



DEMONSTRATING THE EVERYDAY BENEFITS OF U-SPACE

Initial results from SESAR demonstrations (2020-2022)





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ABOUT THE SESAR 3 JOINT UNDERTAKING

The SESAR 3 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. To do so, it is harnessing, developing and accelerating the take-up of the most cutting-edge technological solutions to manage conventional aircraft, drones, air taxis and vehicles flying at higher altitudes. The SESAR 3 JU partnership brings together the EU, Eurocontrol, and more than 50 organisations covering the entire aviation value chain, from airports, airspace users of all categories, air navigation service providers, drone operators and service providers, the manufacturing industry and scientific community. The partnership also works closely with the regulatory and standardisation bodies, notably EASA and Eurocae, as well as key stakeholders, such professional staff organisations, the space and military communities and global partners.

www.sesarju.eu

The logo for U-space, featuring a stylized 'U' in blue with a green signal icon above it, followed by the word 'space' in a blue, sans-serif font.

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INTRODUCTION

U-space is a set of services and specific procedures designed to support safe, efficient and secure access to airspace for large numbers of drones. These services rely on a high level of digitalisation and automation of functions, whether they are on board the drone itself, or are part of the ground-based environment. U-space allows this market to grow by helping to establish technologies, rules and procedures that will eventually enable drones to safely share the airspace with manned aviation. A set of technological capabilities and services U-space services are required for making U-space a reality, starting with foundation services (U1) before progressing to initial services (U2), advanced services (U3) and finally full services (U4).



The innovation story so far

The JU completed a first wave of 19 U-space projects in 2019¹, which demonstrated U-space services from U1 to U3 in a variety of environments. It concluded that U1 and U2 services were essentially ready for use in rural areas, segregated airspace and low-density airspace. This included the delivery of an initial concept of operations for U-space².

In 2020, a second wave of industrial and exploratory research projects and very large-scale demonstrations got underway to extend the scope of U-space to address more advanced services, including addressing the requirements for urban air mobility (UAM).

This has created an innovation pipeline for U-space, supporting the delivery of exciting new opportunities, such as medical services, goods delivery, air taxis and emergency response. The pipeline can demonstrate a host of new capabilities including avoiding no-go areas, giving way to other airspace users and cross border operations. All projects work closely with regulatory and standardisation bodies.

This brochure covers the outcomes of the industrial research and demonstration projects – see pages 15-21 for an overview of each the projects.



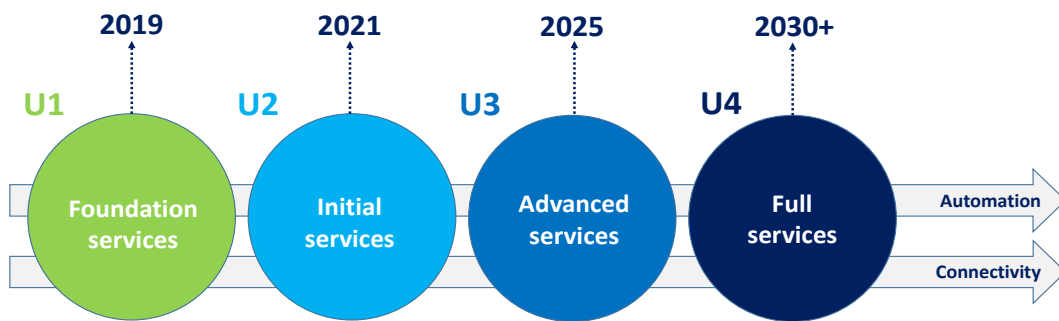
¹ SESAR U-space projects results, 2020, <https://www.sesarju.eu/node/3691>

² CORUS project: <https://www.sesarju.eu/projects/CORUS>

Deployment

The deployment of U-space is taking place progressively based on increasing availability of blocks of services and enabling technologies. As with manned aviation, drone operators and U-space service providers will need to comply with regulations set by the European Union Aviation Safety Agency (EASA). The European regulatory framework and the first U-space regulations, adopted by the European Commission in 2021³, comes into force in January 2023 and will promote a harmonised approach to U-space deployment across Europe.

An implementation monitoring report⁴, released by Eurocontrol annually provides an overview of the level of implementation of U-space services across Europe, according to the timeline set out in the European ATM Master Plan, Europe’s common roadmap for the modernisation of air traffic management, including U-space.



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Smart and sustainable future

The U-space sector is developing rapidly with new innovative ways of using drones emerging at a fast pace. The European Commission has announced plans to publish a Drone strategy 2.0 in 2022. This will provide a forward-looking vision for the future holistic development of the sector while supporting the European Green Deal, Smart and Sustainable Mobility Strategy, Digital Strategy and other Union policies.

³ Commission Implementing Regulation (EU) 2021/664 of 22 April 2021 on a regulatory framework for the U-space: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0664>

⁴ U-space Services Implementation Monitoring Report, 2019, <https://www.eurocontrol.int/publication/u-space-services-implementation-monitoring-report>

WHAT IS IN THIS PUBLICATION?

