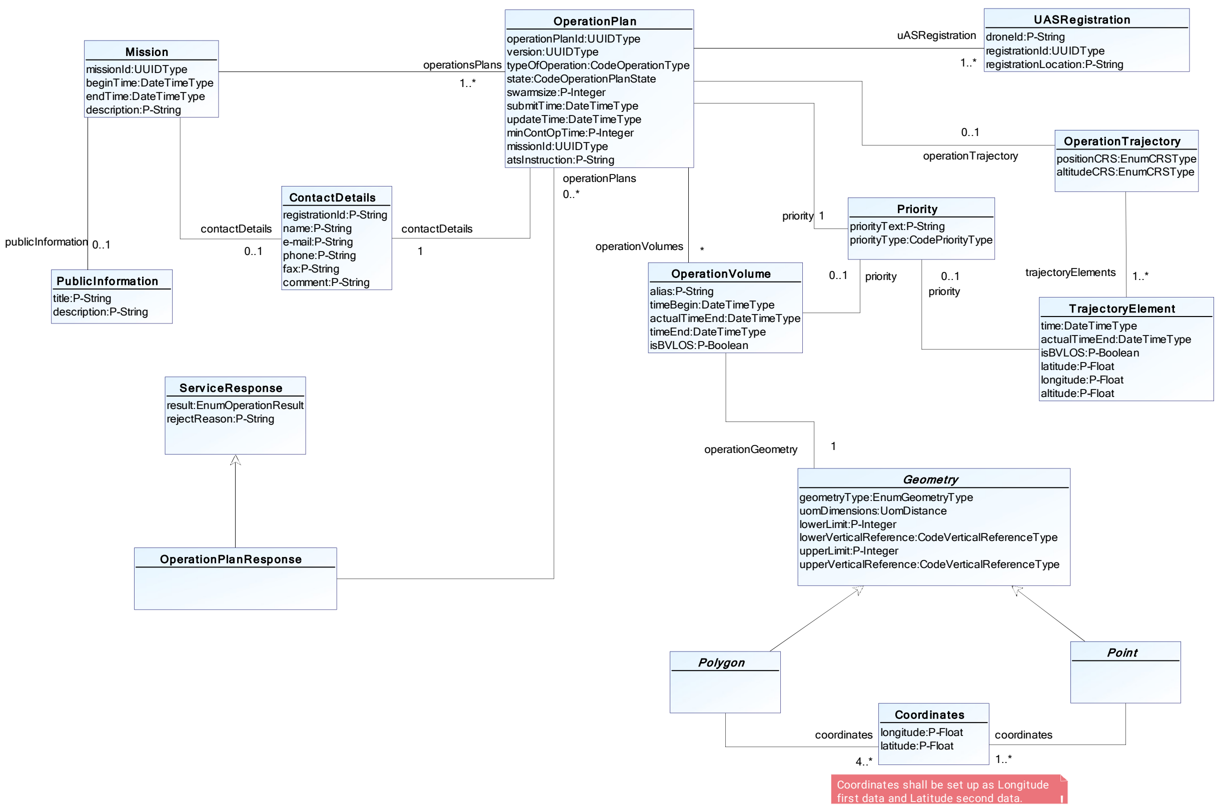
#### 3.1.1.5.2 Operation unsubscribe

A consumer calls this operation at the provider to unsubscribe from operation plan or no flight zone data.

| Input | Service Payload | Data Entity |
|---|---|---|
| | NotificationEndpoint | *NotificationEndpoint |
| **Return** | **Service Payload** | **Data Entity** |
| | ServiceResponse | *ServiceResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * NotificationEndpoint | | | |
| | URL | P-String | Yes |
| * ServiceResponse | | | |
| | result | EnumOperationResult | Yes |
| | rejectReason | P-String | No |

## 3.1.2 Data payload diagram





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## 3.2 Geofence Information Exchange Service

### 3.2.1 Service interface specifications

#### 3.2.1.1 Geofence Information Exchange Publication Interface

The publication interface enables the provider to send UAS Zone information updates to subscribed consumers. It allows sending subscription status information that enable the consumer to verify that the publication interface and the dependencies with the Subscription interface are working as expected.

In order for the provider to be able to send information to consumers, it is required as a prerequisite that the consumers:

- Create a subscription via the subscribeToUASZonesUpdates operation.
- Create a connection to the publicationLocation provided as a result of the subscription operation.
- Activate the subscription via the resumeUASZonesUpdatesSubscription

##### 3.2.1.1.1 Operation notifySubscriptionStatus

This operation enables the provider to send the status of a subscription to the subscribed consumer.

| Return | Service Payload | Data Entity |
|---|---|---|
| | SubscriptionStatusMessage | *SubscriptionStatusNotification |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * SubscriptionStatusNotification | | | |
| | subscriptionID | P-String | |
| | subscriptionStatus | EnumSubscriptionStatusType | Yes |
| | notificationReason | EnumNotificationReason | Yes |
| | notificationReasonDescription | P-String | |

##### 3.2.1.1.2 Operation publishUASZonesUpdates

This operation enables the provider, whenever a UASZone information is changed, to send an update to subscribed consumers.

| Return | Service Payload | Data Entity |
|---|---|---|
| | UASZoneUpdatePublication | *UASZone |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * UASZone | | | |

| | | | |
|---|---|---|---|
| | identifier | CodeZoneIdentifierType | Yes |
| | country | CodeCountryISOType | Yes |

### 3.2.1.2 Geofence Information Exchange Retrieval Interface

The retrieval interface enables the synchronous retrieval of all UAS Zone information available for a particular timeframe, airspace and region of interest. It also enables synchronously retrieving the information that has changed since a particular moment.

#### 3.2.1.2.1 Operation retrieveUASZones

This operation enables the retrieval of UASZonesinformation.

| Input | Service Payload | Data Entity |
|---|---|---|
| | UASZonesRequest | *UASZonesRequest |
| **Return** | **Service Payload** | **Data Entity** |
| | UASZonesReply | *UASZonesReply |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * UASZonesReply | | | |
| | requestExceptionDescription | P-String | No |
| | requestProcessedTimeStamp | DateTimeType | Yes |
| | requestStatus | EnumRequestStatusType | Yes |
| | UASZoneList | UASZone | * |
| * UASZonesRequest | | | |
| | regions | P-Integer | |
| | startDateTime | DateTimeType | No |
| | endDateTime | DateTimeType | No |
| | airspaceVolume | AirspaceVolume | * |

#### 3.2.1.2.2 Operation retrieveUASZonesUpdates

This operation enables the retrieval of recently updated UASZonesinformation. This is not an operation to modify information.

| Input | Service Payload | Data Entity |
|---|---|---|
| | UASZonesUpdatesRequest | *UASZonesUpdatesReply |

| Return | Service Payload | Data Entity |
|---|---|---|
| | UASZonesUpdatesReply | *UASZonesUpdatesReply |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * UASZonesUpdatesReply | | | |
| | requestExceptionDescription | P-String | No |
| | requestProcessedTimeStamp | DateTimeType | Yes |
| | requestStatus | EnumRequestStatusType | Yes |
| | UASZoneList | UASZone | * |

#### 3.2.1.3 Geofence Information Exchange Subscription Interface

The subscription interface enables the Geofencing service consumer to express interest in receiving updates to UAS Zone information for a particular airspace and region of interest.

##### 3.2.1.3.1 Operation getUASZonesUpdatesSubscriptions

This operation allows a subscriber to obtain a list of its subscriptions, detailing.

| Return | Service Payload | Data Entity |
|---|---|---|
| | GetUASZonesUpdatesSubscriptionsReply | *GetUASZonesUpdatesSubscriptionsReply |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * GetUASZonesUpdatesSubscriptionsReply | | | |
| | requestExceptionDescription | P-String | No |
| | requestProcessedTimeStamp | DateTimeType | Yes |
| | requestStatus | EnumRequestStatusType | Yes |
| | subscriptions | Subscription | * |

##### 3.2.1.3.2 Operation pauseUASZonesUpdatesSubscription

This operation sets the subscription to a "PAUSED" state, resulting in updates delivered via the "Publication" interface to stop for the subscribed consumer. New messages are not stored in a paused queue by the provider.

| Input | Service Payload | Data Entity |
|---|---|---|
| | PauseUASZonesUpdatesSubscriptionRequest | *PauseUASZonesUpdatesSubscriptionRequest |
| **Return** | **Service Payload** | **Data Entity** |
| | PauseUASZonesUpdatesSubscriptionReply | *PauseUASZonesUpdatesSubscriptionReply |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * PauseUASZonesUpdatesSubscriptionReply | | | |
| | requestExceptionDescription | P-String | No |
| | requestProcessedTimeStamp | DateTimeType | Yes |
| | requestStatus | EnumRequestStatusType | Yes |
| | subscriptionID | P-String | |
| | subscriptionStatus | EnumSubscriptionStatusType | |
| * PauseUASZonesUpdatesSubscriptionRequest | | | |
| | subscriptionStatus | EnumSubscriptionStatusType | Yes |

#### 3.2.1.3.3 Operation resumeUASZonesUpdatesSubscription

This operation sets the subscription to an “Active” state, resulting in updates delivered via the “Publication” interface to start for the subscribed consumer

| Input | Service Payload | Data Entity |
|---|---|---|
| | ResumeUASZonesUpdatesSubscriptionRequest | *ResumeUASZonesUpdatesSubscriptionRequest |
| **Return** | **Service Payload** | **Data Entity** |
| | ResumeUASZonesUpdatesSubscriptionReply | *ResumeUASZonesUpdatesSubscriptionReply |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * ResumeUASZonesUpdatesSubscriptionReply | | | |
| | requestExceptionDescription | P-String | No |

| | | | |
|---|---|---|---|
| | requestProcessedTimeStamp | DateTimeType | Yes |
| | requestStatus | EnumRequestStatusType | Yes |
| | subscriptionID | P-String | |
| | subscriptionStatus | EnumSubscriptionStatusType | |
| * ResumeUASZonesUpdatesSubscriptionRequest | | | |
| | subscriptionStatus | EnumSubscriptionStatusType | Yes |

#### 3.2.1.3.4 Operation subscribeToUASZonesUpdates

This operation creates a subscription for the consumer, with "PAUSED" state. The operation creates also a publication resource (i.e. queue) at the provider infrastructure, where all information updates related to the subscription will be delivered.

| Input | Service Payload | Data Entity |
|---|---|---|
| | SubscribeToUASZonesUpdatesRequest | *SubscribeToUASZonesUpdatesRequest |
| **Return** | **Service Payload** | **Data Entity** |
| | SubscribeToUASZonesUpdatesReply | *SubscribeToUASZonesUpdatesReply |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * SubscribeToUASZonesUpdatesReply | | | |
| | requestExceptionDescription | P-String | No |
| | requestProcessedTimeStamp | DateTimeType | Yes |
| | requestStatus | EnumRequestStatusType | Yes |
| | subscriptionID | UUIDType | Yes |
| | publicationLocation | P-String | Yes |
| | publicationLinkVerificationFrequency | P-String | |
| | subscriptionStatus | EnumSubscriptionStatusType | |
| * SubscribeToUASZonesUpdatesRequest | | | |

| | | | |
|---|---|---|---|
| | regions | P-Integer | |
| | startDateTime | DateTimeType | No |
| | endDateTime | DateTimeType | No |
| | airspaceVolume | AirspaceVolume | * |

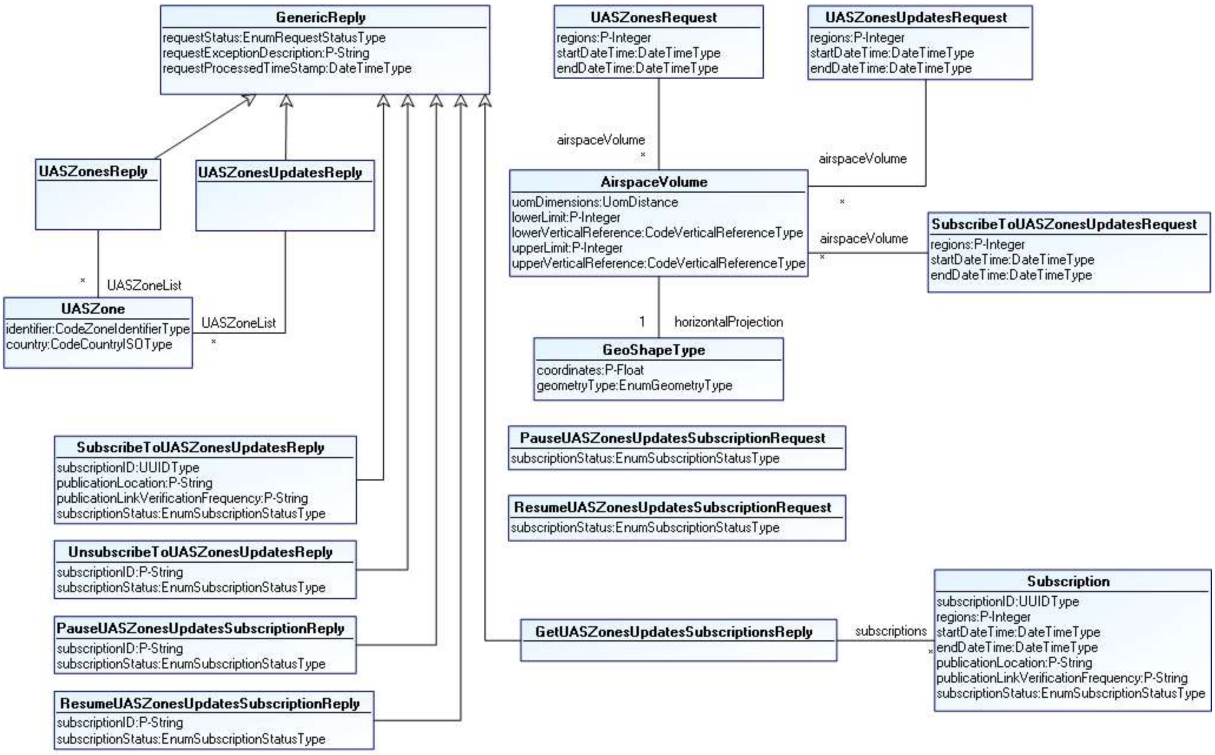
#### 3.2.1.3.5 Operation unsubscribeToUASZonesUpdates

This operation sets the subscription to a "DELETED" state, resulting in updates delivered via the "Publication" interface to stop for the subscribed consumer. The operation also deletes the publication resource (i.e. queue) at the provider infrastructure where all information related to the subscription was being delivered.

| Return | Service Payload | Data Entity |
|---|---|---|
| | UnsubscribeToUASZonesUpdatesReply | *UnsubscribeToUASZonesUpdatesReply |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * UnsubscribeToUASZonesUpdatesReply | | | |
| | requestExceptionDescription | P-String | No |
| | requestProcessedTimeStamp | DateTimeType | Yes |
| | requestStatus | EnumRequestStatusType | Yes |
| | subscriptionID | P-String | |
| | subscriptionStatus | EnumSubscriptionStatusType | |

### 3.2.2 Data payload diagram


GenericReply
requestStatus:EnumRequestStatusType
requestExceptionDescription:P-String
requestProcessedTimeStamp:DateTimeType
UASZonesRequest
regions:P-Integer
startDateTime:DateTimeType
endDateTime:DateTimeType
UASZonesUpdatesRequest
regions:P-Integer
startDateTime:DateTimeType
endDateTime:DateTimeType
airspaceVolume
airspaceVolume
UASZonesReply
UASZonesUpdatesReply
AirspaceVolume
uomDimensions:UomDistance
lowerLimit:P-Integer
lowerVerticalReference:CodeVerticalReferenceType
upperLimit:P-Integer
upperVerticalReference:CodeVerticalReferenceType
airspaceVolume
SubscribeToUASZonesUpdatesRequest
regions:P-Integer
startDateTime:DateTimeType
endDateTime:DateTimeType
UASZoneList
UASZone
identifier:CodeZoneIdentifierType
country:CodeCountryISOType
UASZoneList
1
horizontalProjection
GeoShapeType
coordinates:P-Float
geometryType:EnumGeometryType
PauseUASZonesUpdatesSubscriptionRequest
subscriptionStatus:EnumSubscriptionStatusType
SubscribeToUASZonesUpdatesReply
subscriptionID:UUIDType
publicationLocation:P-String
publicationLinkVerificationFrequency:P-String
subscriptionStatus:EnumSubscriptionStatusType
ResumeUASZonesUpdatesSubscriptionRequest
subscriptionStatus:EnumSubscriptionStatusType
UnsubscribeToUASZonesUpdatesReply
subscriptionID:P-String
subscriptionStatus:EnumSubscriptionStatusType
Subscription
subscriptionID:UUIDType
regions:P-Integer
startDateTime:DateTimeType
endDateTime:DateTimeType
publicationLocation:P-String
publicationLinkVerificationFrequency:P-String
subscriptionStatus:EnumSubscriptionStatusType
PauseUASZonesUpdatesSubscriptionReply
subscriptionID:P-String
subscriptionStatus:EnumSubscriptionStatusType
GetUASZonesUpdatesSubscriptionsReply
subscriptions
ResumeUASZonesUpdatesSubscriptionReply
subscriptionID:P-String
subscriptionStatus:EnumSubscriptionStatusType

## 3.3 Tactical Operational Message Information Exchange Service

### 3.3.1 Service interface specifications

#### 3.3.1.1 Tactical Operational Message Acknowledgement Interface

Consumer provides this interface, allowing the service provider to submit to the consumer acknowledgement messages.

