

PREPARATORY ACTION ON HIGHER AIRSPACE OPERATIONS (HAO)

SUBTASK 2.1. - LITERATURE REVIEW

EASA.2021.FC.14

SPECIAL CONTRACT N°003

Final Report

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SUMMARY

Problem area

The European Union Aviation Safety Agency (EASA) has been entrusted by the European Commission to prepare a regulatory framework for Higher Airspace Operations (HAO). This framework will address emerging aviation activities in the higher airspace, focusing on safety, security, environmental concerns, and cyber risks. EASA aims to adapt existing aviation rules to facilitate these operations while fostering industrial and technological growth in this domain.

A first milestone is to provide a robust understanding on the regulatory needs to facilitate the development of an adequate regulatory framework.

Description of work

EUROCAE has developed a report consisting of a HAO Literature Review. Higher Airspace Operations can be, for the purpose of this literature review, understood as relating to “air transport operations carried out by various types of aircraft or air transport vehicle systems in the volume of the airspace above altitudes where the majority of air services are provided today”, i.e. typically above FL550, the highest airspace altitude is not currently commonly agreed.

Results and Application

The *Higher Airspace Operations (HAO) Literature Review Final Report*, prepared by EUROCAE for the European Union Aviation Safety Agency (EASA), offers an in-depth analysis of current knowledge, trends, and regulatory considerations necessary for developing a regulatory framework for HAO.

Higher Airspace Operations encompass a growing range of innovative technologies and platforms, including High-Altitude Platform Systems (HAPS), supersonic and hypersonic aircraft, and suborbital space vehicles. These new entrants pose complex regulatory, operational, and technological challenges due to their diverse performance characteristics and the lack of a clearly defined boundary between airspace and outer space.

The report’s objectives include improving institutional understanding, identifying legal and technical gaps, and laying the foundation for proportionate regulation. It builds on prior work such as the SESAR ECHO project and synthesises findings from academic publications, industry white papers, regulatory documents, and expert interviews. Key focus areas include airspace delineation, legal frameworks, air traffic management (ATM), communication, navigation, and surveillance (CNS) infrastructure, market developments, environmental and societal impacts, and standardisation efforts.

A key theme is the ambiguity in defining the vertical limit between airspace and outer space. FL550 is often used as the lower boundary for HAO but FL600 or 20 km above earth can also be found in the literature, no global consensus exists on the upper boundary. The von Kármán line (100 km altitude) is commonly cited, but some studies argue for classification based on energy or function rather than altitude alone. This has implications for the legal application of air or space law and sovereignty.

The report compares operational concepts in the U.S. and Europe. The U.S. approach is centred on “Upper Class E Traffic Management” (ETM), emphasizing collaborative separation and info-centric systems. The European SESAR ECHO Concept of Operations (ConOps) advocates for trajectory-based operations (TBO) and 4D operating zones. CANSO and the HAPS Alliance are focusing on Cooperative Zones (CZ) as the core for HAO management to manage diverse missions and vehicle types. All proposed concept models stress the importance of flexible, scalable management tools and real-time coordination between ATM and future space traffic management (STM) systems.

On the technical side, CNS systems for HAO must overcome limitations in current altimetry, GNSS vulnerability, and voice/data communication above FL600. Increased reliance on satellite-based systems and geometric altimetry can be expected, while calling attention to the risk of GNSS jamming or spoofing and the need for alternative positioning, navigation, timing and surveillance solutions. Cyber Security of Communication and ADS-B surveillance is also a sensitive area.

The review identifies strong market interest and rapid technological evolution, particularly in the HAPS sector, space tourism, and reusable launch vehicles. Environmental and societal impacts, including the need for connectivity in remote areas and the management of launch/re-entry debris, are also introduced and further analysis is provided in the HAO-Update Of Higher Airspace Demand Analysis and Market Developments report¹.

Overall, this report concludes that global coordination—particularly through ICAO—is essential to harmonise approaches. It recommends continuing efforts to clarify definitions, supporting infrastructure and services, expected performances and overall architecture with an appropriate governance framework. Continuing efforts will also be necessary to develop international standards to ensure a coherent and secure regulatory framework that can adapt to the fast-evolving HAO landscape. This literature review sets the stage for subsequent regulatory action and stakeholder engagement under EASA’s roadmap.²

¹ EASA.2021.FC.14 Special Contract N°004, HAO-Update Of Higher Airspace Demand Analysis and Market Developments

² [Proposal for a Roadmap on Higher Airspace Operations \(HAO\)](#)

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ABBREVIATIONS

ACRONYM	DESCRIPTION
AAM	Advanced Air Mobility
ADC	Air Data Computer
ADS-B	Automatic Dependant Surveillance Broadcast
ADS-C	Automatic Dependant Surveillance Contract
AGL	Above Ground Level
AI	Artificial Intelligence
AIA	Aerospace Industries Association
ANC	Air Navigation Conference
ANSP	Air Navigation Service Provider
ARE	Adaptive Risk Envelope
AST	FAA office for commercial space transportation
ATC	Air Traffic Control
ATFCM	Air Traffic Flow and Capacity Management
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATMRPP	Air Traffic Management Requirements and Performance Panel
ATS	Air Traffic Service
CAA	Civil Aviation Authority
CANSO	Civil Air Navigation Services Organisation
CATS	Complete Air Traffic system
CFR	(FAA) Code of Federal Regulations
ChatGPT	Generative artificial intelligence chatbot
CNS	Communication Navigation Surveillance
CONOPS	Concept of Operations
CORDIS	(EU) Community Research and Development Information Service
CPDLC	Controller-pilot datalink communications
CS	(EASA) Certification Specifications
CSC	(RTCA) Combined Surveillance Committee
CSINAS	Commercial Space Integration into the NAS
CZ	Cooperative Zones
DG DEFIS	Directorate-General for Defence Industry and Space
DGAC	Direction générale de l'Aviation civile
DME	Distance Measuring Equipment
DRA	Debris Response Area
DSAC	Direction de la Sécurité de l'aviation civile
EASA	European Aviation Safety Agency
ECHO	European Concept of operations for Higher airspace Operations

ACRONYM	DESCRIPTION
ECHO1	ECHO1 - SESAR 2020 project
ECHO2	ECHO2- SESAR 3 project
ECSL	European Centre for Space Law
ED	EUROCAE Document
EDA	European Defence Agency
EOSC	European Open Science Cloud
ESA	European Space Agency
ETC	Emerging Technologies Committee
ETM	Upper Class E Traffic Management
EU	European Union
EUROCAE	European Organisation for Civil Aviation Equipment
EUROCONTROL	EUROCONTROL is a pan-European, civil-military organisation dedicated to supporting European aviation
EUSPA	EU Agency for the Space Programme
FAA	Federal Aviation Administration
FCI	Future Communications Infrastructure
FL	Flight Level
FPSV	Frequency Protected Service Volumes
GB	Gas Balloon
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSMA	GSM Association (GSMA) is a non-profit trade association that represents the interests of mobile network operators worldwide
HA	Higher Airspace
HALE	High Altitude Long Endurance
HAO	Higher Airspace Operations
HAOSP	Higher Airspace Operation Service Providers
HAPS	High-Altitude Platform Systems or High-Altitude Platform Stations or High Altitude Pseudo Satellite
HIBS	HAPS as IMT (International Mobile Telecommunication) Base Stations
HTA	Heavier-than-air
IAC	International Astronautical Congress
IATA	International Air Transport Association
IBAC	International Business Aviation Council
ICAO	International Civil Aviation Organization
ID	Identification
IEEE	Institute of Electrical and Electronics Engineers
IFATCA	International Federation of Air Traffic Controllers Associations
IFR	Instrument flight rules
IMT	International Mobile Telecommunication
INS	Inertial Navigation System

ACRONYM	DESCRIPTION
ITAR	International Traffic in Arms Regulations
ITU	International Telecommunication Union
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
LACAC	Latin American Civil Aviation Commission
LEO	Low Earth Orbit
LTA	Lighter-than-air
MJ	Megajoules
MOPS	Minimum Operational Performance Standard
MS	(EU) Member States
N-RMM	Network Real-time Mission Monitoring
NAA	National Aviation Authorities
NAS	(FAA) National Airspace System
NASA	National Aeronautics and Space Administration
NM	Network Manager
NOTAM	NOTAM or Notice to Airmen
NPA	Notice of Proposed Amendment
OSED	Operational Service and Environment Description
PFD	Power-Flux Density
PNT	Positioning, Navigation and Time
RR	(ITU) Radio Regulations
RTCA	Radio Technical Commission for Aeronautics
SARPs	Standards and Recommended Practices
SBAS	Satellite Based Augmentation System
SESAR JU	Single European Sky ATM Research (SESAR) Joint Undertaking (JU)
SIA	Space Industry Act
SORA	Specific Operations Risk Assessment
SOTA	State-Of-The-Art
SPR-INTEROP	Safety, Performance and Interoperability Requirements
SSA/SST	Space situational awareness/Space Surveillance and Tracking
STAND	SESAR 3 Standardisation deliverable
STM	Space Traffic Management
STS	Space Transport Shuttle
SWIM	System-wide information management
TBO	Trajectory-based operations
TEU	Treaty on the European Union
TFEU	Treaty on the Functioning of the European Union
TWG	(HAPS Alliance) Telecommunications Working Group
TWP	(EUROCAE) Technical Work Plan
UAS	Unmanned Aircraft System
UC	Use Case

ACRONYM	DESCRIPTION
UK	United Kingdom
US	United States of America
UTM	Unmanned Traffic Management
VHF	Very high frequency
VOR	Very high frequency (VHF) omni-directional range
WAM	Wide Area Multilateration
WG	Working Group
WP	Working Paper
WPn	Work Package
WRC	World Radiocommunication Conference

1. Introduction

1.1 Background

The European Union Aviation Safety Agency (EASA) has been entrusted by the European Commission to prepare a regulatory framework for Higher Airspace Operations (HAO). This framework will address emerging aviation activities in the higher airspace, focusing on safety, security, environmental concerns, and cyber risks. EASA aims to adapt existing aviation rules to facilitate these operations while fostering industrial and technological growth in this domain.

1. Background

- A roadmap was delivered in March 2023 that explored the preparatory actions required for a future regulatory framework on Higher Airspace Operations (HAO). (link: [Proposal for a Roadmap on Higher Airspace Operations \(HAO\) | EASA](#)) [1]
- The roadmap recommended progressive measures like studies, tests, and regulatory sandboxes to enable initial operations and inform future regulations.

2. Relevance:

- HAO operations are a nascent field with significant unknown risks.
- The EU seeks to harmonise approaches and avoid fragmentation in regulating HAO, leveraging 3. Objectives:
 - Enhance Knowledge: Improve EU institutions' understanding of HAO.
 - Provide Data: Support decision-making with scientific evidence.
 - Assess Impact: Conduct gap analyses and regulatory assessments.
 - Develop Framework: Create proportionate rules to enable HAO.

4. Excluded Activities:

- Direct industrial support, civil-military coordination, and global interoperability efforts will be handled by the European Commission and supported by entities like EASA, SESAR, and the EDA.

5. Implementation:

- The 3-year action (2024–2027) will involve four tasks:
 1. Building Awareness: Training, guidance on sandboxes, and public webinars.
 2. Scientific Studies: Research technical constraints and data collection.
 3. Regulatory Preparation: Develop a Notice of Proposed Amendment (NPA).
 4. Project Management: Ensure coordination and deliverables.

This approach aims at enabling the safe, efficient, and sustainable development, deployment and operation of vehicles at higher airspace in the European Union over the next decade.

It is expected that any future regulatory framework would be supported by industry standards; in this sense, this task will be important preparatory work.

This report is an essential first milestone to provide a robust understanding on the regulatory needs to facilitate the development of an adequate regulatory framework.

1.2 Scope of literature review report

This document is a literature review consisting of gathering the existing scientific literature and producing a high-level analysis on the subject of HAO, building on the work already performed in the context of the SESAR JU ECHO1 project in 2020-21.

Higher Airspace Operations can be, for the purpose of this literature review, understood as relating to “air transport operations carried out by various types of aircraft or air transport vehicle systems in the volume of the airspace above altitudes where the majority of air services are provided today”, i.e. typically above FL550, the highest airspace altitude is not currently commonly agreed.

Nevertheless, there is no physical delineation between airspace and outer space which makes it difficult to define whether some vehicles and operations are aviation or space related. The definition is discussed in more depth at section 3.2.

This literature review includes documents about space launches or landings as far as they may have an impact on Air Traffic Management over the territory of the EU or associated Member States as well as in the UK. The term “territory of States” refers to the respective territories on the European continent³.

The review will identify additional available literature in particular on (but not limited to) the following aspects:

- Legal Studies or Opinions including Legal and Jurisdictional Challenges
- Legal opinions on the Definition and Delimitation of Airspace and Outer Space
- Existing Legal & Regulatory Frameworks and/or Concepts
- Airspace Delineation and Classifications or Proposals
- Technology and Operational Needs
- Safety and Risk Management
- Stakeholder Considerations
- Environmental and Societal Impact
- Operational Concepts and (if available) Benchmarking.

The literature review will help identify gaps, i.e. elements of HAO which have not been addressed or insufficiently. This may help identify future research needs.

³ The Canary Islands is within scope, whereas French Guiana is not in scope

2. Search Strategy

2.1 Generalities

The search strategy is based on one hand on the identification of relevant databases and sources, and on the other hand on interviews with selected experts. The sources were explored using appropriate methods and tools. Focus is on documentation published since 2021 as an extensive analysis was already performed until April 2021 in the ECHO project (Deliverable D2.1). [2]

All relevant identified documents were listed in an excel spreadsheet “Catalogue HAO Docs 2025.xlsx” prior to further analysis. This spreadsheet facilitated selection based on the author organisation, publication date, category and contains an external access link. In some cases, reference to a web page considered as equivalent to a literature article is identified.

All selected documents were stored on the EUROCAE SharePoint dedicated to the literature review. This can enable retrieval of these documents.

2.2 Identification of relevant databases and sources

2.2.1 SESAR2020 ECHO project literature review database

The ECHO database⁴ has been made accessible for the purposes of this literature review via Eurocontrol SharePoint. It comprises a list of 171 documents, from 1967 (Outer Space Treaty) until 2022 and is a very good baseline of the literature status until 2022. This review consists of 3 main tasks:

- Extract the full list of documents and load all documents on the EUROCAE SharePoint when possible.
- Check validity and available updates of each document. Highlight existence of new version for further analysis.
- Update “Catalogue HAO Docs 2025.xlsx” with the list of documents (with their updated version when necessary) used for the High Level Analysis of this report.

2.2.2 Publication search tools

Various search tools have been used to identify recently published documents since the latest update of the ECHO database (Q3 2022) or any additional relevant document.

Quasi systematic exploration of published literature was performed using documentation specific tools such as Google Scholar, IEEE Xplore, Dimensions.ai and academic journals. It also includes general web search engine tools such as Google, Bing, Yahoo, EOSC⁵ and CORDIS⁶ database.

This exploration was based on the following key words or acronyms: HAO, Higher Airspace Operations, Higher Altitude Operations, Upper E Class airspace, HAPS, High Altitude Airspace Platforms, High Altitude Airspace Pseudo Satellite, HAO/HAPS Operational concept, HAO HAPS CONOPS, HAO/HAPS legal, HAO/HAPS standards, HAO/HAPS regulation, HAO/HAPS airspace, HAO/HAPS Technology, HAO/HAPS CNS, HAO/HAPS Safety,

⁴ H2020-SESAR-2019-2, ECHO, D2.1 ECHO Accessible Database

⁵ European Open Science Cloud

⁶ Community Research and Development Information Service

HAO/HAPS stakeholders, HAO/HAPS Environment, HAO/HAPS vehicle, HAO/HAPS military, HAPS/HIBS Spectrum, Space launches, Space landings, ...