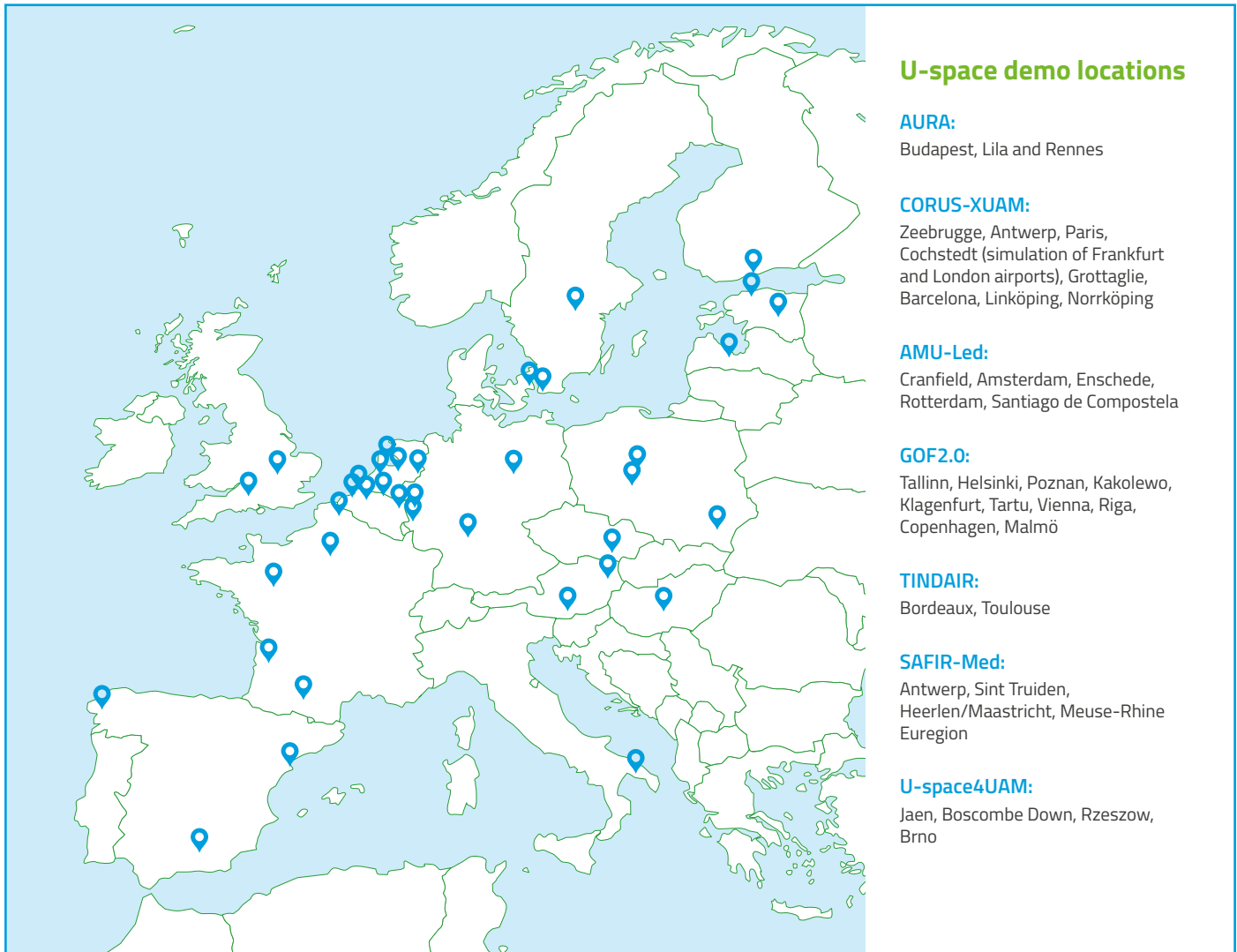
This publication presents the initial results from seven research and innovation projects, namely one industrial research project and six very large-scale demonstrations, which were co-funded within the framework of the Horizon 2020 research and innovation programme.

- **AURA** - ATM U-space interface (Industrial Research PJ.34)
- **CORUS-XUAM**: Concept of operations for European U-space services – extension to urban air mobility
- **AMU-LED**: Air mobility urban large experimental demonstrations
- **GOF2.0**: Integrated urban airspace
- **TINDAIR**: Tactical instrumental deconfliction and inflight resolution

- **SAFIR-MED**: Safe and flexible integration of advanced U-space services for medical air mobility
- **USPACE4UAM**: Bridging the gap between development and deployment of U-space services to enable the safe introduction of UAM in Europe

From 2020 to 2022, these projects carried out tests and trialed solutions aimed at showing the readiness of U-space services to manage a broad range of drone operations and related applications, and their interaction with manned aviation. These range from parcel deliveries between two dense urban locations, medical emergencies and police interventions, as well as air taxi trials in controlled airspace around an airport. The leisure user was also catered for, with projects demonstrating how private drone operators too can benefit from U-space services.





The operations also aimed to demonstrate different levels of automation that are possible, as well as seamless information exchange between multiple service providers in the same geographical area at the same time.

The research work brought together a wide range of actors from traditional aviation, start-ups, research institutes, universities, drone operators, service providers, airports, local/city authorities, law enforcement agencies and civil aviation authorities. Altogether, projects brought together 132 entities from over 20 countries, including 2 European airport groups, 13 air navigation service providers, 23 research centres, 6 universities, and 29 start-ups out of 89 businesses, while over 1 000 experts, shared their knowledge, skills and resources.

The projects were conducted in close coordination with EASA to support the development of the regulatory framework. In addition, the SESAR 3 JU also ensured close cooperation with the European aviation industry standards developing body, EUROCAE, and supported wider standardisation work by the International Civil Aviation Organisation (ICAO), in particular ICAO's UAS advisory Group. Recognising the need to have a broader view on U-space, the projects also involved organisations representing new entrants, such as the Global UTM Association (GUTMA) and Drone Alliance Europe, as well as non aeronautical bodies from the telecom industry.

DEMONSTRATING THE EVERYDAY BENEFITS OF U-SPACE – A LOOK AT SOME USE CASES

Drones are no longer viewed as just leisure equipment. There are a myriad of practical uses for drones in our everyday lives, offering tangible benefits to both citizens and the economy. The SESAR 3 JU and its partners applies different use cases, tested through a number of Very Large-scale Demonstration (VLD) projects, to help define and develop the U-space services that will be

needed to support safe Innovative Air Mobility (IAM) operations. Demonstrating these use cases is the first step towards implementation. SESAR 3 JU and its partners also developing a concept of operations (ConOps), in partnership with other European agencies and industry stakeholders. These VLD projects support this with real-life demonstrations.

Use case 1: Air taxis

Transforming urban transport with faster, more sustainable travel



© CORUS-XUAM - Volocopter

To be part of the urban air mobility (UAM)⁵ transportation revolution, air taxis first need to demonstrate they are safe to fly. SESAR is paving the way for early prototypes to take to the skies by designing a safe and secure concepts and procedures while supporting European regulators. This starts with dedicated operations on specific routes where prototype vehicles, which will be piloted initially, can be tested and monitored. For example, point-to-point journeys between an airport and vertiports located within a city that will need to navigate around manned and unmanned traffic as well as fixed ground obstacles, and take into account vehicle flow management.