##### 3.3.1.1.1 Operation acknowledgeOperationalMessage

A consumer calls this operation to acknowledge an operational message.

| Input | Service Payload | Data Entity |
|---|---|---|
| | AckTacticalOperationalMessage | *ackTacticalOperationMessage |
| **Return** | **Service Payload** | **Data Entity** |
| | ServiceResponse | *ServiceResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * ackTacticalOperationMessage | | | |
| | ackMsgID | UUIDType | Yes |
| | msgBeingAcknowledged | UUIDType | Yes |
| | acknowlegement | EnumAcknowlegement | Yes |
| * ServiceResponse | | | |
| | result | EnumOperationResult | Yes |
| | rejectReason | P-String | No |

#### 3.3.1.2 Tactical Operational Message Notification Interface

Consumer provides this interface, allowing the service provider to submit to the consumer operational messages.

##### 3.3.1.2.1 Operation notifyOperationalMessage

Consumer provides this interface, allowing the service provider to submit to the consumer operational messages.

| Input | Service Payload | Data Entity |
|---|---|---|
| | TacticalOperationalMessage | *TacticalOperationalMessage |
| **Return** | **Service Payload** | **Data Entity** |
| | ServiceResponse | *ServiceResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * ServiceResponse | | | |
| | result | EnumOperationResult | Yes |
| | rejectReason | P-String | No |
| * TacticalOperationalMessage | | | |
| | messageID | UUIDType | Yes |
| | source | P-String | Yes |
| | time | DateTimeType | Yes |
| | messageSeverity | EnumTacticalOperationalMessageSeverity | Yes |
| | messageType | EnumTacticalOperationMessageType | Yes |
| | freeText | P-String | No |
| | messageState | EnumTacticalOperationMessageState | Yes |
| | operationPlanID | UUIDType | Yes |
| | version | UUIDType | Yes |

#### 3.3.1.3 Tactical Operational Message Subscription Interface

Consumer provides this interface, allowing the service provider to submit to the consumer subscription messages.

##### 3.3.1.3.1 Operation subscribeForOperationalMessageMonitoring

A consumer calls this operation to subscribe to monitoring of operational messages related to a certain geographical area of interest.

An operator subscribes to the OperationalMessageExchangeSunscriptionInterface of her USSP for each one of her operationPlanId.

A USSP or ATSU subscribes to the OperationalMessageExchangeSubscriptionInterface for its areaOfInterest of the other USSPs or ATSUs operating that area, as does a monitoring consumer which subscribeOperationalMessageMonitoring.

| Input | Service Payload | Data Entity |
|---|---|---|
| | NotificationEndpoint | *NotificationEndpoint |

| Input | Service Payload | Data Entity |
|---|---|---|

| | | |
|---|---|---|
| | AreaOfInterest | *AreaOfInterest |
| **Return** | **Service Payload** | **Data Entity** |
| | ServiceResponse | *ServiceResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * AreaOfInterest | | | |
| | areaCRS | EnumCRSType | Yes |
| | area | P-String | Yes |
| * NotificationEndpoint | | | |
| | URL | P-String | Yes |
| * ServiceResponse | | | |
| | result | EnumOperationResult | Yes |
| | rejectReason | P-String | No |

#### 3.3.1.3.2 Operation subscribeForOperationalMessages

A consumer calls this operation to subscribe for receiving operational messages related to a certain geographical area of interest, or related to a certain operation plan.

| Input | Service Payload | Data Entity |
|---|---|---|
| | AreaOfInterest | *AreaOfInterest |

| Input | Service Payload | Data Entity |
|---|---|---|
| | NotificationEndpoint | *NotificationEndpoint |

| Input | Service Payload | Data Entity |
|---|---|---|
| | UASOperationPlanId | *OperationPlanID |
| **Return** | **Service Payload** | **Data Entity** |
| | ServiceResponse | *ServiceResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * AreaOfInterest | | | |
| | areaCRS | EnumCRSType | Yes |
| | area | P-String | Yes |
| * NotificationEndpoint | | | |
| | URL | P-String | Yes |
| * OperationPlanID | | | |

| | | | |
|---|---|---|---|
| | operationPlanID | UUIDType | Yes |
| * ServiceResponse | | | |
| | result | EnumOperationResult | Yes |
| | rejectReason | P-String | No |

### 3.3.1.3.3 Operation unSubscribeForOperationalMessages

A consumer calls this operation at the provider to unsubscribe from operational messages related to a certain geographical area of interest or related to a certain operation plan. The operation either expects an operationPlanId or an areaOfInterest input parameter.

| Input | Service Payload | Data Entity |
|---|---|---|
| | AreaOfInterest | *AreaOfInterest |

| Input | Service Payload | Data Entity |
|---|---|---|
| | NotificationEndpoint | *NotificationEndpoint |

| Input | Service Payload | Data Entity |
|---|---|---|
| | UASOperationPlanId | *OperationPlanID |
| **Return** | **Service Payload** | **Data Entity** |
| | ServiceResponse | *ServiceResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * AreaOfInterest | | | |
| | areaCRS | EnumCRSType | Yes |
| | area | P-String | Yes |
| * NotificationEndpoint | | | |
| | URL | P-String | Yes |
| * OperationPlanID | | | |
| | operationPlanID | UUIDType | Yes |
| * ServiceResponse | | | |
| | result | EnumOperationResult | Yes |
| | rejectReason | P-String | No |

### 3.3.2 Data payload diagram

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## 3.4 Tracking Information Exchange Service

### 3.4.1 Service interface specifications

#### 3.4.1.1 TrackingNotificationInterface

Consumer provides this interface, allowing the service provider to submit to the consumer position report data (and flight event notifications, if supported).

##### 3.4.1.1.1 Operation notifyFlightEvent

Once and while subscribed, consumer receives flight event notifications via this operation.

| Input | Service Payload | Data Entity |
|---|---|---|
| | FlightEventNotification | *FlightEventIndication |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * FlightEventIndication | | | |
| | flightEvent | EnumFlightEventType | Yes |
| | operationPlanId | UUIDType | No |
| | startTime | DateTimeType | No |
| | endTime | DateTimeType | No |
| | positionReportFrecuency | P-Float | No |

##### 3.4.1.1.2 Operation notifyPositionReport

Once and while subscribed, consumer receives position report data via this operation.

| Input | Service Payload | Data Entity |
|---|---|---|
| | PositionReport | *PositionReport |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * PositionReport | | | |
| | acquisitionDateTime | DateTimeType | Yes |
| | acquisitionDatetimeAccuracy | P-Float | Yes |
| | operationId | UUIDType | No |
| | origin | P-String | Yes |

| | | | |
|---|---|---|---|
| | reportId | UUIDType | Yes |
| | senderId | UUIDType | Yes |
| | altitude | Altitude | 1..* |
| | position | Position | 1 |
| | velocity | Velocity | 0..1 |

#### 3.4.1.2 TrackingSubscriptionInterface

A consumer calls this operation to subscribe to position report data.

##### 3.4.1.2.1 Operation subscribeForTracking

A consumer calls this operation to subscribe to position report data.

| Input | Service Payload | Data Entity |
|---|---|---|
| | NotificationEndpoint | *NotificationEndpoint |

| Input | Service Payload | Data Entity |
|---|---|---|
| | AreaOfInterest | *AreaOfInterest |
| **Return** | **Service Payload** | **Data Entity** |
| | ServiceResponse | *ServiceResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * AreaOfInterest | | | |
| | areaCRS | EnumCRSType | Yes |
| | area | P-String | Yes |
| * NotificationEndpoint | | | |
| | URL | P-String | Yes |
| * ServiceResponse | | | |
| | result | EnumOperationResult | Yes |
| | rejectReason | P-String | No |

##### 3.4.1.2.2 Operation unSubscribeForTracking

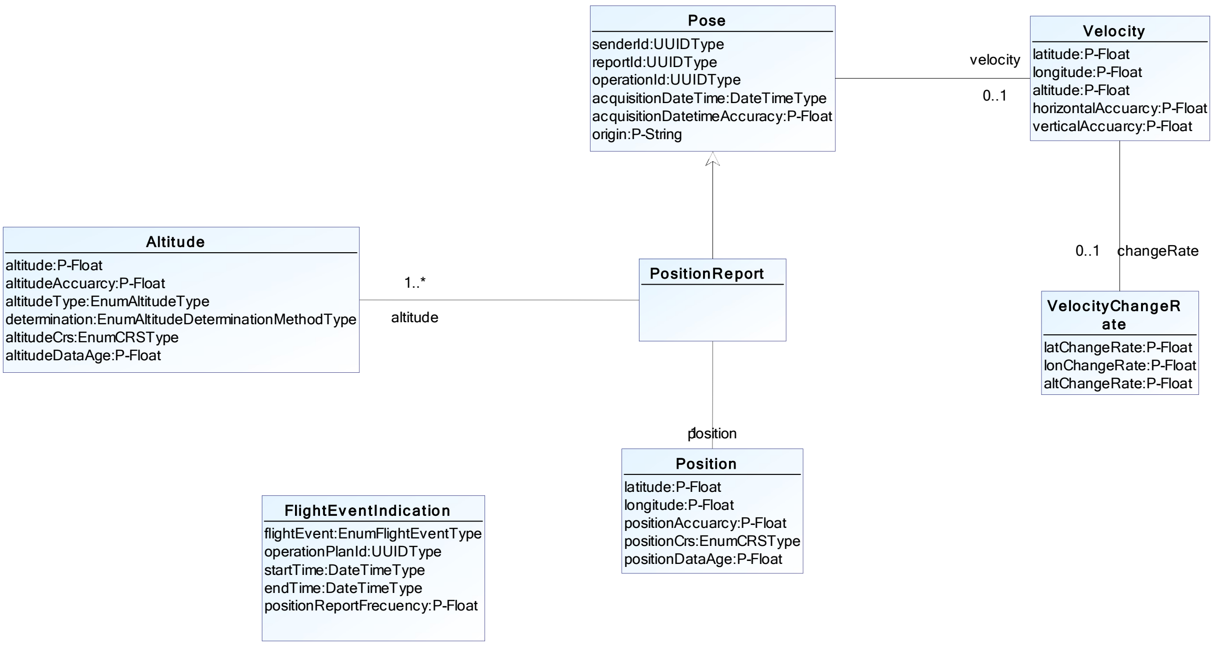
A consumer calls this operation at the provider to unsubscribe from position report data.

| Input | Service Payload | Data Entity |
|---|---|---|

| | | |
|---|---|---|
| | NotificationEndpoint | *NotificationEndpoint |
| **Return** | **Service Payload** | **Data Entity** |
| | ServiceResponse | *ServiceResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * NotificationEndpoint | | | |
| | URL | P-String | Yes |
| * ServiceResponse | | | |
| | result | EnumOperationResult | Yes |
| | rejectReason | P-String | No |

### 3.4.2 Data payload diagram



## 3.5 Traffic Non-Conformance Monitoring Information Exchange Service

### 3.5.1 Service Interface Specifications

#### 3.5.1.1 TrafficNonConformanceMonitoringNotificationInterface

Consumer provides this interface, allowing the service provider to submit to the consumer Traffic Conformance Monitoring report data.

##### 3.5.1.1.1 Operation notifyTrafficNonConformanceMonitoringReport

| Input | Service Payload | Data Entity |
|---|---|---|
| | TrafficNonConformanceMonitoringReport | *TrafficNonConformanceMonitoringReport |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
|---|---|---|---|
| * TrafficNonConformanceMonitoring Report | | | |
| | reportId | UUIDType | Yes |
| | operationPlanId | UUIDType | Yes |
| | version | UUIDType | Yes |
| | positionReportCapability | P-Boolean | Yes |
| | timestamp | DateTimeType | Yes |
| | reportType | EnumNonConformanceMonitoringFunctionType | Yes |
| | reportSubType | P-String | No |
| | flavour | P-String | No |
| | severity | EnumConflictSeverity | No |
| | probability | PercentageType | No |
| | duration | P-Integer | Yes |
| | currentSeparation | Separation | 0..1 |
| | deviation | Separation | 0..1 |
| | estimatedMinimumSeparation | Separation | 0..1 |
| | reportAltitude | Altitude | 1 |

### 3.5.1.2 TrafficNonConformanceMonitoringSubscriptionInterface

A consumer calls this interface to subscribe or unsubscribe to Traffic Conformance Monitoring report notification.

#### 3.5.1.2.1 Operation TrafficNonConformanceMonitoringInformationExchangeService.TrafficNonConformanceMonitoringSubcriptionInterface.subscribeForTrafficNonConformanceMonitoring

| Input | Service Payload | Data Entity |
| --- | --- | --- |
| | AreaOfInterest | *AreaOfInterest |

| Input | Service Payload | Data Entity |
| --- | --- | --- |
| | NotificationEndpoint | *NotificationEndpoint |
| **Return** | **Service Payload** | **Data Entity** |
| | ServiceResponse | *ServiceResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) or Multiplicity |
| --- | --- | --- | --- |
| * AreaOfInterest | | | |
| | areaCRS | EnumCRSType | Yes |
| | area | P-String | Yes |
| * NotificationEndpoint | | | |
| | URL | P-String | Yes |
| * ServiceResponse | | | |
| | result | EnumOperationResult | Yes |
| | rejectReason | P-String | No |

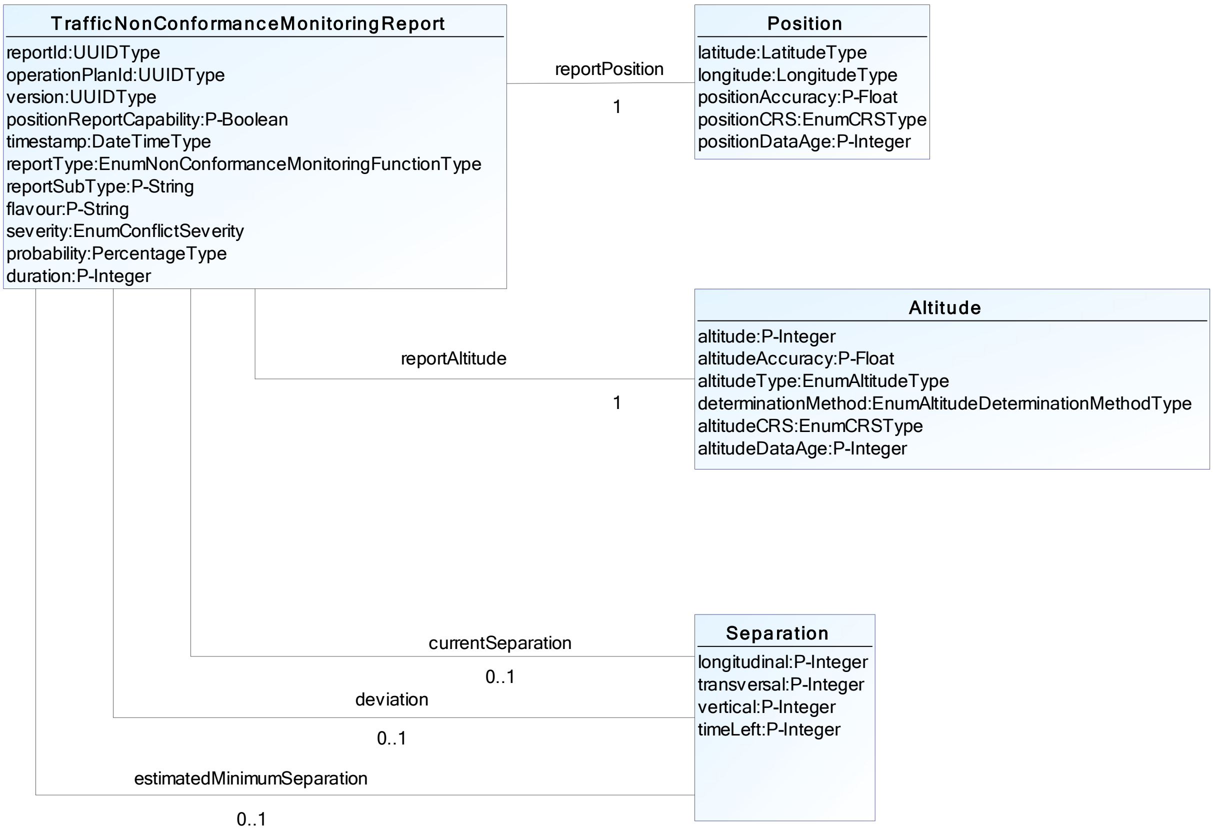
#### 3.5.1.2.2 Operation TrafficNonConformanceMonitoringInformationExchangeService.TrafficNonConformanceMonitoringSubcriptionInterface.unSubscribeForTrafficNonConformanceMonitoring

| Input | Service Payload | Data Entity |
| --- | --- | --- |
| | NotificationEndpoint | *NotificationEndpoint |
| **Return** | **Service Payload** | **Data Entity** |
| | ServiceResponse | *ServiceResponse |

| Data Entity | Attribute | Data Type | Mandatory (Yes/No) |
| --- | --- | --- | --- |

| | | | or Multiplicity |
|---|---|---|---|
| * NotificationEndpoint | | | |
| | URL | P-String | Yes |
| * ServiceResponse | | | |
| | result | EnumOperationResult | Yes |
| | rejectReason | P-String | No |

### 3.5.2 Data payload diagram



# 4 Use Cases

The exercises performed in this AURA Solution 1 aim to demonstrate and validate the potential of U-space services already exposed in section 3 for unlocking these new operations in the short to medium term.

This section addressed the most relevant information related to use cases and services being validated in each one of them but, for further details, AURA Solution 1 documentation is available in STELLAR so that:

- Use cases operations flows are detailed in section 3.3.2.6 of SPR-INTEROP/OSED Part I.
- Scenarios planning of each exercise are detailed in section 5 of the VALP.
- Results obtained from each one of these iterations can be found in Appendixes A, B, C and D of VALR.