Main players Websites were also explored as they may contain additional documentation. The following organisation sites have been identified: ICAO, EU CORDIS EASA, SESAR, Eurocontrol, FAA, NASA, MITRE, HAPS Alliance, Thales, Airbus, EUSPA, ...

Finally similar request to generative AI tools such as ChatGPT/Copilot were made using appropriate prompts.

2.3 Additional interviews

A few stakeholders experts have been contacted to complement the list and identify documents that are under development.

2.4 Selection and appraisal of literature

A comprehensive collection and organisation of past and current research/publications ensures effective use of existing knowledge and information. This may include draft literature currently under development.

The credibility, relevance, and quality of each source is considered, e.g. peer-reviewed articles, books, and reputable journals. Documents published by main reputable or official stakeholders have been selected. Sources that do not meet defined criteria shall be discarded. Inclusion and exclusion criteria to filter the identified literature includes publication date, study design, sample size, geographical location, and relevance to the confirmed scope of the literature review.

A full-text review of selected articles was performed to ensure they meet the criteria. The literature was categorised based on themes, methodologies, findings, and relevance.

The quality and rigor of the selected studies was assessed, considering aspects such as study design, sample size, data collection methods, and potential biases. The credibility and reliability of the findings was evaluated. Common themes, patterns, and trends across the literature are identified, and gaps, inconsistencies, and areas for further research are highlighted.

Publicly available “prominent” or important literature that describes military projects or operations shall be considered, as some military projects may be of a “dual use” nature. Purely military and especially classified documents are out of scope of this contract.

This list of appraised documents is available in Annex A .

In addition, a priority list of documents is identified. To do so, the most relevant and innovative documents that are evaluated as major evolutionary steps for HAO were tagged.

3. High Level Analysis

3.1 Generalities

The list of appraised documents in Annex A comprises 138 documents mainly published since the latest update of the ECHO database and a few documents used for the high level analysis. This indicates that there has been significant publication activities and therefore significant progress in various aspects of HAO.

The high-level analysis identifies significant trends in the publication of new documents, articles, and research publication. The following trends are detailed below:

- Higher Airspace definition
- Market evolutions
- Higher Airspace Concepts of Operations and Airspace management
- Launch and space re-entry
- CNS for HAO
- Environmental and societal impact
- Regulatory aspects
- Standardisation

3.2 Higher Airspace definition

In this report, FL 550 (or altitude 17km) is considered as the lower boundary of Higher Airspace, which extends upward to a point below the orbital space. But there is no physical (geometric, chemical, air density, etc.) delineation between airspace and outer space which makes it difficult to define whether some vehicles and operations are aviation or space related, by using this geographical/physical criteria. The conventional and informal limit of 100 km (the theoretical line proposed by von Karman where the atmosphere is so thin that aircraft wings cannot generate sufficient lift for flight, while a spacecraft cannot orbit because the atmospheric drag is excessive) is often referred to as separating air and space operations but there is no consensus at global level.

These 2 papers have been identified as providing valuable material about Karman line and differentiation based on vehicle speed, altitude, and energy:

- Nicolas Berend's paper (The Missing Calculation behind the Original Kármán Line Definition -A Credible Hypothesis. IAC 2021, Oct 2021, Dubai, United Arab Emirates. hal-03420278 <https://hal.science/hal-03420278v1/document>) gives a valuable insight of the Karman line calculation. [22]
- The document "At Crossroads Of Aeronautics & Space-What Matters" - Patrice Desvallées, Nicolas Bérend, Marie-Christine Bernelin, Marc Valès, Christophe Chavagnac, et al. 72nd International Astronautical Congress (IAC), 2021, Oct 2021, Dubai, United Arab Emirates. hal-03464294 leads to the following conclusion: "Despite the absence, in conventional or customary international laws, of an explicit altitude delimitation between national sovereign airspaces and outer space, this paper will show that the anchoring physical limit for ranking these advanced systems is rather more a matter of embedded energy than altitude or speed alone". [23]

The following figure presents the main classes of vehicle on a velocity and altitude scale. Each aerospace system is represented in the diagram by the point [Altitude; Velocity] at its highest specific (embedded) mechanical energy (Eme) during a nominal operation. Different specific point (e.g. A : ~155 km = Lowest 'stable' non-propelled circular Earth orbit, B : 53 km = Balloon Max theoretical buoyancy altitude, C : Specific (embedded)

mechanical energy threshold (iso-Eme curve ~ 1.1 MJ/kg),) and curves (e.g. F: Re-entry and descent trajectory envelope of the Space Shuttle STS, Mx :Mach, T : Heat Barrier) are given as landmarks. The explanations on the different specific points are accessible with this [link](#). A video is also available to better understand this diagram: <https://www.youtube.com/watch?v=E3PQf9V-spg> 'At Crossroads of Aeronautics and Space - IAC21-D2.4.10: Ministère Écologie Territoires'.

Main classes of Aerospace systems, Altitude-Velocity diagram (1 to 1000km)

(Log. B-10 diagram, see legend and explanations on next page)

Link: https://salledelecture-ext.aviation-civile.gouv.fr/externe/DSAC/20231012_Diagram_ALT-V_main_aerospace_catg_1-1000km.pdf

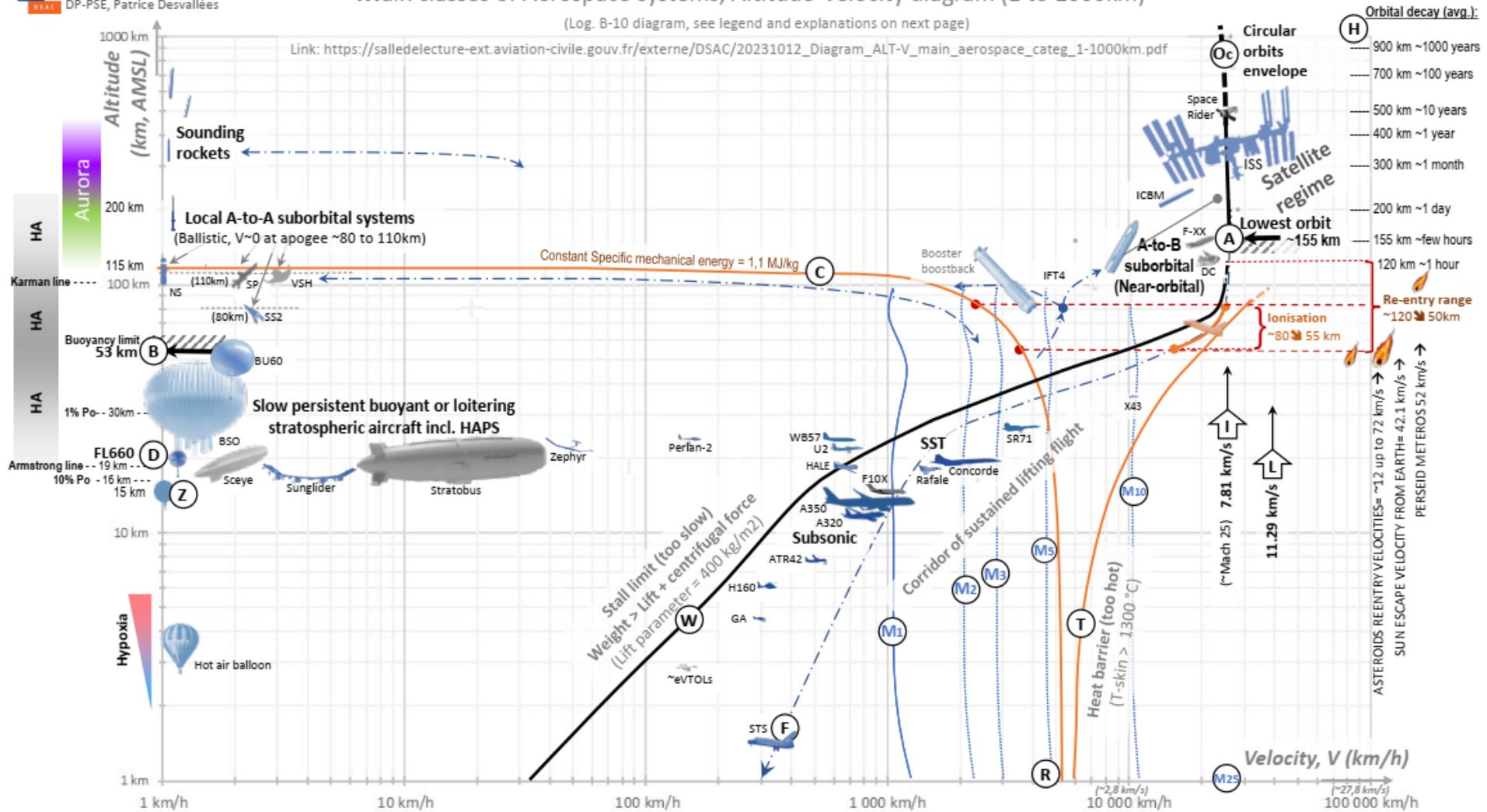


Figure 1 Main classes of Aerospace systems, Altitude-Velocity diagram (1 to 1000km)⁷

Source DGAC-DSAC-2024 (reproduced with the permission of DGAC) https://salledelecture-ext.aviation-civile.gouv.fr/externe/DSAC/20231012_Diagram_ALT-V_main_aerospace_catg_1-1000km.pdf

⁷ The legend and explanation are in the DGAC-DSAC-2024 pdf hyperlink, and the next page

Main classes of Aerospace systems, Altitude-Velocity diagram (1 to 1000km)

Color code for figured craft:



(blue) Maturity is state-of-the-art (operational or not anymore): Already flew at targeted Alt.& V.



(gray) Maturity is R&D phase.

Co-authors: Patrice Desvallées (DGAC),
Nicolas Bérend (ONERA), Marie-Christine
Bernelin and Marc Valès (Dassault Aviation),
Christophe Chavagnac (ArianeGroup).

Diagram Legends:

- Each aerospace system is represented in the diagram by the point [Altitude; Velocity] at its highest specific (embedded) mechanical energy (Eme) during a nominal operation.
- Making the best of both Earth very deep gravity well and thick atmosphere, only ultra-high performance state-of-the-art aerospace systems can fly very high and/or ultra fast.
- The ICAO contracting States recognize that 'every State has complete and exclusive sovereignty over the airspace above its territory' (Chicago Convention, Art.1), while in international Law, there is an absence of an explicit delimitation between the sovereign Airspaces and Outer Space.

Diagram notable points and curves:

- (A): ~155 km = Lowest 'stable' non-propelled circular Earth orbit, $V=7.81$ km/s (28 110 km/h), $E_{me}=32$ MJ/kg, orbital decay and re-entry after only a few 87-minutes orbits (~few hours).
- Armstrong line: altitude (around 19km) above which atmospheric pressure is sufficiently low that water (and blood) boils at normal temperature of the human body.
- (B): 53 km = Balloon Max theoretical buoyancy altitude (JAXA, BU 60-1, Ø54m, 23 May 2002: <https://www.isas.jaxa.jp/e/special/2003/yamagami/03.shtml>).
- (C): Specific (embedded) mechanical energy threshold (iso-Eme curve ~ 1.1 MJ/kg): beyond this curve, a thermal protection system(TPS) is usually needed to survive re-entry heating.
- (D): FL660 = UTA ceiling (Upper Traffic Area) in most of Europe, FL195-FL660= Class-C (Controlled airspace), UIR above FL660= Class-G airspace until UNL (Unlimited).
- (F): Re-entry and descent [Alt.; V]-trajectory envelope of the Space Shuttle STS (from ISS, at $E_{me}=33$ MJ/kg). Ionisation (& blackout) during ~13min, from ~80km ↘ 55km altitude.
- (H): orbital lifetime - mean duration for an average non-propelled space object/ satellite in a circular orbit to fall back down to Earth.
- I: Circular orbital velocity at 155km altitude = 7.81 km/s (=28 116 km/h or ~Mach 25). • L: Earth escape velocity at 100km = 11.27 km/s (=40 557 km/h).
- Karman line: FAI conventional altitude limit of 100km (AMSL) separating aeronautics records from space ones (it is not an int'l legal delimitation between airspaces and outer space).
- (M1) curve: constant Mach 1, (M2): Mach 2, etc. • (Oc): envelope [Alt.; V] of Earth circular orbits. • (R): Rifle bullet speed (~ 1.3 km/s, or 4 700 km/h).
- (T): Heat barrier [$T_{skin} > 1300^{\circ}\text{C}$]. • (W): Stall limit, $\text{Weight} > \text{lift} + \text{centrifugal force}$ [hyp. lift parameter = 400 kg/m²] (Ref.: [IAC-21-E4.2.4](#), N. Bérend, ONERA, 2021 [incl. M.&Gazley, 1956]).
- T/W Corridor of continuous flight with aerodynamic lift (area between T and W curves): theoretical technology limitations for sustained lifting flight to or from space.
- (Z): Loon balloons (project cancelled on 21 Jan.2021) were heavier and flying lower (~FL500-FL650) than originally envisaged (FL600-FL900), while business or military jets can fly at FL520+.

Acronyms used:

- Eme = Specific (embedded) mechanical energy (kinetic + potential)= $(E_k + E_p)/\text{Mass}$ (Joule/kg), Earth Orbital $E_{me} \geq 32$ MJ/kg. • ATR 42-600: regional turboprop airliner.
- AMSL: Altitude (Above Mean Sea Level). • A2B: suborbital Earth-to-Earth (up to 'near-orbital' ~7.2 to 7.7 km/s). • BSO: Open Strato. Balloon (CNES). • DC: DreamChaser, A2B suborbital (Sierra Sp.).
- eVTOLs: electric vertical take-off and landing projects. • F-XX: A2B suborbital (Dassault Aviation). • GA: piston airplane (general aviation). • H160: medium utility helic. (Airbus Helicopters).
- HA: Higher Airspace (tentative definition [EASA HAO-TF]: a volume of the airspace typically above altitudes where the majority of air services, including ATC/ANS, are provided today).
- HALE: turbojet HALE RPAS. • HAPS: High Altitude Platform Systems projects, slow persistent stratospheric unoccupied aircraft (~18 to ~35 km) – purposes: scientific, remote sensing, telecomm.
- ICBM: Intercontinental Ballistic Missile (~ 6 to ~7,7 km/s). • ISS: International Space Station. • LEO: Low Earth Orbit (~155 km to 2000 km). • NS: NewShepard (Blue Origin).
- $P_o = 1$ atm= 1013 hPa (pressure). • Rafale: Supersonic fighter jet, 1500 km/h, 15km alt. • SP: SpacePlane (A2A suborbital, ArianeGroup). • SS2: SpaceShipTwo (A2A suborbital, Virgin G.).
- SR71: hypersonic aircraft (Lockheed), 33m, 66t, 25.9km, Mach 3.2 (in 1976), heating.150°C (canopy) up to 560°C (nozzle). • SST: Supersonic Transport (air-breathing propulsion).
- STS: Space Transp. System (NASA). • VSH: 'Véh. Suborbital Habité' (A2A, Dassault Aviation). • X43(B52): NASA test vehicle, Mach 9.6 at 33km. • X15(B52): NASA test vehicle, 4867 km/h at 107.8km.