The AMU-LED VLD project selected Amsterdam, Rotterdam and Santiago de Compostela to test two U-space architectures

designed to support urban air mobility (UAM) services in sparsely populated and populated urban environments : decentralised and centralised, demonstrating advanced U3 services in both. Among the most demanding use cases for unmanned operations, these examples anticipate future procedures and require U-space services ranging from U1 foundation level to full U4 services.

In a parallel VLD, GOF2.0 integrates air taxi operations with other airspace users in urban airspace supported by highly automated real-time separation assurance alongside precision weather and telecom networks for air-ground communication. Operating beyond visual line of sight (BVLOS), unmanned vehicles need to respond to events without putting anyone or anything at an unforeseen risk. GOF2.0 partners in Estonia, Finland, Poland and Austria are demonstrating how a U-space system of systems, including flight plans, telemetry, alerts, geozones and cellular connectivity, enables drones and manned aircraft to fly in the same airspace at the same time.

U-space deployment depends as much upon societal acceptance as technology, prompting the U-space4UAM VLD to gather feedback from all relevant stakeholders during urban and suburban air mobility demonstration flights in Spain, UK, Czech Republic and Poland.

With the first-generation of UAM aircraft due to be piloted within the next two years – potentially including flights at the Paris 2024 Olympics – establishing a regulatory framework capable of supporting UAM operations represents an essential step towards enabling operations. All SESAR VLDs work closely with the European Union Aviation Safety Agency (EASA) to support the development of appropriate regulation.

BENEFITS

Flexible, faster journeys

⁵ Innovative Air Mobility (IAM) is the overall term capturing the introduction of new air vehicle types, manned and unmanned, such as eVTOL aircraft. This includes inter-city routes. Urban Air Mobility (UAM) is a sub-set of IAM and covers IAM activities that take place in and around a single urban location.



Use case 2: Drone deliveries

Bringing medical supplies to hospitals and packages to your doorstep

Drones already drop vaccines and pick up medical supplies in remote parts of Africa, while grocery orders, packages and point-to-point deliveries are among hundreds of experimental applications in more complex airspace. The speed, convenience and flexibility of these operations has led to growing interest and an urgent need to develop a safe operating environment.

A series of SESAR projects support this activity with real-life demonstrations showing different use-cases ranging from domestic package deliveries from an airport, small items from a warehouse direct to a customer, regular payloads from a company warehouse to field engineers or deliveries between two fixed locations.

The CORUS-XUAM VLD project demonstrated last-mile goods delivery by drones in complex airspace in Spain's Castelldefels city centre in February 2022. Similar activity in an inter-urban environment in Taranto-Grottaglie and Manduria in Italy is taking place to demonstrate very low-level operations in urban, suburban and inter-urban areas to help define U-space service requirements.

High density unmanned operations are also part of the SAFIR-Med VLD in which networks of hospitals and laboratories use drones to shuttle medical samples and tissue using pre-defined corridors.

These drones fulfil medical deliveries at a fraction of the time of road couriers, reducing transport costs and reducing the risk of loss of time-critical samples in traffic jams. There are other benefits: Every minute saved in delivering an automated external defibrillator (AED) to a heart patient improves their life chances by 10%, which is why SAFIR-Med expects smart cities to be among the first applications of this technology.

SESAR research is defining how to manage tactical deconfliction between airspace users, identify priority flights, and respond safely to route deviations. The TINDAIR project is simulating emergencies during medical and cargo delivery flights to test and define specific U-space services that ensure a safe response - an essential step towards building a safe operating framework for regular drone deliveries.

BENEFITS

Faster deliveries with less ground congestion and lower emissions
More rapid response to medical emergencies especially in remote locations

More flexible operations, with the ability to prioritise first response equipment and goods



Use case 3: Infrastructure inspection

Safer and more efficient infrastructure inspection and easier access to remote environments

Inspecting long, linear facilities such as power lines, pipelines and railway tracks are use cases for drones that are already seeing active operations. Studies anticipate steady growth in these areas as users discover the cost and safety benefits of routine remote operations. SESAR is identifying the services needed to support these use cases when operating in the same airspace as manned aircraft and ensure they respond appropriately when encountering higher priority missions or other airspace users.

Such drone inspection activities can also take place at airports. SESAR demonstration applications include routine scheduled runway inspection, in place of vehicle checks to identify debris, fuel or surface damage on the runway, and to assess the condition of runway markings, airfield lighting and signs. This use case features high density manned and unmanned airspace users operating in a fully integrated, controlled, multiple runway environment, simulated by the SESAR AURA project. AURA is testing contingency measures in response to information exchanged between

U-space and air traffic management (ATM) services. The drone is constrained by a geo-cage to the dimensions of the runway, and the route between the inspection site and the depot, which is located within the airport boundary. Using contingency procedures, the drone responds to unplanned events such as other airspace users, jamming or communication failures by landing in a safe zone until the airspace is clear.

By developing the required concept of operations for U-space information exchange with air traffic management, SESAR is helping to define how new actors can be integrated into the air traffic environment.

BENEFITS

- Access to remote and difficult sites with less risk to the work force
- Reduced cost in comparison with conventional manned operations
- Supports beyond visual line of sight operations (BVLOS)

Use case 4: Agriculture

Increasing agricultural output with support from safe and reliable drone operations

Precision agriculture optimises farm production through the use of remote sensing devices, data gathering and satellite position information. Drones can help in crop management through irrigation scheduling, soil texture mapping, disease detection, detection in the variability of crop responses to irrigation, weed management and reducing the amount of herbicides. The deployment of UAVs in precision agriculture is a cost-effective and time saving technology which can help for improving crop yields, farms productivity and profitability in farming systems.

These unmanned services can be geofenced, however they still pose a risk when used in close proximity to other airspace users. SESAR is demonstrating how agriculture drones can be used on a regular basis for farming applications even adjacent to busy airspace where there is a high density of manned and unmanned airspace users.

The SESAR AURA project considers the data exchange requirements between ATM and U-space systems to define a set of services to establish an efficient interface. Using the example of precision agriculture operations adjacent to a busy multiple runway airport, AURA demonstrates how U-space services interact with air traffic control to create a collaborative display that can be used to plan and manage manned and unmanned flights. It enables dynamic

airspace reconfiguration by activating/deactivating geofences without interacting individually with each drone operation. It enables unmanned missions to continue to be planned freely within U-space designated airspace and safeguards ATM-reserved airspace. The project also addresses tactical contingency measures during emergencies.

