EUROPEAN CONCEPT FOR HIGHER AIRSPACE OPERATION

CONCEPT OF OPERATIONS

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European Higher Airspace Operations (HAO)

Concept of Operations

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Authoring and approval

Authors of the document

Organisation	Position / Title	Date
EUROCONTROL	**WP4 Lead**	**1/09/2022**
DLR	WP4.2 Task Member	1/09/2022
DASSAULT	WP4.2 Task Member	1/09/2022
ENAC	WP4.2 Task Member	1/09/2022
ENAV	WP4.2 Task Member	1/09/2022
AIRBUS	WP4.2 Task Member	1/09/2022
THALES	WP4.2 Task Member	1/09/2022
CIRA	WP4.2 Task Member	1/09/2022
DSNA	WP4.2 Task Member	1/09/2022

Reviewers internal to the project

Name / Beneficiary	Position / Title	Date

Approved for submission to the SJU By - representatives of all beneficiaries involved in the project

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ECHO

EUROPEAN HIGHER AIRSPACE OPERATIONS (HAO)

This Concept of Operations is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 890417 under the European Union's Horizon 2020 research and innovation programme

Abstract

This document describes the European Concept of Operations (ConOps) for Higher Airspace Operations (HAO). The ConOps provides the basis from which future operational roles, responsibilities, procedures, and infrastructure required to support HAO over the short, medium and long term can be identified. Following collaboration in the ECHO project with several new entrants, the ConOps describes their operations in Higher Airspace (HA), ranging from low to high-speed activities, plus space missions originating from, to and outside the EUROCONTROL Network Manager area[1].

The ConOps assumes the need for the accommodation of new entrants progressing towards a target concept that facilitates their integration to the maximum extent possible to optimise airspace use. Importantly the ConOps is designed to operate within the current framework of State roles and prerogatives. It is expected that the main principles for maintaining State security and air defence in HA will be in line, when applicable, with the current measures applying to ATS airspace. New entrants may bring new challenges and require further adaptations of both ATM and military systems.

Challenges exist to facilitate the transit of all new entrants from and to the earth's surface via existing ATS airspace and against an expected growth of traffic in this airspace volume. While some vehicles will remain in HA for the entirety of their mission others will rapidly transit HA for the space domain requiring coordination with the future STM currently under development. These vehicles will conduct suborbital or orbital operations while others will include a return to earth for re-use in future missions.

The operational environment of today is described in the document to enable the mapping of future changes to support the phases described in the ECHO roadmap which takes a short, medium and long-term view.

The description of the target concept represents the kernel of the document. Although it is a high-level description, it aims to set the scene expected in the coming decades. The concept applies to both individual vehicles, flying according to their agreed trajectories, and those operating in 4D operating zones, where the separation assurance inside the 4D-volume is the responsibility of the vehicle operator. Pre-flight strategic de-confliction should ensure separation for those operations on

[1] For the ECHO ConOps the "EUROCONTROL NM area" represents the area for which EUROCONTROL performs the function of the "network manager" as defined by COMMISSION IMPLEMENTING REGULATION (EU) 2019/123

an agreed trajectory against other such traffic and the 4D operating zones to the maximum extent possible. When strategic de-confliction is no longer possible, tactical traffic information and monitoring, as part of ATM, may be required to support operators in their separation provision task or provide a separation service for HA users that are unable to fulfil a separation task for themselves. This service may be provided by a Higher Airspace Operation Service Provider (HAOSP).

For higher airspace operations the supporting infrastructure, i.e., CNS based on the classical approach, will no longer apply, owing to the operating environment; new means will be needed. The management of non-nominal events and contingency procedures are managed through continuous surveillance of the vehicles and special training of actors to react and where necessary move other vehicles and aircraft from the subject impacted area.

The document also highlights the next steps required to resolve outstanding issues found during the development of the ConOps with a particular reference to working with pioneers. Validation activities and further research will be required to move the concept closer to operational use. It is also expected that the document will provide input to the creation of the EASA regulatory framework required to support the new entrants.

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1 Introduction

Recent technological innovation has enabled the development of new vehicles with new missions which will need to be integrated with traditional aviation operations. These new higher airspace operations will be conducted generally above FL550 and are expected to be deployed globally.

For the European region, with the complexity of the multiple air traffic management (ATM) systems currently deployed in the EUROCONTROL NM area[2], the development of solutions to accommodate new entrants will also need to take into account both national and regional State responsibilities.

The European Commission in cooperation with EUROCONTROL, the European Union Aviation Safety Agency (EASA), the SESAR Joint Undertaking (SJU), the European Defence Agency (EDA) and the European Space Agency (ESA) organised the European Higher Airspace Operations Symposium in April 2019. The symposium concluded that two actions were required to further advance the development and introduction of new entrant operations in HA: the development of a European Concept of Operations for Higher Airspace and the exploratory work of a regulatory framework underpinning such operations.

Subsequently, a two-year project led by EUROCONTROL was launched to deliver a comprehensive Demand Analysis D3.6, User Requirements D4.1 and al Concept of Operations (ConOps) for Higher Airspace Operations (HAO) D4.3, to allow safe, efficient and scalable operations in this evolving environment. In parallel EASA has set up a regulatory task force to explore the regulatory aspects of higher airspace operations.

1.1 Document objectives, purpose and scope

This document describes the European Concept for HAO. The ConOps provides the basis from which future ATM/ATS operational roles, responsibilities, procedures, infrastructure, standards and regulations required to support HAO over the short-, medium- and long-term can be identified. One key objective is that it should address the operation of vehicles that exist today as well as those and their activities still to be developed.

The ConOps describes operations in HA for all new entrants, ranging from low-speed high-altitude platform systems (HAPS) to very high-speed operations notably supersonic and hypersonic transport, plus commercial space activities conducted from and to European States (see Figure 1), through the EUROCONTROL Network Manager area of responsibility. It also includes the methods of transit through air traffic service (ATS) airspace.

The document identifies new types of services, predicated on flight-centric solutions, which could be deployed to meet the objectives for air traffic services defined in ICAO Annex 11. Whilst the overall concept will be anchored on the principles of trajectory-based operation, it is recognised that certain

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types of operations, such as commercial space, will require the expansion of existing operational interfaces and tools already available between the aviation and space domains.

The document does not include in its scope questions relating to security, sovereignty or the overall legal framework which will eventually govern the interaction between aviation and space. It is fully acknowledged that further evolutions of the legal and regulatory framework will be expected following State collaboration via UN agencies, the EU and other relevant international organisations.

Importantly, this document also aims to propose a common taxonomy for describing envisaged future operations. Both space and aviation operations have their own nomenclature and definitions, hence a common reference and understanding are essential in order to achieve coordination and cooperation in this new field.

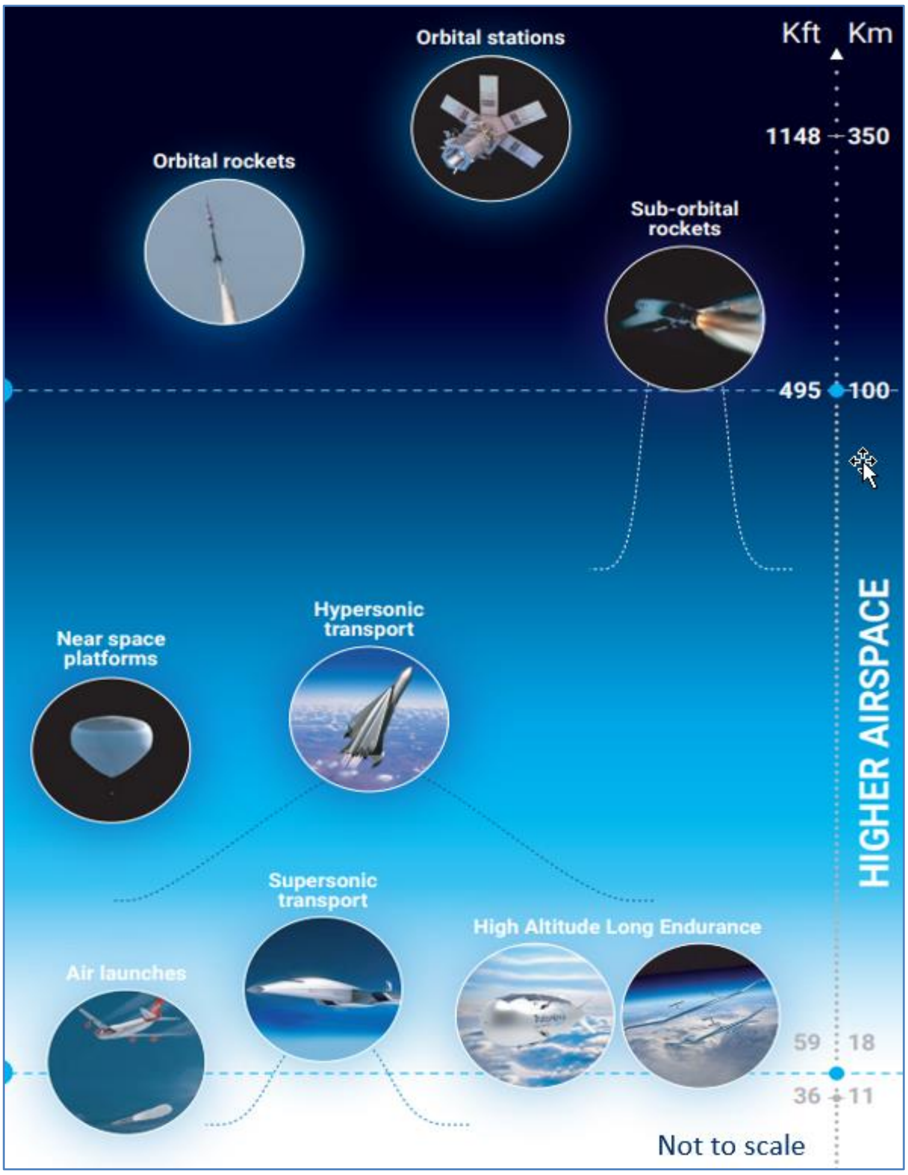

Figure 1 Example operations in HA

2 Context and definitions

2.1 Why we need the ConOps

HAO represent one of the most profound changes to the aviation ecosystem for many years. The number of space operations, HAPS, supersonic and hypersonic vehicles is set to steadily increase in the years ahead. Therefore, it is imperative that such operations can take place safely, efficiently and without a disproportional impact on more conventional air traffic operations. Change is needed to evolve from how we work today to fully support the new HAO and space activities so these operations are able to fully achieve their objectives.

Currently space operations are rapidly developing both in terms of the number of potential spaceport locations, proposed launches and launch methods. They can take place from land, sea and air with reusable components that return to the surface. Traditionally large airspace volumes are reserved for a considerable time to enable a launch or return to take place safely. However, with the increasing number of expected launches, their impact on the European aviation network will significantly grow. Therefore, new processes and procedures at European network level are needed to mitigate the impact of such launches, reducing the need for segregation, and to prepare for both planned and unplanned returns (e.g. debris).

2.1.1 The European operational environment

The operational environment in Europe has certain characteristics that make it unique and require solutions that satisfy both national and regional demands.

HAO offer a unique opportunity to promote an operational vison that, from the outset aims to address some of the structural elements that in the past have required significant time and effort to improve. Perhaps one of the most familiar examples, the airspace organisation and structure across the EUROCONTROL Network Manager area, has been subject to constant developments to reduce fragmentation. Such improvements have required a bottom-up approach and a significant period of time to be fully implemented across the network. The lessons learned from this experience should be taken into consideration and the development of HA should start with a new approach.

The management of the European ATM network has been built on strong cooperation between all stakeholders (e.g. airspace users, service providers, regulators, the EU and its agencies, international organisations, etc.). It has been supported and codified by a coherent set of EU regulations which confers clear responsibilities on all actors involved, the management of the network is an essential component of the European ATM system and by extension for HAO which are an integral part of network operations.

Also relevant, in the context of HAO, is the operational interface between aviation and space which requires a new approach that combines national, regional and global perspectives to deliver the intended solutions for the future when the sharing of airspace becomes critical.

Accommodating very high-speed operations, such as space launches and re-entries or hypersonic flights, will require cross-border procedures and system capabilities that are able to deal with non-nominal events that may extend across multiple national borders.

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Matching the operational requirements from all categories of new entrants with the specificities of the European ATM environment is now essential. The creation of this ConOps aims to meet this need.

2.2 Definitions

In order to establish a common nomenclature in support of the future HAO described in the ConOps, the following definitions have been developed:

4D operating zone – The volume of airspace typically used by vehicles associated with higher levels of uncertainties for their movements. It is allocated to one or several specific vehicle(s) and separated from other airspace users. It is a 4D volume of airspace moving alongside a 4D trajectory profile. Inside the 4D operating zone, vehicle(s) are free to operate as required as long as they stay inside the defined 4D operating zone. Separation for vehicles inside a 4D operating zone may be provided by additional separation service providers and/or self-separation capability

Air-launched flights – Flight of vehicle systems the first stage of which is a carrier aircraft able to carry and release a rocket-propelled vehicle, either a single-stage or multi-stage launcher or a spaceplane, intended to perform an orbital or suborbital operation

A-to-A flight – A flight not intended to land at a destination different to (far from) that of its departure

A-to-B flight – A flight intended to land at a destination different to that of its departure

Aircraft hazard area (AHA) – Area used to segregate air traffic from a launch vehicle, re-entry vehicle, amateur rocket, jettisoned stages, hardware, or falling debris generated by failures associated with any of these activities

Air traffic management – (**ATM)** as defined by ICAO, will apply to HA and existing ATS airspace as a continuum. ATM will interface and coordinate, as necessary, with space traffic management (STM).

Ballistic trajectory – Flight path where a vehicle is not able to develop sufficient aerodynamic forces that significantly affect the flight, also referred to as free ballistic flight

Co-located Spaceport[3] – A spaceport located within the area of an aerodrome, such that following coordination it is possible to carry out both suborbital or orbital operations, and non-HAO (i.e. traditional) aviation operations

Co-located Stratoport – A Stratoport located within the area of an aerodrome, such that following coordination it is possible to carry out both HAPS and non-HAO (i.e. traditional) aviation operations

Contingency hazard area (CHA) – Areas of airspace that are defined and distributed in advance of a launch or re-entry operation and are activated in response to a failure

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[3] **Aerodrome** - A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft (ref. ICAO Annex 14)]

Contingency procedures[4] – Pre-defined and pre-planned procedures intended to be applied to safely recover from an off-nominal condition back to a controlled nominal condition

Cooperative flight – a flight the main related information (e.g. operator, trajectory, purpose, etc.) for which is shared with relevant authorities and/or other airspace users

Emergency procedures[5] – Pre-defined procedures intended to be applied to recover from (a failure or) an off-nominal condition, where it is not possible to recover to a normal condition by applying contingency procedures, in order to minimise the severity consequence of the off-nominal condition.