Reference IAC papers:

- IAC-2021 paper, IAC-21.D2.4.10, "At crossroads of aeronautics and space": <https://hal.science/hal-03464294v1/document>
 - Explanatory video: <https://www.youtube.com/watch?v=E3PQf9V-spg> / weblink to diagram (23 Aug. 2021) in the video description.
- IAC-2021 paper, IAC-21-E4.2.4 (ONERA), "The Missing Calculation behind the Original Kármán Line Definition": <https://hal.science/hal-03420278v1/document>

A [paper](#) 'Suborbital Flights and the Delimitation of Airspace Vis-à-Vis Outer Space: Functionalism, Spatialism and State Sovereignty' [24], submitted in December 2017 to Office for Outer Space Affairs, United Nations Office in Vienna written by Paul Stephen Dempsey and Maria Manoli is listed in the ECHO literature database. The paper presents the differences between air space and outer space law regimes and associated uncertainties, explores two approaches to determine which law applies (functionalism based on the function of aircraft, space object and aerospace vehicle, spatialism based on different type of sovereignties⁸), examines the Law of the Sea Convention of 1982 as a model for delimiting air space and outer space and proposes that a new Treaty or an amendment to Art. 12 of the Chicago Convention could establish:

- The Outer Space Zone, above 120km (re-entry threshold for space systems) or, alternatively, above 160km (lowest practical operating orbit for satellites) subject to Space Law,
- The Near Space Zone, between 50 (upper limit of atmospheric buoyancy (balloons)) and 120km (or, alternatively, 18-160km) subject to aerial safety and navigation rules, It could also be restricted against overflights by foreign State aircraft without permission of the underlying State.
- The Air Space Zone, below 50km (or, alternatively, below 18km): subject to the exclusive territorial sovereignty of the underlying State, as it is today.

In the definition section of the ECHO ConOps (D4.3 European Concept for Higher Airspace Operations (HAO) Concept of Operations [10]), Higher Airspace (HA) is "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" with a note: "In Europe currently these operations are expected to occur typically above FL550 as identified in the ECHO User Requirements Document 4.1. [9] It is expected that this information will be updated once regular operations start".

It can be also noted that [ITU Radio Regulations](#) (RR) define High Altitude Platform Systems⁹ (HAPS) as radio stations located on an object at an altitude of 20-50 kilometres and at a specified, nominal, fixed point relative to the Earth (see section 3.6.5).

3.3 Market evolutions

Several documents published since 2021 are focused on Higher airspace operations and vehicles market. There are also other documents highlighting specific operations or specific new vehicles that can contribute to a wider comprehension of the market evolutions. It is also useful to monitor recent announcements about flight tests or new projects.

The following documents have been identified as providing significant materials in terms of market evolutions.

- SESAR ECHO project D3.4 - Overall new entrants' synthesis [6]
- SESAR ECHO Project D3.6 - Demand scenario specific impact analysis results [8]
- HAPS Alliance - Driving the Potential of the Stratosphere [25]
- HAPS Alliance - HAPS Reference Architecture Series - HAPS Advantages in an Era of Satellite Connectivity [26]
- Frontex WP1 – HAPS Market Report [37]
- AIA Aerospace industry association - Cooperative operations in Higher airspace - a proposal [42]
- GSMA (UK mobile telecom operators) - High Altitude Platform Systems Towers in the Skies [43]
- Mordor Intelligence - Pseudo-Satellite Market Size & Share Analysis - Growth Trends & Forecasts (2025 - 2030) [44]
- Deloitte - Riding the exponential growth in space article [45]
- Point-to-point suborbital space tourism motivation and willingness to fly, US university paper [46]

⁸ Definition from <https://spacesecuritylexicon.org/terminology/outer-space-delimitation>

⁹ ITU HAPS definition is High Altitude Platform Systems

- Space Cargo: Ultra-fast Delivery on Earth –Potential of Using Suborbital Space Vehicles for the Transportation of Cargo, university paper [47]
- A Methodology for Supersonic Commercial Market Estimation and Environmental Impact Evaluation (Part II), Wen et al, Georgia Tech Lorraine Metz, Georgia Institute of Technology, Atlanta. [48]

One of the key documents in this list is the Frontex HAPS Market Report. [37] This document issued in 2023 provides a description and an analysis of the HAPS state-of-the-art (SOTA) as a technology and the regulatory framework. It gathers insights on the market and its foreseen evolution in the short and long terms via market research. The report is divided into three elements:

- Review of SOTA and overview of the legal framework.
- Simplified market research on HAPS, including an assessment of the main available applications.
- Benchmarking and comparative analysis of HAPS and its premier competitive technologies.

The SESAR ECHO D3.4 Overall new entrants' synthesis is also a very good summary of use cases, demand, spaceport, and airspace needs in Europe. [6]

Developed by the HAPS Alliance Telecommunications Working Group (TWG), HAPS Reference Architecture Series - HAPS Advantages in an Era of Satellite Connectivity explores the use cases and potential of HAPS to revolutionise connectivity, complementing both terrestrial and satellite networks. [26]

In addition, the 'Riding the exponential growth in space' article developed by Deloitte gives a comprehensive view of the ever-growing space demand that has direct impact on the number of launches, re-entries, and potential mishaps areas. [45]

These documents will be used to support a more extensive analysis of the HAO update of Higher airspace demand analysis and market development and will be further detailed in a specific report¹⁰.

3.4 Higher Airspace Concept of Operations and Airspace Management

Several documents are focused on Higher Airspace Concept of Operations (ConOps). ConOps provide 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. They include specific aspects of new vehicles operations, spaceports, and airspace management. Concepts of operations are highly dependent on the characteristics of the vehicles flying in Higher Airspace. Therefore, airspace management is also very dependent of some performance characteristics such as speed, vertical profile, cruising altitude and geographical flight areas. These characteristics can vary from quasi fixed balloon to very high speed supersonic or hypersonic transport aircraft, they have very strong impact on dynamic airspace volume management. ConOps documents also address the space launch and re-entry operations integration with traditional ATM. This topic is specifically addressed in section 3.5.

3.4.1 US approach

On the US side, the foundations have been laid down by the Concept of Operation V1.0 Upper Class E Traffic Management (ETM) published by the FAA in 2020. [49] The primary focus of this V1.0 of the ETM Concept of Operations (ConOps) is on ATC interactions with Operators transiting to/from upper Class E airspace and operating just below FL600 in upper Class A airspace.

This Upper-Class E airspace concept has been reassessed more deeply by NASA in recent presentations, conference papers and reports:

¹⁰ EASA.2021.FC.14 EUROCAE Special Contract N°004, HAO-Update Of Higher Airspace Demand Analysis and Market Developments

- Upper Class E Traffic Management: NASA’s Collaborative Research and Technical Development to Enable Routine, Safe, and Scalable High-Altitude Operation [71]
- Cooperative Upper Class E Airspace: Concept of Operations and Simulation Development for Operational Feasibility Assessment, [65]
- Study of Pairwise Deconfliction Metrics to analyse Air Traffic Complexity in Upper Class E Airspace, [67]
- A Web-Based Negotiation Tool for Conflict Resolution in Upper Class E Traffic Management [68]
- Cooperative Separation in Upper Class E Airspace Baseline Functional Requirements for Enabling Cooperative Separation [69]

The FAA has also developed a new vision document titled Charting Aviation’s Future: “Operations in an Info-Centric National Airspace System”. [59] This vision calls for responding to the future needs of NAS users and the expected diversity and volume of operations, by changes in service delivery, infrastructure, and safety management. These changes also incorporate advances in technology and business practices to achieve safety, security, efficiency, and to ensure sustainable evolution and scalability of the NAS.

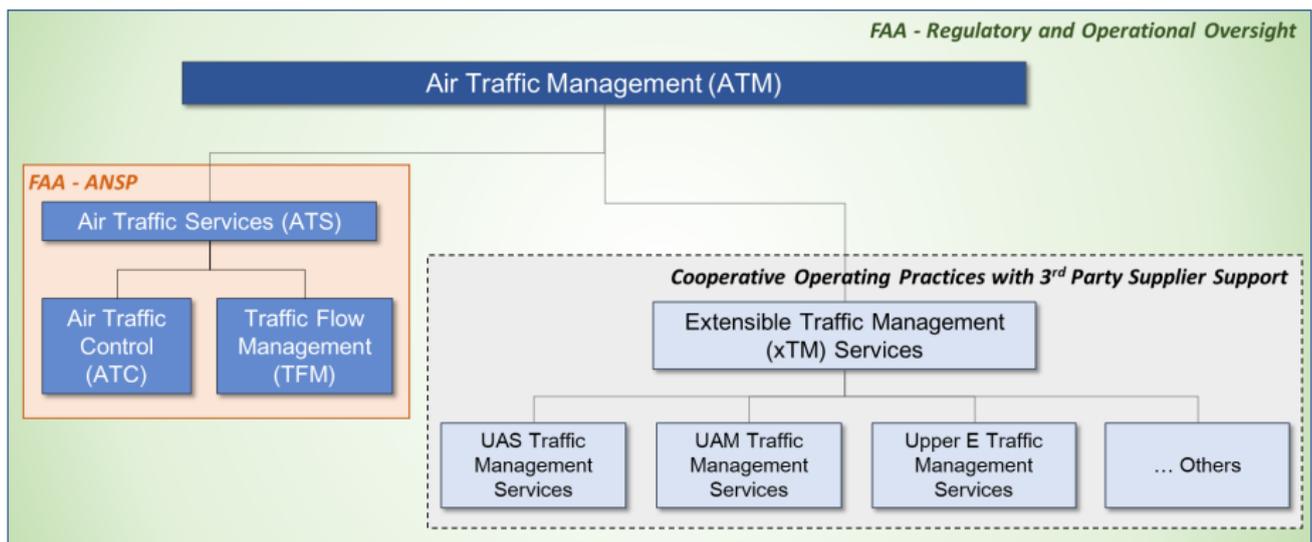


Figure 2 ATM in the NAS

Source: FAA “Initial Concept of Operations for an Info-Centric National Airspace System”. Figure 2.1 [60]

The integration of HAO or Upper Class E airspace into an Info-centric National Airspace System is further detailed in the document “Initial Concept of Operations for an Info-Centric National Airspace System”. [60]

3.4.2 European Concept

On the European side, the latest reference is the SESAR ECHO D4.3 European Concept for Higher Airspace Operations (HAO) published at the end of 2022. [10] This document has soon become a world reference, but its main objective is to be the European Concept for HAO.

The European Concept of Operations (ConOps) for Higher Airspace Operations (HAO), aims to integrate new entrants such as High-Altitude Platform Systems (HAPS), supersonic/hypersonic vehicles, and suborbital/space missions conducted from and to European States, through the EUROCONTROL Network Manager area of responsibility. It also includes the methods of transit through air traffic service (ATS) airspace.

The document provides a framework for managing HAO safely and efficiently, ensuring minimal disruption to conventional air traffic. It describes operations in Higher Airspace (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 or governmental space activities.

The ConOps includes a common nomenclature with definitions of frequently used terms in the document. The ConOps proposes trajectory-based operations (TBO) and 4D operating zones to accommodate diverse flight profiles while maintaining airspace security and state sovereignty. It outlines strategic de-confliction, cooperative air situation awareness, and coordination with air traffic management (ATM) and future space traffic management (STM). The integration of civil and military operations is emphasised, with new service providers, such as Higher Airspace Operation Service Providers (HAOSP), playing a role in managing airspace users.

The document details operational challenges, regulatory needs, and required infrastructure improvements, including communication, navigation, and surveillance systems. It highlights a short, medium, and long-term roadmap for implementation, addressing validation activities, contingency planning, and regulatory advancements. This ConOps supports a flexible, scalable, and collaborative approach to managing Europe's evolving higher airspace, ensuring safe, efficient, and sustainable aerospace operations.

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 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.

This European concept for Higher Airspace Operation will be further refined in the context of the SESAR ECHO 2 project. In this project three new OSED's (Operational Service and Environment Description) [12][13][14] will be delivered in 2026, each OSED is related to one Work Package and refines the operational concept on each particular use case:

- WP1 integrating space operations transiting airspace within the NM area. This work package is dedicated to developing a Space Launch Real Time Monitoring Module for EUROCONTROL, in its pivotal role as the Network Manager for the European air traffic network under the Single European Sky initiative. The primary objective is to significantly enhance situational awareness at the network level. This enhancement is crucial for EUROCONTROL, as it involves supporting Air Traffic Flow Management and effectively managing crises or contingencies, particularly those related to space launches (cross-border).
- WP2 Procedural package for HAPS operations integration. The aim of WP2 is development and validation of specific elements of the European High-Altitude Operations ConOps related to the



integration of High-Altitude Platform Systems (HAPS) in Air Traffic Management (ATM) in particular:

- Procedures based on performance of the HAPS
- Weather Impact (especially during take-off, climb and descent phase)
- Network Impact (effects on overall capacity)
- CNS Requirements (e.g. ADS-B, Mode N, separation)
- Datalink Infrastructure (Datalink requirements, Lost Command and Control Link)
- Ground handling of HAPS on airports

Based on the “ECHO target concept”, the 4D trajectory of the HAPS is the central part of the development. The concept will be applied to both individual vehicles, flying according to their agreed trajectories, and to operating volumes defined as 4D zones.

- WP3 Procedural package for supersonic, hypersonic, and suborbital vehicles. This WP will address in particular:
 - High speed transition and fast usage of airspace
 - Low capabilities to change trajectories during the flight
 - Possible debris generation affecting HA, airspace outside HA, and the ground
 - Regulation under development, and EU / MS competences to be clarified
 - Cross border issues related to States’ coordination, security, and defence
 - Operations influenced by Weather and Space Weather
 - Low capabilities at high altitudes of current surveillance and tracking systems
 - ATM/STM interface for very high-altitude suborbital flight (above 150 km)

3.4.3 AIA proposal for cooperative operations in higher airspace

The Aerospace Industries Association (AIA), Emerging Technologies Committee (ETC), Airspace Working Group has published in April 2022 a proposal for a collaborative traffic management scenario in higher airspace. [42] Considering the performance diversity of the different vehicles expected in the higher airspace, collision resolution scenarios are proposed.

3.4.4 HAPS Alliance

The Cooperative, Seamless, and Global Digital Skies for Higher Airspace white paper published in May 2025 by the HAPS Alliance is making recommendations for a global framework. [35] The following extracts gives some key principles:

- “We propose marrying the FAA “Cooperative Aera” approach and Eurocontrol’s “4D Zone”, in conceptually equivalent, internationally standardised “Cooperative Zone” – a 4D volume of airspace that is published to reflect operational needs, and in which “Cooperative Services” are provided to Cooperative Aircraft”
- “CZs are dynamically published 4D airspace volumes (3D + time bounds) within which operators are responsible to deconflict cooperatively. CZs contain (encapsulate) the near/mid-term intents of one or more Cooperative Aircraft”

More details are given on Cooperative deconfliction within CZs, Interactions between IFR and Cooperative Traffic, interaction with State aircraft, with supersonic and hypersonic aircraft and commercial space operations. Ascent and descent via IFR or pre-coordinated airspace are also addressed.

3.4.5 CANSO CATS Concept of Operations (ConOps) for Future Skies

CANSO has launched an initiative to develop the CATS (Complete Air Traffic system) global vision for the sky in 2045, under the leadership of the CATS Global Council¹¹, to facilitate greater collaboration among leaders across the aviation and aerospace industries: ANSPs, UTM service providers, aircraft manufacturers, drone operators and manufacturers, high-tech companies, airlines, airports, regulatory authorities, space agencies and research bodies.