Each cluster will be centred on a different geographical area and will focus on different validation exercises, allowing the project to cover the full scope of the problem using a "divide and conquer" approach. Moreover, besides the leadership, different partners have collaborated in each one of them so that validations cover a broad variety of ATC systems and practices across Europe.

This annex show NOV-5, NSV-4 and NSV-1 views as being the most representative linked to them, but the rest of operational views (NOV-2) and technical views (NSV-2) are adequately presented and accessible through EATMA tool.

The following table shows the group of clusters and use cases validated with its main description:

| Cluster 1: Led by Indra | Cluster 2: Led by FRQ | Cluster 3: Led by DSNA | Cluster 4: Led by LDO |
|---|---|---|---|
| UC1: Drone Performing Navaid calibration | UC1: Airspace constraints management and information sharing | UC1: Flight authorisation | UC1: Collaborative Interface for emergency originated from ATM and application of Dynamic Airspace Reservation for management |
| UC2: Drone performs a Navaid calibration interrupted by a manned aircraft operation | UC2: Strategic de-confliction involving approval from ATC | UC2: Start of flight | UC2: Application of Dynamic airspace Reservation for management of UAS operation in ATZ in case of IFR departure/arrival |
| UC3: Drone performs scheduled aerial works– Flight Plan submission for approval | UC3: Tactical contingency / emergency situation | UC3: Emergency originated by ATS Operation | |

| | | | |
|---|---|---|---|
| UC4: Drone performs scheduled aerial works – Mission (tactical) | UC4: Two-way communication between ATS and UAS Pilots | | |
| UC5: Drone performs scheduled aerial works - Flight Plan crosses two countries | UC5: Common situational awareness, monitoring and significant change of trajectory | | |
| UC6: Drone performs scheduled aerial works – Mission (Tactical). Two countries. | | | |
| UC7: Drone suffers a failure triggering a Non-nominal situation | | | |

**Table 1: Clusters and use cases associated to PJ34-W3-01**

In order to address which services are covered under which use cases, the traceability to be considered is shown in the following table:

| Cluster | Use case | IEX1 Operational plan Information exchange service | IEX2 Geofencing Information Exchange Service | IEX3 Tracking Information Exchange Service | IEX4 Traffic Non-Conformance Monitoring Service | IEX5 Tactical Op. messages |
|---|---|---|---|---|---|---|
| CL 1 | UC 1 | X | | X | | |
| | UC2 | | X | X | X | |
| | UC3 | X | | | | |
| | UC4 | X | | X | X | X |
| | UC5 | X | | | | |
| | UC6 | X | | X | X | X |
| | UC7 | X | | X | X | |
| CL 2 | UC1 | X | X | | | X |
| | UC2 | X | X | | | X |
| | UC3 | X | X | X | X | X |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **UC4** | | | X | X | X |
| | **UC5** | X | | X | X | |
| **CL 3** | **UC1** | X | | | | |
| | **UC2** | X | | | | |
| | **UC3** | | X | | X | |
| **CL 4** | **UC1** | X | X | X | X | X |