Flight corridor – A pre-defined stationary or dynamic volume, within which a vehicle or a vehicle system is intended to fly, with the required level of probability and confidence

Flight corridor footprint – A pre-defined area of the Earth's surface with defined shape and dimensions, able to contain, with the required level of probability and confidence, any direct or indirect hazardous debris, and hazardous overpressure or other explosion effects, produced by the fall of a vehicle, vehicle system or parts thereof, during the flight phases in nominal and off-nominal conditions

Ground buffer[6] – The safety static or dynamic area at the Earth's surface, sized to contain, with the required level of probability and confidence, any direct or indirect hazardous debris, and hazardous overpressure, or other explosion effects produced by the fall of a vehicle, vehicle system or parts thereof, during the flight phases in nominal and non-nominal conditions

Heavier than air (HTA) HAPS – Motorised aircraft which does not use lifting gas or buoyancy for flying in the atmosphere, intended to operate in the stratosphere

High-altitude platform systems (HAPS) – Aircraft, including UAS, intended to be operated in the stratosphere

Higher Airspace (HA)[7] – A volume of the airspace typically above altitudes where the majority of air services are provided today and where Higher Airspace Operations (HAO) are carried out.

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[4] Examples of contingency scenarios:
- Launch from outside European region goes into non-nominal mode, notification to service providers responsible for areas impacted, scenarios enacted to deviate traffic flows likely to be impacted by debris
- Uncontrolled descent or re-entry (with likelihood to cause severe damage to third parties, etc.)

[5] Examples of emergency scenarios
- Hazardous failure condition that leads to a large reduction in performance
- Explosion and debris generation
- Need to land or re-enter in a non-predefined/pre-planned alternate site

[6] Ground buffer characteristics for mission are considered as possible constraints

[7] In Europe currently these operations are expected to occur typically above FL550 as identified in the ECHO User Requirements Document 4.1. It is expected that this information will be updated once regular operations start.

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Higher Airspace Operations (HAO) – Operations carried out by various types of vehicle systems that operate within or transit through the upper layers of the atmosphere; they include:

- - Supersonic flights;
- - Hypersonic flights;
- A-to-A suborbital flights and A-to-B suborbital flights (including sounding rockets and air launching operations into a suborbital trajectory)
- HAPS, stratospheric weather/scientific balloons, and other subsonic UAS, HALE operations.

In addition, vehicle systems will also transit through and interface with the airspace and will include:

- Orbital operations for access to space (including air-launching operations into orbit)
- And re-entry operations from space

Higher Airspace Operations Service Provider – A service provider responsible for separation services for HAO that are unable to self-separate.

Horizontal spaceport – A spaceport specifically designed to exclusively host horizontal take-off/launching and/or landing/re-entry (HTOL) suborbital or orbital operations

Horizontal Take-Off and Landing (HTOL) – Operations where vehicles systems or parts thereof depart (i.e. take-off or are launched) and arrive on the surface (land or re-enter) horizontally in the final phase

Instantaneous Impact Point (IIP) – A predicted impact point, following thrust termination of a vehicle or part of it, in a specific instant during flight

Launch – Departure of a rocket-propelled vehicle, vehicle system or one its stages, from the Earth's surface or from an aircraft or other vehicle system through the ignition of the rocket propulsion

Multimode spaceport – A spaceport able to host horizontal or vertical take-off/launch, and horizontal or vertical landing/re-entry suborbital or orbital operations

Multipurpose spaceport – A spaceport specifically designed for both suborbital and orbital operations

Orbit – In the context of the CONOPS, an orbit whose perigee is sufficiently outside the Earth's surface, i.e. an orbit able to circle the Earth or to escape from Earth

Orbital operation - An operation intended to place a vehicle system, or any portion thereof, or any payload into an orbit able to circle the Earth (elliptical or circular orbit) or to escape from Earth (hyperbolic orbit), or a re-entry flight. It includes aero-launching operations into orbit and re-entry flights

Orbital spaceport – A spaceport specifically designed for orbital operations only

Orbital vehicle – A vehicle that has capability of executing an Earth orbital trajectory, by entering into an elliptical orbit that circles the Earth or a hyperbolic orbital trajectory that escapes from Earth

Lighter than Air (LTA) HAPS – Airship, motorized airship, or balloons intended to operate in the stratosphere

Launcher – A rocket-propelled vehicle intended to carry out an orbital or suborbital operations.

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Re-entry flight – A controlled flight intended to return or attempt to return a vehicle system, any part thereof, its payload or human being from Earth’s orbit starting from deorbit, or from an outer space orbit to Earth. A re-entry flight starts from deorbit or comes from another space. A flight of a re-entry vehicle system or part thereof from a point inside the atmosphere where the vehicle system or its parts are able to derive control from the reaction of the atmosphere by generating sufficient aerodynamic force is not considered a re-entry flight.

Re-entry vehicle – A vehicle system designed to carry out a re-entry flight.

Re-entry site – Landing or impact site, on land or water, intended to be used for a re-entry of an orbit vehicle on the Earth's surface, including post-landing operations.

Refined Hazard Area (RHA) – Airspace that is defined and distributed after a failure of a launch or re-entry operation to provide a more concise depiction of the hazard location than a Contingency Hazard Area.

Re-usable vehicle – A part of a vehicle system that is reusable for more than one flight or mission. A reusable suborbital vehicle can be part of an expendable system.

Rocket-propelled vehicle – A vehicle or vehicle system propelled by a rocket motor

Spaceplane – A rocket-propelled aircraft, intended to fly beyond the denser layer of the atmosphere where the vehicle is unable to develop sufficient aerodynamic forces to significantly affect the vehicle attitude, its control or flight performances.

Spaceport – A site on the Earth’s surface whose infrastructure, facilities and equipment, as well as its technical requirements, are specifically dedicated to launch/take-off, re-entry/landing, or ground/flight operation of a suborbital or orbital vehicle system. The site is structured to allow all the necessary operations to execute a flight, including related systems maintenance and preparation to flight. With respect to the purpose of operations, a spaceport may be classified as:

- suborbital spaceport
- orbital spaceport, or
- multipurpose spaceport.
- With respect to the take-off/launching or landing/re-entry mode of the vehicle system or parts thereof operated within the spaceport, a spaceport may be classified as:
  - vertical spaceport,
  - horizontal spaceport, or
  - multimode spaceport

Stage – Any powered part of a vehicle system, irrespective of the type of the motor

Stratoport – A site on the Earth’s surface whose infrastructure, facilities and equipment, as well as its technical requirements, are specifically dedicated to high-altitude platform systems (HAPS) operations

Suborbital Flight – The intentional flight of a vehicle, vehicle system or any portion thereof, that reaches high altitudes above those reachable by conventional air-breathing aircraft, and the instantaneous impact point (IIP) of which does not leave the Earth’s surface (i.e. the vehicle is not able to reach and maintain orbital speed around the Earth). A suborbital flight may be either:

a. a flight such that in a portion of the flight path the vehicle is not able to develop sufficient aerodynamic forces to significantly affect the flight (ballistic flight), or

b. a trans-atmospheric flight.

Suborbital operation – The whole set of ground and flight activities related to a suborbital vehicle system, carried out within from/on an identified launching/take-off or re-entry/landing site (e.g. a spaceport), an operator, manufacturer or service provider infrastructure, or in flight, needed to safely and securely prepare and carry out a suborbital flight (including the implementation of contingency and emergency procedures) which does not have the aim to send the suborbital vehicle, any portion thereof or any payload to outer space by placing it on an orbit able to cycle the Earth or escape from the Earth. This includes operations of sounding rockets and aero-launching vehicle systems into a suborbital trajectory

Suborbital spaceport – A spaceport specifically designed for suborbital operations only

Suborbital vehicle – A vehicle or vehicle system intended to execute a suborbital flight

Trans-atmospheric flight – A flight transiting through the atmosphere up to high altitude, in which the vehicle is able to continuously use air-breathing propulsion, or is able to continuously use aerodynamic forces to control the (hypersonic) flight (note: no ballistic phase)

Vehicle – Any object intended to fly in the atmosphere or in outer space. A vehicle may be a system composed of more than one part. An aircraft is a particular type of vehicle

Vehicle system – A system intended to fly in, or to transit through, the higher airspace, composed of one or more vehicles, also generally referred to as stages. The stages of a vehicle system may have different types of propulsion systems

Vertical spaceport – A spaceport specifically designed to exclusively host vertical take-off/launching or landing/re-entry suborbital or orbital operations

Vertical Take-Off and Landing (VTOL) – Operations where vehicles systems or parts thereof depart and arrive on the surface vertically in the final phase

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3 Challenges, assumptions, and principles

In the context of the ECHO project, the challenges, assumptions, and principles listed below have formed a set of guidelines and beliefs agreed between ECHO stakeholders which have been adhered to during the development of the ConOps.

3.1 Challenges presented by new entrant operations

While very limited HAO are supported today by existing ATM processes, owing to innovation the number of operations is expected to grow substantially in the coming years. This will involve different geographical distributions and types of vehicles, ranging from slow-moving HAPS to very high-speed vehicles. New entrants will provide new challenges in terms of flight-performance envelopes, operating at level bands not used today and where their behavior and performance may generate additional uncertainty in ATM. Therefore, the major challenge is to develop new solutions needed for a safe and effective accommodation of the new entrants in the new operational environment.

3.2 Key assumptions

In the context of ECHO ConOps an assumption is seen as something which the project expects to exist now, or which will be established in the future. The key assumptions considered in the project are listed below.

3.2.1 Trajectory-based operations

Operations are 4D trajectory based with all pertinent information being exchanged during the planning, execution, and termination of operations between all involved airspace users and service providers. This will be enabled by different systems being interoperable to permit such exchanges. However, it is acknowledged that space operations, owing to their short transit time in HA, may not require the same level of exchanges than those HAO remaining within HA for their entire mission.

3.2.2 Notification of flight/mission intentions

All new entrants have the capability to notify their flight/mission intentions to the authorities responsible for the respective airspace they will penetrate.

3.2.3 Integration of all operations in national defence/security plans

The real-time plans and operations of new airspace users will be processed by existing systems in order to notify defence security/authorities as necessary. For overflights by state/military aircraft, existing diplomatic clearance arrangements will still be in force.

3.2.4 Higher airspace design

While the sovereignty of each participating State will be respected, it is assumed that from an operational perspective HA will aim to be a volume of airspace which will be free from the fragmentation currently existing in the ATS airspace volume below HA. The design will be driven by the new users' needs, being simple to understand, with operations being easy to plan and operate.

3.2.5 ATM/STM interface

The ATM/STM interface will be determined using elements related to planning, contingency management and traffic management which will take all key factors into consideration. In particular, a single planning process is seen as essential for space operations.

3.2.6 Global operations

Some users are expected to conduct operations in a global scenario. As a consequence, they will be required to comply with regulations, rules, procedures and standards across the globe to enable them to conduct their missions globally. As a first step and as a minimum, this consistency must apply across European States for a given activity type.

3.3 Key principles

In the context of the ECHO project, the principles documented below and agreed with stakeholders have been used during the development of the ECHO ConOps.

3.3.1 Higher airspace

HA with its vast expanse is to be considered as a shared resource. The airspace will be organised and managed in a manner that will accommodate all current and potential new users of HA.

Access to HA must be on a fair and equitable basis. Users will access HA vertically from the current ATS airspace volume below, from space above and horizontally from adjacent regions. Fair and equitable access will rely on a regulatory framework to include safety, security and environmental considerations.

3.3.2 Safety

Operations will be conducted in accordance with the safety regulations provided by authorities. In order to ensure safety, the new entrants' operational behaviour will need to be validated.

3.3.3 Environment

As a key principle HA users should ensure that:

- HAO comply with European Environmental Standards and Requirements; as applicable
- HAO develop in a sustainable way, striving to minimise their environmental impact

3.3.4 Security and defence

The principles for maintaining State security and air defence in HA will be maintained and should be consistent with measures taken in the current ATS airspace below HA. Air defence monitoring by

States of the airspace volume is expected to continue as today as well as military effective and safe access to HA. New means of notification regarding airspace users may be necessary.

All HA required infrastructure for CNS (either ground or satellite-based) will have to be protected against cyber-threats.

The nature of the airspace volume and its users will require cross–border solutions and agreements to ensure security needs.

This concept of operations, including the potential new service providers, operational procedures and technologies shall not impact States role and prerogatives.

3.3.5 ATM and services

ATM, as defined by ICAO, will apply to HAO. The NM functions will apply across existing ATS airspace and HA as a continuum. A new range of services will be offered to exploit new technology for the benefit of the user.

3.3.6 Civil/military coordination and cooperation in HA

In HA, civil/military coordination, and cooperation (as per CDM process) will become a cornerstone for operational stakeholders and the Network Manager. With due regard to future military airspace requirements, based on cutting-edge technologies and performance of a new generation of manned and unmanned aircraft/platforms, civil/military coordination will be a necessary precondition for safe, secure, and efficient flight operations.

The need of States to guarantee their capability to detect and identify any object overflying their territory or territorial waters shall be respected. Surveillance and trajectory data is to be shared with States for security and separation purposes in advance of flight execution.

4 Description of the operational environment

This chapter describes three operational environments, notably the Earth's surface, airspace, and space. These are the environments on and within which new entrants will operate. The chapter provides a baseline description detailing the current situation and immediate developments taking place within the respective environments. It is from this baseline that future changes will need to be identified according to the objectives of the ConOps in the short-, medium- and long-term.

4.1 Surface

4.1.1 Horizontal take-off and landing (HTOL) spaceports

Horizontal take-off and landing (HTOL) suborbital and air-launched orbital operations are expected to be carried out from horizontal and possibly co-located spaceports. A co-located horizontal spaceport is an aerodrome specifically adapted in terms of infrastructure and organisation, to allow within the same site, both aviation operations and HTOL suborbital or air-launched operations. This will be in accordance with the terms of reference of its authorisation or certification issued by the competent national authority, based on European or national regulation.

Air-launched operations are not expected to be substantially different from traditional large transport operations at the take-off and landing site (both for the spaceplane and for aircraft), giving the vehicle the possibility to be fully integrated into the airspace and within the aerodrome. Therefore, the subsequent considerations mainly refer to HTOL suborbital operation at the surface.

To reduce undue duplication that may lead to inefficiency and unnecessary hazards and safety concerns, it is recommended that for a co-located horizontal spaceport site the spaceport operator is also the airport operator, as the ultimate subject responsible for all the operations carried out within the site. If the airport operator and spaceport operator do not coincide, adequate coordination must be granted.

Within the framework of the overall flight operational flow (see Figure 2) the ground activities must support, as necessary, all phases of the operation (e.g., telemetry acquisition, tracking, communication, etc.). In this regard it cannot be excluded that for some specific operations the ground support may include a ground control station (GCS) to remotely command and control a suborbital vehicle or support the suborbital flight, either for the whole course of the flight (e.g., as in the case of an unmanned or remotely piloted suborbital vehicle), or in some specific phases of flight.