The goal of this innovation forum is to:

- drive the next era of aviation and forge a more adaptable, resilient industry
- explore, imagine, and shape a shared vision for how our global skies can innovate and interoperate safely in the future
- show the way and go the way, enabling all aviation and aerospace players to learn, evolve and advance so that they are fit for this exciting future.

The Complete Air Traffic System (CATS) Concept of Operations (ConOps) for Future Skies outlines a transformative pathway to achieving a fully integrated, scalable, and sustainable air traffic management (ATM) system by 2045. [84] Developed by the CATS Global Council, this ConOps provides a strategic vision to modernise airspace management globally, ensuring seamless integration of emerging airspace users like drones, Advanced Air Mobility (AAM) aircraft, and High-Altitude Operations (HAO).

This ConOps is a public document and is available on the [futureskyvision](https://www.futureskyvision.com) website. The vision outlined in the ConOps focuses on an integrated airspace environment and an advanced automated ATM system that enables traditional commercial aircraft and new entrants — including uncrewed and highly automated vehicles — to operate seamlessly, safely, and efficiently.

The ConOps is structured in 3 phases:

- Phase 1: Airspace and Flight optimisation based on Advanced Digital Information Sharing
- Phase 2: Advanced Automation and Real-Time Performance Management
- Phase 3: Seamless Airspace

All along the 3 phases The CATS ConOps is adding a Focus Scenario called “Optimizing Higher Airspace Operations”. This focus scenario addresses the complexities of managing HAPS, suborbital flights, and long-endurance missions, ensuring their safe and efficient integration into the existing airspace management framework.

This focus scenario includes the introduction of Cooperative Zones (CZs), a Global ATM Services Network, Continuous Automated Dynamic Planning, and Cooperative Deconfliction within CZs.

These CZs will be the Core of HAO Management:

“CZs will be dynamic, cross-border airspace volumes inside which separation is managed cooperatively by airspace users, according to rules agreed with national authorities. The CZ boundary will dynamically separate ATC managed operations from Cooperatively Managed Operations, allowing for diverse operations, and the integration of multiple concepts in the airspace. CZs will be established dynamically to meet the mission needs of airspace users while respecting the constraints set by ANSPs or National Authorities”.

¹¹ an independent innovation forum, initiated by CANSO
EASA.2021.FC.14.SC.003 – HAO Literature Review, D3, Final Report

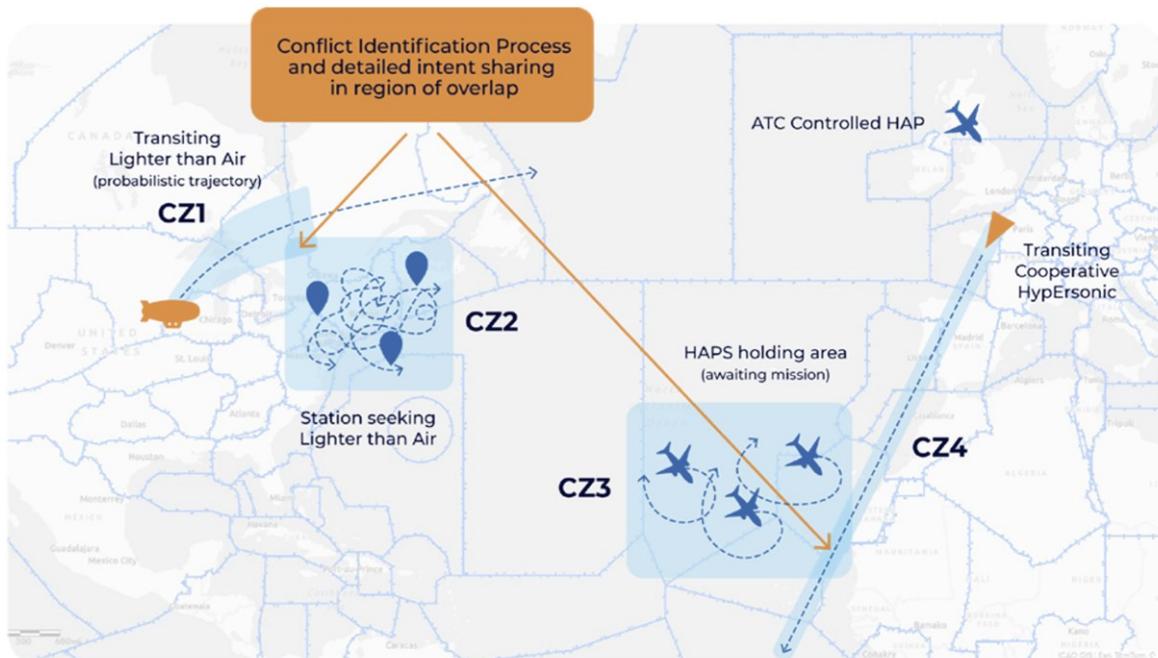


Figure 3 Examples of Cooperative Zones (CZs)

Source: CATS ConOps future skies (reproduced with permission of CANSO).

3.4.6 Initial conclusions

There has been a significant work and publication on concepts of operations mainly on both sides of the Atlantic. While US is very focused on Upper Class E airspace, Europe has published mainly on trajectory-based operations (TBO) and 4D operating zones. The HAPS Alliance “Industry’s vision for integrating highly automated operations in a global and cross-border Higher Airspace environment” and the CATS ConOps for future skies also introduce the concept of Cooperative Zones (CZ).

The description of the services to be provided is partially addressed by ECHO ConOps [10]: “ECHO 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)”. One or several HAOSP may be established for practical or political reasons, FAA/NASA may provide similar services under the concept of cooperative separation. [69]

These three approaches have similarities, but harmonisation seems necessary, and ICAO will play a role via the ATMRPP under which an HAO WG was established in spring 2025 with a first meeting in June 2025.

The ICAO ANC 14 has recommended (recommendation 3.1.7 [83]) that ICAO:

- “develop a holistic vision and global concept for higher airspace operations, including regulatory approval, coordination responsibilities and liability, for inclusion in its work programme for the next triennium; and
- develop provisions related to the safe and efficient transit of aircraft through controlled airspace and separation management in higher airspace, including air traffic management procedures contingency planning and risk assessment and monitoring methodologies, especially for uncontrolled descents.”

The ATMRPP (Air Traffic Management Requirements and Performance Panel) has been tasked by ICAO secretariat to address these topics.

During the ATMRPP-WG/46 (7-11 April 2025), the HAPS community provided up to date information on their sector including their Vision for the concepts, operations, and other issues of interest to the expert group community of ICAO. The ATMRPP will be developing a holistic vision and concept of operation for HAO over the next years, bringing together various global strategic efforts on this topic. HAPS is a key part of the HAO sector which, in general, will touch on many aspects of the aviation system. It is expected that some future work, as well as some existing work, of the various expert groups could benefit from being informed by the latest HAPS developments.

HAO Global Vision and Concept of Operations should be a new ICAO document to provide a global holistic vision and concept of operations for HAO covering all ICAO domains.

3.5 Space Launch and re-entry

Space vehicles launch and re-entry phases are considered in HAO Concepts of operation, their operations are not directly stratospheric operation, but they have to transit via ATM legacy airspace and stratospheric airspace. Mishaps may also occur with the fall of debris through lower airspace on a wide area. The website <https://orbit.ing-now.com/> provides a lot of information about launches, satellite in orbit, orbital decays and re-entries.

The increasing number of space launch and re-entry has raised many operational and safety issues that are addressed in various documents. [45] These issues are to be considered by ANSP for ATFM and ATC but also by airspace users in terms of airspace restriction, diversion, and fuel management.

As an example, the failed Space X Starship launch on the 16th of January 2025 has led to a safety critical situation due to the falling debris into a wide area in the Caribbean airspace. A Debris Response Area (DRA) was suddenly activated, some diversion airfields were not any more accessible. Several flights had to hold for an unknown duration or divert with high risk of being short of fuel. The following videos available on YouTube are very demonstrative of this situation:

- <https://youtu.be/NnVfLeMND0Y?si=NETBMLQV2lsAzYog> 'Starship Rocket EXPLODES OVER CARIBBEAN | Multiple Flights Delayed!: VASAviation'
- <https://www.youtube.com/watch?v=ZT11EpInk5c> 'Numerous FUEL EMERGENCIES after Starship Explosion over Caribbean!: VASAviation'

The impacts of the growing number of space launches and re-entries is assessed in this article entitled "ATM strategies for, and impacts of, space launches" (<https://iopscience.iop.org/article/10.1088/1742-6596/2716/1/012083/pdf>) N Robson et al 2024 J. Phys.: Conf. Ser. 2716 012083. [74] An extract of the summary of the report is cited hereafter: "In the tactical phase, the consequences of impacts on airspace users (such as the re-routing of flights) and on air navigation service providers (such as the demands of coordinating airspace closures in the context of considerable re-entry/splashdown uncertainty) are discussed. A key contribution we make in this paper is the first aircraft-specific, fuel and operating cost analysis of HAO impacts, and the first such European cost assessment, with basic impact geometries. We also propose improved aircraft-specific impact models, which include passenger-centric costs".

3.5.1 ICAO

At ANC 14, several Working Papers have called for actions from ICAO to develop material related to the safe and efficient transit of aerospace vehicles through controlled airspace. This was initiated in December 2023 by a Joint statement by the European Union and its Member States, the Governments of the United States of America, Canada, Japan, and the United Kingdom, expressing support for ICAO's efforts to address the challenges and opportunities associated with higher airspace operations (https://transport.ec.europa.eu/news-events/news/joint-statement-higher-airspace-operations-hao-2023-12-18_en).

The WP/58 presented by a large number of states (European Union and its Member States, the other Member States of the European Civil Aviation Conference, EUROCONTROL, Bolivia, Chile, Costa Rica, Cuba, Ecuador, Honduras, and Mexico) is proposing clear actions and recommendation. [77] The executive summary states “This working paper presents priorities required to support the safe and efficient integration of aerospace vehicles used for higher airspace and space operations. Where these aerospace vehicles transit through controlled airspace, prioritised action is necessary to support the growth of this industry while ensuring the safety and efficiency of existing traffic networks. Longer term objectives should be incorporated into the ICAO work programme, including to ensure good cooperation between the space and aviation sectors”.

WP/72, presented by International Air Transport Association (IATA), International Business Aviation Council (IBAC) and International Federation of Air Traffic Controllers Associations (IFATCA), is also urging ICAO to address the accommodation of the launch and re-entry of commercial spacecraft in the air transportation ecosystem. [78]

WP/110, presented by Chile, cosponsored by 20 Latin American Civil Aviation Commission (LACAC) Member States, is inviting ICAO to study and develop Standards and Recommended Practices whose scope covers operations to and from outer space or near the Kármán Line. [76]

WP/162, presented by Spain, describes the benefits of having a Space Alert Protocol for uncontrolled re-entry of space vehicles and space debris in terms of national safety and security, coordination, and public confidence. [80] In addition, it presents potential benefits that could be potentially useful and taken into consideration for a coordinated approach regarding such protocols at a regional and global level.

WP/205, presented by South Africa, presents the potential impact of the re-entry of space objects affecting South African Airspace and the need to improve coordination between all stakeholders in the management of these activities. [81]

Finally, the report of the committee on agenda item 3, WP/213, of the ANC/14 is making this recommendation:

“Recommendation 3.1/6 – Addressing the safe integration of space transport operations into the airspace system that ICAO:

- a) work with Member States and international organisations to identify, compile and publish best practices, as necessary, related to the safe and efficient air navigation of aircraft around space transport operations; and
- b) develop guidance material for air navigation services providers related to the integration of space transport operations, including NOTAM dissemination, stakeholder communication associated with specific operations, air traffic flow management, and data-sharing for real-time updates on the status of the airspace, excluding telemetry data of launch vehicles”. [83]

3.5.2 SESAR ECHO concepts

The ECHO ConOps (D4.3 European Concept for Higher Airspace Operations (HAO) Concept of Operations) is addressing the differences between airspace and space operational environments. [10] In particular the ECHO ConOps provides clarification on the interface between airspace and space environment: “With ATM covering aviation activities within the atmospheric domain, STM (Space Traffic Management) 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 spacecraft¹² 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". The synchronisation between the aviation and space domains in planning phase of launches and re-entries and in the execution phase is also described.

Atmospheric and space domain are not explicitly defined in the definition section of the ECHO ConOps, nevertheless ATM is defined as such: "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)". So, it can be considered that atmospheric domain includes existing ATS airspace (below FL550) and Higher Airspace (below orbital space).

ECHO 2 solution 1 is about Network Real-time Monitoring and Management of Launch and Re-entry Missions. This solution will validate a new N-RMM (Network Real-time Mission Monitoring) service in European ATFCM and NM to be implemented as part of an upcoming NM Space Desk. A prototype & procedure package for an NM Space Desk will be developed. SPR-INTEROP documents will be produced to describe the different solution 1 Use Cases:

- UC1 - Uncrewed vertical rocket launch from European spaceport to orbit with two stage drop (Nominal and Non-nominal)
- UC2 - Uncrewed space vehicle re-entry from orbit to a European spaceport with horizontal landing (Nominal and Non-nominal)
- UC3 - Uncrewed vertical rocket launch, from a location outside the monitoring and management area (Non-nominal only)

3.5.3 FAA

Space is an integral part of FAA missions; this is well described on the FAA dedicated web site for space: <https://www.faa.gov/space>.

The FAA has set up an Office of Commercial Space Transportation called AST. A presentation of the missions of this AST can be found on the FAA web site: <https://www.faa.gov/media/24826>. The AST licenses, permits, regulates, and inspects United States commercial space industry.

The FAA is also responsible for the safe and efficient integration of space operations into the U.S. airspace system. This includes space operations for FAA-licensed commercial space operators and for NASA, the U.S. military and other U.S. government agencies. A brief on the missions of 'FAA Air Traffic Organization Space Operations' can be found on the FAA web site: <https://www.faa.gov/media/24831>. The FAA Air Traffic Organization Space Operations addresses:

- FAA Air Traffic Organization Operator Operational Onboarding and Letter of Agreement
- Risk Assessment and Aircraft Hazard Area Development
- Mission Planning
- Traffic Flow Management
- Real Time Mission Support
- Post Operations Analysis

The [Commercial Space Integration into the NAS \(CSINAS\) Concept of Operations](#) describes future commercial space operations, with an emphasis on managing integration of launch and re-entry vehicles as they transition

¹² spacecraft is not defined in the ECHO ConOps definition chapter, spaceplane is defined as "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"

through the National Airspace System (NAS). [58] This extract of the document gives a good overview of the guiding principles used in developing the CSINAS ConOps:

“These principles are consistent with the FAA’s approach to other operations such as small Unmanned Aircraft System (UAS) and Operations above Flight Level 600 (FL600), the expectation is that:

- 1) Launch/reentry vehicles that can meet the flight characteristics and performance requirements of operating aircraft in the airspace being transited will be integrated into normal operations and within the Communication Navigation & Surveillance (CNS)/Air Traffic Management (ATM) procedures and infrastructure.
- 2) Launch/reentry vehicles that are not integrated will have operations conducted in a cooperative environment with required information provided by the operator to the FAA network demarcation. Communications, Navigation and Surveillance (CNS) capabilities are operator provided.
- 3) To support this cooperative airspace management environment, the FAA will work with the launch/reentry operator community to develop standards for information exchange of surveillance, and intent with associated Adaptive Risk Envelope (ARE).
- 4) There will be different levels of access resulting from risk-based assessments that consider vehicle/operator capabilities (e.g., CNS capabilities), the manner of operation, and the airspace transited”.