**Table 2: Clusters and use cases traceability against collaborative services of PJ34-W3-01**

## 4.1 Cluster 1 Operational views

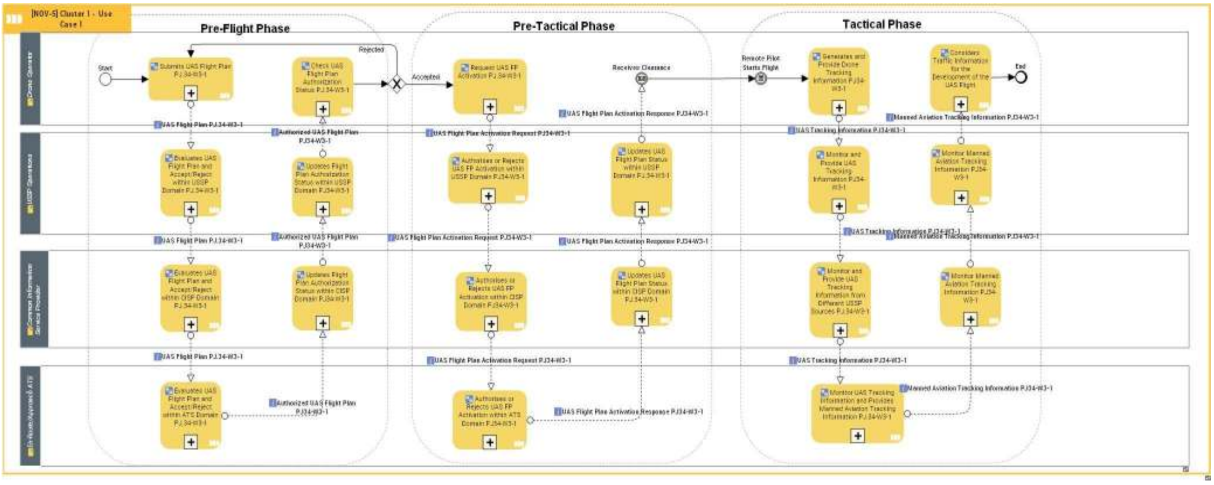



**Figure 7: Cluster 1- Use Case 1 - NOV-5 view**

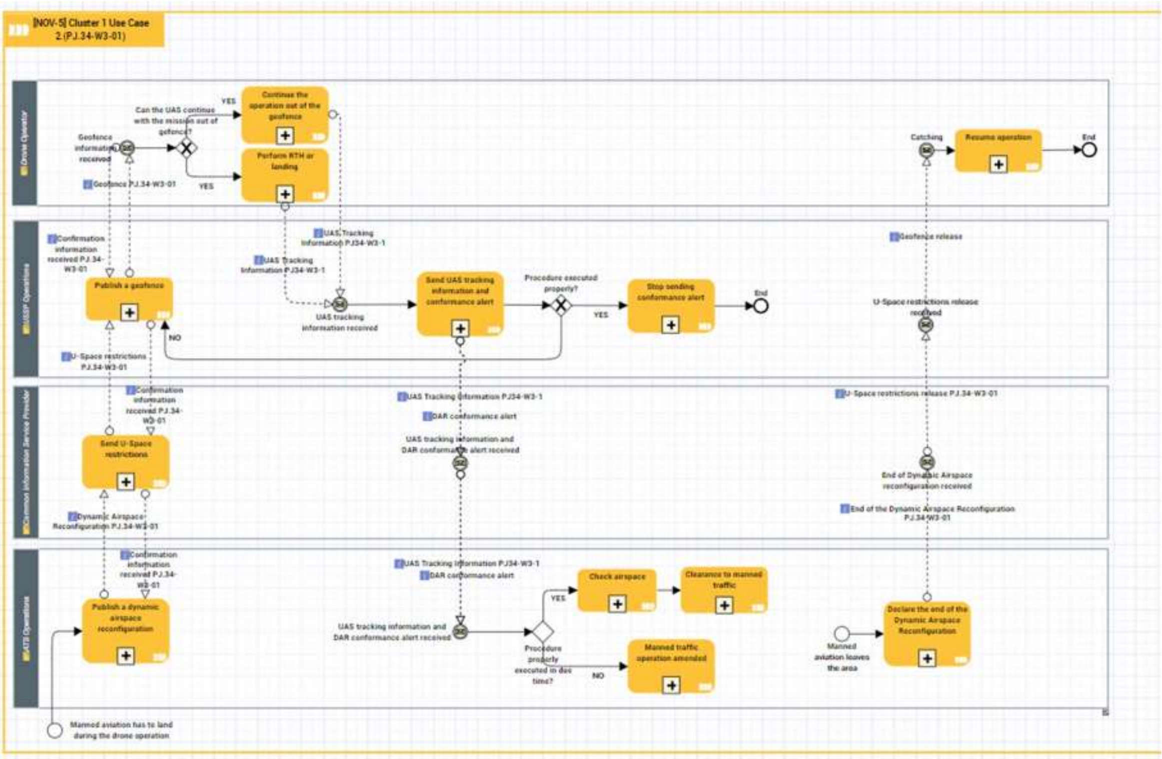


Figure 8: Cluster 1- Use Case 2 - NOV-5 view

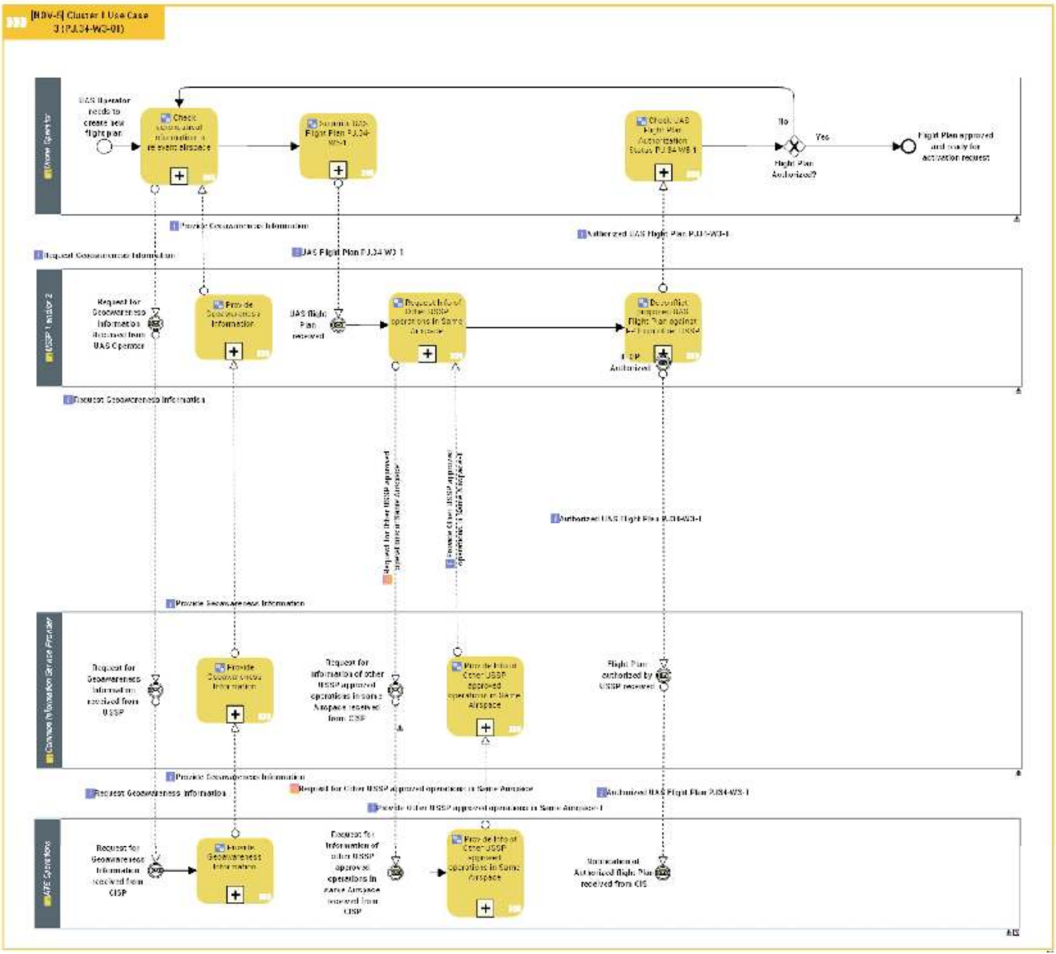


Figure 9: Cluster 1- Use Case 3 - NOV-5 view

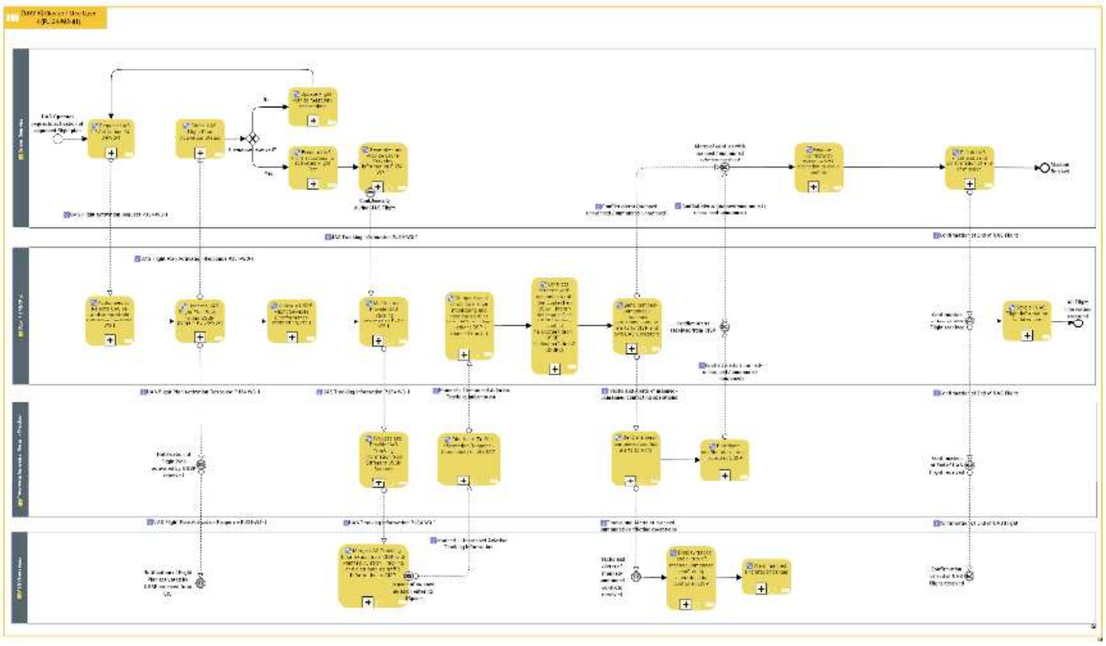


Figure 10: Cluster 1- Use Case 4 - NOV-5 view

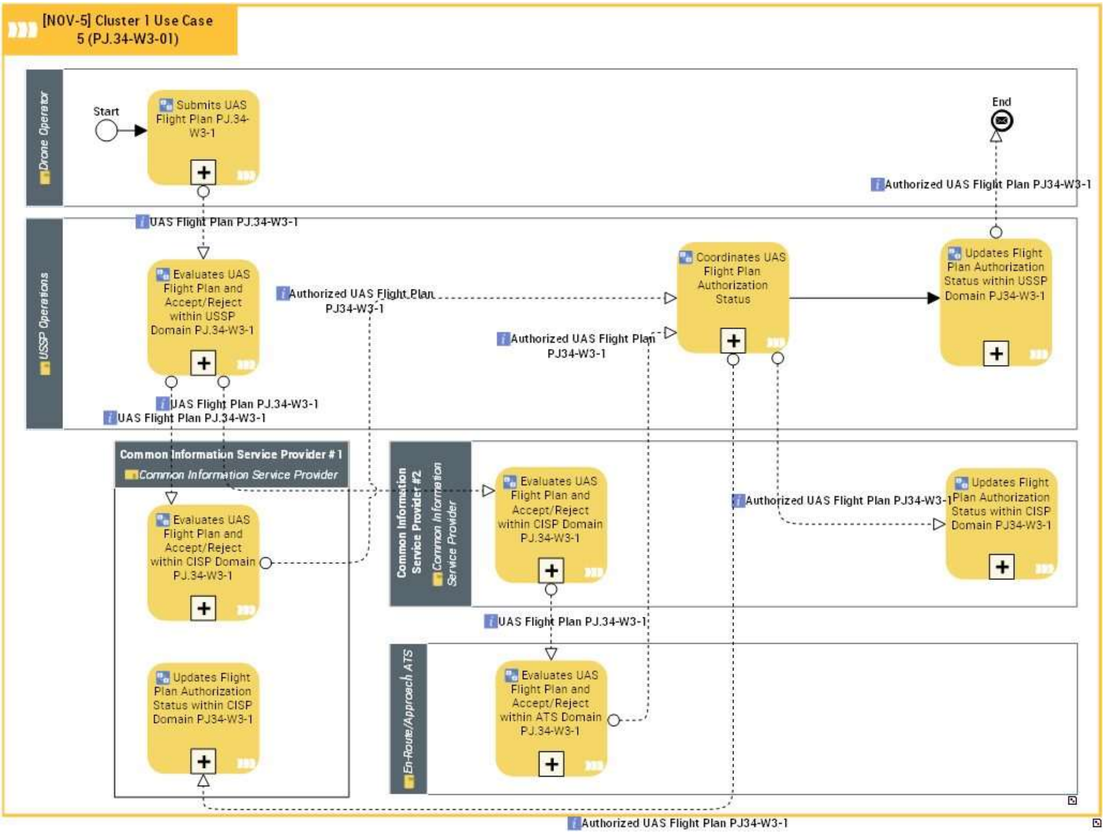



**Figure 11: Cluster 1- Use Case 5 - NOV-5 view**

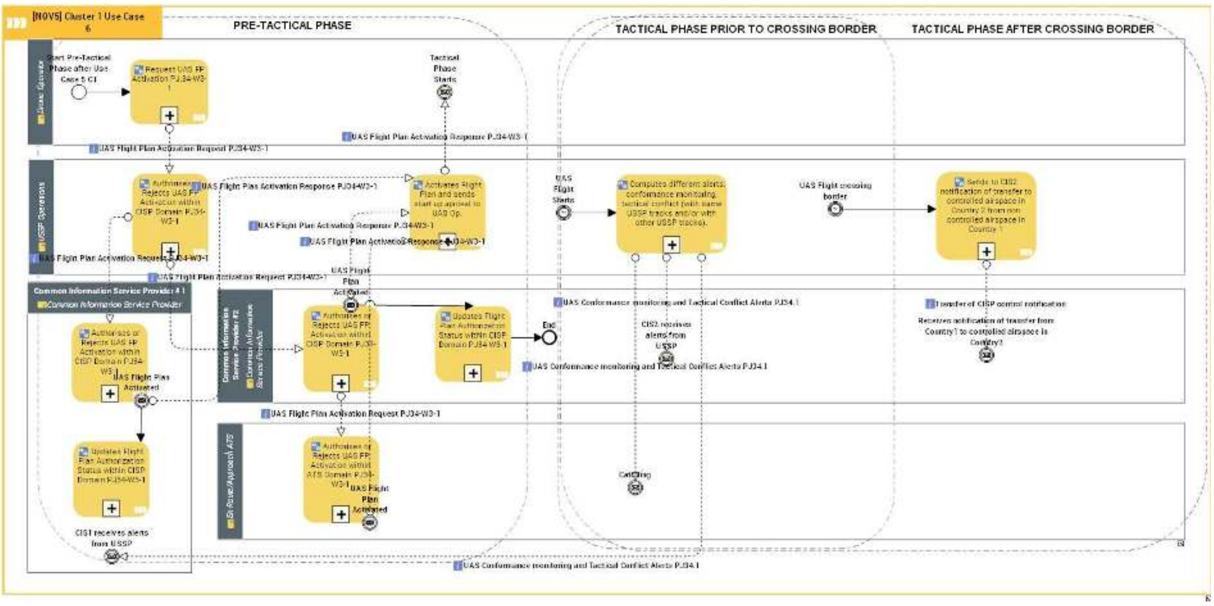



**Figure 12: Cluster 1- Use Case 6 - NOV-5 view**

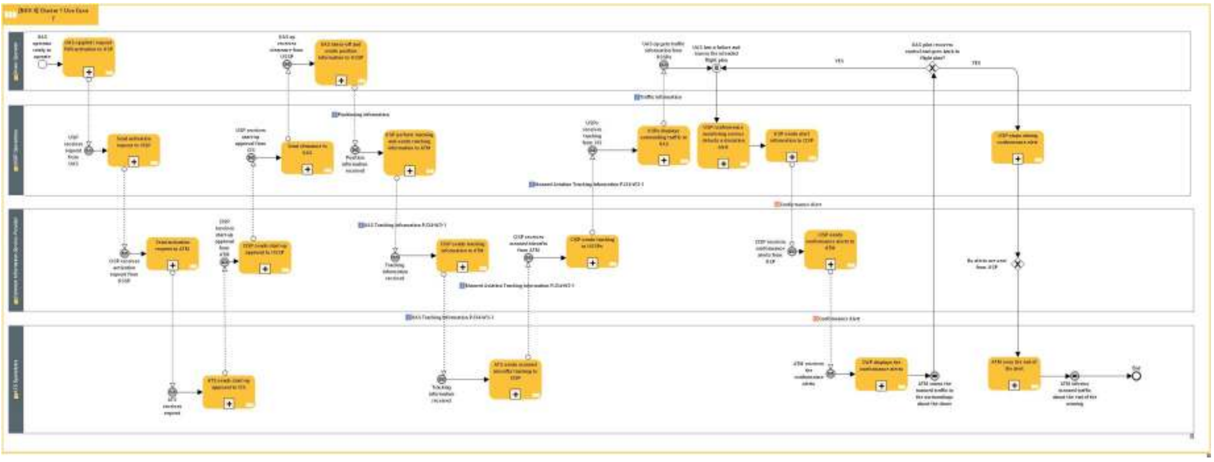