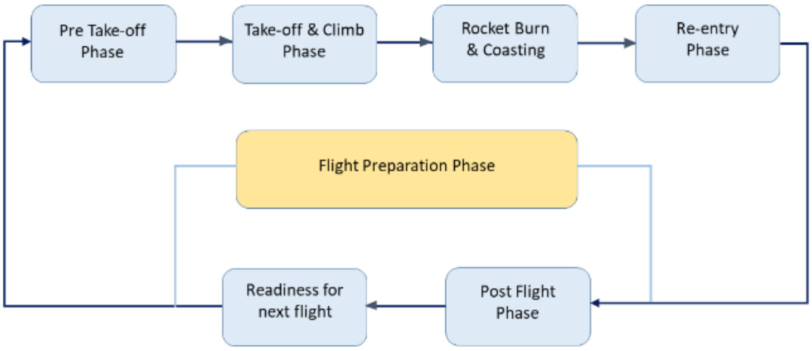

Figure 2 Typical HTOL flight - operations flow

4.1.1.1 Activities and features

The activities expected to be carried out on ground or through the ground assistance are described below for each phase.

a. Pre-launch/pre-take-off

This phase includes specific integration (e.g., clean room assembly), test and checkout procedures to demonstrate that all the vehicle sub-systems and equipment, and all the ground segment is ready to support the intended mission. Security checks, safety checks, health checks and passenger briefing are carried out. The readiness of all the authorities and control centres involved in the flight and the weather and SW (space weather) clearances are also verified during this phase. This phase also includes taxiing operations, (where necessary, for example in the event of captive carry launch); coordination among the Mission Control Centre (MCC), ATM and space traffic management (STM) is required before taxiing.

b. Launch/take-off

In this phase the vehicle starts by taxiing for departure. When engines are ignited at the surface, the related hazards must be taken into account for safety and environmental protection issues. In the event of unplanned situations after launch/take-off, contingency or emergency recovery procedures are implemented in this phase, as part of the Emergency Response Plan (ERP). This plan should cover all possible failures and be integrated in the airport ERP documentation. Coordination between the vehicle operator's MCC, ATM and possibly STM service providers is required.

c. High-altitude flight and re-entry

Continuous vehicle's trajectory tracking, and telemetry monitoring is expected to be performed during this phase. The flight and payload may be monitored and controlled as needed, from the remote MCC on the ground. This also covers the condition of re-entry abort situations where the coordination with local rescue and safety authorities must be assured. In case of anomalous situations during re-entry through the corridors and landing, contingency or emergency recovery procedures are implemented through another published ERP.

d. Landing

The Spaceport must be ready for the landing and re-entry of the vehicle systems' components (e.g., air-carrier and spaceplane) as needed by the specific mission. If they have to use the same infrastructure (e.g., the same runway), close coordination and planning is needed. The ERP must be in place and ready to be activated in case of emergency.

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Due to the large variety of HAO space vehicles and mission profiles, the features of the spaceport infrastructure will depend upon the specific vehicles and operations to be hosted.

In the case of a HTOL A -o-A suborbital flight the overall duration of the operation is in the order of two hours, which is representative of the time slot required for the spaceport infrastructure's availability.

4.1.2 Vertical take-off and landing (VTOL) spaceports

Vertical spaceports are aimed to host vertical launches into orbit or sounding rockets and related vertical re-entry/landing operations. Aerodromes are not expected to host this type of operation, except in specific cases. This type of spaceport needs to be located in an area where all the services and structures can be safely installed.

The launch system consists of two parts:

- Ground segment
- Space segment

The ground segment is named as the "Stage 0" of the launcher, and it is composed of two other parts listed below (collectively known as Launch Base):

- Launch Complex: the set of launch facilities needed for the integration of the launcher elements;
- Launch Range: the set of facilities necessary to ensure safety and security of person, assets, and protection of the environment.

4.1.2.1 Activities and features

Ad hoc ground procedures must be studied for nominal and non-nominal situations. The activities expected to be carried out on the ground are described below for each phase.

a) Prelaunch

This phase includes:

- Assembling the launcher;
- Security and safety checks, health checks and passenger briefing;
- Clean room for preparing payloads (in case of non-touristic flight, e.g., sounding rockets).

At this stage the launcher must be fuelled and all the connections and telemetry systems must be checked. A dedicated manoeuvring system brings the rocket to the vertical launch station.
A meteorological analysis is carried out to be sure that the right conditions are in place to start take-off/launch. The occupants, if any, are boarded and connected to the on-board life-support system.

b) Launch/take-off

Telemetry and ground control room infrastructure must be ready to monitor and control the launcher during flight, as requested. An ERP must be ready in case anomalous situations arise.

c) High-altitude flight and re-entry

In this phase the ground infrastructure and operations must ensure vehicle systems' components and payload monitoring and control function.

d) Landing

For the re-entry of the rocket, the control systems for vertical landing must be activated and the spaceport must be equipped with a platform where it can land. A dedicated ERP must be activated in case of failure of vertical landing.

In case the mission foresees the re-entry and landing on the same site of different vehicle systems' components (e.g., different reusable stages and capsules) close coordination is needed and different re-entry/landing pads must be available and ready.

For the re-entry of capsules with occupants on-board, it will be necessary to bring back passengers from the landing site (possibly at sea) and take them to appropriate facilities where their state of health can be checked.

4.1.3 Stratoports for HAPS

Stratoports are sites for HAPS that are chosen based on the avoidance of weather constraints related to HAPS take-off and landing operations, the avoidance of airspace where significant air traffic exits and preferably in areas of low population density.

HAPS stratoports fulfil four main functions as follows:

- Final integration and testing of the vehicles
- Take-off and landing operations
- Maintenance
- Dismantling HAPS at the end of their life

A stratoport may also include an operational facility for vehicle command and control from the ground to its operating level and return, as well as in the dedicated operational area for vehicle take-off and landing. Integration and maintenance facilities may consist of a hangar scaled to the vehicle concerned. If the stratoport is used by several types of vehicles, e.g. an airship – lighter than air (LTA) and/or an aeroplane – heavier than air (HTA), a specific facility could be devoted to each type of vehicle as follows:

- LTA require large hangars for maintenance, with significant length and height, with infrastructure for lifting gas management for its activities.

- Balloons require less infrastructure for deployment, while a simple hangar or even containers could be enough for storage on the ground.

A stratoport could also be part of an aerodrome in which case it may be referred to as co–located stratoport. Take-off and landing areas might not need the aerodrome facilities such as the runways. Balloons have specific requirements and can be launched from other dedicated areas.

4.1.3.1 Ground control stations and crew

Each stratoport will benefit from a GCS dedicated to the transit of HAPS from ground to the stratosphere and return in the following phases:

- Take-off
- Ascent through the troposphere up to targeted operational level in the stratosphere
- Descent from the stratosphere down to the proximity with the ground
- Landing within the stratoport perimeter, which is the most critical phase for all kinds of aircraft including HAPS

These flight phases are complex and require a crew with the following specific skills:

- Knowledge of atmospheric weather forecasts accounting for HAPS constraints; HAPS are vehicles sized for stratosphere benign weather environment which request specific set of conditions to withstand tropospheric environment (wind and clouds in particular). This skill is specific to the stratoport local configuration, and high expertise is required for this subject.
- An interface with the ground-activity team which physically manage the release from ground, and the capture at return to ground.

4.2 Airspace

This sub-chapter aims to summarise all the elements that are linked to the airspace environment today.

4.2.1 Regulation

Airspace and its regulation across the EUROCONTROL NM area[8] is organised and managed according to global provisions agreed upon at ICAO and complemented by EU legislation for the following:

- EU Member States;
- Non-EU member States that have a bilateral agreement in the field of aviation with the EU;

[8] For the ECHO ConOps the "EUROCONTROL NM area" represents the area for which EUROCONTROL performs the function of the "network manager" as defined by COMMISSION IMPLEMENTING REGULATION (EU) 2019/123

- Non-EU member States that do not have a bilateral agreement in the field of aviation with the EU but they are part of EUROCONTROL convention.

User demand on the airspace is served by this regulation, notably airspace organisation, design, performance and management, all of which form the fundamental building blocks of the European ATM network.

4.2.2 Organisation

The following elements listed below make up the basis of the airspace organisation across the European network.

4.2.2.1 Structure

Airspace is structured according to Flight Information Regions (FIRs) and Upper Information Regions (UIRs) (see Figure 3), Prohibited (P), Danger (D) and Restricted Areas (R), plus controlled and non-controlled airspace. Within controlled airspace, operations are conducted according to the use of SIDs and STARs in the vicinity of some aerodromes, the ATS route network and Free Route Airspace (FRA). This serves the needs of climbing, descending and en-route air traffic (see EUROCONTROL ERNIP Part 1 European Airspace Design Methodology Guidelines).

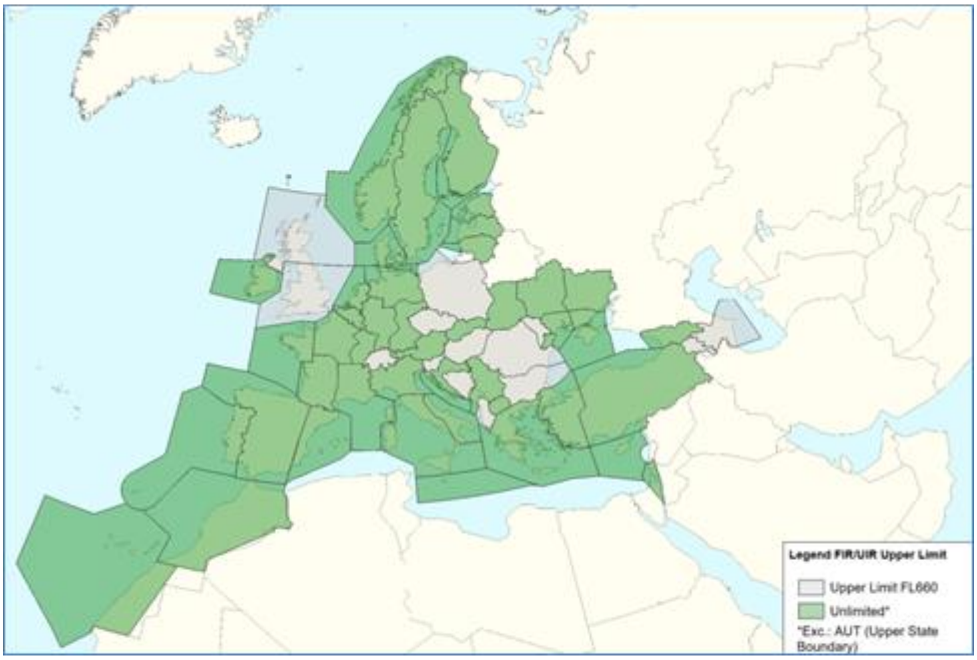

Figure 3 European FIR/UIRs – published lateral and vertical limits as per AIRAC 2204

4.2.2.2 Classification relevant to HA

The classification of the European airspace as Class C above FL195 has been derived from the regulatory requirement for the provision of common procedures by ATC owing to the type and density of traffic above this level (EU Regulation 923/2012 Article 6001 (b)). Where implemented, States have defined the vertical limit of the Class C airspace at FL660. Above FL660 States have published different classifications of the airspace ranging from Class G to no classification at all (see Figures 4 and 5).

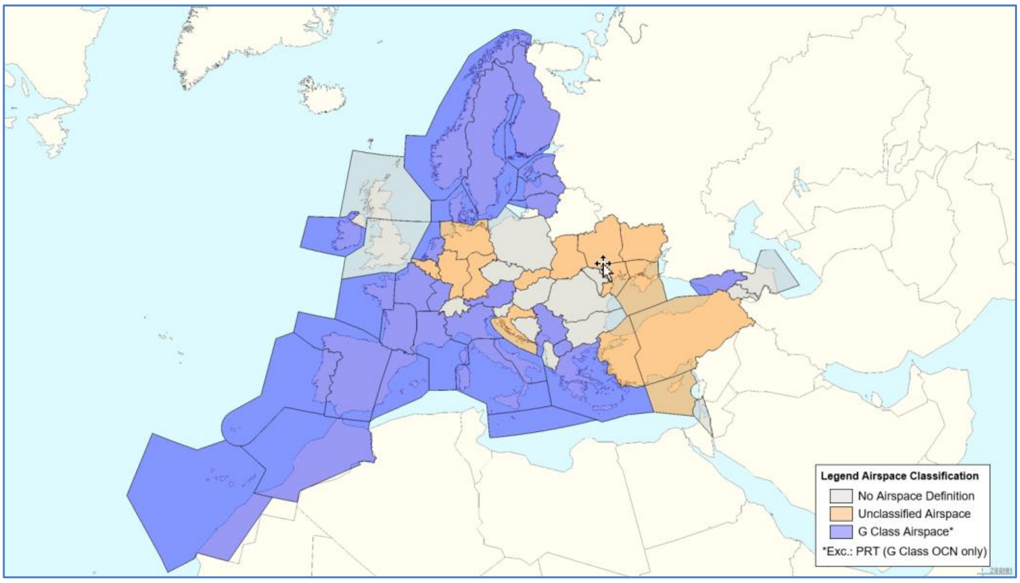

Figure 4 States' published airspace classification above FL660 to unlimited as per AIRAC 2204

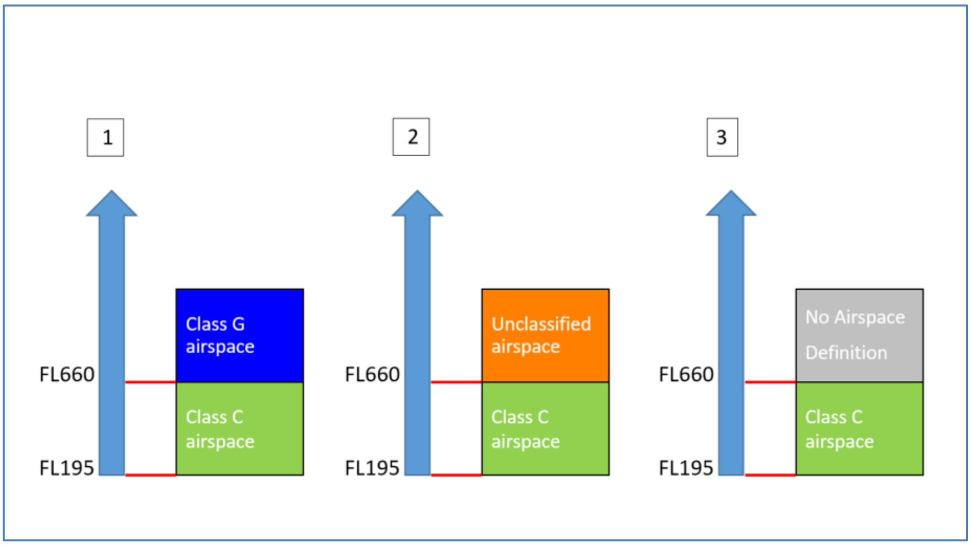

Figure 5 Three methods of current airspace classification as published by States above FL660 to unlimited

4.2.2.3 Airspace management (ASM)

ASM has been well established in Europe for the last 25 years. Its objective is to achieve the most efficient use of the airspace based on actual needs and, where possible, to avoid permanent airspace segregation while optimising the network performance. It is fully described in the European Route Network Improvement Plan (ERNIP) - Part 3 Airspace Management Handbook published by EUROCONTROL.