The FAA has also established an Office of Spaceports, a centralised policy office within the FAA Office of Commercial Space Transportation. The FAA Office of Spaceports is responsible for development of policies that promote infrastructure improvements and strengthen the competitiveness of US spaceports, supporting launch and re-entry site licensing activities, providing technical assistance and guidance to existing and proposed new spaceports, and the domestic and global promotion of US spaceports.

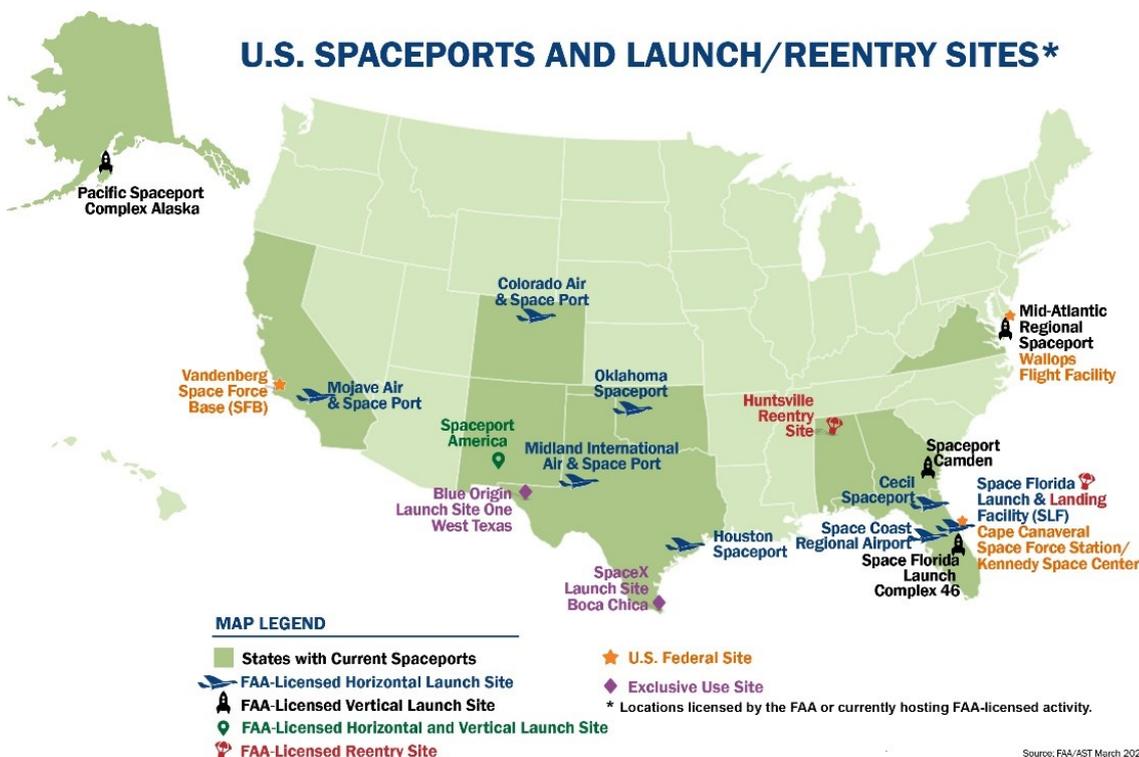


Figure 4 U.S. Spaceports and Launch/Reentry sites

Source FAA/AST March 2025 (<https://www.faa.gov/media/91921>)

3.5.4 CANSO

Recognizing the growing need for management of Space Operations, CANSO has published a document called “ANSP Considerations For Managing Space Operations”. [85] This document highlights the growing complexity of space activities, the need for coordination between space and air traffic management, and the importance of regulatory frameworks. The document outlines challenges such as space debris, integration of space launches with aviation, and the necessity of real-time tracking and communication. It also emphasises collaboration among stakeholders, technological advancements, and policy development to ensure safe and efficient airspace operations.

It introduces the notion of coordinating and integrating ANSPs: the ANSP in whose controlled airspace the launch or re-entry is taking place is the coordinating ANSP, the other ANSPs whose airspace may be affected, are called the integrating ANSPs. The integration of space launch and re-entry considerations are addressing:

- notification for airspace,
- airspace planning including NOTAMs and Airspace Management Plan,
- Day of activities management (System readiness, situation awareness, weather monitoring and managing airspace, ATFM, contingency plan),
- post Operations Analysis

3.5.5 Initial conclusions

The increasing number of space launches and re-entries, the operational disruption such as airspace closure and potential safety issues especially regarding debris is clearly reflected in many ICAO working papers and several documents. The need for extensive collaboration to manage these operations is also highlighted. This collaboration between, States, space organisations¹³, ANSPs, regulators may also imply organisational aspects and international coordination mechanisms. Appropriate Regulations will probably have to be developed.

The ICAO work programme and production needs to be actively monitored to establish the future regulations and organisational arrangements.

3.6 CNS for HAO

CNS is mainly addressed in the ECHO D2.2 Analysis report section 4, in the ECHO Concept of operation section 7 (Infrastructure) and in 4 FAA Upper Class E Traffic Management (ETM) white papers: one summary for all CNS and one document for C, N and S. [3]

The ECHO Analysis report section 4 called “Suitability of current CNS” is drawing the following conclusion, cited hereafter:

“Above FL600, the airspace is assumed as being able to serve as test bed for new CNS technologies which in the longer term could create opportunities to facilitate the integration in the airspace below. GNSS based navigation is seen as the primary navigation system of the future and will constitute, due to limitations of conventional navigation aids at these altitudes, probably the only viable option for the Higher Airspace. It is to be noted, that separation standards in general are based on positioning relative to one another, not on absolute position (This should be considered when assessing the impact of possibly abandoning barometric altimetry).

Full integration of STM and ATM should be considered the ultimate goal for surveillance and tracking. In this regard, it is proposed, that all vehicles including spaceplanes shall be equipped with ADS-B and GNSS to ensure a safe integration. SWIM is the core element of the ATM system designed as well in SESAR as in NextGen. For

¹³ For example, CNES (Centre National d'Études Spatiales) is the French government's space agency, responsible for developing France's space program, and DLR (Deutsche Zentrum für Luft- und Raumfahrt) is the national aeronautics and space research centre of the Federal Republic of Germany.

full integration of STM and ATM (and the traffic management of the Higher Airspace), SWIM is expected to be an essential element as well. Data transmission between space tracking networks and aviation surveillance is currently assessed to be a challenge but will be needed for integrated operational re-entry procedures". [3]

It can be noted that the ECHO ConOps has been written during year 2022. Since that, GNSS resilience has become an even more significant issue to be considered for a future resilient automation architecture.

The FAA Upper Class E Traffic Management (ETM) Communication, Navigation, and Surveillance (CNS) Summary Report provides a comparison of current Communication, Navigation, and Surveillance capabilities, their advantages, their disadvantages, and the feasibility to use them in the Upper Class E Traffic Management (ETM). [50]

The "Cooperative, Seamless, and Global Digital Skies for Higher Airspace" white paper published in May 2025 by the HAPS Alliance is making recommendations for electronic conspicuity in CZs (Cooperative Zones):

"we strongly support an e-Conspicuity solution that is

- a) technology and frequency agnostic,
- b) secure, to enable privacy and strong authentication, and
- c) leveraging the existing redundant data links to the HAO aircraft.

A network-based e-Conspicuity framework similar to Network Remote ID, would be a strong candidate". [35]

3.6.1 Altimetry

The ECHO Concept of operation section 7.3 (Navigation) states that "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". [10] This is particularly important when various types of vehicles would need to be vertically separated.

The FAA Upper Class E Traffic Management (ETM) Navigation document also gives additional precision:

"The standards for dashboard-mounted altimeters and ADCs allow manufacturers to decide the maximum altitude of their devices, but the test criteria within those standards go no higher than 50,000 ft.

While some commercial barometric altimeters have been approved for use between 50,000 ft and 60,000 ft (e.g., business jets and Concorde), it is generally believed that most traditional civilian systems do not provide useful information above 60,000 ft. At least one modern system has been approved for use up to 70,000 ft based on extrapolation of requirements defined to 50,000 ft. One manufacturer/operator employed these units in HALE telecommunication balloons that operated in various locations around the world up to FL700. Some military barometric altimeters were required to indicate pressure altitude up to 80,000 ft per MIL-STD-843.

Above FL800, it is possible that atmospheric density is too low to support accurate pressure altimetry measurements with commercial systems". [52]

The SESAR 3 ER 1 Green-GEAR D3.1 – Initial OSED – Geometric Altimetry June 2024 is about the use of geometric altitude in a fully geometric environment or in a mixed capability environment. HAO is mentioned as a specific case where geometric altitude is needed. [86] This document is not specific to HAO and is more focused on traditional aviation, but it gives some consideration on this topic.

It also highlights that, in recent years, there has been an increase in GNSS jamming and spoofing occurrences. The vulnerability of GNSS and SBAS is also mentioned in the FAA Upper Class E Traffic Management (ETM) summary and Navigation documents. [52][50]

CANSO CATS ConOps recognises the need to move to a unified altitude reference system to support seamless integration of new entrants such as drones, high-speed platforms, and AAM vehicles. **Error! Reference source**

not found. It is noted that “achieving widespread adoption of a standardised altitude reference requires extensive collaboration and standardisation across the aviation industry”. Four Altitude Reference Options are presented in this ConOps:

- Pressure Altitude (QNH) Standardization: This approach proposes using pressure altitude (QNH) as the reference for all local Very Low-Level (VLL) operations.
- GNSS-Based Altimetry Systems: This option suggests adopting GNSS-based altimetry for local VLL operations, offering enhanced accuracy and reliability
- Tailored Altimetry Approach: This flexible strategy accommodates varying operational requirements while ensuring safety and interoperability.
- Adaptive Altitude Reference System: This innovative solution supports the coexistence of multiple altitude reference systems. It leverages dynamic conversion capabilities, transparent data sharing through APIs, and adjustable separation standards based on the reference system used by each aircraft. This adaptive approach enhances flexibility, resilience, and safety, offering significant benefits for managing diverse airspace operations.

This last option could be particularly envisaged for HAO, nevertheless the CONOPS states that ' Each of these options requires further evaluation to determine the optimal path forward in establishing a seamless and integrated altitude reference system that supports both traditional and emerging airspace users.'

In conclusion, altimetry is an important topic for HAO considering:

- the transit of HAPS in the ATS airspace currently based on barometric altitude,
- the operations at high altitude that may require vertical separation or segregation with geometric altitude,
- the use of GNSS as a source for geometric altitude calculation,
- the risks of GNSS jamming and spoofing to be better assessed for Higher Airspace Operations.

3.6.2 Communication

The ECHO Concept of operation section 7.2 (Communication) emphasises:

- The need for satellite communication for the most demanding services, in the Future Communications Infrastructure (FCI) for the long term
- 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
- All frequencies allocated for communications must be protected from interference.
- 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.

The FAA Upper Class E Traffic Management (ETM) Communication document also gives additional precisions on the use of existing communication technologies for HAO:

- VHF voice and VHF data-link may be usable in lower ETM environment with potential signal availability up to 70,000 ft Above Ground Level (AGL) but testing standards for airborne equipment are only specified to FL700 and Frequency Protected Service Volume are only defined up FL600. Protection against potential interference above that Flight level is not ensured.
- Satellite voice and data communication are viable and presently in use by UAS but could be problematic with supersonic and hypersonic aircraft due to speed limitations (potential doppler shift above Mach 1.4 to Mach 1.66 depending on service provider). Testing standards for airborne transceivers do not characterise performance above FL700.

The JARUS CS-HAPS, Airworthiness recommendations for HAPS is addressing the command and control communication system requirement including contingency, many of these Higher Altitude vehicles being remotely piloted. [87]

These reports demonstrates that communication systems for Higher Airspace will require additional studies, it may not be possible to use common technologies for different types of vehicles and operations (HAPS, Supersonic, Hypersonic). Appropriate equipment standards and testing needs also to be defined.

Ground-ground connectivity between HA operators, ATFM and higher-airspace operation service provider needs also to be addressed. SWIM is mentioned in the ECHO Concept of operation section 7.1 'Information management'.

3.6.3 Navigation

The ECHO Concept of operation section 7.3 (Navigation) mentions: “

- *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”.*

The FAA Upper Class E Traffic Management (ETM) navigation document also gives additional precision on the use of existing navigation technologies for HAO:

- The main factor limiting VOR navigational support for ETM is the elevation of Frequency Protected Service Volumes (FPSV) ceilings.
- DME is potentially viable for lower ETM airspace, limited to “High” installations where transmitters are located at sufficient heights above ground level,
- DME/DME (using two or more DMEs to determine aircraft location may be the best existing Ground based navigation system for lower ETM operations
- International Traffic in Arms Regulations (ITAR) mandate that airborne GNSS¹⁴ receivers be disabled at speeds exceeding 600 m/s (~Mach 2.03)
- All ETM operations traveling less than Mach 2.03 should be able to employ GPS and SBAS navigation in the horizontal dimension
- GPS and SBAS are vulnerable to jamming, spoofing and solar activity
- Inertial Navigation System (INS) are well suited for ETM operations as there is no upper altitude limit for use; however, other technologies (e.g., DME/DME) may be needed to compensate for errors or drift.

3.6.4 Surveillance

The ECHO Concept of operation section 7.4 (Surveillance) emphasises:

- the need 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

¹⁴ Common examples of GNSS (Global Navigation Satellite System) include the American GPS, European Galileo, and Chinese BeiDou

surveillance, currently, less than 30 percent of the world’s airspace being covered by ground ADS-B stations. 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.

The FAA Upper Class E Traffic Management (ETM) surveillance document also gives additional precision on the use of existing surveillance technologies for HAO:

- Radar surveillance has been experienced with Concorde at 60 000 ft but coverage will be limited, precision degrades with range and is dependent on commercial barometric altimeters, many of them do not function well above 60,000 ft.
- WAM could provide Coverage of operations in transit to/from ETM airspace, but WAM will be limited by system configurations and pressure altimeter constraints.
- The most recent Version of Mode 3 1090ES (Extended Squitter) ADS-B standards (ED-102B/DO-260C) were developed to accommodate support for supersonic, hypersonic, and commercial space vehicles.[88]
- ADS-B ground station coverage may be limited but Space-based ADS-B offers potential for worldwide surveillance.
- Most vehicles traveling less than Mach 2.03 in ETM airspace could employ ADS-B with a dependency on accurate pressure altitude reporting. This Mach 2.03 limitation is due to ISTAR restrictions.
- ADS-B is also susceptible to jamming and spoofing. ADS-B jamming could occur as interference to GPS signals. Spoofing is possible through the creation of false GPS signals or transmission of false ADS-B messages.
- Automatic Dependant Surveillance Contract (ADS-C) may be a feasible surveillance mechanism in the lower ETM environment with appropriate altimetry; however, service provider and automation configurations may limit coverage.