The research aims to avoid segregation of the airspace by introducing a collaborative interface between U-space and ATM. It relies on a common information service provider (CISP) facilitating this data exchange, including relaying geographical zones and sharing updated flight plans. Information exchange is also an important part of GOF2.0 research, which includes advanced flight trials using system wide information management (SWIM) principles based on international standards to enable easy sharing of safety-related information.

Agriculture remains one of the fastest growing applications for drone use and this use case demonstrates it can continue to expand within ATM/U-space shared airspace in a controlled area.

BENEFITS

Unmanned missions can be planned freely within U-space designated airspace

Collaborative display allows easy redistribution of airspace



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Use case 5: Public safety and security

Adding an aerial dimension to protecting the citizen

Drones are especially useful for emergency services, providing rapid first response to incidents and events. Police and fire services already take advantage of visual line of sight (VLOS) flights, and by adding U-space services, these operations benefit from information about other users and airspace constraints. Whilst current activity comprises mainly surveillance and information gathering, future applications are likely to include high-priority people transport for first-response services in an urban environment, and scheduled or on-demand services that support the daily life of citizens and public authorities.

SESAR demonstrations for this use case include a search and rescue operation for a group of hikers in distress. This features a

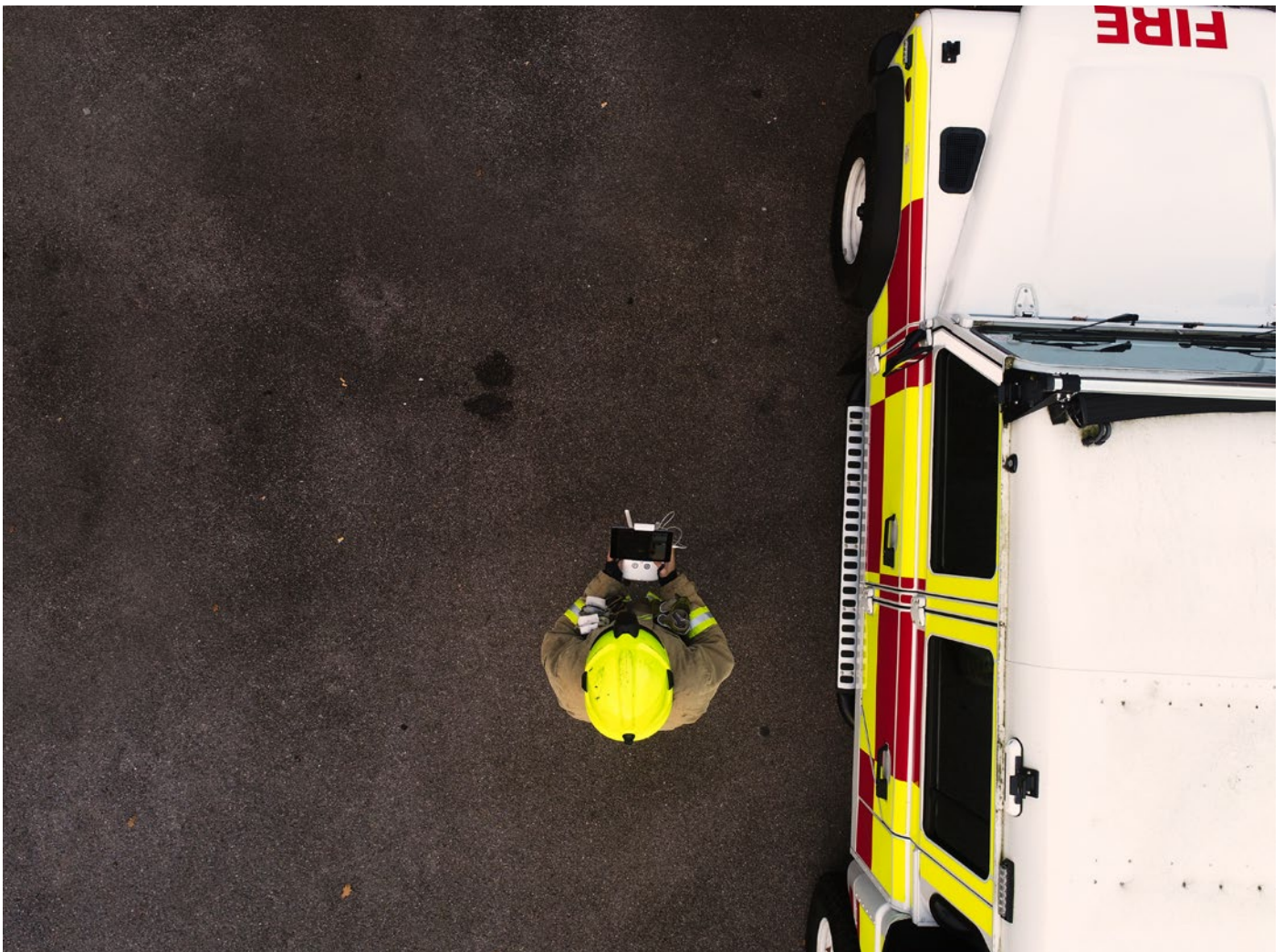
coastguard drone that locates stranded hikers in a military training area and relays video information to the search and rescue centre. The airspace includes other airspace users such as helicopters and low flying, fast moving military aircraft. The research anticipates the introduction of BVLOS flights in a collaborative environment, while avoiding segregation of the airspace. The application is an important step towards operating in more complex environments with advanced U-space services.

BENEFITS

First response services can be prioritised

Citizens benefit from many more day-to-day safety services

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Use case 6: Drone inspection services

Bringing increased safety, flexibility and convenience to routine tasks

Tall buildings, high bridges and infrastructure with access challenges all stand to benefit from unmanned inspection services. To ensure these operations do not come into conflict, or interfere with other airspace users, U-space can provide flight planning tools, alerts and dynamic information updates to help manage drone operations in low level airspace. SESAR is researching which services are needed to enable inspection services to perform safely in different environments.