Figure 13: Cluster 1- Use Case 7 - NOV-5 view

## 4.2 Cluster 1 Technical views

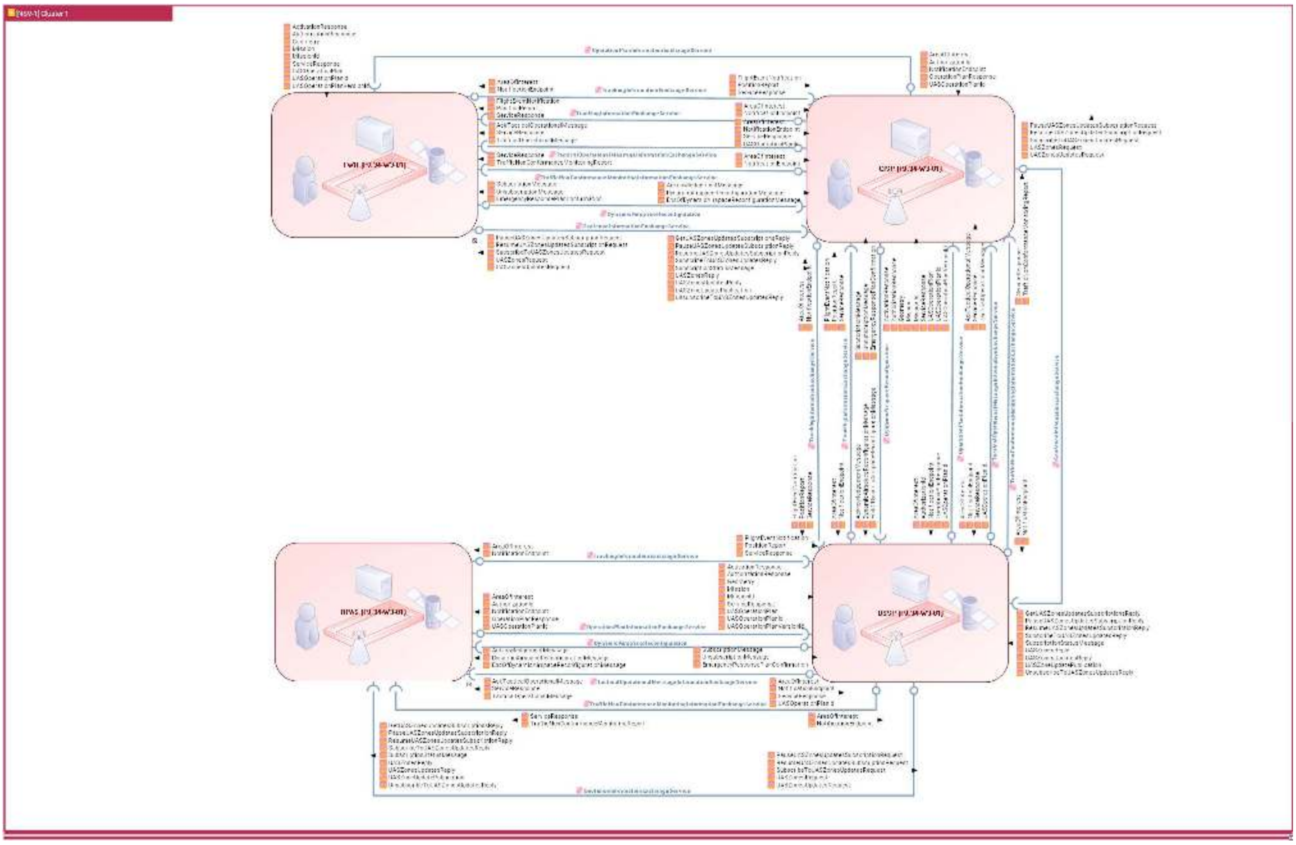


Figure 14: Cluster 1 - NSV-1 view

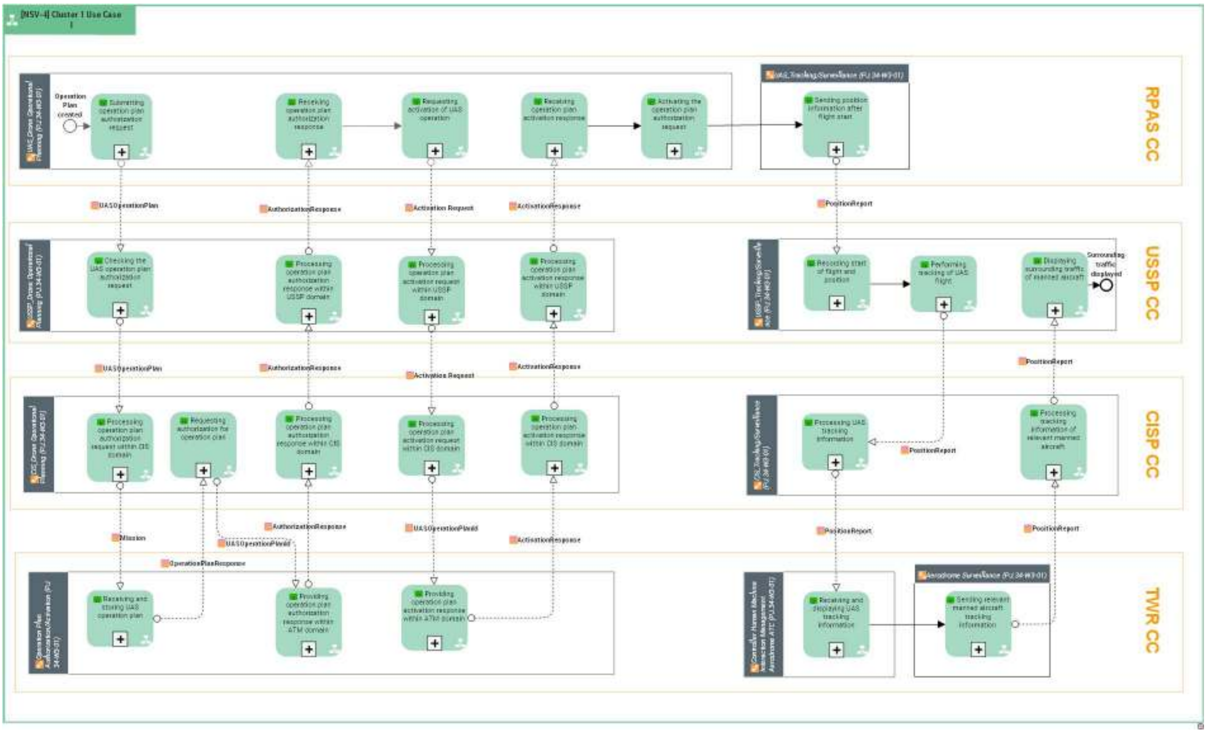



Figure 15: Cluster 1- Use Case 1 - NSV-4 view

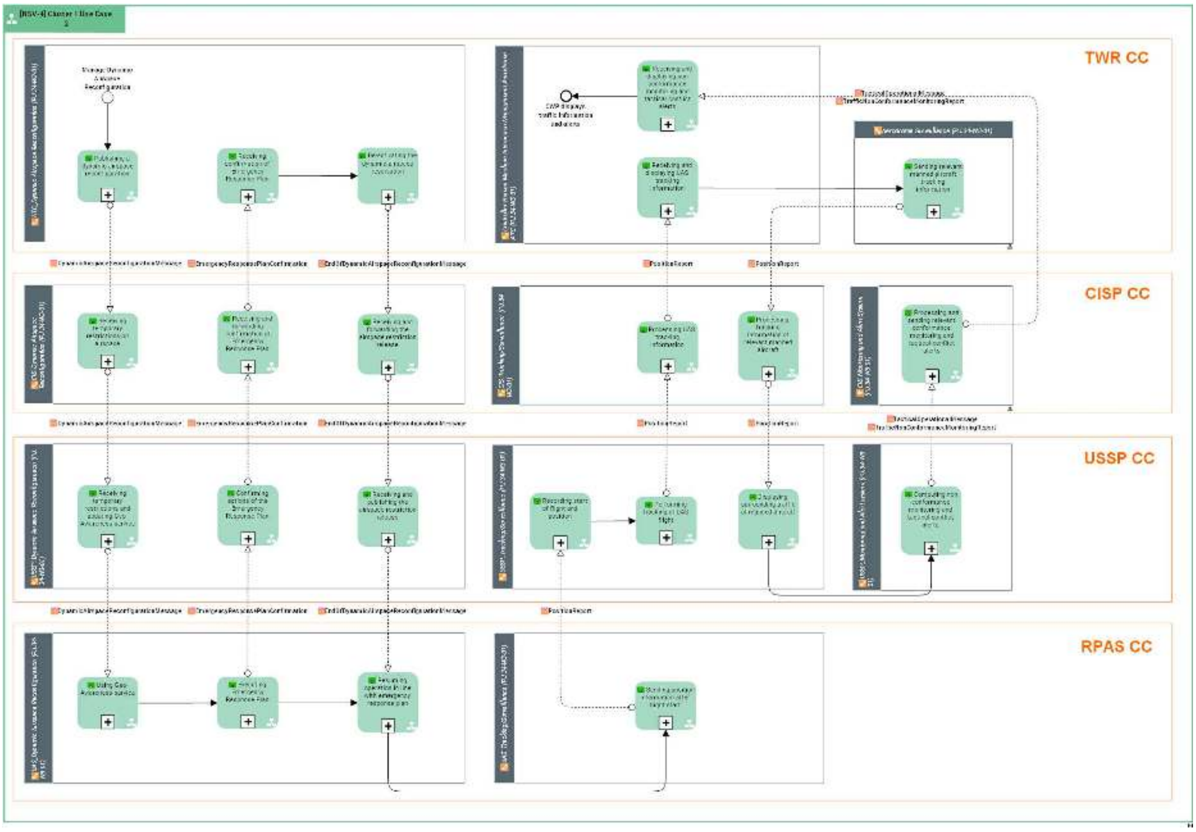



Figure 16: Cluster 1- Use Case 2 - NSV-4 view

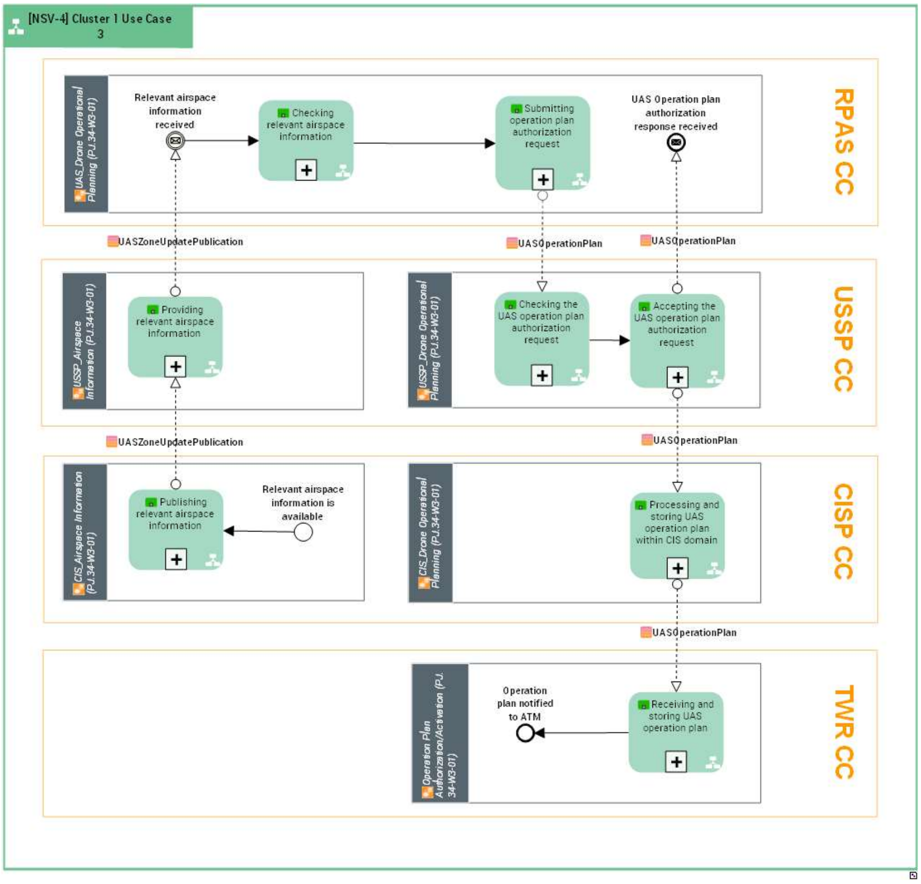



**Figure 17: Cluster 1- Use Case 3 - NSV-4 view**

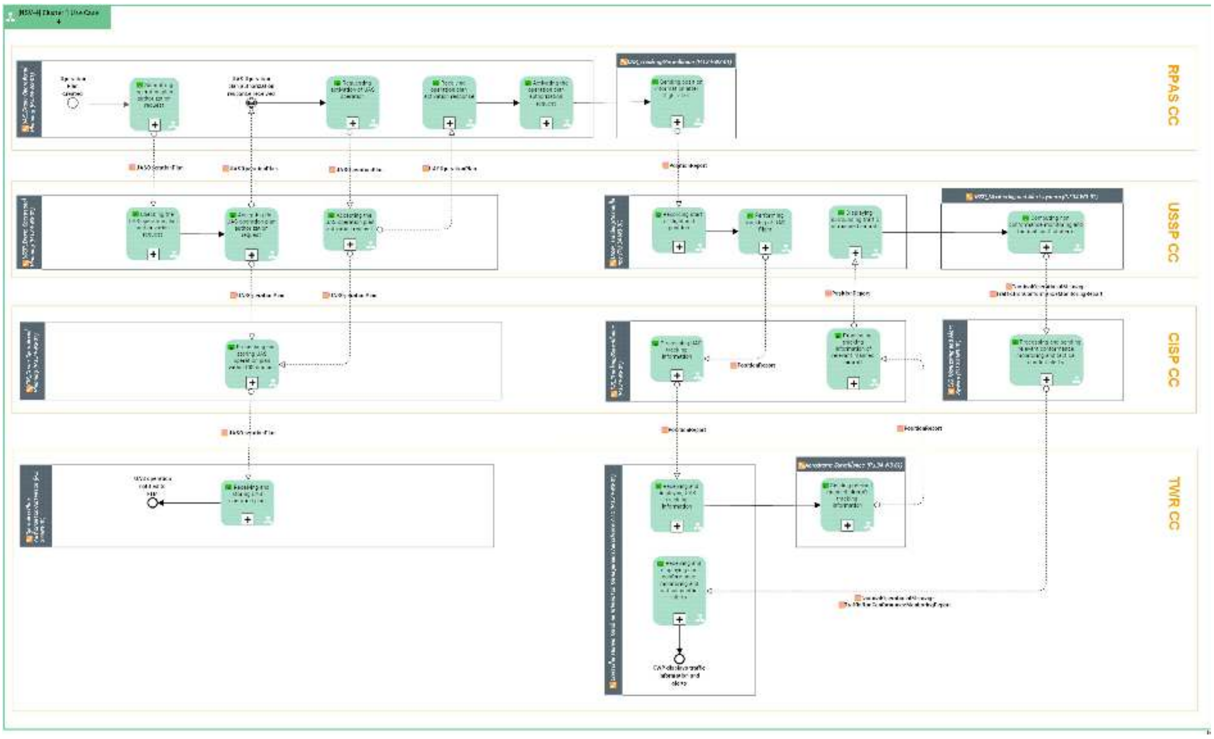



**Figure 18: Cluster 1- Use Case 4 - NSV-4 view**

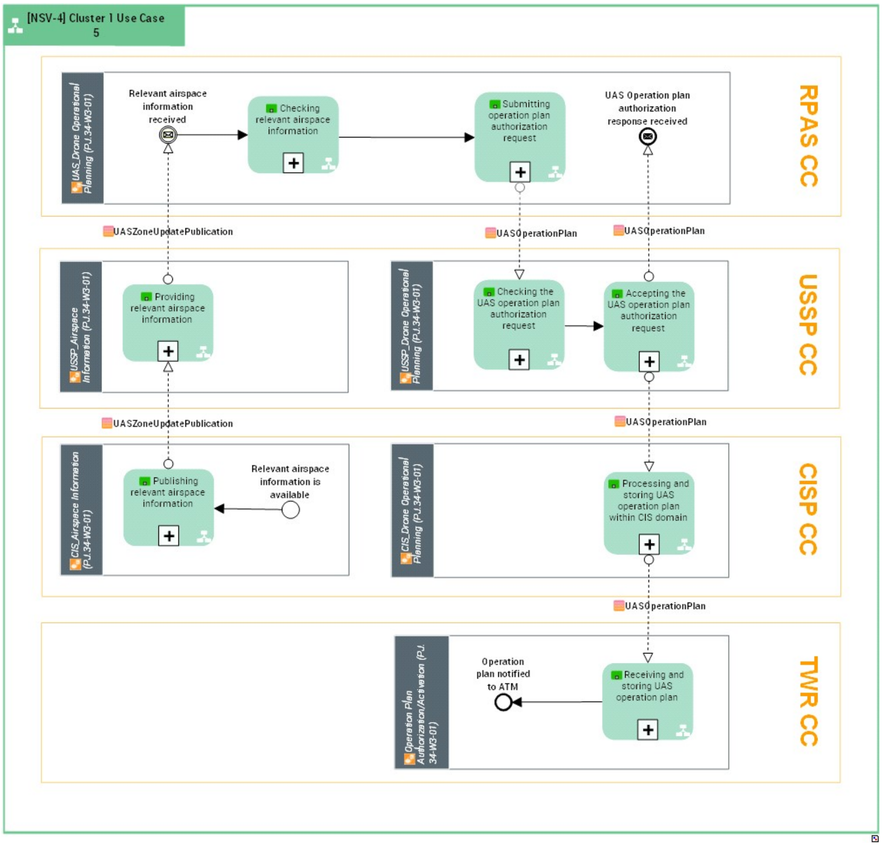



Figure 19: Cluster 1- Use Case 5 - NSV-4 view

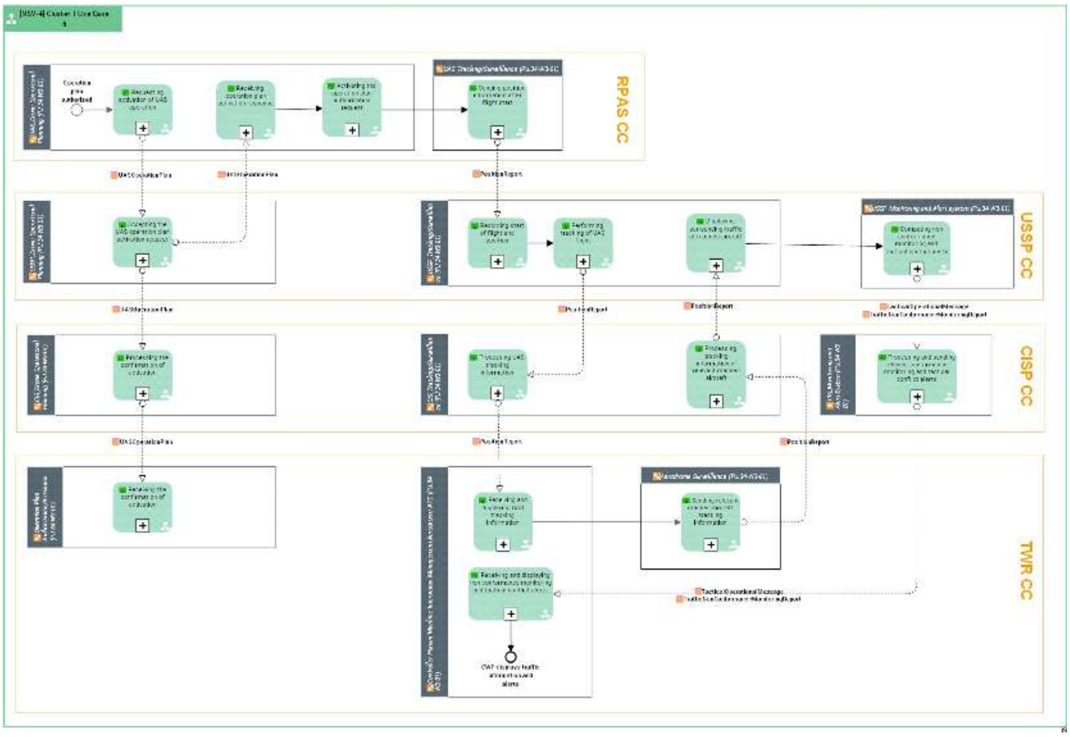



Figure 20: Cluster 1- Use Case 6 - NSV-4 view