The High-Altitude ADS-B Flight Tests on a NASA ER-2 Research Airplane report provides valuable and detailed information on the use of ADS-B at higher altitude and particularly on the use of barometric or geometric altitude reporting. One test flight, conducted up to 63 000 ft, is showing significant differences. [70]

The “Cooperative, Seamless, and Global Digital Skies for Higher Airspace” white paper published in May 2025 by the HAPS Alliance is considering that inside Cooperative Zones, where operators deconflict cooperatively by exchanging operational intents and identifying conflict, traditional surveillance would therefore likely not be needed for deconflicting aircraft. [35] The white paper indicates that E-Conspicuity is paramount for National Security considerations and that States need to know who is operating in their airspace and under what authority. It also highlights that, for many commercial operations in HAO, privacy is paramount. HAO aircraft will provide critical commercial services such as connectivity infrastructure, for which it may be undesirable to reveal the exact position and layout of the network. The current surveillance infrastructure (e.g., ADS-B or Radar) may not be able to support privacy, authentication, and verification of identity. The HAPS Alliance “strongly support an e-Conspicuity solution that is

- a) technology and frequency agnostic,

- b) secure, to enable privacy and strong authentication, and
- c) leveraging the existing redundant data links to the HAO aircraft”.

3.6.5 Spectrum

[ITU Radio Regulations](#) (RR) define HAPS as radio stations located on an object at an altitude of 20-50 kilometres¹⁵ and at a specified, nominal, fixed point relative to the Earth.

Spectrum allocation for HAPS has been discussed at WRC-19 (World Radio Conference). Global and regionally harmonised designations of frequency bands for HAPS have facilitated the development of HAPS services and allowed trials to move towards commercial deployments.

The last WRC was WRC-23 in November-December 2023 at Dubai. Agenda item 1.4 included studies of the possible new identifications for using HAPS as IMT (International Mobile Telecommunication) Base Stations (HIBS) as part of IMT networks. The HAPS Alliance Telecommunications Working Group (TWG) has developed a presentation "The HAPS Alliance views on WRC-23 agenda item 1.4" that contains justification elements and recommendation for additional frequency allocation, regulation for the protection of existing systems and appropriate PFD limits enabling sharing between HIBS and existing services without large separation distance. [36] Many resolutions (Number 165, 166, 167, 168, 213, 218, 221) were taken at WRC-23 to allocate frequencies in various frequency bands for High Altitude Platform Stations.

The WRC-23 reports appendix 4 includes a specific table called "AP4- 98 –MOD TABLE 2 (REV.WRC-23) Characteristics for frequency assignments to high-altitude platform stations (HAPS) and high-altitude platform stations as International Mobile Telecommunications base stations (HIBS) in the terrestrial services". [90]

3.6.6 Initial conclusions

CNS is a key topic for efficient and safe High Airspace Operations. Satellite based CNS will play an important role for all components of Timing, Communication, Navigation, and Surveillance. GNSS can provide an appropriate navigation infrastructure¹⁶ with a special role for geometric altitude calculation. It is also the main source of navigation data for surveillance based on ADS-B. The FAA documents highlight some issues with GNSS for Supersonic and hypersonic aircraft due to ITAR restrictions. [50][52][53] Nevertheless, this may not be a short-term issue as the most advanced project for civil supersonic transportation (Boom Overture) is flying at Mach 1.7, well below Mach 2.03, and FL 600.

Security issues such as GNSS or ADS-B spoofing and jamming or ADS-B are also well identified. Further studies are needed to define alternative or complementary technological solutions to GNSS for timing and positioning, appropriate technology solutions for non-cooperative surveillance and definition of contingency procedures.

3.7 Environmental and societal impact

3.7.1 Environmental impact

The presentation at the European Space Agency (ESA) Clean Space Industry Days on environmental sustainability of future proposed space activities is based on a study coordinated by the Space Generation Advisory Council, and the Space Safety and Sustainability. [92] It is very focused on space activities but gives some indication on environmental impact for suborbital activities especially space tourism. This conference concluded that suborbital flights have significant but much lower impact than orbital flights. Stratospheric tourism balloons was out of the scope of this study.

¹⁵ <https://www.itu.int/en/mediacentre/backgrounders/Pages/High-altitude-platform-systems.aspx>

¹⁶ IRS and quantum sensing could also provide a reliable source of information in the future

3.7.2 Societal impacts

The various use cases that HAPS can support will have significant social impact in terms of connectivity. HAPS can provide connectivity in areas where there are no terrestrial cellular networks.

The HAPS Alliance “Advantages in an Era of Satellite Connectivity” white paper analyses various uses cases in automotive, public safety or agriculture and farming. [26] Typical use cases are described:

- Automotive: emergency calls, remote unlocking of shared cars, the provision of safety-related traffic information, vehicle software updates and in-car entertainment.
- Public safety: natural disasters (e.g., floods, fires) detection, enabling communications during disaster relief and recovery,
- Agriculture and Farming: crop and soil health monitoring, geofencing (to detect movement into and out of the farm) and livestock tracking.

The Frontex final report called “Preliminary Assessment on the impact on Fundamental rights” is screening the positive and negative impacts on fundamental rights potentially affected by the use of HAPS based on a few use cases for HAPS related to earth observation, navigation and communication. [40] It assesses potentially affected rightsholders and fundamental rights according to the Treaty on the European Union (TEU) and the Treaty on the Functioning of the European Union (TFEU).

3.8 Regulatory aspects

3.8.1 ICAO

The AN-Conf/14-WP/213 REPORT OF THE COMMITTEE ON AGENDA ITEM 3 has made the Recommendation 3.1/7 – Higher airspace operations:

That ICAO:

a) develop a holistic vision and global concept for higher airspace operations, including regulatory approval, coordination responsibilities and liability, for inclusion in its work programme for the next triennium;

and

b) develop provisions related to the safe and efficient transit of aircraft through controlled airspace and separation management in higher airspace, including air traffic management procedures contingency planning and risk assessment and monitoring methodologies, including for uncontrolled descents of higher airspace operations vehicles”. [83]

At the ATMRPP-WG/46 meeting in April 2025, one agenda item was to discuss and prepare a job card to develop a new document to provide a global holistic vision and concept of operations for HAO covering all ICAO domains. This new document will play a major role in the future regulatory framework. An HAO WG was established in spring 2025 to address this task. The job card is covering all ICAO domains, as a consequence Standards and Recommended Practices (SARPs) amendments or manual development can be expected afterwards, if required.

3.8.2 FAA

3.8.2.1 Space launches and re-entries

The Commercial Space Launch Act of 1984, as amended, authorises the Secretary of Transportation to oversee, license, and regulate commercial launch and re-entry activities, and the operation of launch and re-entry sites within the United States or as carried out by U.S. citizens.

In this context the document RIN 2120–AL17 “Streamlined Launch and Reentry License Requirements” has been published in December 2020 and provides a detailed regulatory framework as indicated in its summary: “This rule streamlines and increases flexibility in the FAA’s commercial space launch and reentry regulations and removes obsolete requirements. It consolidates and revises multiple regulatory parts and applies a single set of licensing and safety regulations across several types of operations and vehicles. The rule describes the requirements to obtain a vehicle operator license, the safety requirements, and the terms and conditions of a vehicle operator license”. It is also mentioned that “This rule amends 14 CFR parts 415, 417, 431, and 435 by consolidating, updating, and streamlining all launch and reentry regulations into a single part 450. After March 2026, parts 415, 417, 431, and 435 will be removed”. [56]

A table that provides planned means of compliance for 14 CFR Part 450 is accessible on the FAA web site: <https://www.faa.gov/media/85526>. All means of compliance seems to be under development in June 2025.

The FAA presentation of February 2023 (<https://www.faa.gov/media/24826> describes the AST, the Office of Commercial Space Transportation, one of 5 business lines of the FAA. [54] The AST is involved in commercial launch/re-entries licences, experimental permits, spaceports licences, safety elements approval, inspections and payloads reviews. AST works with the commercial space applicant and brings in the ‘FAA Air Traffic Organization’ for airspace integration.

3.8.2.2 Supersonic flights

The current regulation (FAA 14 CFR 91.817) is banning civil supersonic flight over land. [Civil Supersonic Airplane Noise Type Certification Standards and Operating Rules](#) document is giving the FAA noise policy in 2008. This regulatory framework is going to change with the executive order of the 6th of June 2025 by the White House. Its web page <https://www.whitehouse.gov/presidential-actions/2025/06/leading-the-world-in-supersonic-flight/> is mentioning a presidency regulatory reform request for Supersonic flight: “The Administrator of the Federal Aviation Administration (FAA) shall take the necessary steps, including through rulemaking, to repeal the prohibition on overland supersonic flight in 14 CFR 91.817 within 180 days of the date of this order and establish an interim noise-based certification standard, making any modifications to 14 CFR 91.818 as necessary, as consistent with applicable law. The Administrator of the FAA shall also take immediate steps to repeal 14 CFR 91.819 and 91.821, which will remove additional regulatory barriers that hinder the advancement of supersonic aviation technology in the United States”.

3.8.3 HAPS Alliance

The HAPS Alliance has addressed certification aspects its White Paper “HAPS Certification Pathways” and its position paper “Creating an Enabling Regulatory Environment for HAPS Deployment”. [30][28]

The purpose of the white paper is “to identify the key challenges faced by the High-Altitude Platform Systems (HAPS) community in getting regulatory approval to start commercial operations and to recommend actions that the HAPS Alliance can take to address these challenges”. It identifies certification challenges such as safety requirements, certification for Ground systems, environmental criteria, turbulence, lightning, environmental testing, Detect and Avoid, Communicating with the ANSPs, component failure rate. It concludes with some recommendations such as to establish HAPS as a separate category.

The position paper is more focused on HAPS connectivity and HAPS as IMT (International Mobile Telecommunication) Base Stations (HIBS). It addresses spectrum, licensing, telecommunication fees or Rapid Equipment Type Approval.

HAPS Alliance has also published an “Acceptable Levels of Risk for HAPS” document. [31] This document “discusses how the safety metrics traditionally used in aviation (e.g., the probability of catastrophic accident per flight hour, or per mission) are not adequate to establish target levels of safety for HAPS” and instead, “propose to use ‘third-party-centric’ metrics that measure the risk from the perspective of the exposed third parties (risk per human hour/year)”.

3.8.4 JARUS

JARUS has published in July 2024 a CS-HAPS document to be used as recommendations for the Type Certification of High-Altitude Platform Systems (HAPS). [87] JARUS is a global group of experts from National Aviation Authorities (NAAs), EUROCONTROL and the European Aviation Safety Agency (EASA). Its purpose is to recommend a single set of technical, safety and operational requirements for all aspects linked to the safe operation of Unmanned Aircraft Systems (UAS), which includes High Altitude Platform Systems (HAPS).

The CS-HAPS document consists of:

- A set of recommendations considered as applicable to all HAPS
- A set of structural recommendations for HTA (Heavier-Than-Air) fixed wing HAPS
- A set of structural recommendations for LTA (Lighter-Than-Air) airship HAPS
- References to EASA CS.31 GB (Gas Balloon), Subpart C – Structure, para. CS-31GB.21, CS-31GB.23, CS-31GB.25 and CS-31GB.27

The document also refers to the “Acceptable Levels of Risks for HAPS” document published by the HAPS Alliance.

The CS-HAPS document is pointing out that Acceptable Levels of Risks for HAPS defined in the current SORA 2.5 context is currently not suitable for HAPS operation, but this may change in future versions of SORA.

It is planned to further elaborate the structural and where required other requirements for LTA balloon HAPS in the next issue of this CS-HAPS.

3.8.5 Outer Space Institute

The “Montreal Recommendations on Aviation Safety and Uncontrolled Space Object Reentries paper” presents results of discussions held at a workshop in February 2023, organised by the Outer Space Institute, the McGill Institute of Air and Space Law, and the International Association for the Advancement of Space Safety. [93] There are recommendations for States to establish a new international body or build upon an existing one to provide a focus on the safety implications of uncontrolled re-entries, to establish requirements to avoid uncontrolled re-entries of space objects and to promote the development of advanced re-entry prediction capabilities.

3.8.6 National regulations

The European Space Agency (ESA) has a web page ([https://www.esa.int/About_Us/ECSL - European Centre for Space Law/National Space Legislations](https://www.esa.int/About_Us/ECSL_-_European_Centre_for_Space_Law/National_Space_Legislations)) enabling access to existing national space legislation in Europe and in the world. Some States like the UK and France have Space regulation in place for many years, and others are developing or updating theirs, e.g. Italy’s Council of Ministers has approved the country’s first comprehensive framework law on space and the space economy on the 20th of June 2025.

UK and France legislation are described hereafter in more details and the Spanish protocol for space alert also needs some specific attention.

3.8.6.1 UK

The Space Industry Act 2018 (SIA) is available on the UK legislation web site: <https://www.legislation.gov.uk/ukpga/2018/5/contents/2018-03-15> It requires that an operator who wants to carry out space activities, suborbital activities, and associated activities in the UK must get a licence. Different types of licences can be obtained: spaceport licence, range control, launch operator, orbital operator, return operator.

UK CAA has published in 2024 its second version of a guidance document “Applying for a licence under the Space Industry Act 2018”. [94] This guidance document explains the core requirements of applying for any licence under the SIA. It also summarises the additional requirements for each type of licence.

UK CAA has also published in 2024 its second version of “Guidance for spaceport licence applicants and spaceport licensees” document. [95] This guidance document explains how to apply for a spaceport licence under the SIA.

3.8.6.2 France

France has also established regulation for space with the law of the [3rd of June 2008](#) which has been specified by additional legal text (“decret” and “arrêté”). [131] These documents define the applicable authorisation and licenses required for space operations, the registration of space vehicles, Third Parties liabilities and responsibilities of people involved in space operations.

3.8.6.3 Spain

The ICAO “AN-Conf/14-WP/162 THE EXPERIENCE OF SPAIN WITH A PROTOCOL FOR SPACE ALERTS” paper describes the [Spanish Space Alert Protocol](#) issued in 2022. [80] This protocol provides a comprehensive framework for managing space-related threats, particularly focusing on uncontrolled re-entries of space debris. According to this paper, the protocol not only enhances national safety and security but also could be considered as an example of best practices.

3.8.7 EU regulation

3.8.7.1 European Space Act

In September 2024, the mission letter assigned to Commissioner designate for Defence and Space, Andrius Kubilius, invites him to lead the work on the preparation of the proposal for an EU space law, which should introduce common EU standards and rules for EU space activities, as well as harmonising licensing requirements. On 25 June 2025, the Commission has published a proposal for an EU Space Act strengthening Safety, Resilience and Sustainability in Space. [99]

The Whereas section, point 55) addresses the impact on the economic, environmental, and efficient performance of the Single European Sky. Coordination with authorities, Air Traffic Service providers and Network Manager is considered to minimise the risk of disruption of air traffic. It is mentioned that “The increasing risk of collision with aircraft during the transition phase of space launch and re-entry can be supported by well-established aviation safety methodologies and best practices on risk assessment”. Safety and coordination measures during launch and re-entry are prescribed in article 58 and 59. Some coordination requirements are defined in the Annex 1 of the proposed regulation.

3.8.7.2 EASA

3.8.7.2.1 Basic Regulation

Regulation (EU) 2018/1139¹⁷, the so-called EASA Basic Regulation, is the foundational legal framework that governs aviation safety in the European Union and is as such the most important current regulatory framework in Europe in its scope of applicability, when such activities fall within the EU's competence.

It gives EASA the tools to adapt regulatory oversight to new aviation frontiers while ensuring consistency with European safety, innovation, and environmental goals.

In principle, the EASA Basic Regulation is already applicable to HAO today, which makes it a critical enabling mechanism for the safe and sustainable development of Higher Airspace Operations in the EU. The Basic Regulation is not setting any limitation in terms of altitude, therefore several topics such as HAPS approval,

¹⁷ <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02018R1139-20241201>

certification or Permit to Fly (PtF), ATM/ANS services provision and constituents, airspace design would likely fall under the existing regime. The issue is that the current provisions and related implementing rules were not written with HAO in mind, which means that amendments will likely become necessary.