4.2.2.4 Traffic density and complexity

Within European airspace, traffic density varies across Europe. In the ATM context, traffic complexity refers to the number of simultaneous or near-simultaneous interactions of trajectories in a given volume of airspace. Complexity of the traffic and flows (see Figure 6) have a major impact on definition, scoping and execution of ATS provided in today's airspace environment.

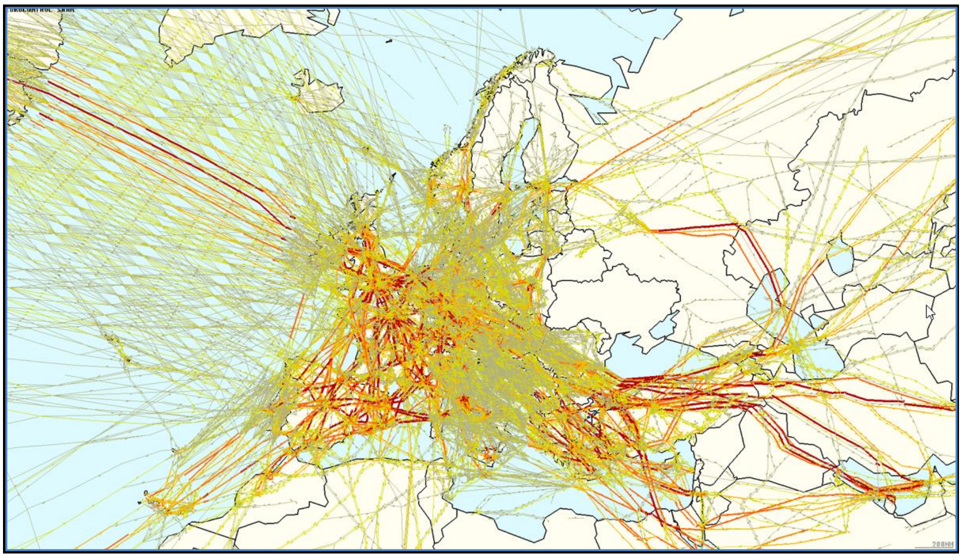

Figure 6 European traffic flows 2022

4.2.3 Provision of ATS

An ATS is provided by more than 60 ACCs and by more than 30 ANSPs where Class C airspace has been published from FL195 up to FL660 (all States except the Republic of Türkiye). Above FL 660 in some States no classification and ATS is published, while some have published Class G airspace to unlimited and as a consequence a basic ATS should be provided (e.g., FIS and Alerting). It should be noted that the current surveillance and communication capability provided by ANSPs above FL660 is very limited or non-existent.

4.2.4 Network Manager and functions

EC Implementing Regulation (EU) 2019/123 of 24 January 2019 lays down detailed rules for the implementation of ATM network functions. Members states and all relevant stakeholders shall execute network functions wherever applicable with the support of the appointed Network Manager. The functions relate to the gate-to-gate management processes associated with airspace management (ASM), air traffic flow and capacity management (ATFCM), air traffic services (ATS), flight planning and synchronisation with airports. Network Management is achieved through a collaborative decision-making (CDM) process involving all participants and is performed, as appropriate, at European, regional, and national level.

4.2.5 The European Aviation Crisis Coordination Cell (EACCC)

Unforeseen events in recent years have demonstrated the vulnerability of the European aviation system for emergency situations within its airspace, in particular affecting safety. One example being the eruption of the Eyjafjallajökull volcano in Iceland in 2010. The level of disruption and impact on the air transport industry was unprecedented and required urgent action at both European and global level. Following this event, the European Union, led by the European Commission (EC) supported by EUROCONTROL, established the European Aviation Crisis Coordination Cell (EACCC). A legal basis was given to the EACCC in Commission Regulation (EU) No 677/2011 of 7 July 2011 on the ATM network functions (under Chapter IV, Articles 18 and 19) which set the requirements for its establishment and responsibilities for the Network Manager to support the EACCC.

4.2.6 Standardised European Rules of the Air (SERA)

Within European airspace and to ensure safe, efficient, and expeditious operations, airspace users are required to adhere to a common set of rules known as SERA. The following examples may require adaption or change:

- Flight Planning
- Avoidance of collisions
- Interception
- VFR rules
- IFR rules
- Unlawful interference

4.3 Space

4.3.1 Space as an operational environment

Space as an operational environment differs significantly from the operational constraints as they apply to airspace. There are no borders and national territories to be considered. Outer space can be freely explored, and no nation or State can restrict another State's lawful access to outer space for peaceful purposes. This freedom is embodied in the primary source of space law, the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, the "Outer Space Treaty". The Outer Space Treaty regulates a balance between rights and obligations. On the one hand, there are the freedoms to use and explore outer space. These are offset by the obligations listed in the treaty. These oblige States to perform certain actions, and they prohibit other inappropriate actions.

One of the main freedoms stated is the free access to space (including the Moon and other celestial bodies). This means that emerging actors in space have just as much right to explore and use space for peaceful purposes as the established space actors.

This becomes even more important nowadays as the space sector is changing very rapidly, both on an industrial and political level. Space has become an area of interest for private companies, entrepreneurs, and investors. The so-called "new space" is a driving development (maturation) in an emerging sector.

The rise of new players and innovative ways of conducting space activities open up new perspectives but also new challenges for the sector as a whole. An important cross-cutting issue in this new era of space is, and increasingly will be, ensuring the safety and sustainability of space activities and securing our ability to deploy and operate systems in space. In addition, space systems are also exposed to a naturally hazardous space environment (e.g., geomagnetic storms, solar radiation, etc.) and increasingly to "man-made" threats. These include both unintentional hazards resulting from human actions (e.g., debris, interference, etc.) and capabilities to intentionally disrupt space systems or services (e.g., anti-satellite technologies, signal jamming, cyberattacks, etc.).

4.3.2 International framework

The Outer Space Treaty is the basic international treaty defining the framework under which operations in space should be performed. The core space treaties were negotiated and drafted by the United Nations (UN) Committee on the Peaceful Uses of Outer Space (COPUOS) and entered into force between 1967 and 1984. [Secure World Foundation, Handbook for new actors in space, 2017 Edition] It includes the Convention on International Liability for Damage Caused by Space Objects (Liability Convention) and the Convention on Registration of Objects Launched into Outer Space (Registration Convention). As there is no state sovereignty in space, the Convention on Registration of Outer Space Objects has the effect of establishing a crucial component of state sovereignty. A State's right to exercise sovereignty over space objects is dependent on that State entering its launched objects in a national registry.

Every State enjoys sovereignty over its territory. Accordingly, the possibility of others gaining insight into what is happening on a State's territory, whether for economic, political or military purposes, is a sensitive issue. To date, no international treaty directly governs remote sensing, but several United Nations General Assembly (UNGA) resolutions established certain principles relevant to this subject.

According to principle XII of UNGA 41/65, which is a non-binding resolution, a sensed State shall have access to the primary data and the processed data concerning the territory under its jurisdiction as soon as it's produced, on a non-discriminatory basis and on reasonable cost terms. This reflects a best practices principle of spacefaring States. Open data-exchange at international level has been upheld especially for global meteorological data and related products, as adopted in World Meteorological Organization (WMO) Resolution 40.

Protection of both terrestrial and space environments is necessary to ensure their continued habitability and usability. Space activities, especially launches, are considered inherently hazardous and risky. Various laws and regulations protect the environment, prohibit certain activities, or specify who is responsible in the event of damage. In addition, there are various principles for protecting the space environment, especially the most useful orbits. On the international level, States are generally responsible for transboundary international harm they cause to other States. Particular to space law, Article VII of the Outer Space Treaty creates the liability rules for space launches and includes liability for launching States causing damage on the Earth or in airspace to other States of the treaty.

Additionally, States are absolutely liable for damage their space launches cause on the surface of the ground, or damage to aircraft in flight. Consequently, while space activities are generally lawful, their ultra-hazardous nature is reflected in this absolute liability regime from the Outer Space Treaty and the Liability Convention. [Quelle: Handbook of new actors in Space].

4.3.3 Characteristics of current space operations

Global space activity has experienced a massive growth since 2013. 5681 spacecraft were launched between 2012 and 2021, which 1849 of those being in 2021 while only 110 spacecraft were launched in average per year between 2000 and 2012.

The numbers in part increased that much through a significant increase in launches of very small satellites, in particular CubeSats, with a mass below 10kg. Therefore, the number of total launches over those years did not increase proportionally.

Other trends such as the entry of new governmental and commercial actors, the noticeable increase in Chinese space activity and major developments across various space segments (launchers, remote sensing, telecommunication, navigation), are profoundly impacting the space arena. The launch of so-called "mega-constellations", starting in 2019 with a number of operators, is expected to bring launch activity to another level. Forecasts suggest that the deployment of mega-constellations, which have already started, will contribute to an even bigger increase in global space activity in the coming years, with 500 to 700 satellites to be launched per year by 2023.

Operating satellites actually account for a very small fraction of the total population of objects currently in orbit. In other words, only a very small portion of the space traffic is actually "operationally useful" or "economically valuable" [Source: ESPI]. After more than 60 years of space activities, space debris is becoming an important and increasingly concerning issue. According to ESA, in 2020 in contrast to about 2,700 operating satellites more than 1,950 discarded rocket stages, 2,850 defunct satellites, 21,000 unidentified debris objects and fragments and more than 34,000 fragments larger than 10cm are classified. Estimates calculate the number of debris fragments of 1 mm - 1cm size to around 128 million.

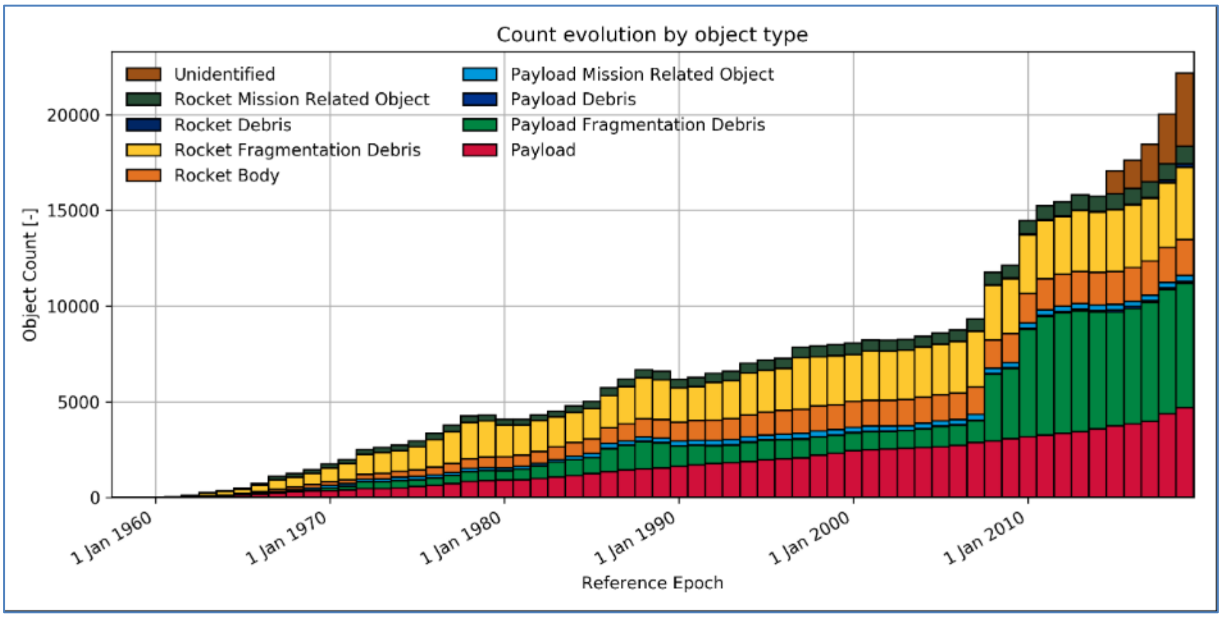

Figure 7 Evolution of the number of objects in orbit (source: ESA Space Environment Report)

A congested space environment naturally creates a number of risks for space operations - in particular concerning collision and interference hazards. An object as small as 5 mm can disrupt or even completely incapacitate a satellite. This means that each debris is a serious hazard to operational systems in orbit, and to astronauts. A collision with a larger object, be it an operating satellite or a large chunk of debris, can be even more disastrous

The risk of collision between two objects in space is complex to calculate and even more to forecast as it is a function of many parameters. There are two different types of collision risks, the risk of collision between two objects of which at least one has the capacity to perform a collision-avoidance manoeuvre, and the risk of collision between two objects that do not have the capacity to perform a collision-avoidance manoeuvre.

The protection of operating satellites from collisions entails the capability to properly detect, evaluate and respond to collision risks. The capability to monitor space objects and to predict and alert about risks of collision is known as space surveillance and tracking (SST) in Europe. It is one of the three pillars of space situational awareness (SSA). [Source: ESPI]

4.3.4 Space traffic management and space situational awareness

Air traffic management (ATM) is defined as "the dynamic, integrated management of air traffic and airspace including air traffic services, airspace management and air traffic flow and capacity management — safely, economically and efficiently — through the provision of facilities and seamless services in collaboration with all parties and involving airborne and ground-based functions". On the other side, there is currently no (broadly accepted) definition of space traffic management (STM). The AIAA STM Working Group describes "The function of Space Traffic Management is to enhance the safety, stability, and sustainability of operations in the space environment. Distinct phases of a space operation are 1) the TRANSPORTATION PHASE, which covers the transportation of persons or objects to, from, or through an orbital domain, and 2) the ORBITAL PHASE, at which a space object is in orbit around the Earth". The core functions of STM are described as "Space Traffic Monitoring – current and predictive assessment of the space operational environment, Space Traffic Regulation – Principles, norms and rules for space operation, and Space Traffic Coordination – Stakeholder working together in an organized way".

STM is not a new topic. Even though no national STM policy framework comparable to the one in the United States has been formally enacted in any other country, it should be recalled that most spacefaring countries have, in fact, already embarked upon various activities that fall within the concept of STM. From those, the three main areas are the building-up and operation of space traffic monitoring functions through the setting-up of SSA capabilities, the development, implementation, and verification of regulations relevant to STM, and reinforcement of efforts in the domain of space traffic coordination [Source: ESPI].