One SESAR application concerns the visual inspection of an external structure such as telecommunication antenna or bridge located on a route used by a local city hospital helicopter or similar high priority traffic. The airspace is used by other unmanned vehicles and some low-density manned traffic such as air taxis and helicopters. Research conducted by CORUS-XUAM project includes advanced forms of interaction using digital data exchange in urban, sub-urban and inter-city scenarios as well as adjacent airspace under air traffic control. Real-life demonstrations tested coordination between U-space and air traffic control, and between controllers and drone operators. The activity also includes working with EASA and national regulatory authorities to share the lessons learned and support the transition from demonstration to implementation.

In another application, the GOF2.0 project is conducting real-life BVLOS flights in Austria, Estonia, Finland and Poland executing a range of tasks, including construction and infrastructure inspection services. The flights rely on strategic deconfliction services that cause operations to be suspended when manned operations are too near. Performing the demonstrations with real flights, supplemented by simulated flights, GOF2.0 is able to show the contingency services work in a real dynamic environment.

Demonstrations can also lead directly to implementation, which has been the case in the island city of Tromsø, Norway. Following real-life trials by partners in GOF2.0, VLOS unmanned inspection flights are now permitted within the town, despite being within the 5km exclusion zone of Tromsø Airport. This application uses foundation U-space services, but it represents an excellent step towards the wider target of defining the performance and operating parameters for advanced U-space services.

BENEFITS

Routine tasks become safer and easier

Unmanned and manned platforms can share the same airspace

Use case 7: Aerial mapping

Capturing a bird's eye view with safe aerial mapping in controlled airspace

Aerial mapping is used by real estate management, geographical and topographical agencies for professional purposes. In addition to meeting safe operating standards, these unmanned platforms need to comply with airspace rules and regulations to minimise risks for other airspace users and people on the ground. SESAR is simulating different scenarios and conducting real-life demonstrations to discover which performance requirements are needed by the drone and the U-space services it uses to fly safely and reliably.

The AURA VLD operates an aerial photography drone in amongst other manned and unmanned traffic to test dynamic operations at an airport. The project takes place in non-segregated airspace, requiring interaction between air traffic control and U-space service providers as well as tactical conflict detection during flight. Key services include common information service provision and dynamic geofencing to ensure unmanned traffic remains within safe areas of operation. The use case applies to professional operations such

as fauna and flora mapping activities, heritage mapping of historical sites and digital maps of critical infrastructure like railway lines and fuel pipelines.

A separate case study by partners in the AMULED project simulates a demonstration in Santiago de Compostela, where unmanned aerial photography platforms are operating in the same airspace as other users, including taxi services and helicopter emergency medical services (HEMS). The scenario simulates nominal and off-nominal situations and tests a range of U-space services from foundation geo-awareness and networked identification to dynamic geofencing and conformance monitoring.

The demonstrations are helping to define the U-space services that will enable aerial mapping operators to deploy unmanned platforms while in segregated airspace.

BENEFITS

Safe unmanned aerial mapping flights in manned airspace

Shared information about all airspace users



PROJECT FICHES

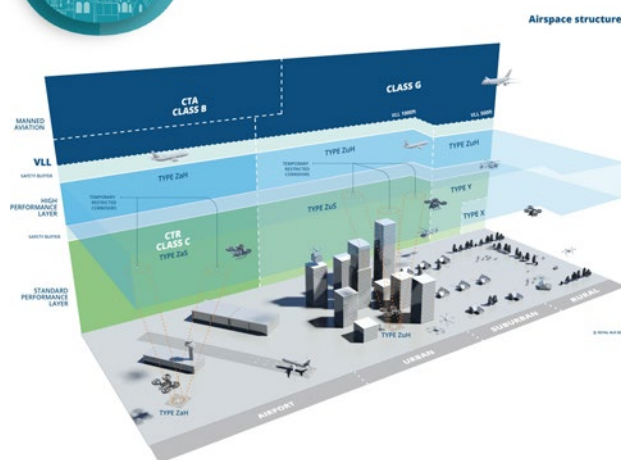
AMU-LED - Air mobility urban - Large experimental demonstrations

Unmanned flight in a city environment calls for a robust safety framework

Adding an aerial dimension to urban transport brings a new set of challenges never experienced before in city environments. To ensure unmanned operations fly safely, they need to avoid conflicts with other airspace users, operate within the U-space framework and comply with regulations. SESAR's AMU-LED large experimental demonstrations tested these concepts in different environments – from less complex airports like Cranfield in the UK or Enschede in the Netherlands, to industrial and city areas like Rotterdam, Amsterdam and Santiago de Compostela. Selecting these locations allowed the project to grow in complexity, testing and validating some of the latest standards. Two U-space architectures were examined: centralised and decentralised, proving advanced U4 services in both cases.

The use cases included air taxi operations operating in the same airspace as other UAVs and helicopter traffic; emergency and first response services for paramedics and patients in an urban environment; surveillance, infrastructure inspection and aerial photography; point to point deliveries, high priority delivery and last mile deliveries. Several different U-space service providers (USSPs) participated in the demonstrations along with common information service providers (CISPs) and U-space technology suppliers.

AMU-LED demonstrated that any city or urban region has the capability to offer UAM services, taking into account any specificities, in a standardised and safe form



Among the most important outcomes, AMU-LED showed that U-space services can manage prioritised flights safely. This includes rerouting flights and enabling different vehicles and mission types to co-exist. Other capabilities included safe management of planned and unintended flight paths, coordination with air traffic control making use of CISP and USSP services, and beyond visual line of sight (BVLOS) flights.

The project significantly contributed to defining the needs and features of UAV on-board equipment

AMU-LED stakeholders collaborated with aviation safety authorities in each state to ensure all planned flights were authorised, and provided feedback to standardisation bodies and regulators, which is helping define the future U-space regulatory framework. The project also identified gaps in standards development, and specifically how it can evolve to enable UAM operations.