Some HAO activities will challenge traditional aviation rules due to their hybrid nature—operating at the intersection of air and space, often involving novel technologies, uncertain traffic patterns, and cross-sectoral interfaces.

The applicability of the Basic Regulation to Higher Airspace Operations depends on:

1. Type of operation: Is it civil, commercial, or experimental?
2. Nature of the vehicle: Is it aircraft-like (e.g., a spaceplane) or closer to a spacecraft?
3. Operational impact: Does it interact with controlled airspace or other airspace users?
4. Regulatory intent: Is the operation within the EU and does it affect EU aviation safety?

In cases where activities fall outside its clear scope—such as purely space operations—the Basic Regulation may not apply directly, but EASA can still play an enabling role through advisory input, experimental frameworks, and cooperation with national and international stakeholders.

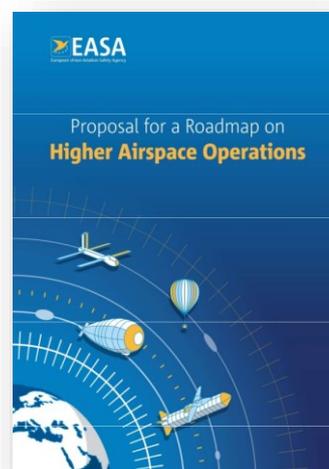
Article 4 of the Regulation allows for a proportionate and risk-based approach to regulation. This is crucial for HAO, as traditional airworthiness and operational rules may not fit new vehicles or mission profiles. communication Regulation empowers EASA to tailor requirements based on safety risk, innovation level, and operational context.

The Basic Regulation requires coordination with Member States and other EU bodies, which is essential given that HAO interfaces with areas such as space policy, cybersecurity, defense, and spectrum management. It supports a system-level approach to safety and integration.

3.8.7.2.2 Roadmap on Higher Airspace Operations

At the request of the European Commission, EASA was tasked with developing a comprehensive roadmap to establish a European regulatory framework for Higher Airspace Operations (HAO). With support from several Member States, EASA submitted its proposed roadmap[1] in March 2023, outlining a phased approach to create dedicated rules for HAO. The roadmap is based on a holistic approach to ensure the introduction of new entrants is safe, secure and environmentally sustainable. Section 4 of the roadmap provides a comprehensive analysis of the expected impact on the EU aviation regulatory framework under the regulatory competence of the EU/EASA on each domain of the EU regulatory framework such as:

- Design,
- Production and maintenance,
- Operations,
- Air Traffic Management / Air Navigation Services,
- Aerodromes/stratoports/spaceports,
- Personnel licensing,
- Drones / UAS,
- Cybersecurity,
- Environment,
- Occurrence reporting,
- Civil-military coordination.



This roadmap was subsequently endorsed by the Member States Advisory Body (MAB) and the EASA Management Board, which includes representation from the European Commission. Following this endorsement, the Commission formally requested EASA—via a letter dated 27 March 2023—to begin implementing the roadmap. Since then, it has served as the primary reference for regulatory activities related to HAO in Europe.

The roadmap is structured into three main phases:

1. Exploration and Preparation (2023–2025):

The initial phase focuses on research, stakeholder engagement, and data collection. EASA is collaborating with Member States, Eurocontrol, and the European Defence Agency to assess operational concepts, vehicle types, environmental and safety implications, and airspace integration challenges. A key feature of this phase is the use of regulatory “sandboxes”—controlled environments for testing new HAO technologies.

2. Regulatory Development (2025–2027):

Building on the insights gathered, EASA will begin drafting a new regulatory framework specifically for higher airspace. This includes defining operational categories, communication and surveillance requirements, and ensuring civil-military coordination. EU-funded research initiatives support this phase, with a Notice of Proposed Amendment (NPA) targeted for publication by late 2027.

3. Implementation and Harmonization (post-2027):

The final phase will focus on the adoption of harmonized EU-wide rules, including detailed guidance material, certification procedures, and alignment with international standards—particularly with ICAO and space and telecommunications regulators.

Through this phased, collaborative, and future-oriented approach, EASA aims to ensure safe, secure, and sustainable access to the upper layers of European airspace.

3.8.7.3 Fundamental rights

The third report in the context of Frontex “Research Study on High-Altitude Pseudo-Satellites” is the “HAPS Preliminary Assessment of the Impact on Fundamental Rights”. [40] The report includes 3 main chapters:

- Chapter 2 – Overview of developed use cases for HAPS and potentially affected rightsholders,
- Chapter 3 – Screening of fundamental rights potentially affected by the use of HAPS within the context of the study, of individual HAPS technologies, including a comparison of the platforms, payload analysis, technological challenges, and regulatory barriers,
- Chapter 4 – Detailed preliminary assessment of the impact on fundamental rights, identifying the impacts as well as principal safeguards to mitigate the impact on the fundamental right involved.

One of the bases for this analysis are the Treaty on the European Union (TEU) and the Treaty on the Functioning of the European Union (TFEU) that are the sources of primary law within the European legal framework. Several articles of the TFEU are to be taken into consideration regarding potential positive or negative impacts of HAPS use cases on Fundamental rights.

3.8.8 SESAR ECHO2 project

In the context of the SESAR ECHO 2 project, one regulatory document will be delivered per solution[18][19][20]. The work is divided into the following work packages (WP):

- WP1: integrating space operations transiting airspace within the NM area. This work package is dedicated to developing a Space Launch Real Time Monitoring Module for EUROCONTROL,
- WP2: Procedural package for HAPS operations integration. The aim of WP2 is development and validation of specific elements of the European High-Altitude Operations ConOps related to the

- integration of High-Altitude Platform Systems (HAPS) in Air Traffic Management (ATM),
- WP3: Procedural package for supersonic, hypersonic, and suborbital vehicles.

Each of these work packages will assess existing regulatory provisions applicable to each solution, capture new needs for evolution of existing regulation or new regulation development.

These final deliverables are expected to be delivered in 2026 and will be publicly available when accepted by the SESAR JU.

3.9 Standardisation

3.9.1 [75]EUROCAE

The EUROCAE Technical Work Plan (TWP) is a strategic document which presents a clear view of the EUROCAE scope of work. [89] It provides insight into the context of current and potential future EUROCAE activities for aviation executives and stakeholders of standardisation in the broad field of aviation. The focus of the TWP is to provide guidance for future activities in a globally consistent and harmonised way. A clear view of planned activities for EUROCAE is given. This does not contradict the fact that EUROCAE is a flexible organisation, amending its plans as necessary. As shown in the recent past, EUROCAE is well-able to react on short notice and produce high-quality standards on demand.

The TWP version 2025 is addressing the HAO topic in these terms:

“Although EUROCAE currently has no dedicated WG developing related standards, the topic is followed closely and provisions for High Altitude¹⁸ and Velocity message were already included in ED-102B/DO-260C, the MOPS for ADS-B Version 3¹⁹. [88] EUROCAE is a member of the advisory board of the SESAR 3 research project ECHO2 (European Concept for Higher Altitude Operations Phase 2 SESAR 3 Research). The SESAR project ECHO2 may liaise with WG-51 to enable efficient surveillance at higher altitudes, when necessary.

The variety of operations emerging for this airspace volume is such that some form of management will be needed, but it does not necessarily need to follow the model of ATM below it. Operators may be able to take more of a role in managing their fleets within new ICAO guidelines, making use of innovative services and technologies. It may be possible to adapt existing or emerging ATM concepts to support such operations, for example trajectory-based operations or advanced flexible use of airspace, or it may need an entirely new model such as U-Space / UTM. This will need regional and global harmonisation since higher airspace operations will involve international and even intercontinental trajectories.

It is certain that all these emerging activities will, to varying degrees, have an impact on current aviation and on the air navigation system as a whole. Consequently, they must be integrated appropriately to encourage and enable innovative new businesses while maintaining the high levels of safety, regularity, efficiency, and security for all existing airspace users.

These considerations highlight several areas where EUROCAE currently has little standardisation activity. Enabling these operations will require the standardisation of new applications for existing technologies, as well as the introduction of new technologies that will need standardisation.

The European Commission (DG DEFIS) wants to strengthen Europe as global actor, with a tailored space strategy to foster innovation and entrepreneurship and to encourage applications as well as to reinforce autonomy and security. This includes supporting rocket launches from European sites in such a way that it can be managed

¹⁸ High altitude in the TWP is equivalent to Higher Airspace.

¹⁹ Minimum Operational Performance Standard (MOPS) for the 1090 MHz Extended Squitter ADS-B and TIS-B Datalink for ADS-B Version 3

safely and economically, in coordination with the ATM environment, as well as by creating a regulatory framework for orbital and sub-orbital activities that integrates with other users of the Higher Airspace.

All this is foreseen as performance-based regulation, supported by standards. Industry and operators are calling already today for more harmonisation and standardisation to develop quick and innovative operations in a predictable environment worldwide”.

This will be further updated in the EUROCAE Technical Work Plan 2026.

3.9.2 SESAR ECHO2 project

In the context of the SESAR ECHO 2 project, one standardisation document (STAND) will be delivered per solution[15][16][17]:

- WP1 integrating space operations transiting airspace within the NM area. This work package is dedicated to developing a Space Launch Real Time Monitoring Module for EUROCONTROL,
- WP2 Procedural package for HAPS operations integration. The aim of WP2 is development and validation of specific elements of the European High-Altitude Operations ConOps related to the integration of High-Altitude Platform Systems (HAPS) in Air Traffic Management (ATM),
- WP3 Procedural package for supersonic, hypersonic, and suborbital vehicles.

Derived from regulatory documents, each of these documents will assess existing standards applicable to each solution, capture new needs for evolution of existing stand or new standards development.

These 3 documents are expected to be delivered in 2026 and will be publicly available when accepted by the SESAR JU.

4. Conclusion

4.1 Main findings of literature review

Although it was not possible in this report to analyse and check all details of the assessed documentation, the following points are highlighted in view of further studies, harmonisation actions or decisions at European or global level:

- The literature review has confirmed the lack of precise and agreed definition of Higher Altitude airspace definition. The definition can be geographical with an airspace bottom that can be FL550, FL600 or 20 km above earth and a top at the Karman line, 100km or above in the various documents. It can also be linked to specific vehicle operation and energy. Future regulations and standards will need further clarification on Higher Airspace definition to ensure consistency and to address any potential legal consequences.
- Many documents are related to use cases and market demand. They will be used to support a more extensive analysis of the HAO update of Higher airspace demand analysis and market development and will be further detailed in a specific report²⁰.
- The need to better define Higher Airspace concepts of operation has led to multiple documents and concepts elements defined by SESAR, the FAA, HAPS Alliance, CANSO and others. Similarities can be observed but there is a need for vocabulary, definitions, and concept elements harmonisation. An HAO Global Vision and Concept of Operations ICAO document is needed, covering all ICAO domains.
- Many documents are addressing the impact on ATM and Higher airspace of space launches and re-entries due to their increasing number. The impact of mishaps and debris on operation such as airspace closure, flight diversion and potential safety issues is also an area of concerns. The need for extensive collaboration to manage these operations is highlighted. This collaboration between, States, space organisations, ANSPs, regulators may also imply organisational aspects and international coordination mechanisms.
- There is already a large regulatory framework for space operations (launches, re-entries, mishaps, spaceport, licences) especially by States who have a long space experience. The European Space Act, when adopted, will also be part of this framework. But there is probably more to come to enhance safety and reduce operational impact on aviation.
- CNS infrastructure for HAO is addressed in several documents that tends to demonstrate that CNS systems for Higher airspace will require additional studies. The different ConOps are identifying the need for CNS but a performance-based CNS capabilities are still to be defined.
- Many of these High-altitude vehicles being remotely piloted, consideration should also be given to the command-and-control communication system availability and performance in Higher Airspace.
- One of the key features of CNS for HAO is altimetry. The performance of Barometric altitude and Flight Level calculation between FL550 and FL700 or FL800 needs to be validated and standardised. The use of geometric altitude at these levels and above needs further definition at ConOps level and technology assessment. Above FL800, it is possible that atmospheric density is too low to support accurate pressure altimetry measurements, therefore only geometric altitude could be used.
- GNSS could provide accurate geometric altitude and is expected to be used for Positioning, Navigation and Time (PNT) as it is currently available. It can be anticipated that it could provide the

²⁰ EASA.2021.FC.14 EUROCAE Special Contract N°004, HAO-Update Of Higher Airspace Demand Analysis and Market Developments

required performance levels even if these performance levels are not fully defined and agreed. But security issues such as jamming and spoofing could necessitate alternative technologies. Further studies are needed to define alternative or complementary technological solutions to GNSS for timing and positioning as well as contingency procedures.

- The conventional navigation system based on ground equipment (such as DMEs) performance also needs to be validated and standardised for Higher Altitude if it was required in particular for resilience issues.
- ADS-B is considered in a few documents as a solution to surveillance as traditional radar performance and coverage for HAO may be insufficient. But current dependence of ADS-B on GNSS must be tackled. The HAPS Alliance also notes that HAPS may provide critical commercial services such as connectivity infrastructure, for which it may be undesirable to reveal the exact position and layout of the network.
- HAPS Alliance and Jarus have proposed recommendations for HAPS safety analysis, regulatory approval and certification to be considered in future regulatory process.
- US is progressively adapting its regulations for civil supersonic flights to enable operations overland in connection with the progress of the Boom supersonic aircraft.
- Standardisation organisations (ICAO, EUROCAE) are already considering the need for Higher Airspace vehicle, equipment and operation standardisation in their work plan. Increasing maturity at concept and technology level will enable concrete actions to support development and certification of HAPS.

4.2 Gap analysis

Significant progress in many areas can be observed through this literature review. However some key topics would need further activities to create a fully friendly environment for the development of HAO:

- Traffic management service provision: What would be the requirement for Higher Airspace traffic management services and the duties of a higher-airspace operation service provider (HAOSP)?
- Performance based approach: similarly to traditional aviation and ATM, a performance based approach seems to be best. What is the expected level of performances for HAO services and supporting infrastructure?
- Total system architecture: HAO is made of very different types of operations with very different types of vehicles and will require different level of services. Is it possible to define a total system architecture that would facilitate a consistent coexistence of all these different vehicles, use cases, services taking also into consideration military and State necessary collaboration in this Higher Airspace?
- Governance: this airspace is currently not managed nor regulated. The complexity of this new environment may require an appropriate governance involving all stakeholders and facilitating civil military coordination.
- Civil Military Coordination: The military authorities are paying more and more attention to the Higher Airspace, as highlighted by the recent publication of the French 'STRATÉGIE DES ARMÉES POUR LA TRÈS HAUTE ALTITUDE' [137] and the declaration of the French ministry at Le Bourget 2025 and also by the EDA initiative for 'Enablers for safe airspace integration of military air capabilities in the European sky'. This civil military use of the higher airspace will have significant impact on the total system architecture for Higher Airspace and its governance.

4.3 Overall conclusion

Up to now, the Higher Airspace has been very scarcely used by civil operators and by military organisation. Scientific, weather balloons and transit of space vehicle from earth to the space and return have been the main

civilian use of this airspace that is, to a large extent, not regulated nor managed. This study has identified a significant production of new documentations by various organisations and multiple projects, showing an increased interest for operations in this airspace for both military and civil purposes. It demonstrates the industrial and technological growth in this domain.

The growth in this new business is also confirming the need to prepare a regulatory framework for Higher Airspace Operations (HAO) to address emerging aviation activities in the Higher Airspace, focusing on safety, environmental concerns, and cyber risks.