With ATM covering aviation activities within the atmospheric domain, STM is intended to cover all activities related to the space domain. During the transportation phase, covering launch and re-entry operations as well as suborbital flight trajectories, both domains are utilised. During this operational phase, a transition occurs from one domain to the other; suborbital trajectories can make this transition in either direction in a timely manner and may complete an extended portion of their flight in the transition region between the two domains.

This transition makes it necessary to design the operation of a spacecraft in this phase to meet the requirements of both domains. This applies to the operational planning, the execution as well as to the adaptation and reaction to disturbances and events.

5 Managing higher-airspace operations

5.1 Target concept

The **target concept** for managing HAO is based on the principles of collaborative decision-making, including cooperative air situation awareness and strategic cooperative de-confliction which forms part of trajectory-based operations (TBO). The concept will be applied to both **individual vehicles**, flying according to their agreed trajectories, and to **operating volumes**, which are called **4D operating zones**.

4D operating zones in this regard are used by vehicles associated with higher levels of uncertainty in their flight paths (e.g. the operating zone of a quasi-stationary HAP to fulfil its mission over an area of interest). The 4D operating zone is allocated to one or several specific vehicles and is separated from other airspace users. For operation in HA, a 4D operating zone can therefore be equivalent to a dynamic airspace reservation, where size and duration is determined through a CDM process. The 4D operating zones encompass key elements of the SESAR Dynamic Mobile Areas (DMA) type 3 concept, its describes a vehicle-centric area with defined lateral/vertical dimensions, described as a 4D volume of airspace moving alongside a trajectory profile, which can be activated and de-activated during specific timeframes. As for the DMA type 3, the 4D operating zone is "attached" to a vehicle in charge of sharing its real-time flight data. Specific to the 4D operating zone is its capability to be expanded dynamically by additional vehicles joining and potentially extending its volume or to have multiple 4D operating zones merging into one. Separation between a 4D operating zones and other traffic (in ATS airspace) is ensured by ANSPs in controlled airspace, while separation services for vehicles inside a 4D operating zone may be provided by additional separation service providers (see 5.1.2.2 and 5.1.2.4). Outside controlled airspace, a combination of strategic de-confliction, cooperative traffic management and self-separation capability will be applied.

Operation in HA is carried out in an airspace considered to be unified and non-fragmented with limited segregation, only associated with the operational needs of specific HA users, taking into consideration the characteristics of overflown areas in terms of ground and air risks.

The airspace of Europe, including HA, is designed as a continuum that is flexible and reactive to changes in response to all airspace users' needs. HAO include the transit through ATS airspace, where the required level of safety for all airspace users is maintained.

The objective of the target concept is to outline solutions on how to enable a mix of operations with a large variation of velocity in the trajectory profiles between vehicles. The concept makes use of the established strategic, pre-tactical and tactical ATM planning horizons.

5.1.1 Planning phase

Pre-flight, operators share their flight intent via extended flight-plan information. Operators provide their desired 4D-trajectory (from point of departure to arrival, which also can be the zone of operation or the space entry point, the position at which the vehicle enters the space domain) together with any other relevant information for the safe execution of the operation. This information is incorporated in the network planning process. The network planning process will coordinate the request with other trajectories. Operators will receive information from supporting services providers e.g., weather, space weather, population density and aeronautical information that are relevant to their flight intent, and information about environmental constraints relevant to the planning and execution of their flight.

Based on all information exchanged with the Network Manager, the operator supports a continuous collaborative decision-making process within the planning phase. The NM will coordinate this requested trajectory with other planned trajectories and airspace constraints. As part of this coordination, the Network function may look to balance the desired trajectory flows and initiate a trajectory negotiation. This negotiation will take place with the stakeholders concerned to find the best trajectory to meet the operator's needs. The negotiation and coordination process follows a set of agreed-upon rules that also apply to resolve conflicts of interest and competition between operators.

Flight planning also covers the transition from ground to HA and vice versa, requiring adequate planning for transiting ATS airspace. Based on the vehicle class and type, its certification status and flight-performance capabilities, transition has to be carried out either in segregated airspace volumes or as a cooperative airspace user. A separation service is provided to HA operators during transition of ATS airspace by ANSPs based on the requirements for the described type of airspace integration.

Before the start of the planning phase, it has been determined if a flight will require **airspace segregation** or if it can be handled by its 4D-trajectory. An airspace segregation might be either a **static airspace volume** activated at a specific time and duration or a **dynamic airspace volume** representing the amount of uncertainty associated with this specific type of operation. The dynamic airspace volume describes a volume of airspace of defined dimensions, which forms an integral part of a mission trajectory and has been agreed upon in a CDM process which satisfies the airspace user's requirements.

Vehicles able to interact with other traffic as a cooperative airspace user are integrated, addressing applied TBO trajectory planning, control, and surveillance processes, including the usage of the buffer zones provision. Specific equipage of avionics enabling a separation standard might be necessary based on vehicle (category) specific capabilities. Certain prioritisation requirements, e.g., for vehicles operating in the glide phase of flight without power, might arise.

During pre-flight planning operators must assure notification and authorisation of their flights depending on the vehicle type they are operating.

5.1.2 Execution phase

5.1.2.1 ATS airspace transition (ascent to and descent from HA)

Launch and take-off of a vehicle intending to operate in HA or as well as re-entry and landing from HA is performed in accordance with the accepted and maintained flight plan, following the constraints applicable for the first or final phase of flight based on the agreed trajectory.

Separation is ensured by ATC based on established separation criteria using available surveillance information and information provided by the operator. Separation criteria are dependable on the vehicle class and its associated performance capabilities.

Typical ascent and descent trajectories vary between vehicle classes. During execution, the agreed trajectory is used by the operator. Based on deviations in environmental or performance conditions or operator intent, the agreed trajectory may be updated. If those updates require modifications to constraints or an optimisation of the flight, a revision of the agreed trajectory might become necessary and trigger an in-flight trajectory negotiation process.

In case of an emergency, predefined emergency procedures are activated (e.g., the emergency response plan on side of the operator). They are specific to the emergency or contingency, based on the vehicle category involved and the traffic situation as a whole.

5.1.2.2 HA operations

Operations in the HA are conducted based on the agreed trajectory or 4D operating zone, acting as a dynamic airspace reservation. Size and duration of an airspace reservation is determined through a CDM process between the relevant operational stakeholders and the NM. Long endurance flights or possible uncertainties during the operation may lead to a requirement to modify the flight profile, leading to an evolution of the agreed trajectory or 4D operating zone until a definitive revision becomes necessary. If the operators flight intent changes (e.g., on changed or modified mission requirements) it generates a new desired trajectory which ideally considers existing operational constraints and resource contentions or otherwise engages in collaboration on the trajectory or 4D operating zone.

One specific operational constraint is separation requirements regarding other planned or executed HAO. Those separation requirements are defined specific to the vehicle class.

Strategic de-confliction is applied as far as possible to ensure conflict-free flight execution of operations in HA already through the planning phase. This includes a variety of airspace route structures such as entry/exit routes for hypersonic flights, launch/re-entry structures for space operation or dynamic airspace volumes for HAPS. Consideration should be given to the complexity of certain operations, where there may be multiple items with their own trajectories (i.e. commercial rocket launch, where multiple stages and fairing elements can generate individual trajectories).

If de-confliction through regularly updated coordination measures cannot be achieved, collision-avoidance procedures must be applied. Collision-avoidance procedures are standardised but vary for the different vehicle categories based on their performance and maneuvering capabilities. For certain vehicle categories, active collision avoidance is limited due to the nature of their operation or performance limitations. Therefore, the execution of collision-avoidance maneuvers is also dependent on the conflict partner and its categorisation. The separation requirements applied at strategic de-confliction will consider necessary safety buffers between critical vehicle category combinations to avoid situations where conflict resolution cannot be achieved as both vehicles would no longer be able to maneuver accordingly.

When strategic de-confliction is no longer possible**, tactical traffic information and monitoring**, as part of ATM services, may be required to support operators in their separation provision task or provide a separation service for HA users that are unable to fulfil a separation task for themselves. This service may be provided by a **higher-airspace operation service provider (HAOSP).**

Inside the 4D operating zone reserved for HAO operations (e.g., HAPS, focusing on low-speed vehicles which are capable of self-separation), solutions may be used to avoid collisions using AI, machine learning or other evolving technologies which use information-sharing to enable safe operations within the reserved airspace. Furthermore, once the protective volume has been established, the organisation and management of the operations is the responsibility of the agreed entity through the planning process. The HA vehicle has the operator responsibility for the evolution of the 4D operating zone over time and providing the information to all stakeholders. It ensures the provision of required services for all actors operating inside the protective airspace volume. In addition, the responsibility for separation management and collision avoidance is clearly allocated to a specific actor based on the individual capabilities of the vehicles.

To maintain consistent situational awareness and predictability of operation, operators provide changes to their intent, enrich surveillance information where necessary by additional information (e.g., telemetry data), maintain awareness of their operational environment and flight intent of other operators and participate in collaborative coordination measures.

Systems are supporting the management of trajectories, the coordination process, and the provisions of information necessary to monitor, revise and update flight planning. Those systems are designed under consideration of interoperability and use established data-communication formats based on System Wide Information Management (SWIM). This includes sharing of intent information, flight-information updates (supporting real-time separation management) and airspace configuration and constraint information. Additional information that supports flight safety like weather data, atmospheric environment information or space weather data is provided through additional services.

5.1.2.3 Civil-military coordination

Civil-military coordination is the final stage, preceded by collaboration and cooperation between civil and military authorities, operational stakeholders, and the NM. While collaboration entails the long-term planning and development of future global aviation systems and cooperation addresses more practical mutually agreeable optimised solutions in the pre-tactical phase, the coordination refers to the real-time exchanges of information and joint tactical decisions at operational level.

Given the nature of military operations, HAO requirements may vary and depend on the type of mission and the flight characteristics of the manned/unmanned aerial vehicle used. For Security and Defence reasons some missions in HA, imply limited and/or restricted exchange of information, as it is practiced in the ATS airspace. However, the information provided reaches the sufficient level to enable a thorough and complete situational awareness. This permits the continuity of the civil/military collaboration, cooperation, and coordination to ensure together the safe separation and timely avoidance of other vehicles operating in the same volume of airspace.

It is more likely that missions are flown in segregated airspace to ensure safe separation. Such airspace reservations may appear overly large, where vehicles require flexibility to maneuver or to disguise the details of their operating parameters. In order to avoid this problem, the creation of a “trusted agent” to enable a discrete method of military operation should be considered.

Exploiting the same airspace resource by civil and military operational stakeholders applies in HAO. This is achieved by using the same mechanisms for the allocation and use of airspace. New airspace design principles cater for a higher level of dynamism and flexibility combined with new automated functions of their support systems making it easier to optimise the performance of the entire network. Advanced system capabilities provide a new seamless interface between military and civil actors in the HAO and use of SWIM profiles to exchange information.

Collaborative decision-making (CDM) applies in HAO as an integral mechanism of civil-military cooperation/coordination that enables optimal solution-making at the planning stage and joint tactical decision-making at the execution stage, taking into consideration the preferences and priorities of civil and military operational stakeholders.

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5.1.2.4 Operations at the lower boundary of HA

The lower boundary of HA is not necessarily defined as a fixed level throughout European airspace. Certain types of HA vehicles operate at levels where other types of traffic routinely operate. For example, nominal trajectory profiles of balloons or HAPS might require operation potentially down to FL550 (e.g., night time battery drain prevention for solar-powered HAP). On the other hand, conventional aircraft may reach altitudes above FL550 (e.g., high-performance business aviation) but participate in HA only via a specific trajectory coordination process and are not considered HA vehicles. Supersonic flights may as well operate on trajectories that also utilise a similar level band.

There are several challenges associated with such a traffic mix. It is likely that the more challenging aspect refers to operations in classes of airspace designed and managed for conventional IFR traffic. It is highly probable that there are different minimum equipment requirements based on airspace classes (currently Class C in European airspace up to FL660) and changes between air traffic control procedures/services could apply. All this while a wide range of vehicle flight performance and manoeuvrability must be considered.

High-altitude vehicles which need to operate at the lower levels require a dynamic airspace to ensure separation management. This requires the establishment of a 4D operating zone for the HAPS, while the IFR traffic are cleared on flight paths to ensure separation assurance. Rules are established for priority of the different operations. The access through airspace where both operations are foreseen to interact is strategically managed through CDM processes. This will ensure that the vehicles are appropriately separated. It should be noted that at these lower levels there may be additional constraints placed on these 4D operating zones such as the boundary limits, volume, and time availability of airspace, to ensure that safety, capacity, and performance of the ATM network can be maintained.

The responsibility for tactical separation within the 4D operating zone is allocated to a recognised entity. This entity may not be the service provider managing the IFR traffic. Separation assurance of IFR traffic against the 4D operating zone is the responsibility of an ANSP.

Clear procedures for non-nominal situations are developed in case a vehicle exits a 4D operating zone unexpectedly. The controlling entity of that 4D operating zone is to inform the responsible ANSP managing the airspace around the zone. Appropriate contingency procedures are developed to protect the IFR traffic which could be in conflict with the malfunctioning vehicle.

5.1.3 Integrated space operations

Operation of vehicle categories using the atmospheric and space domain during its mission are in need of harmonised and interoperable traffic management. Such HA vehicle categories have specific interfacing requirements with operations outside HA, as they not only transit through ATS airspace but also enter the space domain. During launch and re-entry of space vehicles, a transition occurs from one domain to the other; suborbital trajectories can make this transition in either direction in a timely manner and complete an extended portion of their flight in the transition region between the two domains.

5.1.3.1 Synchronisation between the aviation and space domains

When the operational profile of an HA vehicle and the flight intent of its operator result in a trajectory extending beyond HA and enters the space domain, it requires not only separation from other operating vehicles in ATS airspace and HA, but also from active and passive space objects. During the planning phase, the operator extends the coordination of its intended trajectory beyond ATS airspace and HA, using services provided by STM or other additional service providers.

During the planning phase, the planned trajectory, together with the airspace restrictions associated with it, is reviewed for its impact on the operation of the ATS network. This coordination is done together with Network Management (NM). As part of this coordination, the NM may look to balance the desired trajectory flows and initiate a trajectory negotiation (as described in 5.1.1). In this process, mission requirements must be coordinated and reconciled with the impact of operations on other traffic. The mission requirements should be achievable with as little impact as possible on the mission requirements of other users and the entire European network.

The planning of the re-entry of a vehicle from space takes place as part of the flight-planning process. Here, the various vehicle and mission-specific constraints must be considered. The re-entry of a space vehicle may already be part of the initially planned flight trajectory (for example for suborbital flights A-A or A-B as well as for parts of the launch system like single rocket stages). However, the re-entry of an orbital or interplanetary mission can also take place after a considerable time; its exact time can be determined only in the course of the mission and depend on various boundary conditions. Planning of re-entry operation considers the aspect of limiting unnecessary interactions and impairment of other traffic participants and is thereupon likewise reviewed and co-ordinated with Network Management. It is considered that the flight phase of the re-entry is irreversible after it has been initiated and that the resulting flight phase can be associated with the need for prioritised execution.