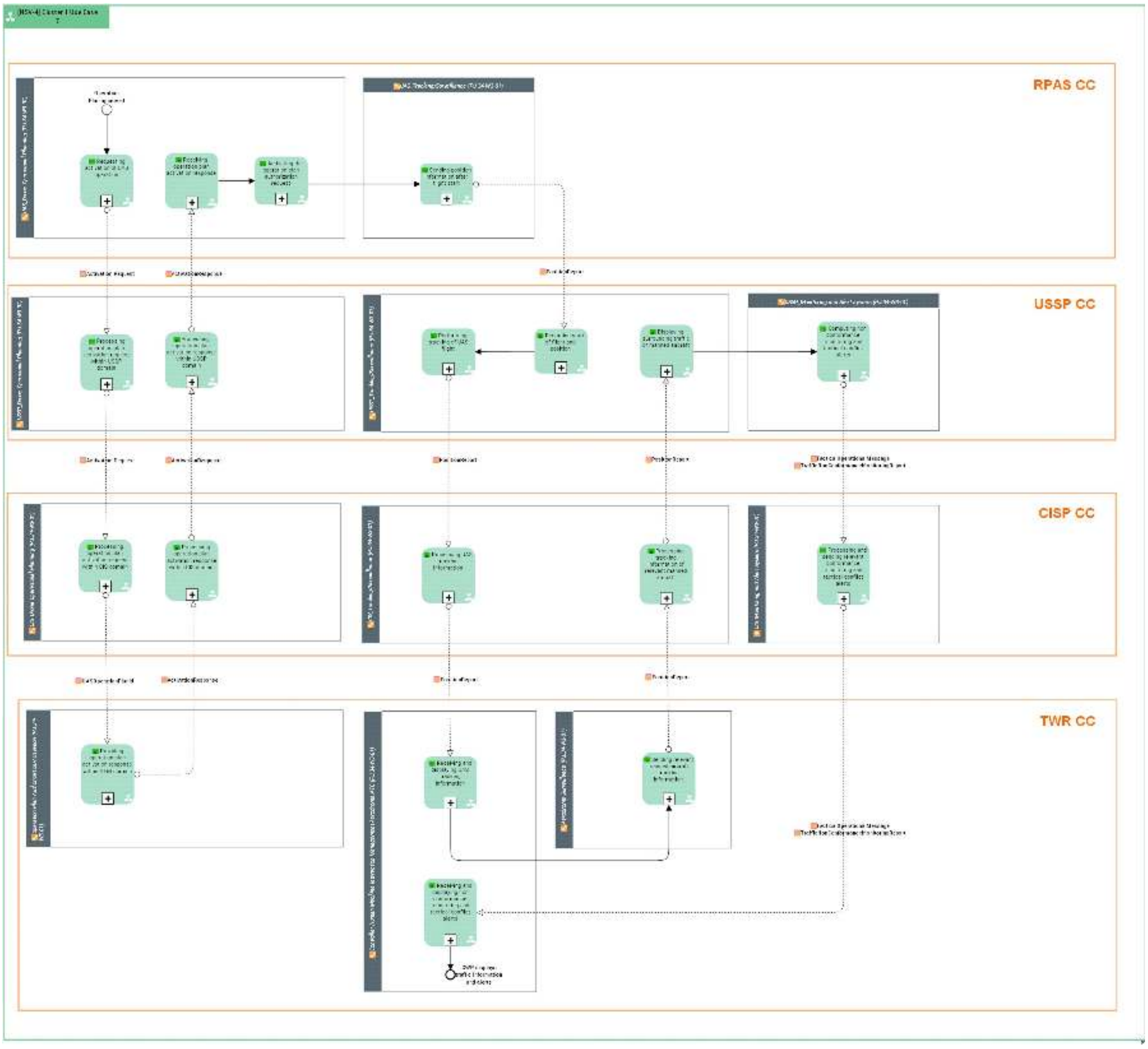



**Figure 21: Cluster 1- Use Case 7 - NSV-4 view**

## 4.3 Cluster 2 Operational views

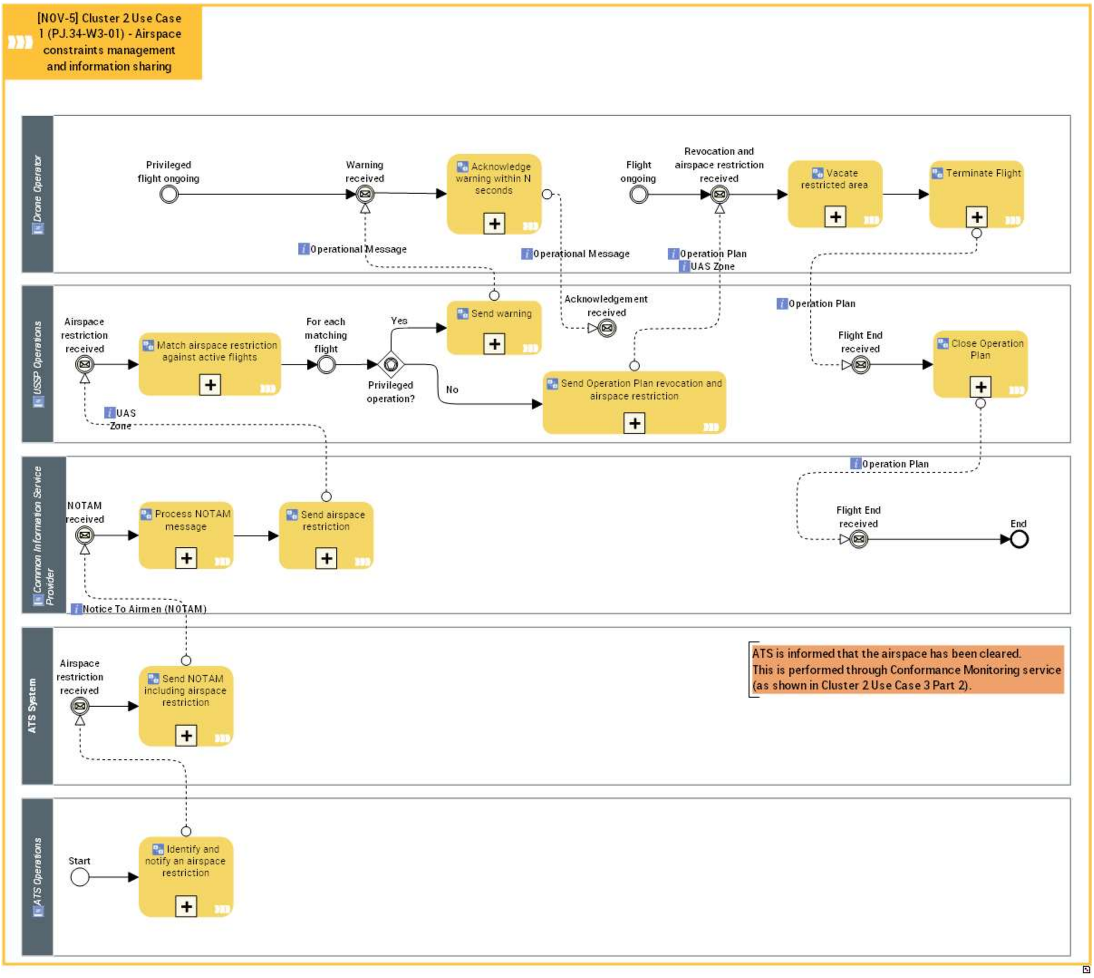



Figure 22: Cluster 2 - Use Case 1 - NOV-5 view

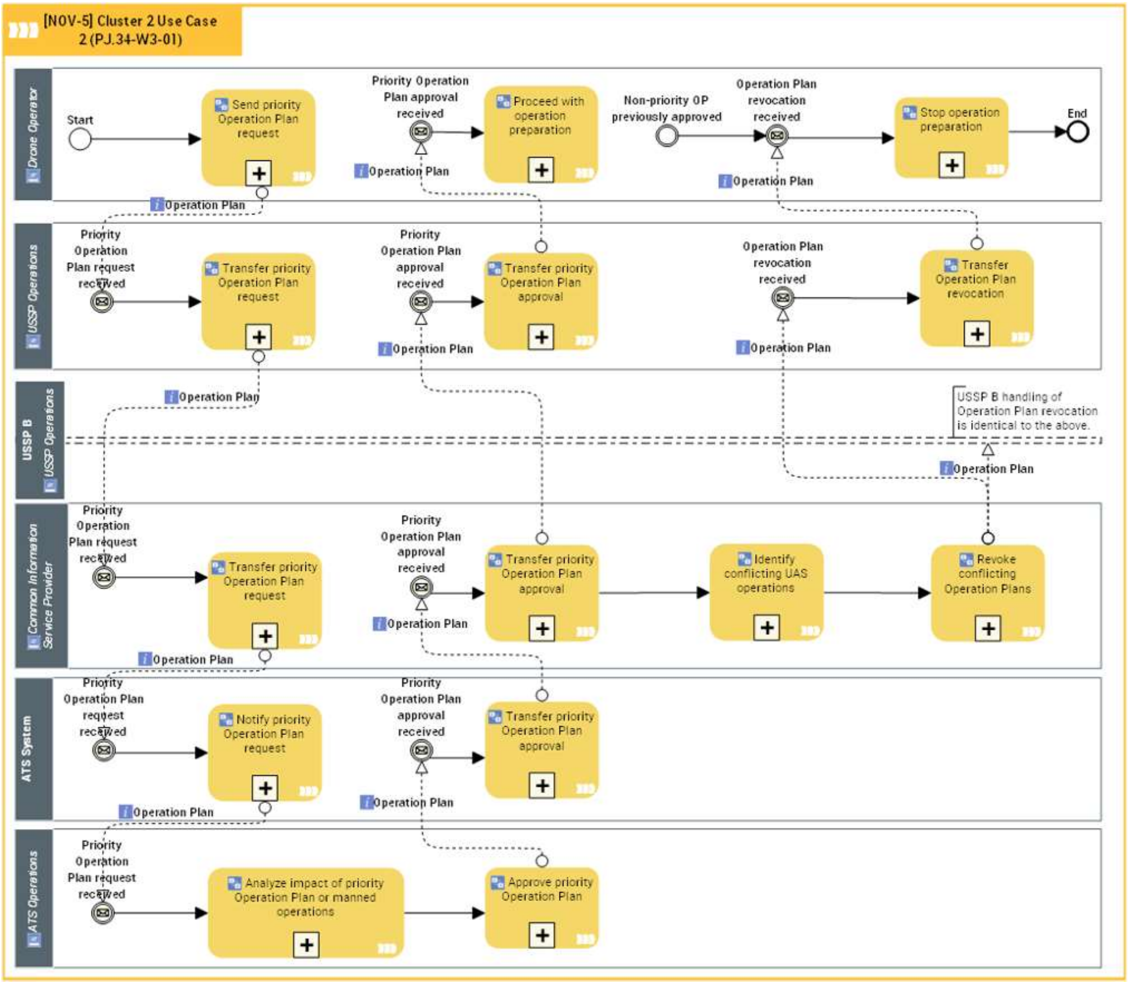



**Figure 23: Cluster 2 - Use Case 2 - NOV-5 view**

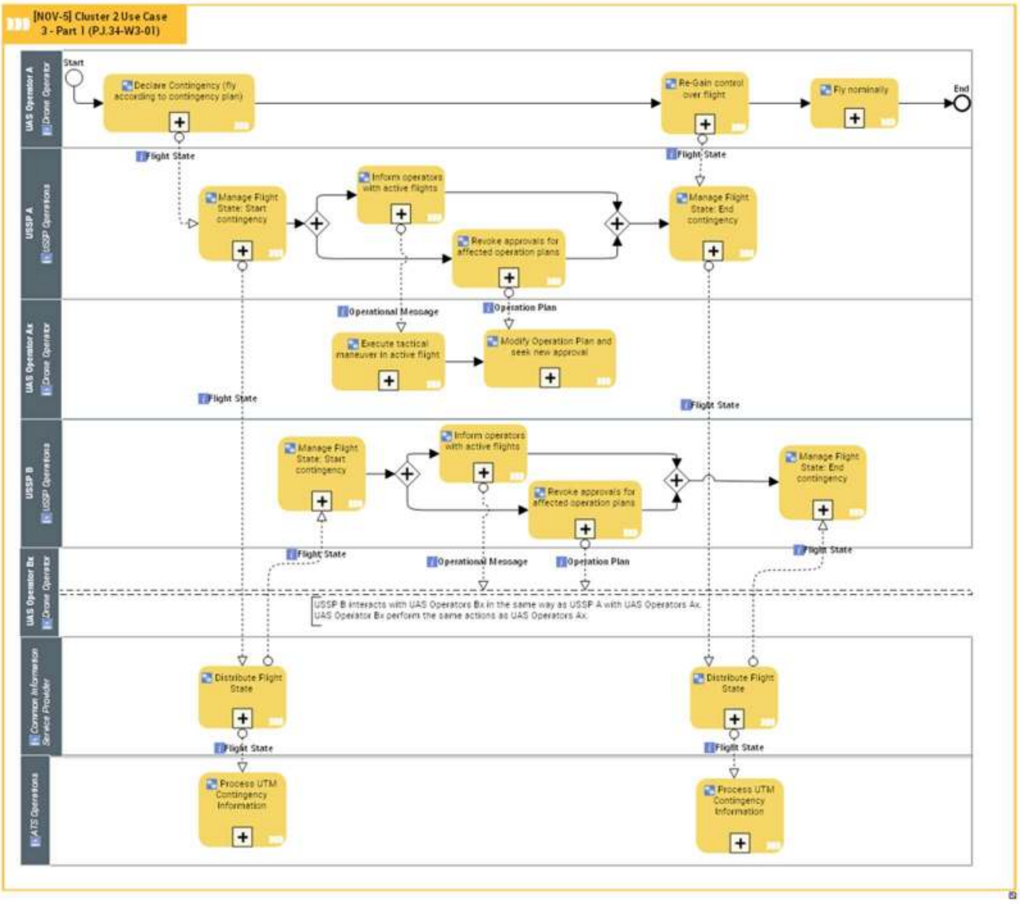


Figure 24: Cluster 2 - Use Case 3 (Part I) - NOV-5 view

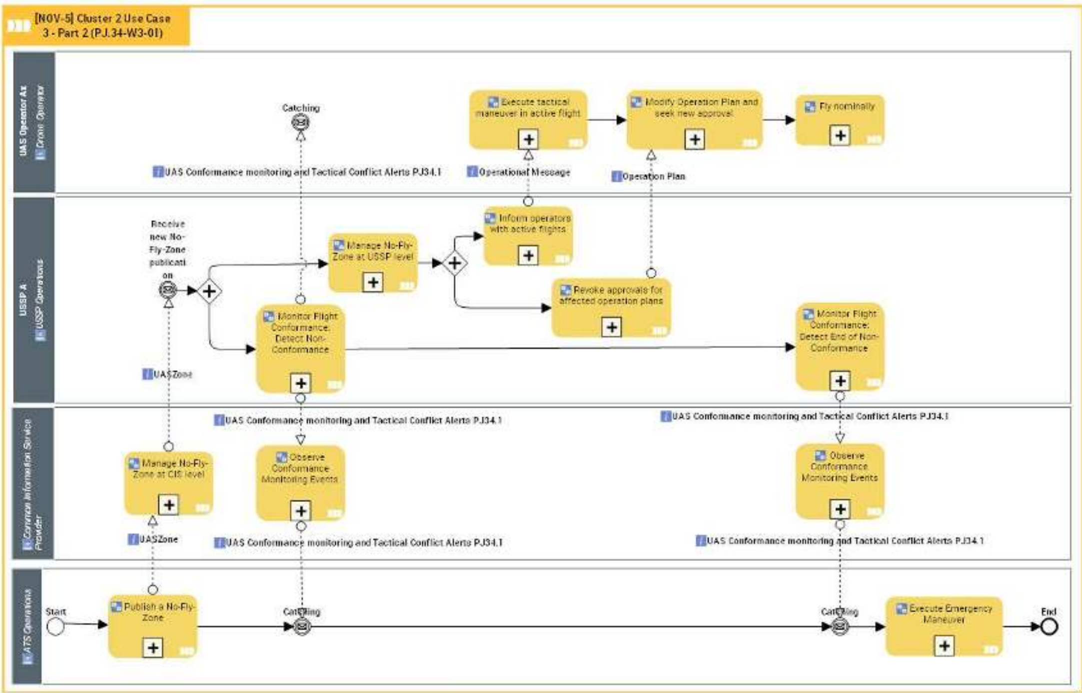


Figure 25: Cluster 2 - Use Case 3 (Part II) - NOV-5 view

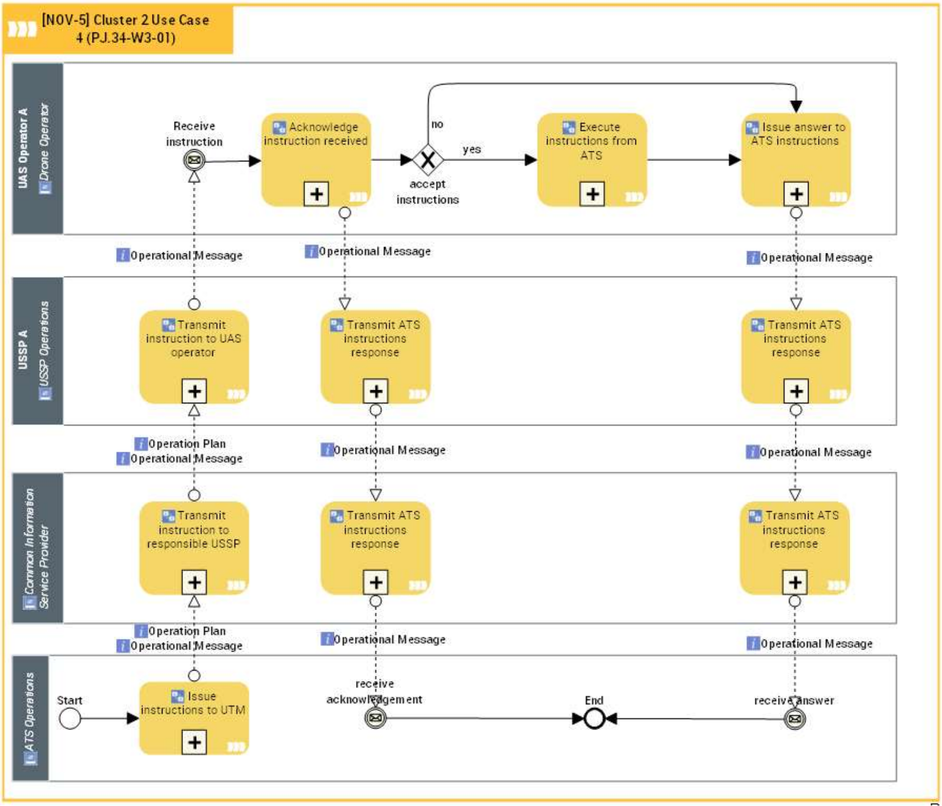



Figure 26: Cluster 2 - Use Case 4 - NOV-5 view

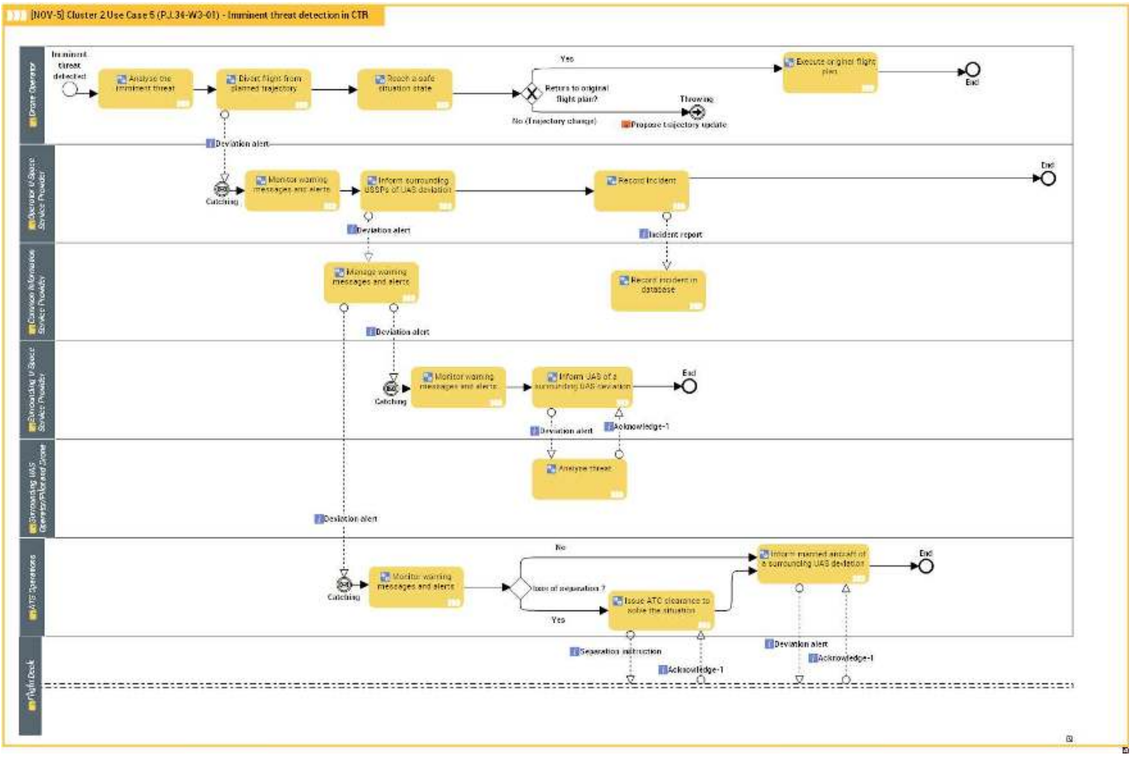



Figure 27: Cluster 2 - Use Case 5 - NOV-5 view