BENEFITS

- Proof of UAM applications and its safe integration in U-space
- Definition and validation of a concept of operation, centralised and decentralised U-space architectures

Web: <https://amuledproject.eu>

Partners

- NTT DATA Spain (Coordinator)
- Airbus
- AirHub B.V.
- ANRA Technologies
- Boeing Research & Technology- Europe
- Advanced Center for Aerospace Technologies (CATEC)
- Cranfield University
- EHang
- ENAIRE
- Fundación Instituto Tecnológico de Galicia (ITG)
- Ineco
- Jeppesen GmbH
- Netherlands Aerospace Centre (NLR)
- TECNALIA
- Space53

AURA - ATM U-space Interface (PJ.34)

Defining U-space services needed to safely integrate unmanned and manned traffic

One of the main hurdles facing urban air mobility is the safe integration of drones into low-level airspace without impacting conventional air traffic operations. The AURA solution first sets about defining the requirements for U-space information exchange with airspace management before developing a new concept of operations and validating the data exchanges through System Wide Information Management (SWIM) to create this collaborative environment.

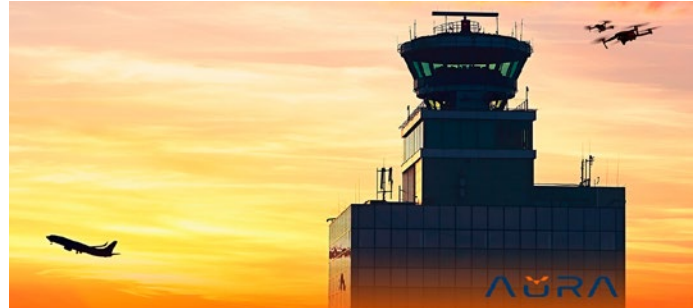
AURA demonstrated a set of services and identified the information exchange needed to permit and guarantee ATM and U-space systems interoperability.

To generate a set of services that allows an efficient interface between U-space and air traffic management, two approaches were investigated in parallel.

First, the project identified U-space services that can manage information sharing, airspace constraints, strategic deconfliction with ATC approval and tactical contingency in cases of emergency.

Partners

- Indra (coordinator)
- Airbus
- Royal Netherlands Aerospace Centre (NLR)
- German Aerospace Center (DLR)
- Air Navigation Services of the Czech Republic (ANS CR)
- Oro Navigacija
- Polish Air Navigation Services Agency (PANSNA)
- Austro Control
- Swedish Civil Aviation Administration
- DFS Deutsche Flugsicherung
- Direction des Services de la navigation aérienne (DSNA)
- ENAIRE
- ENAV
- EUROCONTROL
- Frequentis
- Hungaro Control
- Honeywell Aerospace
- Leonardo
- SINTEF
- NATS
- Thales LAS and AVS France
- Letové prevádzkové služby (LPS SR)
- Croatia Control - COOPANS Alliance
- Irish Aviation Authority – COOPANS Alliance
- Naviar – COOPANS Alliance
- ATOS
- Airtel
- Saab



© AURA

Second, it validated the findings on existing airspace management operations to identify the mechanisms required to facilitate the ATM-U-space interface, evaluating the impact on human performance, safety and cost efficiency in various environments and scenarios including:

- New shared airspace concept configuration,
- dynamic operation plans with commercial aerial airport inspections,
- adaptive traffic information exchange in an urban environment,
- management of the airspace in the vicinity of the airport runway by ATC when U-space contingencies occur, and
- manned aircraft in emergency situations entering U-space airspace.

The project introduced new actors in a safe, harmonised, sustainable and efficient way, compatible with current airspace environment.

The project results serve as input to regulators such as EASA, and to standardisation bodies working actively in U-space.

BENEFITS

- A collaborative ATM-U-space environment increases airspace interoperability and improves the security of operations
- New standards enable development and realisation of the economic potential of the drone market
- New drone applications will drive societal benefits such as delivery and urban air mobility

SESAR is facilitating seamless operations of drones and manned aviation in non-segregated airspace, relying on highly automated systems and fully dynamic airspace management.

Web: www.pj34aura.com

CORUS-XUAM - Concept of Operations for European U-space Services - Extension for Urban Air Mobility

Maturing the initial U-space rules to make them fit for the urban environment

SESAR research partners delivered an early set of rules for low-level airspace operations, known as a concept of operations (ConOps), for European U-space in 2019. The latest CORUS-XUAM research builds on these early findings to demonstrate how U-space services could support integrated UAM flight operations, allowing electric vertical take-off and landings (eVTOLs) to operate safely with other airspace users in fully integrated airspace.

CORUS-XUAM selected six very large-scale demonstrations to demonstrate the safe integration of a variety of UAM missions - ranging from logistics and deliveries to passenger transport - in city locations in Belgium, Germany, Italy, Spain, Sweden, France and the UK. The activities rely on advanced forms of interaction through digital exchange in urban, sub-urban and inter-city scenarios as well as near airports. By expanding the U-space ConOps to address the specificities of urban environments, the research is the first step towards creating a roadmap designed to deliver results in both the short and long term. The final goal of the roadmap, in 10-15 years, will be to deploy complex use cases such as air taxis.

For example, during the Spanish trial in the city of Castelldefels, four different drone operators conducted last-mile delivery missions between a network of vertiports. Channelling the flights through a specific airspace structure enabled participants to

CORUS-XUAM U-space ConOps, integrated services and capabilities significantly contributes to, and supports, the UAM airspace integration challenge.

Partners

- EUROCONTROL (coordinator)
- Aéroports de Paris (Groupe ADP)
- Aslogic
- British Light Aviation Centre Limited (AOPA)
- DFS Deutsche Flugsicherung
- DLR
- Droniq
- DSNA
- ENAIRE
- ENAV
- Hemav Foundation
- Indra
- Swedish Civil Aviation Administration
- NATS
- Pipistrel Vertical Solutions
- SkeyDrone
- Unify
- UPC
- Volocopter



© CORUS-XUAM

identify the necessary technology, infrastructure and regulatory requirements to safely integrate unmanned and manned aircraft.

CORUS-XUAM worked with regulators and hosted workshops and seminars to gain stakeholder support. SESAR research partners also shared lessons learned with the European network of U-space demonstrators, a European initiative that is helping businesses transition from demonstration to implementation. The final outcome of the project is linked to the success of the UAS and UAM market in realising their full potential without compromising the current high level of air transport safety.

CORUS-XUAM is helping drone and passenger taxi vehicles to operate safely, securely, sustainably and efficiently in a controlled and fully integrated airspace.