Within the execution phase, deviations from the planned trajectory must be checked for their impact in both domains and appropriate measures must be initiated with the help of the respective processes of ATM and STM. STM service providers maintain situational awareness and support the vehicle operator through means of SSA. Potential non-nominal behaviour must already be taken into account in planning and evaluated within both regimes with regard to ensuring the required safety margins.

5.1.4 Specific integration measures for HA and ATS airspace

Specific HA vehicle categories as space vehicles during launch and re-entry or A-A/A-B suborbital vehicles may operate with authorisation that requires efficient segregation procedures, maintaining safety requirements and protecting other airspace and space users. Areas along their flight trajectory, for which sufficient levels of safety cannot be assured by other means, will be segregated as the vehicle moves along its trajectory through this airspace region. Further along its flight trajectory, the vehicle is separated from other airspace users by operating within a 4D operating zone which also considers the level of uncertainty associated with the individual type of operation. Below their flight trajectory, airspace regions that would be endangered in case of non-nominal situations, but which can be cleared of other airspace users on time to prevent any collision with resulting debris are protected by dynamic aircraft hazard areas (AHA) using real-time monitoring and data-processing capabilities. Dynamic AHA complements the use of 4D operating zones and DMAs to separate the operational volume of the vehicle itself.

The use of 4D operating zones covering the operating space vehicle in real-time (e.g., through adaptation of the concept of DMA to the physical and operational requirements of launch and re-entry operation) minimises the need for static airspace closures and thus airspace segregation. This is achieved based on the real-time provision of all necessary information to all involved stakeholders allowing dynamic adaptation to non-nominal events, supported by higher levels of automation.

The potential effects of space-related operations can only rarely be limited to a single region owing to their physical execution characteristics. They therefore need to be coordinated on a trans-regional to partially global basis. To support operations with trajectories that may have such trans-regional impacts (including effect of non-nominal events), a network-wide management architecture is provided. It captures space-related operations from planning through execution to post-operational assessment. It furthermore coordinates the provision of the necessary information for safe flight execution in advance of the mission as well as during its execution, to all stakeholders involved (including all potentially affected ANSPs). This architecture and the systems connected to it are essentially linked to the required contingency management and in this context also ensure the link to the European Crisis Management Cell. This is particularly necessary for events that have a transnational and supra-regional character and cause impacts on the European air traffic network. In addition to planned and controlled space operations, these mechanisms also apply to unplanned, unforeseen events also in the event of uncontrolled re-entry events, provided that their impact on air traffic can be limited on the basis of sufficiently reliable forecasts.

Since the information required to plan the safety aspects associated with the aforementioned operations must access data, some of which is sensitive, the management architecture is subject to a framework for handling and sharing confidential information. The operational interface is closely linked to the elements of civil-military coordination.

5.2 Stakeholders and roles

HA operation involves several stakeholders who may assume different roles during the planning and execution of flights.

5.2.1 HA vehicle operator

The HA vehicle operator is responsible for carrying out the flight of a vehicle that operates within HA. This includes all the different categories of vehicles using or traversing the HA for their operations. It may be a person or an entity. Launch and Re-entry Operators (LROs) also fall under this category. The HA vehicle operator's area of responsibility includes all tasks to meet regulatory requirements, to plan and carry out operations, to provide and use all necessary information in exchange with other stakeholders and to ensure the safety of the operation of one's own vehicle.

HA vehicle operators may be responsible for civil, State or military operations.

5.2.2 ATS airspace users

An ATS airspace user is distinct from a HA vehicle operator against the background of the operation described here. The ATS airspace user does not intend to operate in the HA itself, but interacts with HA vehicles as an airspace user, be it during their ascent or descent within the ATS airspace or within the transition zone in the border area of the HA.

5.2.3 Air Navigation Service Provider

An Air Navigation Service Provider (ANSP) provides services related to the safety and efficiency of HA vehicles during transit through ATS airspace and for managing HA operations in relation to IFR traffic at the lower boundary of HA in coordination with the HAOSP.

5.2.4 Higher Airspace Operation Service Provider (HAOSP)

A HAOSP may provide services related to the safety and efficiency of HA operations.

An HAOSP:

- Is responsible for operating systems supporting ATM;
- Provides a coordinating role within the collaborative decision-making process of trajectory negotiation;
- Monitors conformance with agreed trajectories;
- Supports the operator in its separation provision task or provides a separation service for HA users that are unable to fulfil a separation task for themselves;
- Coordinates trajectories between HAO and ATS operating airspace users in collaboration with the responsible ANSP.

5.2.5 Network Manager (NM)

The NM performs the network functions as described in 4.2.4 across the entire continuum of airspace.

Where necessary, at the request of its stakeholders, NM may adapt and add capabilities to meet the operational needs of HA stakeholders and its interfaces with ATS airspace, adjacent HA volumes and STM. The NM will operate within its defined role to support ANSP's, authorities and other relevant operational stakeholders (e.g. space agencies) relevant for global safe and efficient HA operations.

5.2.6 Support services providers

Additional support services providers offer information to support the planning and execution of missions, improve their predictability and provide means to maintain situational awareness. They may primarily address the needs of vehicle operators, but also HAOSP, ANSPs and/or the Network Manager. Such services include (but are not limited to) weather information, especially for the HA environment, space weather, surveillance information derived from alternative sources (e.g., space-based ADS-B reception), historical databases that may help predict environmental and flight conditions or traffic demand.

5.2.7 4D operating zone separation service provider

Inside the 4D operating zone, separation provision, conflict detection and collision avoidance are to be provided by a dedicated service. This could be implemented either by an airborne function or a dedicated service provider (e.g., HAOSP).

5.2.8 Regulators and authorities

There may in the future be different entities acting as regulators or competent authorities distributed between the EU/EASA level and the Member States also depending on the types of HAO.

6 Development and implementation roadmap

This chapter aims to describe the high-level development and implementation roadmap linked to the ConOps. It avoids specifying a specific chronological timeline but acknowledges that full implementation is likely to be conducted over the time phases described below. It also recognises that in today's economic climate the principle of building according to demand, while staying ahead of the trend to ensure users' needs are met, is likely to be the most practical approach taken by stakeholders during implementation.

6.1 Short term

The pioneers comprise launches to space (sub-orbit and orbit) from spaceports, or from aircraft in flight, and the introduction of new vehicles conducting operations in the stratosphere (e.g., between FL550 and FL700). In the short term the main issues concern the transit of ATS airspace and a favourable weather window to conduct operations. From the ATM perspective, there is a requirement to accommodate these operations on a mission-by-mission basis on the day of operation. Specific preparation and bilateral briefings are required ahead of the start of the operation for setting the strategic objectives for the mission. Furthermore, once the vehicle is in flight, the contact between ATC and the operator is based upon infrastructure such as a direct telephone communication for the tactical coordination to take place and for surveillance a transponder and ADS-B technologies.

Once above ATS airspace, typically above FL550, where a full ATC service may no longer be possible and depending on the level reached, surveillance means and tracking is limited or non-existent, the operator is then free to navigate and to monitor the flight by its own means. However, it is assumed that since FIS may be applicable, communicating position and flight intentions regularly by the operator through a periodic reporting contract, based on the average speed of the vehicle, will be possible.

The transit of space launches and re-entries are coordinated between the relevant regulators and authorities, space agencies/operators, the Network Manager and the ANSPs and where applicable STM service providers.

It is assumed that the short term represents the accommodation phase of HAO and is focused on securing initial processes to be implemented with the pioneers. Infrastructure requiring security, i.e., the telephone link, automation of the reporting contract and the reception of surveillance data for visualisation on ATC displays for the ATS airspace transit are key elements. Provisions for the management of contingency procedures for non-nominal events are also considered and implemented. In addition, it is assumed that basic data and information from any new airspace user (civil, military, experimental, HAPS, space launches or re-entries, Unmanned Aerial Systems -UAS) are made available with flight intentions and flight monitoring to ATC. However, these elements are neither enough for developing a conflict probe function nor offer a de-confliction service. The dynamic segregation of the pioneers and the application of the flexible use of airspace will remain the best tools for managing the operation and airspace safely in the short term.

6.2 Medium term

As the number of operations steadily increases in the European ATM network, new entrant operations become more and more common practice. The experience gained from pioneer operational trials and initial deployments is incorporated into harmonised operational procedures and ground system upgrades.

The transition from accommodation of pioneers to converging to a more integrated manner of operating will mean that new entrants will be supported by several developments including but not limited to the following:

- Significant progress of the regulatory framework for HAO
- The launch and successful conclusion of airspace organisation projects with a view to ensuring that airspace above FL550 is designed and managed where fragmentation is avoided
- Development of harmonised operational procedures that clarify roles and responsibilities with assignment at national, regional, and global level
- Adoption of new, more advanced airspace management techniques, e.g., 4D operating zone concept, which significantly improves the utilisation of airspace between all categories of new entrants
- Deployment of local solutions to ensure maximum flexibility of airspace whilst not compromising the harmonisation and future development of a unified airspace block for HA
- Where necessary, revision or adaptation of the rules of the air according to HAO and vehicle capabilities

From a traffic perspective, supersonic operations have returned to the European ATM network as routine operations. Commercial space operations from spaceports located within the geographical area of the EUROCONTROL NM area, and its neighbouring regions, will be routine occurrences. The missions to meet the need of LEO satellite deployment and maintenance continue, while suborbital space tourism is operating from Europe to the maximum extent possible to meet demand. The operational interfaces between the Network Manager, ANSPs, space agencies and other relevant authorities will have been defined and implemented. Exchange of data relevant for launches and re-entries will have been largely automated, scenarios for specific actions in cases of non-nominal events are developed and adopted by relevant actors. HAPS operations are conducted routinely over entire FIRs and self-separation methods are being employed within dynamic airspace volumes that separate them strategically from other participants in traffic either in HA or in ATS airspace.

Crucially, the network planning for airspace usage includes checks that all operations and processes are in place to ensure global coordination with operators that are launching from outside the EUROCONTROL NM area.

Civil-military coordination will have developed bespoke procedures to ensure that new operational scenarios for very high-speed operations are addressed. Key decisions relating to the security and safety of the European ATM network are taken based on clear responsibilities at State and regional level with all actors subscribing to the principles of flexible use of airspace. Interoperability, systems infrastructure usage and other relevant aspects required for seamless operation and civil-military cooperation will have included specific aspects related to new entrants' operations.

Management of scarce resources and other specific Network Management functions will include the entire spectrum of new entrants' operations. The adaptation of systems required to support network operations to complement ANSPs and non-aviation actors, such as space agencies, will have progressed significantly to the point where space data integration into ATM systems has become the norm.

Based on lessons learned from operations such as what type of services are needed in specific volumes of airspace above FL550, progress has been made in understanding what airspace classification would be better suited to the European operational environment. Hard data from operations is driving the refinement of airspace organisation across States, which, coupled with smart service provision assignment, will ensure Europe offers seamless services across vast functional airspace blocks evolving ever closer towards a unified HA volume.

6.3 Long term

The target concept described in Chapter 5 will be phased in according to traffic demand and represents fully integrated operations. The concept will need to remain scalable, sustainable, and robust until such time as operations prove that an alternative concept is required. The long-term vision is described below:

- The HA traffic will reflect the following characteristics:

- Traffic levels lead to extensive use of HA leading to significant density and complexity in some locations requiring demand and capacity balancing by the NM
- Access to space happens on a daily base, from multiple locations worldwide including multiple European States. Missions will support the deployment of satellites and their maintenance. The transport of passengers to orbital space stations for tourism has become popular: pioneers start establishing communities on the Moon and Mars while space-debris cleaning vehicles and services are finally making inroads into reducing the hazard that debris poses to the whole community and its development
- Transcontinental suborbital hypersonic A-to-B flights are available, offering two-hour flights from Europe to Australia
- Fleets of HAPS fill the stratosphere, finally achieving the wide-scale operations they were designed for, either over single locations for months at a time or moving from region to region on specific tasks allocated tactically. Free balloon tourism has now reached a level where a day can now be spent at the Stratopause by small groups of people from multiple locations across Europe.

- Operations are conducted as follows:

- HAO are seamlessly integrated with ATS airspace below and above HA
- HAOSP have been assigned for designated volumes
- Airspace reorganisation has delivered an un-fragmented, continuous HA
- TBO implementation is ongoing and has reached a level where trajectories are shared, maintained, and used for CDM, complemented by dynamically managed 4D operating zones
- Use of desired airspace is negotiated and ensured while being highly automated

- Improvements in technology have facilitated the following:
  - HA platforms, suborbital spaceplanes and reusable space transportation are all a reality
  - Supersonic and hypersonic transport is common with flight over land and sea

Figure 8 Long-term vision — full exploitation of HA and integration of operations

7 Enabling infrastructure

7.1 Information management

The future architecture of European airspace benefits from digitalisation which is one of the key objectives of the Single European Sky and will be applicable to HAO and HA (see Figure 9).

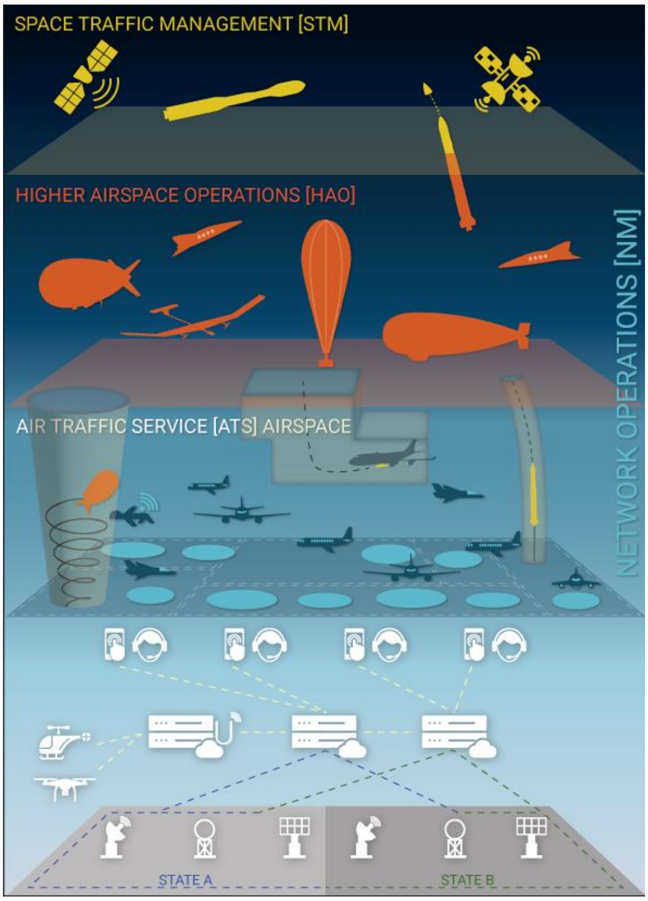

Figure 9 Future configuration

In the future, in line with the expectation of the aeronautical community, the new concept of System Wide Information Management (SWIM) moving ATM from system-centric to information-centric operations will be developed.