## 4.4 Cluster 2 Technical views

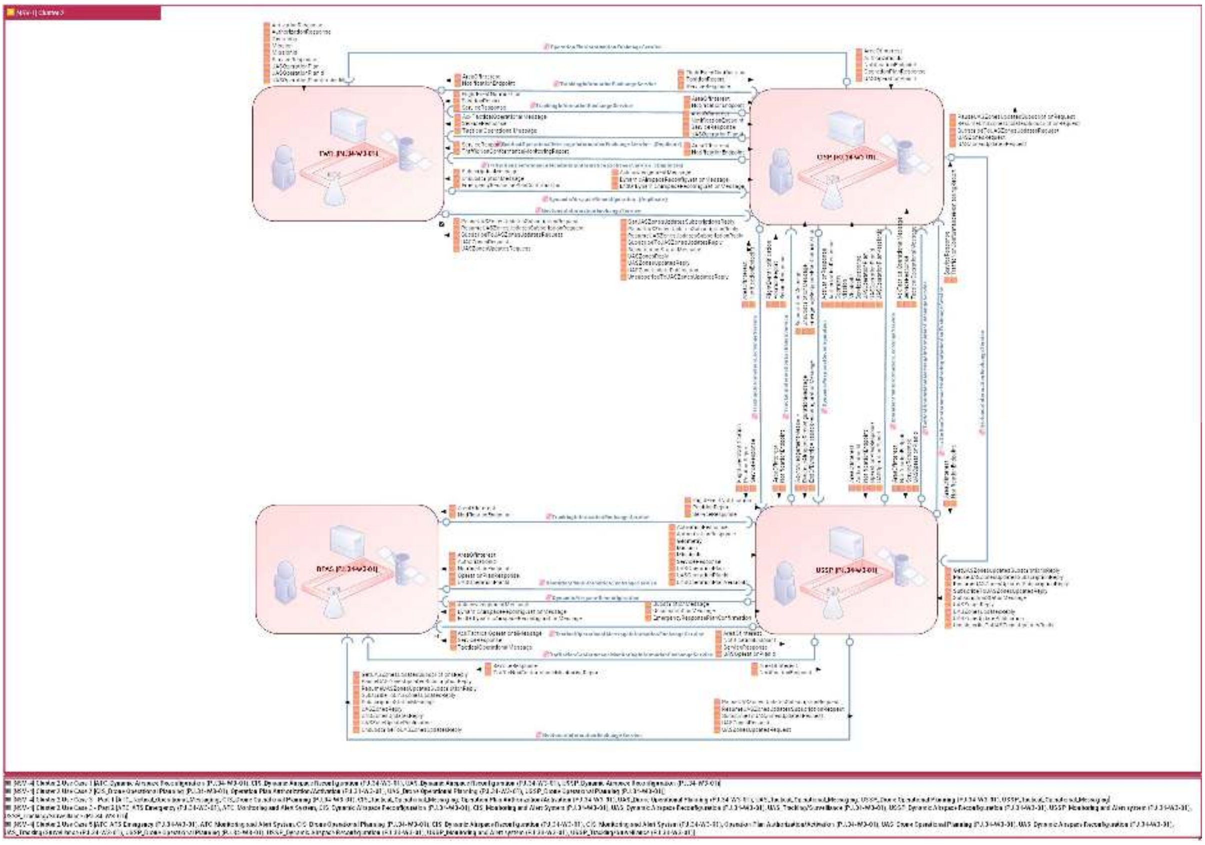


**Figure 28: Cluster 2 - NSV-1 view**

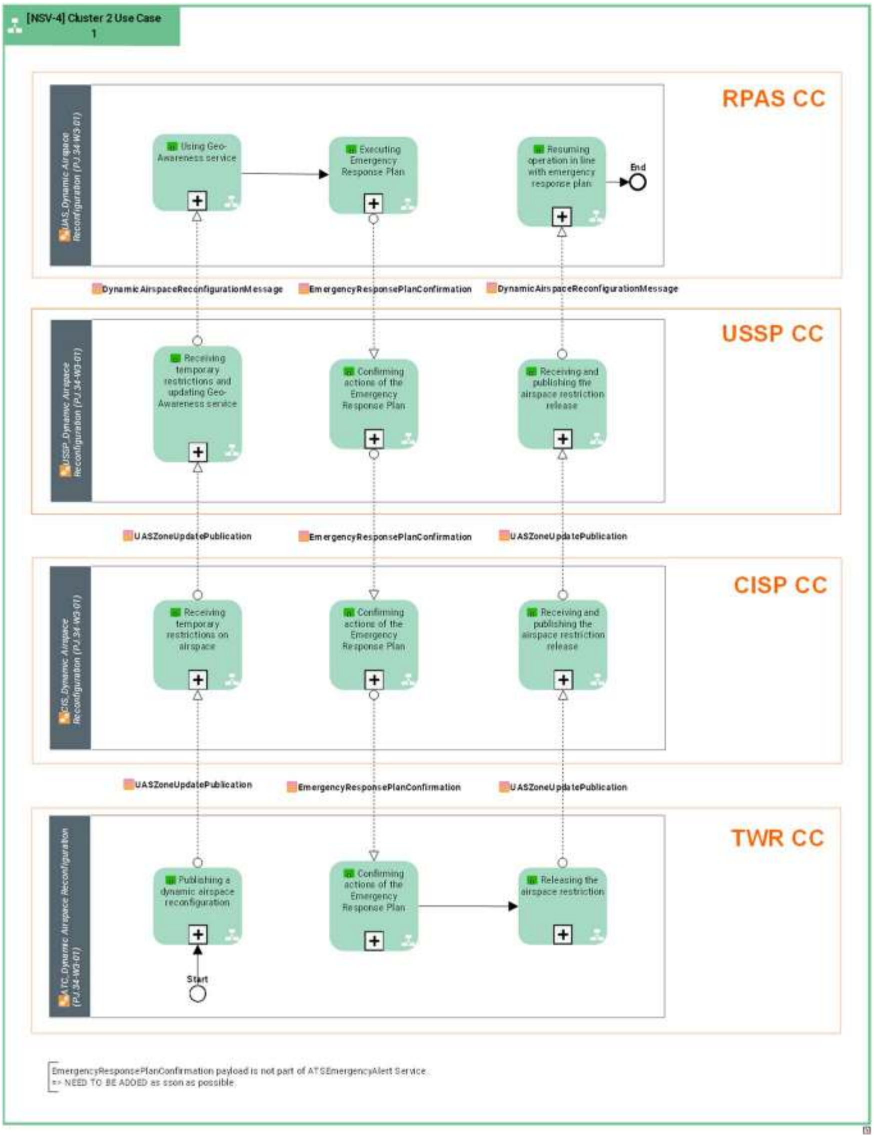



**Figure 29: Cluster 2 - Use Case 1 - NSV-4 view**

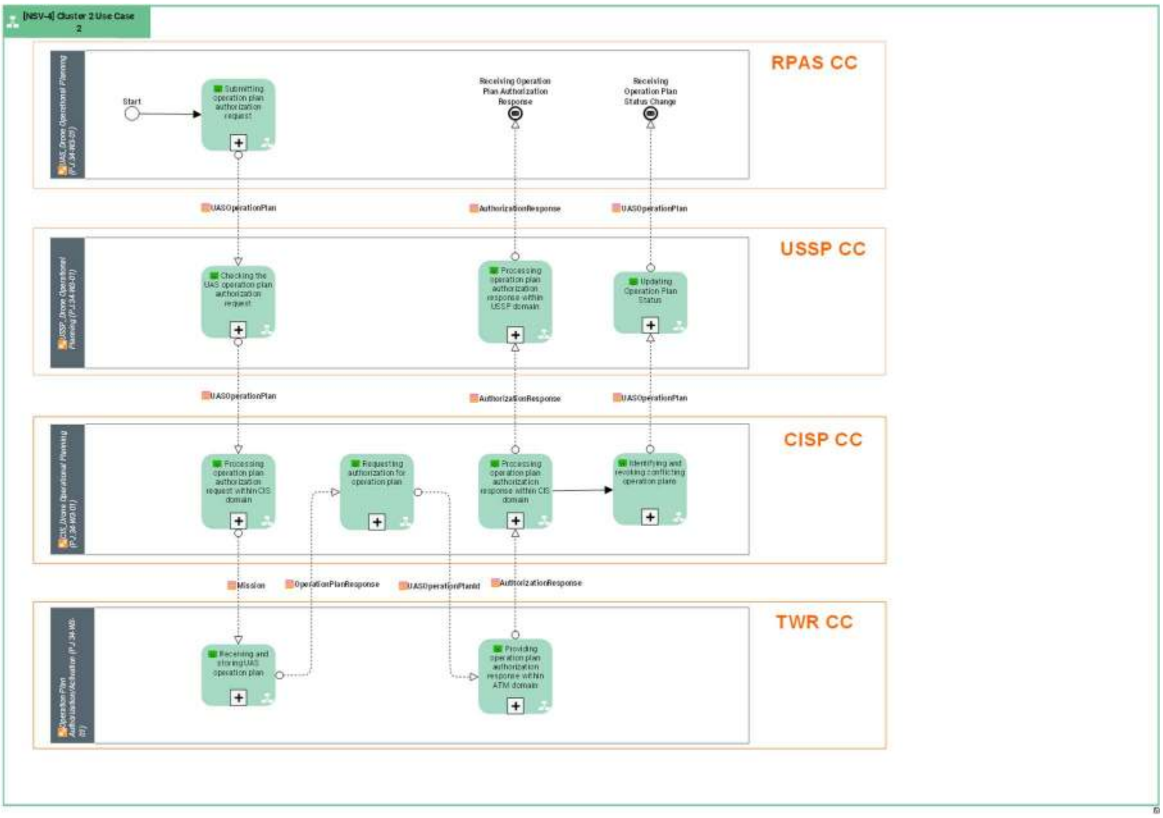



Figure 30: Cluster 2 - Use Case 2 - NSV-4 view

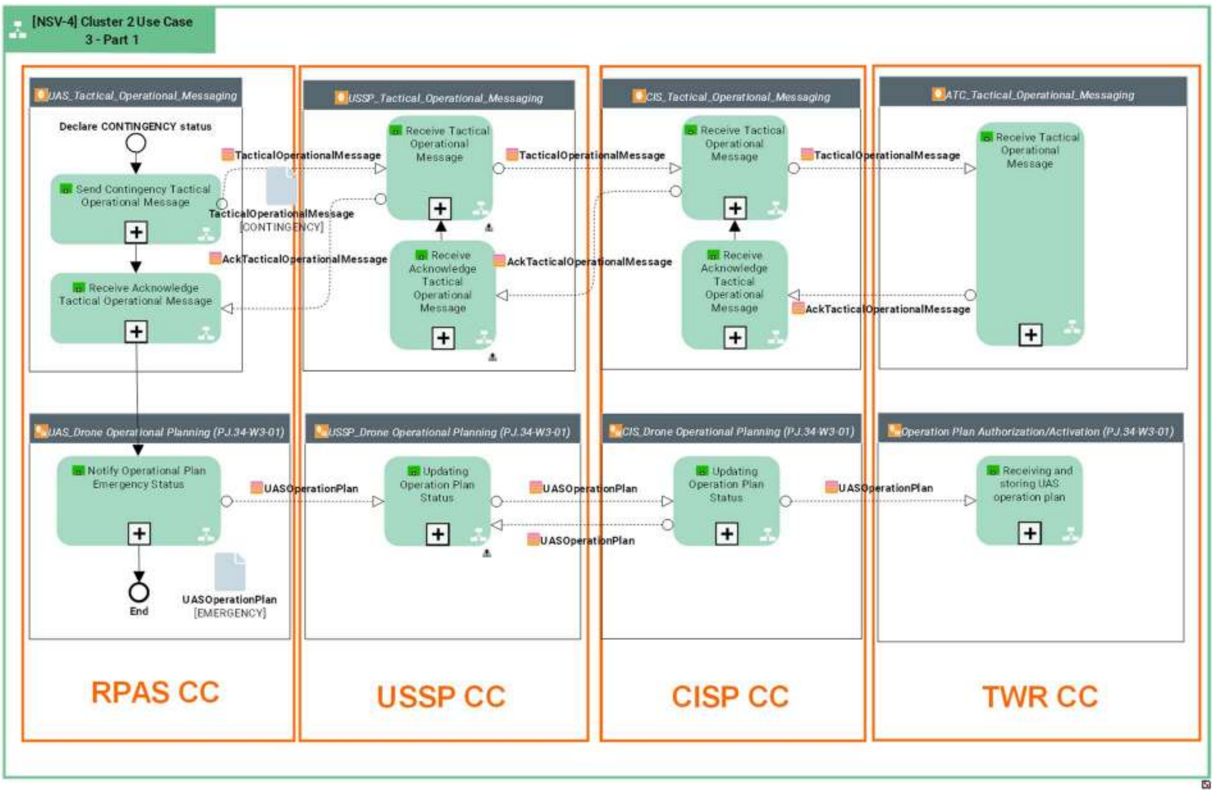



Figure 31: Cluster 2 - Use Case 3 (Part I) - NSV-4 view

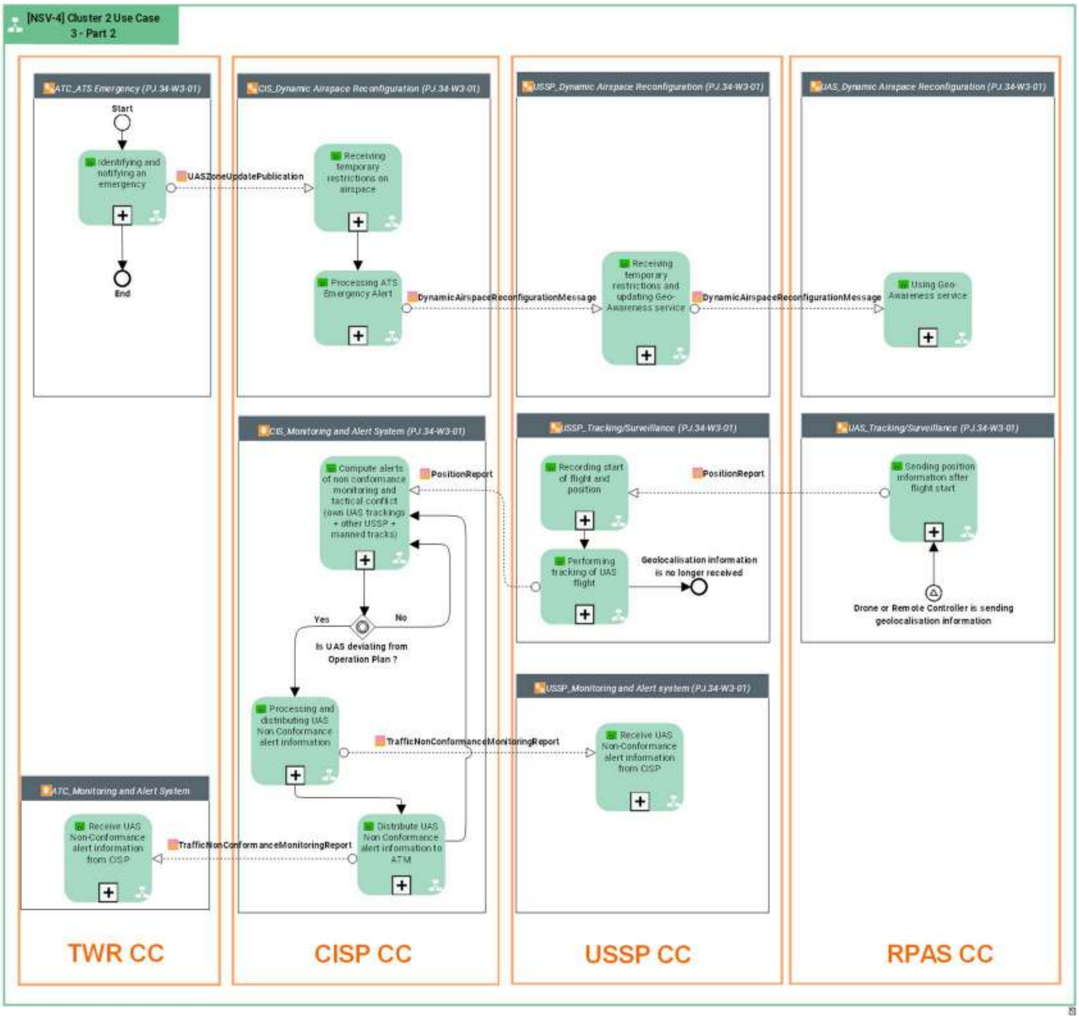



**Figure 32: Cluster 2 - Use Case 3 (Part II) - NSV-4 view**

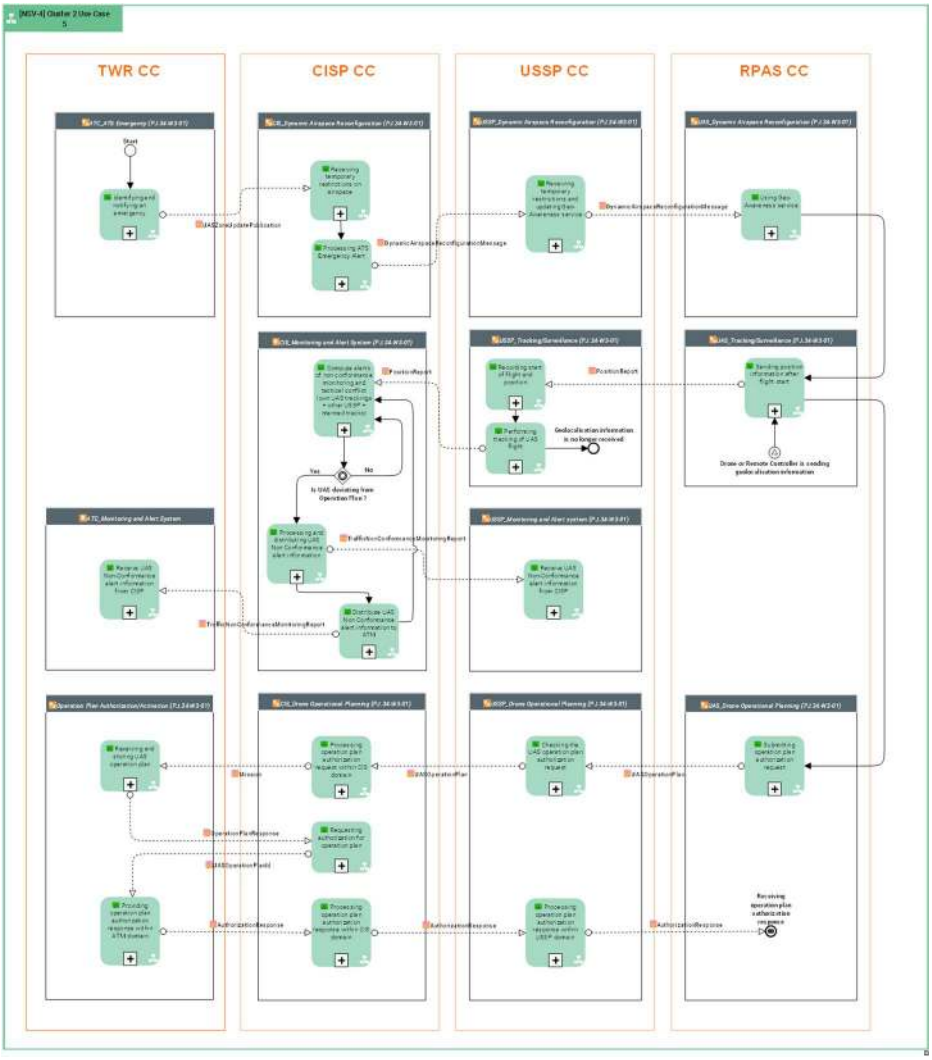



Figure 33: Cluster 2 - Use Case 5 - NSV-4 view





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## 4.5 Cluster 3 Operational views