BENEFITS

- Definition of U-space advanced services for UAM operations and recommendations for the relevant procedures in urban/sub-urban areas
- Development of recommendations for the evolution of regulations and standardisation
- Support the evolution of the U-space/UAM related technical and infrastructure development and deployment activities in and around urban areas

Web: corus-xuam.eu

GOF2.0 Integrated Urban Airspace VLD

Real-life demonstrations provide the experience needed to write the rules for U-space

Both airspace management and U-space depend extensively on the provision of timely, relevant, accurate and quality-assured digital information to collaborate and make informed decisions. GOF2.0 establishes a scalable U-space architecture and defined the information exchange services needed to connect all airspace users based on service-oriented architecture (SOA) and system wide information management (SWIM).

During two waves of real-life validation exercises, GOF2.0 tested three types of drone operating environments: Dense operations in controlled airspace; entering and leaving U-space; and cross-border integrated operations. The first wave demonstrated the baseline functionality of strategic conflict resolution, followed by increased automation in the second wave to test tactical conflict resolution.

A fourth trial was carried out with third-party partners LfV (Sweden), NaviAir (Denmark), LMT and LGS (Latvia) to validate the scalability and interoperability of the GOF2.0 solution.

Real-life flights demonstrated multiple operational, technical and business examples ranging from package and medical deliveries to inspection and mapping services, and finally air taxi applications without passengers in the Gulf of Finland. The demonstrations showed the U-space architecture supporting highly automated real-time separation assurance in dense airspace including precision weather and reliable telecom networks.

The research highlighted the need for UAS operator ground stations to be digitally integrated with U-space service providers to ensure consistently good data quality, and to predictably respond to

Efficient use of airspace for mixed operations in and out of airport environments requires ATC to be able to directly interact with U-space, but only on a must-know, exception basis.



© GOF 2.0

changes in operating conditions and flight missions. Situational awareness increases dramatically for all aviators in uncontrolled airspace when manned and unmanned aviators share the same digital information, while detailed information about local wind conditions also increases flight safety.

Among other findings, UAS operators were able to reduce congestion by splitting strategic deconfliction operational plans into smaller segments, and ATC collaborative procedures with U-space actors need to evolve only to focus on exception management. Overall, the demonstrations increased understanding of how to safely integrate UAM and other commercial drone operations into ATM airspace without degrading safety, security, or disrupting current airspace operations.

Scalable interoperability across Europe requires standardised information exchange services to enable UAS operators, USSPs, CIS and ATSPs to share data.

Partners

- Estonian Air Navigation Services (EANS) (coordinator)
- Airbus Urban Mobility GmbH
- Aviamaps
- CAFA Tech
- Dimetor
- Droneradar
- EHang
- Fintraffic ANS
- Frequentis
- Poznan Supercomputing and Networking Center (PSNC)
- PANSA
- Robots Expert Finland
- Threod Systems
- Unmanned Life
- Vaisala

BENEFITS

- GOF2.0 produced guidelines for safe UAM operations, along with recommendations for regulatory measures
- GOF2.0 delivered nine service descriptions for information exchange services that allow interoperable and scalable exchange of machine-readable information between all U-space and ATM stakeholders

Web: <https://gof2.eu>

SAFIR-Med: Safe and Flexible Integration of Advanced U-space Services Focusing on Medical Air Mobility

Medical deliveries are at the forefront of real-life trials to advance urban air mobility

Drone deliveries promise radical change for the healthcare sector, ferrying medical samples and vaccines swiftly and efficiently between laboratories and hospitals. SESAR is facilitating the growth of this market to demonstrate U-space architecture principles, which are equally relevant to other sectors.

The SAFIR-Med project used real-life healthcare applications in Belgium and the Netherlands to transport medical supplies along pre-defined airspace corridors.

The project managed high-density unmanned traffic safely by means of flight authorisations, strategic, pre-tactical and tactical deconfliction measures. The project also managed emergency flights and inter-city connections.

SAFIR-MED used five unmanned platforms to demonstrate 16 different scenarios including the transport of human tissue, biological lab samples and medicine, emergency defibrillator delivery and in one instance simulated patient transport. The project builds on earlier SESAR wave one research in which SAFIR introduced initial U-space services including strategic and tactical deconfliction, tracking and monitoring, geofencing and e-identification for beyond visual line of sight flights at Belgium's DronePort test site. SAFIR-Med augmented the test flights with demonstrations and added dynamic geofencing, detect-and-avoid services, air traffic prioritisation rules and layered communications comprising 3G, 4G and 5G networks to provide a resilient "swiss cheese" model.

According to a recent EASA study on the social acceptance of drones, the use cases that are valuable to all, such as emergency or medical services, receive the greatest public support.



© SAFIR Med

The flights are indicative of operations that will become possible when new European regulations start to take effect from 2023, and the experience gained represents the first step towards using UAS in smart cities to benefit citizens. The results help to inform current U-space architecture and create measurable indicators for UAM that will accelerate the adoption of drones into the low-level airspace in a safe and socially acceptable way.

Current figures show only 1 in 10 out-of-hospital casualties survive a heart attack, yet every minute saved in delivering an automated external defibrillator (AED) to a patient improves their life chances by 10%.

BENEFITS

- Helping urban authorities to take their first steps in the UAS world
- Safer transport infrastructure with a positive social impact
- Sustainable, efficient service delivery within a medium-term horizon

Web: www.safir-med.eu

Partners

- Helicus (Coordinator)
- Future Needs Management Consulting
- Skeyes
- Unifly
- AgentFly Technologies
- Hellenic U-Space Institute
- SkeyDrone
- Droniq
- NSX
- INVOLI
- Aachen University, Institute of Flight System Dynamics
- flyXDrive
- TUDelft, MAVlab
- HyFly
- SABCA
- EHang
- City of Aachen

TINDAIR – Tactical INSTRUMENTAL Deconfliction And In-flight Resolution

Integrating manned and unmanned traffic with strategic and tactical deconfliction services

As demand for unmanned aerial systems (UAS) in urban settings continues to grow, so does the need to ensure unlimited, unrestricted and safe cohabitation of the airspace for all users. The SESAR TINDAIR project set out to deliver a reliable tactical deconfliction service with a robust communication link to enable new aircraft types to be integrated safely into the skies alongside existing manned aviation and air traffic control.