In support of the interoperability required for HAO, SWIM allows seamless information access and exchange. It permits the establishment of the 'intranet' for aviation and access to the right information at the right time by all ATM stakeholders in support of the decision-making process (see Figure 10).

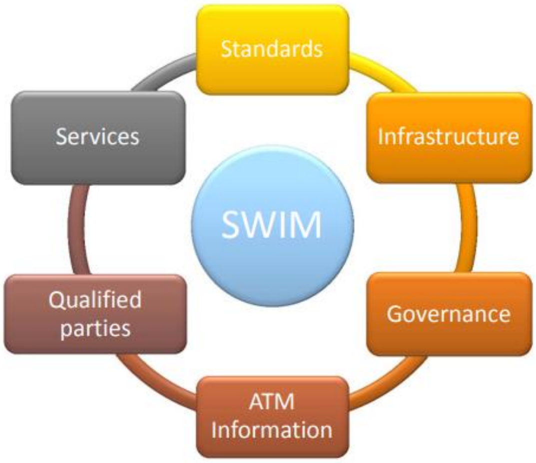

Figure 10 SWIM Global Interoperability Framework

SWIM brings standards and best practices in information technology including service-oriented architecture, lowering integration costs, enhancing architectural flexibility, lowering complexity and maintenance costs.

The implementation of SWIM for HAO is achieved by the implementation of SWIM services, which enables participating organisations to automate the exchange of information based on mainstream technologies and ATM widely adopted information exchange models.

A data exchange provides the required information to the planning functions of ATM via SWIM using the Flight Information Exchange Model (FIXM) that covers the necessary parameters. The NM intends to deliver the flight planning and flight data exchanges as required within the European ATM Master Plan. In addition to these regional plans, global developments — notably FF-ICE and FIXM — will provide enabling steps towards TBO.

7.2 Communication

Communication among involved stakeholders of HAO will act as a key enabler for ensuring safe conduct of the flight. Several communication solutions are applicable. Satellite communications can play a fundamental and unique role to offer the secure and reliable connectivity required for safety-related communications, with a wide coverage including HA where ground-based systems are less effective.

SatCom systems for ATM in HA will be required to support the most demanding aviation services (i.e., Full 4D) in the Future Communications Infrastructure (FCI) for the long term.

Efficient and stable communication channels are the bonds that ensure aviation operates efficiently, predictably, and safely. They ensure that information is exchanged efficiently among involved stakeholders. In order to increase efficiency and capacity, the aviation community is progressively digitalising its data exchanges — replacing or enhancing legacy communications systems.

All frequencies allocated for communications must be protected from interference. Air-to-air communications should enable HA platforms in flights out of range of VHF ground stations to exchange the necessary operational information and to achieve flight-centric solutions; this will be reliant on the available spectrum.

It is assumed that datalink communications will also be available initially on the basis of CPDLC. In the future a move from voice to full datalink communication may be envisaged.

Dependent on the speed of the vehicle in the proposed airspace and the characteristics of the HAO, a voice communication channel must be defined to take into consideration high-speed vehicles and the Doppler effects.

Ground-ground connectivity with HA operators, in direct connection with the platform/vehicle, can be leveraged to ensure exchanges (e.g., position reporting as an alternative means for cooperative surveillance) among interested parties.

7.3 Navigation

Navigation is a key enabler of aviation, involving sophisticated technology to locate where an aircraft is and to get it to its destination — laterally (the aircraft must follow the route centre-line); vertically (the aircraft must remain at the right altitude, even on a slope), longitudinally (being over a particular point within permitted margins) and temporally (reaching a point within a particular time).

The navigation Instructure provides the inputs required for the on-board system to compute a position that is used by the area navigation system. Positioning can be provided by ground- or space-based navigation aids. Not all ground-based navigation aids are suitable for HAO purposes.

The Global Navigation Satellite System (GNSS) consists of one or more core constellation(s) together with a set of possible augmentations. It is a worldwide position and time determination system that includes one or more satellite constellations, aircraft receivers, and system integrity monitoring, augmented, as necessary.

Vehicles operating to, from and within the HA must have the required lateral and vertical navigation performance, with appropriate integrity and continuity, commensurate with the planned operation. For access to and from the HA, unless segregated from ATS airspace operations, all vehicles meet the navigation performance requirements of the current ATS airspace volume to enable safe separation between vehicles as applied by ATC. Barometric pressure altimeters in HA are not a reliable source of vertical position and therefore a level will need to be established above which the vertical reference of vehicles must be measured according to geometric means.

In the event of a detected loss of navigation, appropriate contingency operations are defined to enable the safe recovery of the impacted vehicle with minimum risk to other actors. Where contingency procedures are based on other applications such as ADS-B and/or communication (relative navigation), interdependency has been assessed and the core infrastructure assured.

7.4 Surveillance and tracking

Surveillance is a cornerstone of aviation, providing users with knowledge of the “who”, the “where” and the “when”.

The main requirements for surveillance with regards to HAO are:

- Interoperability: ensuring that the interfaces between all the components in the chain from avionics through to the displays operate as required with each other; globally. Interfacing with non-ATM components is also essential to avoid interference from and to other systems
- Performance: all the various components must perform properly, even in demanding operational environments, such as HA, so that users like ATM are able to use the surveillance service effectively where applicable
- Efficiency: the essential tasks must be carried out in the cost-effective way. Proper use of the valuable radio frequency spectrum must be made

It is important to extend surveillance to airspace in which surveillance could not be done before. In the short-to-medium term, the provision of surveillance should be met by cooperative surveillance technology. Provisions need to be in place for failures and outages, especially with regards to positioning and timing based on GNSS.

Space-based solutions and ADS-B technologies can provide solutions for satellite-based surveillance, mounting transponders/antennas on satellites. Currently, less than 30 percent of the world's airspace is covered by ground ADS-B stations. The introduction of space-based ADS-B provide global surveillance of air traffic. The enhanced ADS-B surveillance systems covers oceanic, polar, and remote regions, as well as augmenting existing ground-based systems that are limited to terrestrial airspace. Along with the improvement in coverage provided by space-based ADS-B, the position update rate provided by the space-based system is about six times faster than traditional radar. For example, low Earth orbit (LEO) satellites may provide global coverage at high altitudes. The constellation listens to ADS-B messages broadcast from aircraft and forwards them to subscribers using a low latency link.

Non-cooperative surveillance technologies will also be possible to complement the cooperative surveillance when required. There is the need to address non-cooperative traffic including both intentional and non-intentional traffic, considering the characteristics and dynamics (slow-moving — or quasi static — traffic from fast-moving and because of the high dependence on GNSS). SSA/SST need to be assessed in detail for performance and accessibility.

Sensor fusions and tracking will also be required to build the air situation picture in support of air traffic management and higher airspace traffic management.

In the short term, airborne safety nets, based on current technology would not be able to support HAO operations owing to the disparate performance of the new airspace users.

7.5 Meteorology

The majority of the Earth's weather occurs in the troposphere (see Figure 11), which, depending on the geographical location and season, is the part of the Earth's atmosphere which extends from the surface to around 8-15 km altitude. The weather in this part of the atmosphere is the most diverse and changeable, characterised by a relatively constant rate of temperature decrease with height, as shown below.

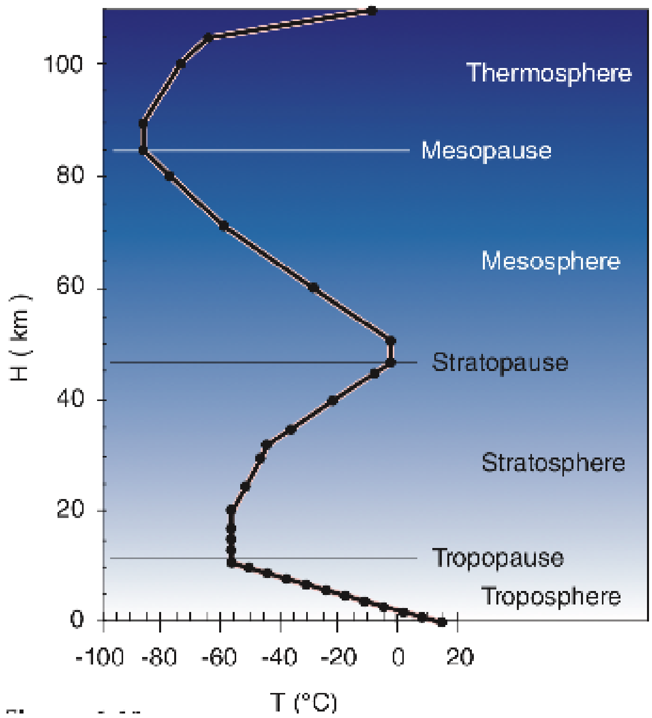

Figure 11 Middle atmosphere — the relationship between temperature and altitude

Weather in the troposphere is generally well documented with global networks sharing observations and forecast information, including those dedicated to aviation purposes. HAO will be influenced by the weather in the troposphere, particularly slow-speed operations, during the transition to and from HA. Once above this tropospheric “weather layer”, HAO will pass into the stratosphere and mesospheric layers and will be under the influence of very different atmospheric conditions. Notably very low temperatures that may influence the operation of vehicles.

In the stratosphere (approximately 10-50km in mid-latitudes) and mesosphere (approximately 50-85km), it is usual to have a westerly wind component in the winter at mid-latitudes; and an easterly component in the summer. The highest zonal winds are around 60–70 ms^{-1} (135–155 mph) at 65–70 km altitude.

Weather (and wind) information above FL600 is not readily available and beyond the capabilities of most numerical weather predication systems. That said, above FL600, the atmosphere is very thin and the primary weather concerns will be wind as well as space weather phenomena. In order to enable HAO, further investments will be needed in HA weather forecasting and now casting.

7.5.1 Measure and share data

Those parts of the atmosphere which are not widely used at present have no regular or widespread source of direct observations. Radio-sonde balloons are a standard tool for measuring the atmospheric conditions but have a vertical extent of around 35km and are relatively sparse in their geographical coverage. Observations of wind and temperature are recorded and transmitted by some aircraft, but these observations are limited to where those aircraft are operating. Ground-based LIDAR and RADAR technologies can be used to measure wind in the troposphere and lower stratosphere, but again are limited by the location of these instruments. Studies using space-borne remote sensing technology have been shown to measure wind between 50-85km altitude, using airglow of oxygen and hydroxyl. However, none of these techniques are in widespread operational use.

Operationally, HA vehicle operators should aim to measure and share in real time the atmospheric conditions their vehicles experience, in order to improve the global network of information for everyone. It will also be important to engage with MET service providers and regulators, to articulate emerging requirements for atmospheric observations and forecasts in these parts of the atmosphere.

7.5.2 Space weather

From an operational perspective, space weather events occur when solar activity causes disruptions to aviation communications, navigation, and surveillance systems, and elevates radiation-dose levels at flight altitudes. This is particularly relevant for operations at high levels and in Polar Regions. Space weather events may occur on short time scales, with the effects occurring seemingly instantaneously or a few days in the future.

For HAO, space weather impacts may occur and affect communications, navigation, surveillance, radiation-sensitive electronics, as well as human health. In particular, system impacts may include:

a) unexpected loss of communications

    i. HF voice and HF data link i.e., Controller Pilot Data Link Communications (CPDLC), on routes where HF is employed

    ii. poor or unusable performance of L-band SATCOM

b) degraded performance of navigation and surveillance that rely on Global Navigation Satellite System (GNSS)

    i. Automatic Dependent Surveillance – Broadcast (ADS-B) and/or Automatic Dependent Surveillance – Contract (ADS-C) anomalies

    ii. sporadic loss-of-lock of GNSS, especially near the equator, post-sunset

c) unanticipated non-standard performance of on-board electronics, resulting in reboots and anomalies; and

d) issues related to radiation exposure by aircrew and passengers

ICAO has established a global network of designated Space Weather Centres (SWXC) which have at their disposal information from satellite and ground-based sensors enabling both prompt event detection as well as providing input for predictive models. Existing SWXC information provisions for aviation do not extend above FL600.

Operationally HA vehicle operators should aim to measure and share in real time the impact of space weather on their operations, in order to improve the global network of information for everyone. It will also be important to engage with the Space Weather Centres and regulators, to articulate emerging additional requirements in those parts of the atmosphere not already within their scope (i.e., above FL600).

8 Contingency

8.1 Introduction

The main aim of this chapter is to describe the short-term and medium-to-long-term operational concept elements for managing the impact of non-nominal events encountered during HAO. The proposals include the necessary changes and improvements required to ensure efficient and safe handling of events such as accidents, emergencies, diversions, and incidents. It also proposes some high-level descriptions of future roles, responsibilities, procedures, and improvements required to handle these events.

8.1.1 Non-nominal event and vehicle types

The non-nominal events and their contingency requirements are dependent on the performance of vehicles, vehicle design and mission type conducting HAO. They may be broadly categorised into two types, low-speed and high-speed operations.

Low-speed vehicles

The following vehicle types are considered as low-speed vehicles: free balloons, manoeuvring balloons, motorised lighter-than-air airships, motorised heavier-than-air aircraft.

The requirement for managing the effects of a non-nominal event may originate from the following occurrence:

- Uncontrolled landing or diversion from the nominal trajectory
- Loss of ascent
- Loss of speed control
- Loss of altitude control
- Landing under non-nominal conditions
- Reduced tracking capability
- Loss of control
- Status of the vehicle becomes unknown
- Structural failure
- Non responsive vehicle/degraded flight performance
- Loss of communication links between the vehicle and launch operator or ATC

High-speed vehicles

The following types are considered as high-speed vehicles: hypersonic spacecraft, direct launch expendable and reusable rockets, rocket planes, re-entry vehicles, de-orbited spacecraft, vertical rockets, air-launch rockets, supersonic aircraft, hypersonic aircraft, sounding rockets, multiple-stage air-launched rockets.

The requirement for managing the effects of off-nominal events may originate from the following:

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- Fragmentation/catastrophic failure
- Loss of flight performance
- Impaired vehicle controls
- Unknown or degraded knowledge of vehicle status
- Loss of communications link between vehicle and launch operator or ATC
- Transponder failure/telemetry failure
- Diversion from the nominal trajectory
- Uncontrolled descent
- Unwanted or early capsule release
- Uncontrolled re-entry
- Need for assistance to land in an alternate site or landing out of nominal conditions

The contingency responses could range from State, European network and potentially global level. This may be necessary for events that have a transnational and supra-regional character and cause impacts on the European air traffic network. The responses will also apply to unplanned, unforeseen events as well as uncontrolled re-entry events, provided that their impact on air traffic can be limited on the basis of sufficiently reliable forecasts from space monitoring organisations.