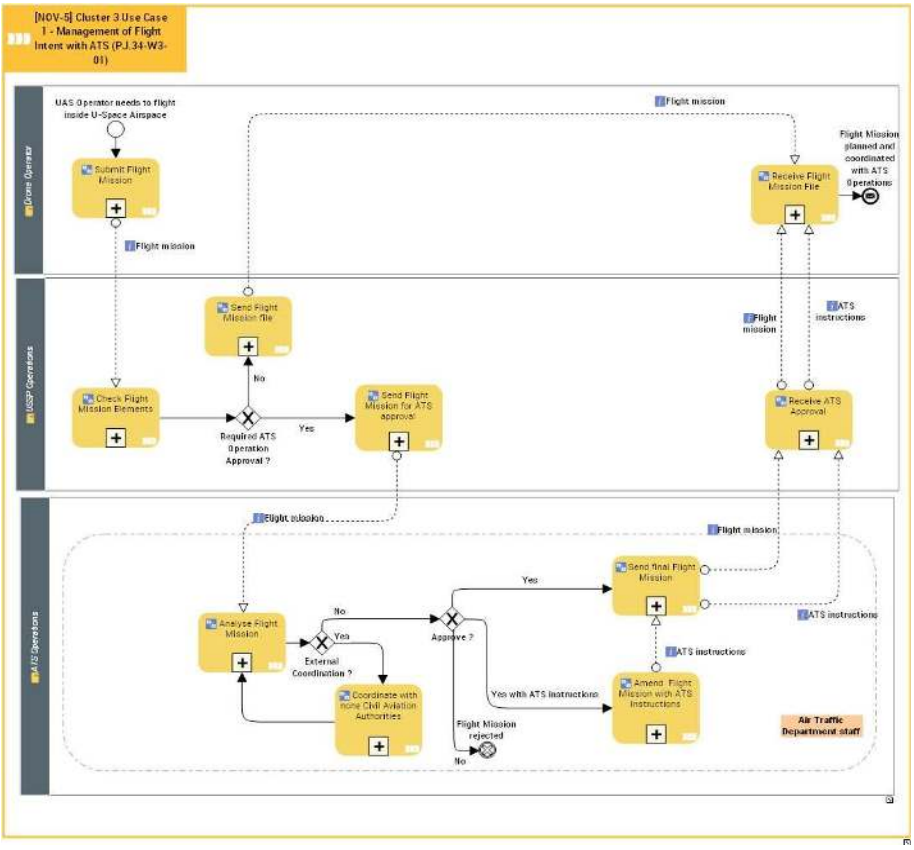


**Figure 34: Cluster 3 - Use Case 1 - NOV-5 view**

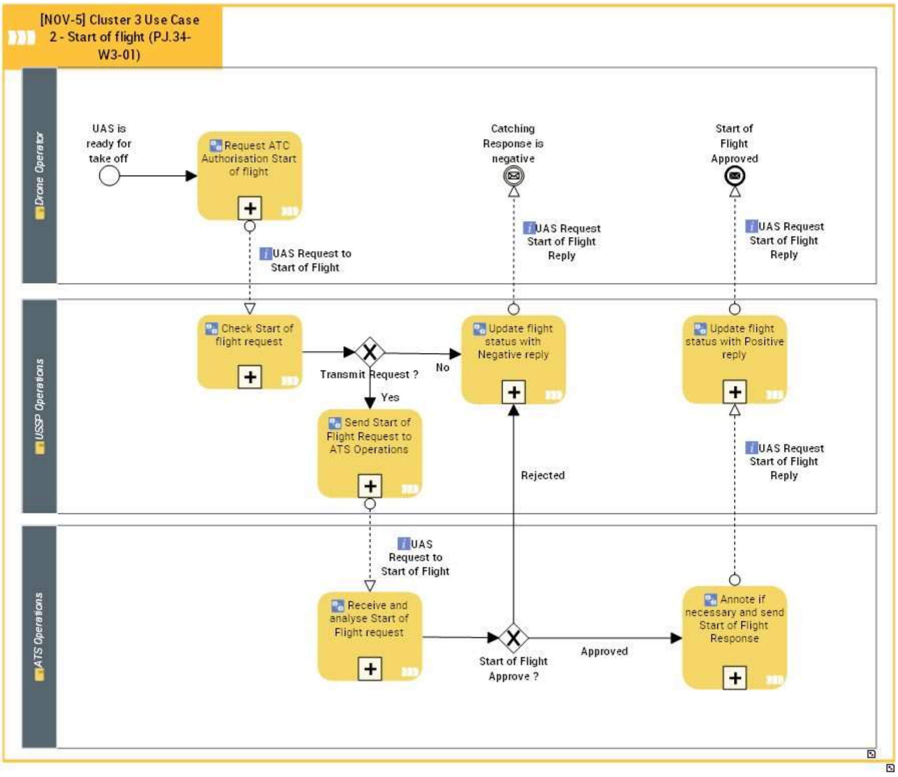


**Figure 35: Cluster 3 - Use Case 2 - NOV-5 view**

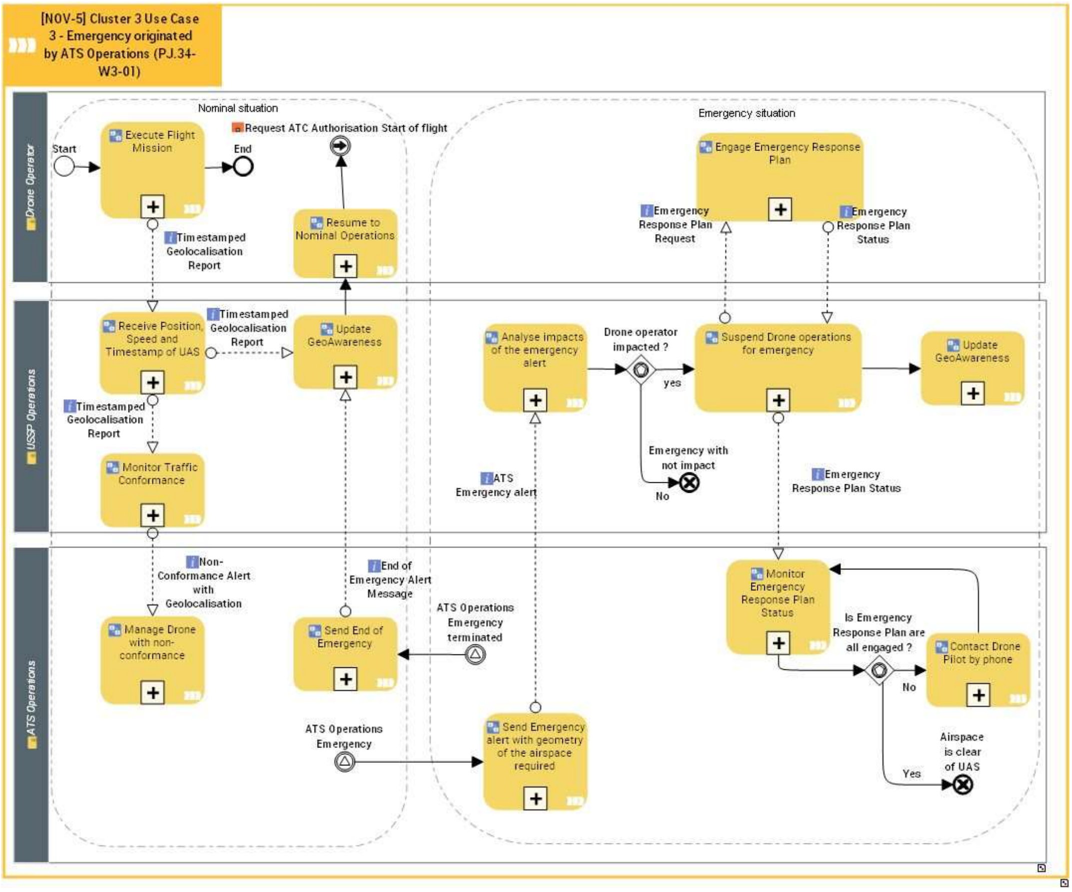


Figure 36: Cluster 3 - Use Case 3 - NOV-5 view

## 4.6 Cluster 3 Technical views

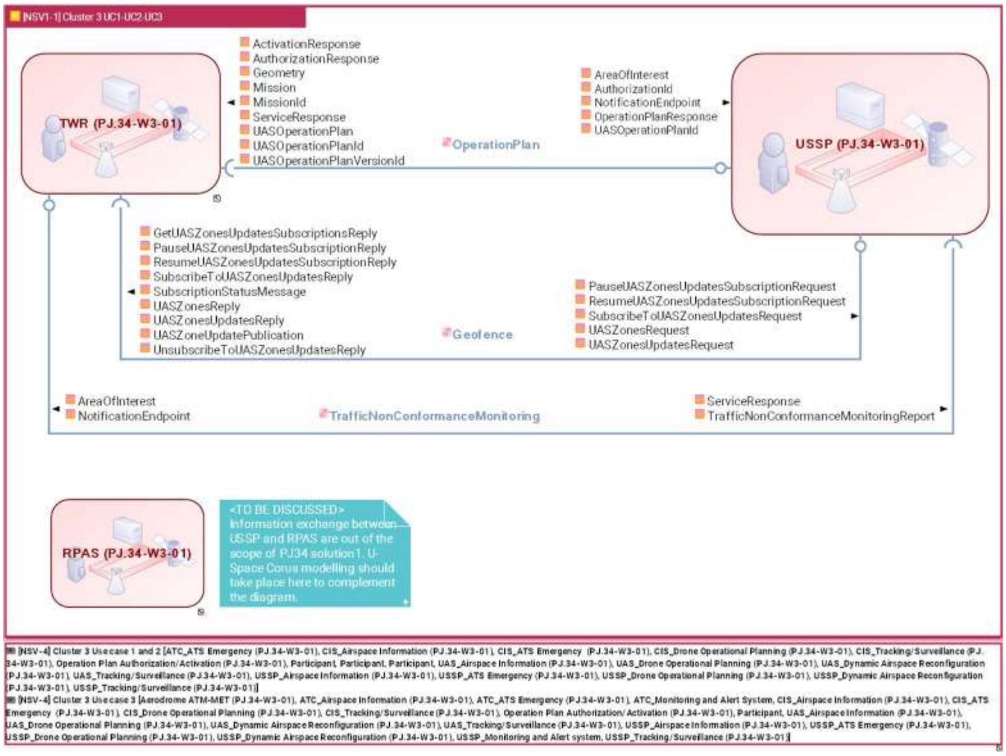


**Figure 37: Cluster 3 - NSV-1 view**

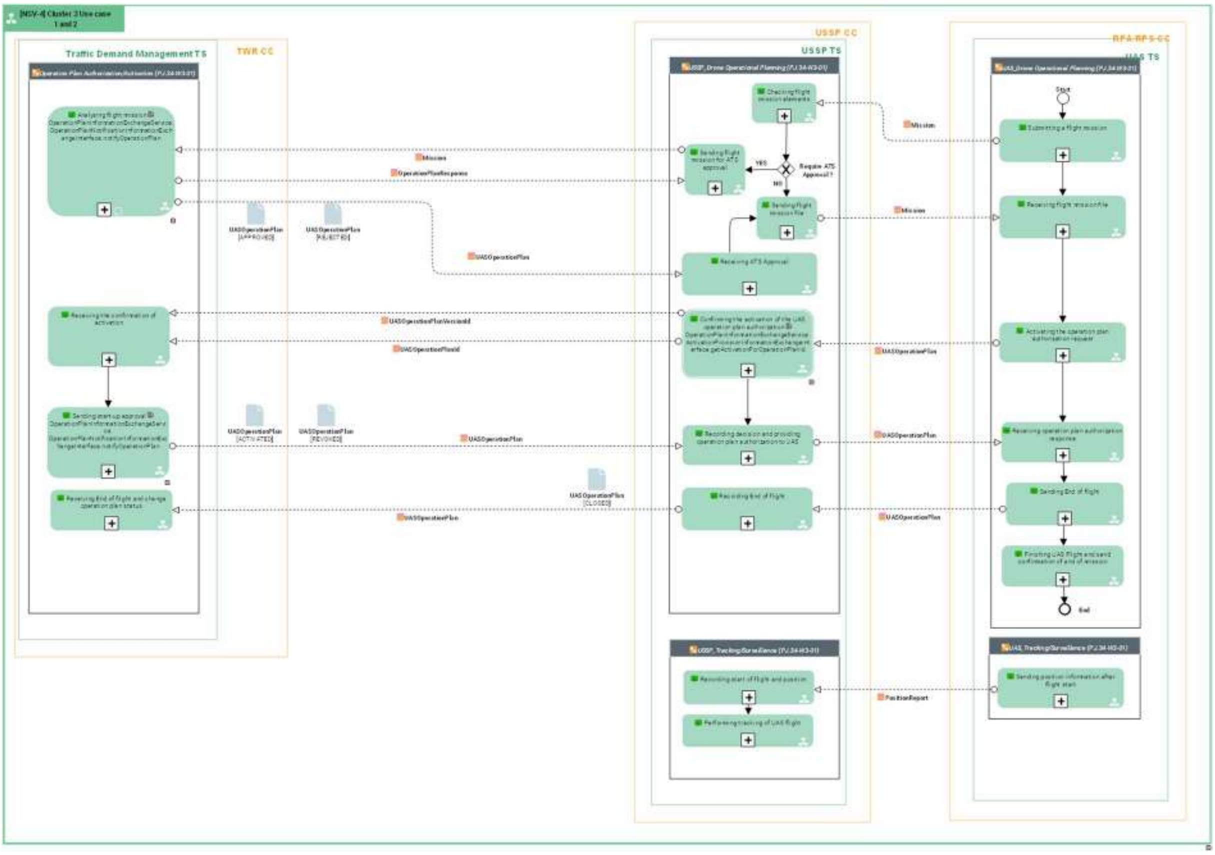


**Figure 38: Cluster 3 - Use Case 1&2 - NSV-4 view**

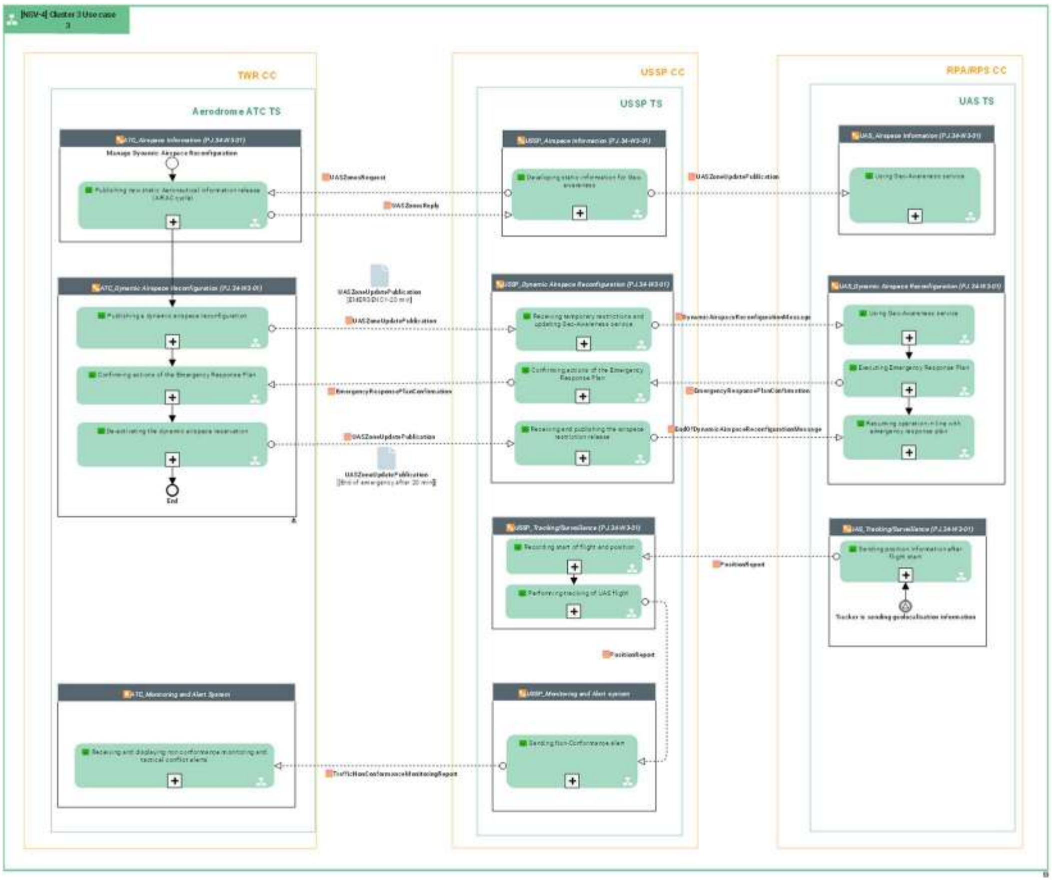


Figure 39: Cluster 3 - Use Case 3 - NSV-4 view

## 4.7 Cluster 4 Operational views

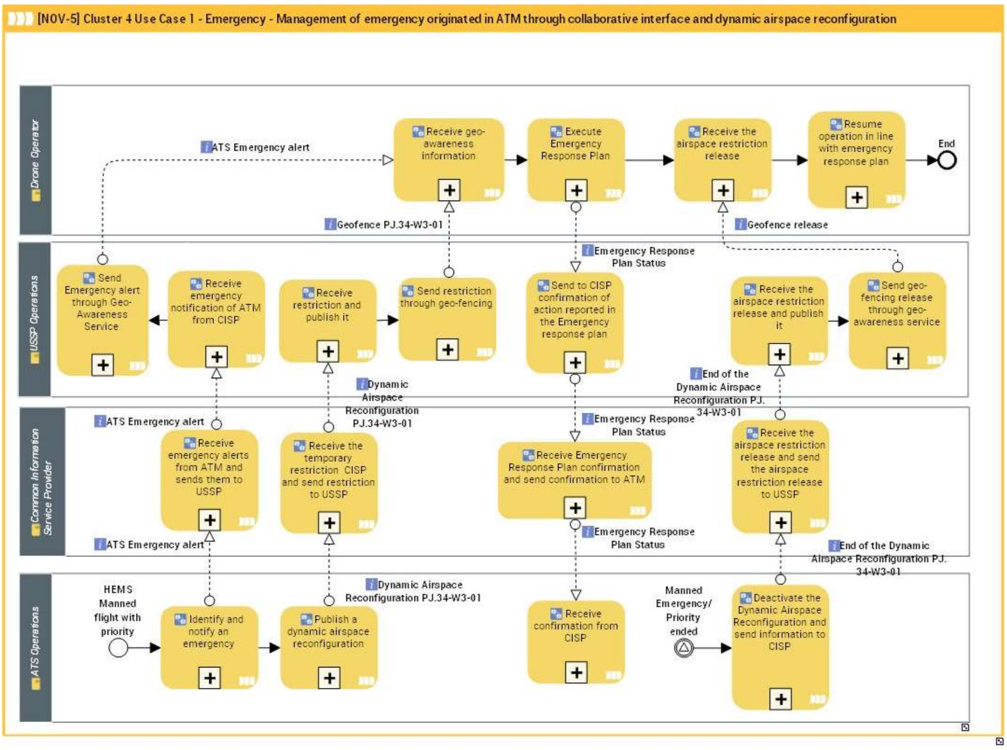


**Figure 40: Cluster 4 - Use Case 1 - NOV-5 view**

## 4.8 Cluster 4 Technical views

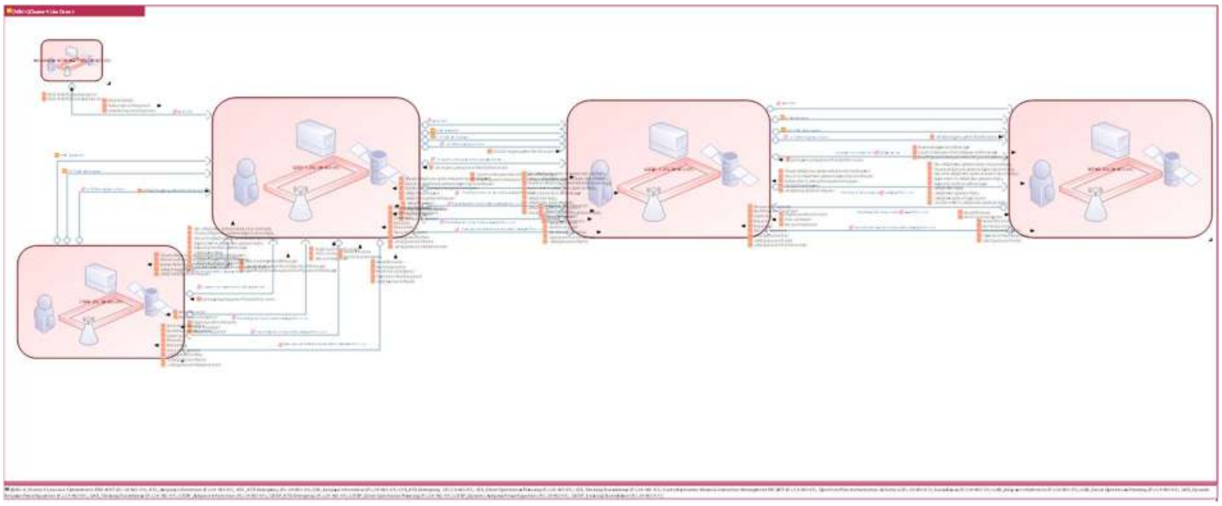

**Figure 41: Cluster 4 - NSV-1 view**


**Figure 42: Cluster 4 - Use Case 1 - NSV-4 view**

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