The research featured four very large-scale demonstrations in suburban areas of the French cities of Toulouse and Bordeaux to test advanced U-space services including strategic deflection, tactical conflict resolution, emergency landing and in-flight mechanisms such as detect-and-avoid – all necessary to enable UAS to operate in highly complex airspace. The flights also provided an opportunity to demonstrate a tactical conflict resolution service module that embeds an artificial intelligence algorithm, which could be integrated into the future U-space deployments.

Innovative tactical deconfliction services were demonstrated in complex airspace.

The core of the demonstration was to show the reliability of these essential services with each one focused on a different issue:

- Tactical deconfliction and prioritisation of medical emergency flights,
- tactical deconfliction between different kinds of vehicles, including eVTOLS with simulated passengers,
- tactical deconfliction and interaction with manned aviation, and
- tactical deconfliction and management of emergency landing.

The research also featured other activities such as safety and security, human factors and social acceptance, as well as emergency management.

Partners

- Innov'ATM (Coordinator)
- Aerospace Valley
- Apsys
- CIRA - Italian Aerospace Research Center
- Collins Aerospace
- Italian Institute for Sustainable Society and Innovation (ISSNOVA)
- French Aerospace Laboratory (ONERA)
- PildoLabs
- SkybirdsvieW
- Skyports
- Tecnalía



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Data and feedback from the demonstrations is helping to define the performance requirements of U-space services and inform the relevant standardisation bodies. This activity is supported by the TINDAIR advisory board, which is composed of a broad panel of UAM stakeholders ranging from national aviation authorities, city councils, innovative companies, aviation clusters and future potential users. TindAIR has also created a community circle to encourage other stakeholders to share feedback about their UAM experiences and help to improve U-space services.

Operational scenarios addressed compelling use cases including medical emergency transport, passenger flights, and extreme emergency management.

BENEFITS

- Creation of a tactical deconfliction service
- Shared data from the demonstrations
- Research on human factors, social acceptance, safety and security

Web: <https://tindair.eu/>

Uospace4UAM

Highly automated airspace requires advanced U-space services and social acceptance

The future urban aerial environment will include high levels of automation, connectivity and digitisation for airspace users and the U-space system. Showing the pathway to fully autonomous taxiway services, SESAR's Uospace4UAM project demonstrated U-space capabilities developed to enable safe integration of UAS operating at low and very low levels in suburban and urban areas.

The project tested the limitations of current U-space services through a wide range of use cases and expanded on the current concept of operations to take into account higher levels of automation and more complex urban environments. In addition to demonstrating how various UAM operations, such as drone-delivery, air taxis and public emergency services are enabled by U-space services, the project also examined multilateral business requirements to make these services commercially viable.

Five demonstration campaigns were held in four countries (Czech Republic, Poland, Spain, and the UK) covering flights of both drones and eVTOL vehicles in multiple operational scenarios to mimic tailored business use cases. Feedback from relevant stakeholders including ANSPs, original equipment manufacturer (OEMs), drone and vertiports operators, city representatives, and regulatory bodies was gathered through the Uospace4UAM advisory board and during technical workshops typically coupled with the demonstrations. Input from the general public was also encouraged by means of online surveys in each country.

Uospace4UAM demonstrated on-board capabilities and U space services to enable UAM with special focus on safe integration of unmanned operations conducted at low and very low levels in suburban and urban areas.

Partners

- Honeywell (coordinator)
- UpVision
- Fundación Andaluza para el Desarrollo Aeroespacial
- DLR
- Dronehub
- Austro Control
- ENAIRE
- Vertical Aerospace Group Ltd
- TECNALIA Research & Innovation
- Centro de Referencia de Investigación Desarrollo e Innovación ATM, A.I.E. (CRIDA, AIE)
- Air Navigation Services of the Czech Republic (ANS CR)
- Lilium Aviation
- Altitude Angel

USPACE 4UAM



© USPACE 4UAM

Project partners flew more than 150 flights and 50 simulated scenarios to obtain sufficiently representative demonstration results.

Building on early-movers experience, the project delivered insight and solutions that are sustainable from societal and economical points of view. It also contributed to maturing of technology needed for higher levels of automation and autonomy in UAM operations, and actively engaged in standardisation and regulation efforts for enabling such operations. Finally, this project helped to progress towards an internationally acceptable concept of operations, which is a key prerequisite for safe integration of UAM in U-space and traditional air traffic.

BENEFITS

- Maturation of selected technologies
- Validation of ConOps through demonstrated scenarios
- Pioneering regulatory approval process

Web: www.sesarju.eu/projects/uspace4uam



LIST OF ACRONYMS

AED	Automated external defibrillator
AMU-LED	Air mobility urban - Large experimental demonstrations
ANSP	Air navigation service provider
ATC	Air traffic control
ATM	Air traffic management
ATSP	Air traffic service provider
AURA	ATM U-space Interface
BVLOS	Beyond visual line of sight
CISP	Common information service provider
ConOps	Concept of operations
CORUS-XUAM	Concept of operations for European U-space services - Extension for Urban air mobility
EASA	European Union Aviation Safety Agency
EU	European Union
EUROCAE	European Organisation for Civil Aviation Equipment
eVTOLS	electric vertical take-off and landings
GOF2.0	Gulf of Finland 2.0
GUTMA	Global UTM Association
HEMS	Helicopter emergency medical services
IAM	Innovative Air Mobility
ICAO	International Civil Aviation Organization
JU	Joint Undertaking
OEM	Original equipment manufacturer
SAFIR-Med	Safe and Flexible Integration of Advanced U-space Services for medical Air Mobility
SESAR	Single European Sky ATM Research
SESAR3 JU	SESAR 3 Joint Undertaking
SOA	Service oriented architecture
SWIM	System-wide information management
TINDAIR	Tactical instrumental deconfliction and in flight resolution
U1 - U4	Level of U-space services
UAM	Urban air mobility
UAS	Unmanned aerial system
UAV	Unmanned aerial vehicle
Uspace4UAM	Bridging the gap between development and deployment of U-space
USSP	U-space service provider
UTM	Unmanned aircraft system traffic management
VLD	Very large-scale demonstration
VLOS	Visual line of sight

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