8.2 Contingency management — short-term

Currently, HAO are planned well in advance. During the strategic planning phase, wherever applicable, either the operator files a flight plan or the airspace at the launch and re-entry site is reserved by the State in response to a request of the operator. Consequently, other traffic is required to avoid this segregated airspace when active. This is largely a strategic measure to ensure safety in the event of an incident during HAO itself. This process could potentially be improved in particular the reaction to a non-nominal event and its management and processes. It must also address situations causing important deviations from the nominal mission plan, requiring a contingency response by other actors (especially ATC).

In Europe, to ensure safety following an event that takes place across borders and from a Network Management perspective, the management of such a non-nominal event requires coordination at network level. Therefore, the NM must address this as part of the CDM process with the agreement of all actors.

8.3 European context and contingency challenges for the medium-to-long term

This section describes the management of non-nominal events for the target concept which is considered to be applicable in the medium-to-long term.

Where a non-nominal event occurs involving a low-speed vehicle in HA, and requiring transit of ATS airspace, it is expected that the event will be handled in a timely and efficient manner, minimising risks to other airspace users. The operator is responsible for notifying the non-nominal event to the NM and HAOSP; appropriate procedures according to predefined scenarios are enacted to notify potentially impacted civil and military ANSP(s). The ANSP(s) then trigger the local published contingency procedure. The ANSP(s) may require the NM to apply capacity measures for the ATSU concerned. The ANSP(s) notify the NM when the event has terminated.

For a non-nominal event involving a high-speed vehicle in HA, the consequences are different. The event may take place over one State but the impact may be far reaching, due to the speed of the vehicle, with time being a critical factor in the notification of the event by the operator to other actors. It may impact a number of other States and their ANSPs across a region.

For any required transit of ATS airspace, effective cross-border coordination is necessary. One solution is for the operator to notify the event to the NM who would then rapidly identify and coordinate with the impacted HAOSP and ANSPs/ATSUs concerned.

In the worst-case scenario of a high-speed accident, depending on the type and level of the vehicle, a debris field may extend across hundreds of kilometres taking tens of minutes to reach the surface (see NASA Report of Columbia Accident Investigation Board, Volume I August 2003). This could form a hazard to other airspace users flying below the falling debris. In this case in Europe, contingency procedures would need to be cross border or regional in nature. Today in the absence of any systematic procedure to facilitate the resolution of such an event, an enhancement of the current NM capabilities, could meet this challenge and consideration should be given to the handling of a real-time warnings of an accident or emergency directly from a vehicle operator or from a space agency responsible for monitoring space operations which could then trigger a rapid response at network level across the States impacted. The response should include dissemination of relevant information about the event to those organisations required to be involved in such scenarios and coordination between the NM, authorities (civil and military), ANSPs, RCCs, etc. The ANSPs concerned may then take action based on the information received to move traffic tactically away from potential hazard areas. This process would involve new methods of coordination and communication between the NM, operators, ANSPs and space agencies and organisations (either national or international).

8.3.1 New contingency roles and responsibilities

The following roles and responsibilities may be necessary to support the contingency challenges in the medium-to-long term.

8.3.1.1 Vehicle operators

- Operators are responsible for ensuring safe operation (including public and property) during the mission and when in HA should notify the NM of the event
- Vehicles used should be capable of providing the necessary trajectory, telemetry data and other information required for mission monitoring and that may be required for managing non-nominal events
- Operators must engage in contingency planning with all the actors concerned
- Operators must inform the NM in real time of a non-nominal event and consequent effected airspace volume

8.3.1.2 The NM

- The NM continuously monitors HA operations and receives notification from the operator of the start of a non-nominal event. It determines the HAOSP/ANSP/ATSU to be notified at the start and end of an event and apply capacity measures if requested by the relevant ANSP

- Other actors to be notified as appropriate

8.3.1.3 ANSP

- An ANSP receives notification from the NM of the start of the event and triggers contingency procedures which may include reactively moving traffic in its airspace away from hazard areas following a low/high speed vehicle, a space-related accident, uncontrolled re-entry, or the application of capacity measures
- It must foresee the necessary procedures development and training that this may require
- It should agree on the policies and regulations concerning the HAO with their NSA and European regulator (EASA)

8.3.1.4 HAOSP

- A HAOSP receives notification from the NM of the start of the event and triggers contingency procedures which may include reactively moving traffic in their airspace away from hazard areas following a low/high speed vehicle, a space-related accident, uncontrolled re-entry, or the application of capacity measures
- It must develop the necessary procedures and training that this may require

8.3.1.5 European Commission and European Aviation Crisis Coordination Cell (EACCC)

- The European Commission should develop a suitable regulatory framework for supporting a coordinated response to incidents at European level that uses regional and national capabilities and identifies clear responsibilities for structures such as the Network Manager
- Where applicable, EACCC should support the management of HAO contingency events and all the actors in the regulatory and policy-related areas

8.3.1.6 Existing airspace users (AUs)

- AUs must be made aware of the new entrant HAO in their planning processes and possible contingency procedures where they may be affected following a non-nominal event
- They must provide the necessary training to flight crews

8.3.1.7 State/military organisations

- The triggering of contingency procedures may impact military reserved airspace and operations. In such cases military authorities must be promptly informed and updated with latest information for subsequent decisions in charge to the State military authorities which might result in the suspension of the operations to ensure safety.
- They must develop necessary procedures and competence for this action
- They must be part of the contingency planning process

9 Next steps

9.1 Validation

The ConOps, with its concept elements and operational requirements to be developed, will need to be validated on an incremental and continuous basis. This will ensure that the concept proves successful at implementation and the services defined are appropriate to the needs of the different vehicle types operating within and transiting to and from HA. This approach will help confirm that in regions of low-density operations, services and infrastructure will be limited. Whereas in regions of medium- to high-density operations, users may require traffic management services. The principle of building according to demand is a key element that will need to be tested.

Another aspect that will influence the validation approach is the entry into service (EIS) estimation since it will be different for the types of vehicles using the HA. Therefore, the validated plan, services and procedures might need further refinement to fit new entrants into the process. An international level regulatory coordination will be needed for certain types of vehicles planning global operations. There will also be a key role for industrial associations who provide an exchange between pioneers to foster the discussion and development of new projects.

9.1.1 Pioneers to partners

Contributions to the ConOps have been made by a number of pioneers planning HAO where vehicles are either in design, under testing and development or about to commence operations in Europe. Early pioneering activity will lead to strong future partnerships as the concept evolves and operations become routine. Outside Europe some pioneers have already started supporting the development of new regulations, others are no longer in research and development nor in the market but fortunately their legacy continues to contribute to current developments.

A summary of the relevant pioneers and projects under development per each category of vehicle is provided in Appendix A.

9.1.2 Use regulatory sandboxes

Regulatory sandboxes allow testing and validation of new products and services that do not fully fit within the scope of existing regulations, in a safe and secure controlled environment.

In general, regulatory sandboxes will help HAO to operate in Europe enabling the authorities to better understand how new technologies work and then to develop the future regulatory framework.

The use of a regulatory sandbox will enable the validation of HAO operations on real scenarios in the short-to-medium term. It will also enable the validation of authorisation and regulatory schemes from the perspective of European harmonisation.

In addition, it will enable the pioneers to test new solutions and to explore new options with the guidance of the authorities to validate the regulatory framework in a commercial environment.

Applicants that operate within a regulatory sandbox would describe their specific use-case that fits the wider HAO concept of operations. While authorities will identify the appropriate sandbox environment to ensure operations are carried out safely and securely with minimum impact on the external environment. During the operations the scope of the sandbox may evolve and change, and it may be adapted as necessary.

Number and types of regulatory sandboxes may depend on the following:

- types of operations to be regulated
- use cases and scenario
- operators
- ground infrastructures

In the short-to-medium term (by 2030) regulatory sandboxes may be activated for a specific demand scenario at an identified site and are expected in the beginning at least to cover the following HAO operations: A-A suborbital flights, HAPS, sounding rockets and re-entry from orbit.

9.2 Research and international coordination

Several issues identified during the preparation of the HAO ConOps indicate a requirement for further research in this domain and where industry and research institutions should participate. For Europe, one of the most important research initiatives will be the future SESAR exploratory research activities, in which HAO should be fully included. International coordination will also be necessary to support research into the concept and new procedures at a global level with a need to involve different global institutions, i.e., ICAO and UNOOSA **Creating synergies and fixing gaps**

Results and experience gained from the validation of other concepts, e.g., unmanned traffic management, can be evaluated to create synergies and to fix any gaps found in this ConOps. Therefore, further studies will be needed to identify these aspects that may need attention and to be covered in the future, e.g., the important domain of human factors. Furthermore, collaboration between industry and institutions might be fostered by groups representing the interests of HA users.

10 References

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Appendix A

A.1 Relevant pioneers

This table represents a snapshot of a list of pioneers where known discussions are ongoing regarding their current or future operations with relevant operational stakeholders.

Category of vehicle	Subcategory of vehicle	Pioneer	EIS in European HA	Comments
HAPS	LTA balloon	Stratospheric balloons, SSC CNES	In-service in Europe	In 2024+ will start research for manoeuvring balloons
	Motorised LTA airship	StratoBus, Thales Alenia Space HHHA, CIRA, Italy	Before 2030 in Europe 2024	Demo flights already performed
	Motorised HTA airplane	Zephyr, Airbus Defense & Space	2023+ in Europe	Flight tests in the USA with respective airworthiness approval from the FAA Flight tests were also performed in Australia
A-to-A suborbital flights	Air launch - Reusable Air Launch Rocket Plane	White Knight Two / SpaceShipTwo (Air launch), Virgin Galactic	Before 2030 in Europe	
	Air Launch- orbital rockets	Virgin Orbit Spaceport Cornwall, UK and over the Celtic Sea	From end 2022	
Launchers	VTOL – orbital and sounding rockets	HyImpulse Spaceport Shetland, UK	From 2022/3	
		Skyrora Spaceport Shetland, UK	From 2023	
	VTOL - orbital rockets ship launch	German Offshore Space Alliance North Sea	From 2023	

Table 1 Pioneers

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A.2 Examples of projects under development or investigation

6	Subcategory of vehicle	Pioneer	EIS	Comments
A-to-B suborbital flights	Supersonic aircraft	Overture, Boom Technology	Before 2030	Not clear date for flights to EU
	Supersonic aircraft	Spike S-512, Spike Aerospace		
	Hypersonic aircraft concepts/developments	Stratofly, European consortium	Not foreseen before 2040	Potential partial demonstrations flights before 2025
		Halcyon, Hermeus Corporation		
		Hyperplanes - Gamma, Delta, Epsilon,Zeta Destinus		
		Boeing hypersonic airliner, The Boeing Company		
	Hypersonic spacecraft	Starship (VTVL), SpaceX	Not foreseen before 2040	Potential demonstration flight before 2025
		Spaceliner (VTHL), DLR		Potential demonstration flight before 2030
		Falcon XX (VTHL), Dassault Aviation		
Launchers	Direct Launch - Sounding rocket	Texus,		

6	Subcategory of vehicle	Pioneer	EIS	Comments
	Direct Launch - Expendable rocket	ESA Ariane 5		
	Direct Launch - Reusable rocket (VTOL)	Falcon 9H booster landing, SpaceX		
	Direct Launch - Reusable rocket (HTOL)	Skylon space plane, Reaction Engines		
	Direct Launch - Reusable rocket plane (VTOHL)	Concept for Ariane 5, LFBB		
	Air launch - From airplane reusable rocket	Vehra, Dassault Avion,		
	Air launch - From balloon, expendable rocket	Bloostart, Zero2Infinitiy		
	Air launch - From airships, expendable rocket	Havoc, NASA (concept)		
From orbit flight		European re-entry vehicles (ARD, IXV, Space Rider)		
		Dream Chaser Sierra Space USA Spaceport Cornwall UK		
		End of life satellites or space stations		
HAPS	Motorized HTA airplane	StratoStreamer Germany		

Table 2 Examples of projects under development

Appendix B Acronyms and abbreviations

Term	Definition
ACC	Area control centre
ADS-B	Automatic dependant surveillance – broadcast
ADS-C	Automatic dependant surveillance – contract
AHA	Aircraft hazard area
AIP	Aeronautical information publication
AIRAC	Aeronautical information regulation and control
ANSP	Air navigation service provider
ASM	Airspace management
ATC	Air traffic control
ATFCM	Air traffic flow and capacity management
ATS	Air traffic services
ATM	Ait traffic management
AU	Airspace user
CDM	Collaborative decision-making
CHA	Contingency hazard area
ConOps	Concept of operations
CNS	Communication navigation and surveillance
CPDLC	Controller pilot data link communications
DAA	Detect and avoid
DMA	Dynamic mobile areas
EACCC	European Aviation Coordination Crisis Cell
EASA	European Aviation Safety Agency
EC	European Commission
ECAC	European Aviation Civil Conference
ECHO	European Concept for Higher Airspace Operations
EDA	European Defence Agency
EIS	Entry into service
ERND	European Route Network Design
ERP	Emergency response plan
ESA	European Space Agency

Term	Definition
EU	European Union
FCI	Future communications infrastructure
FIR	Flight information region
FIS	Flight information service
FIXM	Flight Information Exchange Model
FL	Flight level
FUA	Flexible use of airspace
GCS	Ground control station
GNSS	Global Navigation Satellite System
HA	Higher airspace
HALE	High-altitude long endurance
HAOSP	Higher-airspace operations service provider
HAPS	High-altitude platform system
HAO	Higher-airspace operations
HOTOL	Horizontal take-off and landing
HTA	Heavier than air
IIP	Instantaneous impact point
IFR	Instrument flight rules
LRO	Launch and re-entry operator
LTA	Lighter than air
MCC	Mission control centre
MET	Meteorology
MVO	Military vehicle operator
NEO	Near earth object
NM	Network Manager
NSA	National supervisory authority
RCC	Rescue coordination centre
RHA	Refined hazard area
RPAS	Remotely piloted air systems
SAR	Search and rescue
SATCEN	Satellite centre
SATCOM	Satellite communications

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Term	Definition
SERA	Standardised European rules of the air
SESAR JU	Single European Sky Joint Undertaking
SID	Standard instrument departure
SSA	Space situational awareness
STM	Space traffic management
SST	Space situation and tracking
STAR	Standard arrival route
SUR	Surveillance
SWIM	System-wide information management
SWx	Space weather
SWXC	Space weather centre
TBD	To be determined
TBO	Trajectory-based operations
UAS	Unmanned aircraft system
UC	Use case
UHF	Ultra-high frequency
UNOOSA	United Nations Office for Outer Space Affairs
UTM	Unmanned traffic management
VHF	Very-high frequency
VO	Vehicle operator
VTOL	Vertical take-off and landing

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