This regulatory framework will be built on maturing concepts, a clearer definition of this airspace, improved definition of supporting infrastructure and services, definition of expected performances, an overview of the architecture with an appropriate governance framework.

This regulatory framework will also be built on the availability of necessary standards and guidance material that are to be developed in the coming years. A standardisation roadmap based on an in-depth review of existing standards update needs and identification of new standards needs will be paramount to support future regulation and to foster industrial and technological growth in this domain.

Annex A Documents list

ID and Document Title	Authors	Publication Date	Document type	Category	Free	Download Link
[1] Proposal for a Roadmap on Higher Airspace Operations.	EASA	March-23	Report	Roadmap	Yes	https://www.easa.europa.eu/sites/default/files/dfu/easa_hao_roadmap_-_final_-_01.03.2023.pdf
[2] D2.1 ECHO accessible database	SESAR ECHO	April-21	Report	General	Yes	https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5eccbccf0&appId=PPGMS
[3] D2.2 ECHO analysis report	SESAR ECHO	September-21	Report	General	Yes	https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5eccbadb1&appId=PPGMS
[4] D3.1 Scenario Use Case Design	SESAR ECHO	December-21	Report	Conops	Yes	https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5eccb92f8&appId=PPGMS
[5] D3.3 Vehicles Use Cases	SESAR ECHO	September-22	Report	Conops	Yes	https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5f16e0573&appId=PPGMS
[6] D3.4 Overall new entrants synthesis	SESAR ECHO	July-22	Report	Market	Yes	https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5f0565f39&appId=PPGMS
[7] D3.5 Vehicles Validation Plans	SESAR ECHO	November-22	Report		Yes	https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5f4139296&appId=PPGMS
[8] D3.6 Demand scenario specific impact analysis results	SESAR ECHO	October-22	Report	Market	Yes	https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5f413aa23&appId=PPGMS
[9] D4.1 ECHO WP4 User requirements	SESAR ECHO	January-23	Report	Conops	Yes	https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5f72d7bf5&appId=PPGMS

ID and Document Title	Authors	Publication Date	Document type	Category	Free	Download Link
[10] D4.3 European Concept for Higher Airspace Operations (HAO) Concept of Operations	SESAR ECHO	December-22	Report	Conops	Yes	https://www.sesarju.eu/sites/default/files/documents/reports/D4.3_ConOps_1.0_public.pdf
[11] SESAR ECHO 2 projects NAT Workkshop on new entrants integration	SESAR ECHO 2	May-24	Presentatio n	General	Yes	https://www.icao.int/EURNAT/Other%20Meetings%20Seminars%20and%20Workshops/NAT%20Workshop%20on%20New%20Entrants%20Integration%20(2024)/NATWKSCO%20PR03%20ECTL%20ECHO.pdf
[12] SESAR ECHO 2 WP1 integrating space operations transiting airspace within the NM area OSED	SESAR ECHO 2	Draft	Report	Conops		
[13] SESAR ECHO 2 WP2 Procedural package for HAPS operations integration OSED	SESAR ECHO 2	Draft	Report	Conops		
[14] SESAR ECHO 2 WP3 Procedural package for supersonic, hypersonic, and suborbital vehicles OSED	SESAR ECHO 2	Draft	Report	Conops		
[15] SESAR ECHO 2 WP1 integrating space operations transiting airspace within the NM area STAND	SESAR ECHO 2	Draft	Report	Standardisa tion		
[16] SESAR ECHO 2 WP2 Procedural package for HAPS operations integration STAND	SESAR ECHO 2	Draft	Report	Standardisa tion		

ID and Document Title	Authors	Publication Date	Document type	Category	Free	Download Link
[17] SESAR ECHO 2 WP3 Procedural package for supersonic, hypersonic, and suborbital vehicles STAND	SESAR ECHO 2	Draft	Report	Standardisation		
[18] SESAR ECHO 2 WP1 integrating space operations transiting airspace within the NM area REG	SESAR ECHO 2	Draft	Report	Regulatory		
[19] SESAR ECHO 2 WP2 Procedural package for HAPS operations integration REG	SESAR ECHO 2	Draft	Report	Regulatory		
[20] SESAR ECHO 2 WP3 Procedural package for supersonic, hypersonic, and suborbital vehicles REG	SESAR ECHO 2	Draft	Report	Regulatory		
[21] SESAR ECHO 2 dissemination Workshop	SESAR ECHO 2	November-24	Presentation	General	Yes	https://www.eurocontrol.int/event/echo-2-first-dissemination-workshop
[22] The Missing Calculation behind the Original Kármán Line Definition -A Credible Hypothesis	Nicolas Bérend ONERA	October-21	Article		Yes	https://hal.science/hal-03420278v1/document
[23] At Crossroads Of Aeronautics & Space-What Matters For Aerospace Vehicles Featuring Ultra-High Performance	HAL Open Science Patrice Desvallées, Nicolas Bérend, Marie-Christine Bernelin, Marc Valès,	October-21	Article	Technology	Yes	https://hal.science/hal-03464294v1/document

ID and Document Title	Authors	Publication Date	Document type	Category	Free	Download Link
	Christophe Chavagnac, Jean-Philippe Dutheil Arianegroup					
[24] Suborbital Flights and the Delimitation of Airspace Vis-à-Vis Outer Space: Functionalism, Spatialism and State Sovereignty	Paul Stephen Dempsey, Maria Manoli Mc Gill University	December-17	Paper	Regulatory	Yes	https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID3295332_code372699.pdf?abstractid=3295332&mirid=1
[25] Driving the Potential of the Stratosphere	HAPS Alliance	August-21	Report	Market	Yes	https://hapsalliance.org/wp-content/uploads/formidable/12/Driving_the_potential_of_the_stratosphere_HAPSAlliance_082021.pdf
[26] HAPS Reference Architecture Series HAPS Advantages in an Era of Satellite Connectivity	HAPS Alliance	April-25	White Paper	Market	Yes	https://hapsalliance.org/wp-content/uploads/formidable/12/2025_HAPSAlliance_Reference_Architecture_Advantages_Satellite_Connectivity_TWG_Whitepaper.pdf
[27] Unlocking the Potential of the Stratosphere	HAPS Alliance	April-24	Presentation	General	Yes	https://hapsalliance.org/wp-content/uploads/formidable/16/HAPS_Alliance_Pitch_Deck_Q2_2024-Final.pdf
[28] Creating an Enabling Regulatory Environment for HAPS Deployment	HAPS Alliance	May-24		Regulatory	Yes	https://hapsalliance.org/wp-content/uploads/formidable/12/HAPS_Alliance_TWG_Regulatory_Positions_Paper_2024.pdf
[29] HAPS Reference Architecture Series: Cell Towers in the Sky	HAPS Alliance	October-24		Architecture	Yes	https://hapsalliance.org/wp-content/uploads/formidable/12/2024_HAPS_Reference_Architecture_Cell_Towers_In_The_Sky_White_Paper.pdf

ID and Document Title	Authors	Publication Date	Document type	Category	Free	Download Link
[30] White paper : HAPS Certification Pathways	HAPS Alliance	February-24		Regulatory	Yes	https://hapsalliance.org/wp-content/uploads/formidable/12/HAPS_Certification_Pathways_2024-3.pdf
[31] Acceptable Levels of Risks for HAPS	HAPS Alliance	January-24		Safety	Yes	https://hapsalliance.org/wp-content/uploads/formidable/12/Acceptable_Levels_of_Risk_for_HAPS_2024.pdf
[32] Guidelines for Payload Operation in the Stratosphere	HAPS Alliance	December-24	White Paper	Technology	Yes	https://hapsalliance.org/wp-content/uploads/formidable/12/Guidelines_for_Payload_Operation_in_the_Stratosphere_WhitePaper_2022.pdf
[33] HAPS Operation Using Attended Autonomous Fleet Systems	HAPS Alliance	April-22	White Paper	Traffic Management	Yes	https://hapsalliance.org/wp-content/uploads/formidable/12/HAPS_Operations_At_Scale_White_Paper_2022.pdf
[34] Bridging the Digital Divide with Aviation in the Stratosphere	HAPS Alliance	December-21	White Paper	Use Case	Yes	https://hapsalliance.org/wp-content/uploads/formidable/12/SpA_Flight_Communication_Tests_White_Paper_English_Final_2021.pdf
[35] Cooperative, Seamless, and Global Digital Skies for Higher Airspace	HAPS Alliance	May-25	White Paper	General	Yes	https://hapsalliance.org/wp-content/uploads/formidable/12/HAPSAlliance-Global-Digital-Skies-Higher-Airspace-Whitepaper-2025.pdf
[36] HAPS ALLIANCE VIEWS ON WRC-23 AGENDA ITEM 1.4	HAPS Alliance	February-23	Presentation	Spectrum	Yes	https://www.apf.int/sites/default/files/2023/02/APG23-5-INF-20_HAPS_Alliance_Views_on_WRC-23_Agenda_Item_1.4.pdf
[37] Frontex WP1 – HAPS Market Report	Frontex	October-23	Report	Market	Yes	https://www.frontex.europa.eu/assets/EUresearchprojects/2023/FX_HAPS_WP1_-_Market_Report_V4.pdf
[38] Fontex HAPS Final report	Frontex	October-23	Report	General	Yes	https://www.frontex.europa.eu/assets/EUresearchprojects/News/2023/HAPS_Final_Report.pdf
[39] Frontex HAPS Fourth Insight	Frontex	October-23	Factsheet	General	Yes	https://www.frontex.europa.eu/assets/EUresearchprojects/News/2023/HAPS_Fourth_Insight.pdf

ID and Document Title	Authors	Publication Date	Document type	Category	Free	Download Link
[40] Frontex HAPS Preliminary Assessment of the Impact on Fundamental Rights	Frontex	October-23	Report	Social	Yes	https://www.frontex.europa.eu/assets/EUresearchprojects/News/2023/HAPS_Preliminary_Assessment_of_the_Impact_on_Fundamental_Rights.pdf
[41] Frontex HAPS WP2 – Technological Assessment Report	Frontex	October-23	Report	Technology	Yes	https://www.frontex.europa.eu/assets/EUresearchprojects/2023/FX_HAPS_WP2_-_Technological_Assessment_Consolidated.pdf
[42] Cooperative operations in Higher airspace - a proposal	AIA Aerospace Industry Association	April-22	Report	Market	Yes	https://www.aia-aerospace.org/wp-content/uploads/AIA-Cooperative-Operations-in-Higher-Airspace-Proposal-April-2022-Final33.pdf
[43] High Altitude Platform Systems Towers in the Skies	GSMA (UK mobile telecom operators)	April-21	Report	Market	Yes	https://www.gsma.com/solutions-and-impact/technologies/networks/wp-content/uploads/2021/06/GSMA-HAPS-Towers-in-the-skies-Whitepaper-2021.pdf
[44] Pseudo-Satellite Market Size & Share Analysis - Growth Trends & Forecasts (2025 - 2030)	Mordor Intelligence	January-23	Report	Market	No	https://www.mordorintelligence.com/industry-reports/high-altitude-pseudo-satellites-market
[45] Riding the exponential growth in space	Deloitte	March-23	Article	Market	Yes	https://www2.deloitte.com/us/en/insights/industry/aerospace-defense/future-of-space-economy.html
[46] Point-to-point suborbital space tourism motivation and willingness to fly	Brian T. Musselman, Scott R. Winter, Stephen Rice, Joseph R. Keebler, Keith J. Ruskin, US Universities	January-24	Paper	Market	Yes	https://doi.org/10.1016/j.annale.2024.100119
[47] Space Cargo: Ultra-fast Delivery on Earth – Potential of Using Suborbital Space Vehicles for the Transportation of Cargo,	Robert O. Walton, Robert A. Goehlich, Embry-Riddle Aeronautical University	January-22	Paper	Market	Yes	https://doi.org/10.15394/ijaaa.2022.1671
[48] A Methodology for Supersonic Commercial Market Estimation and Environmental Impact Evaluation (Part II)	Wen et al, Georgia Tech Lorraine Metz, Georgia Institute of Technology, Atlanta	June-20	Conference Paper	Market	Yes	https://www.researchgate.net/publication/342020545_A_Methodology_for_Supersonic_Commercial_Market_Estimation_and_Environmental_Impact_Evaluation_Part_II

ID and Document Title	Authors	Publication Date	Document type	Category	Free	Download Link
[49] Concept of Operation V1.0 Upper Class E Traffic Management (ETM)	FAA	May-20	Report	Conops	Yes	https://nari.arc.nasa.gov/sites/default/files/attachments/ETM_ConOps_V1.0.pdf
[50] Upper Class E Traffic Management (ETM) Communication, Navigation, and Surveillance (CNS) Summary Report	FAA	July-23	Report	CNS	Yes	https://www.faa.gov/uas/advanced_operations/upper_class_etm/ETM-CNS-White-Paper-Summary-Report.pdf
[51] Existing Communication Technologies for Upper Class E Traffic Management (ETM)	FAA	July-23	Report	CNS	Yes	https://www.faa.gov/uas/advanced_operations/upper_class_etm/ETM-Comm-Technologies.pdf
[52] Existing Navigation Technologies for Upper Class E Traffic Management (ETM)	FAA	July-23	Report	CNS	Yes	https://www.faa.gov/uas/advanced_operations/upper_class_etm/ETM-NAV-Technologies.pdf
[53] Existing Surveillance Technologies for Upper Class E Traffic Management (ETM)	FAA	July-23	Report	CNS	Yes	https://www.faa.gov/uas/advanced_operations/upper_class_etm/ETM-Surveillance-Technologies.pdf
[54] FAA office for Commercial Space Transportation (AST)	FAA	February-23		Regulatory	Yes	https://www.faa.gov/media/24826
[55] Airspace Integration of Launch and Reentry operations	FAA	February-23		Conops	Yes	https://www.faa.gov/media/24831
[56] Streamlined Launch and Reentry License Requirements	FAA	December-20		Regulatory	Yes	https://www.govinfo.gov/content/pkg/FR-2020-12-10/pdf/2020-22042.pdf
[57] 14 CFR Part 450 Subpart C Accepted Means of Compliance Table	FAA	September-24		Regulatory	Yes	https://www.faa.gov/media/85526
[58] Commercial Space Integration into the National Airspace System	FAA	May-20	Report	Conops	Yes	https://www.faa.gov/sites/faa.gov/files/space/airspace_integration/Final_CSINAS_ConOps.pdf

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[59] Charting-Aviations-Future-Operations-in an Info-centric National Airspace System	FAA	September-22	Report	Conops	Yes	https://www.faa.gov/sites/faa.gov/files/Charting-Aviations-Future-Operations-in-ICN_0%20%281%29.pdf
[60] Initial Concept of Operations for an Info-Centric National Airspace System	FAA	September-22	Report	Conops	Yes	https://www.faa.gov/sites/faa.gov/files/ICN-ConOps-Dec2022.pdf
[61] Notice of Updated Factors for Optimizing Use of the National Airspace System	FAA				Yes	https://www.faa.gov/space/Notice_Revised_Factors_Optimization_of_National_Airspace_System.pdf
[62] Charter for National Spaceport Interagency Working Group	FAA	June-22	Charter	WG	Yes	https://www.faa.gov/sites/faa.gov/files/2022-06/NSIWG-Charter-signed-2-Jun-2022.pdf
[63] Introduction to Higher Airspace Operations Including Collaboration on Risk-Based Conflict Detection Framework	MITRE	March-21	Presentatio n	Conops	Yes	https://apps.dtic.mil/sti/trecms/pdf/AD1172263.pdf
[64] Architecture of High-Altitude Operations (HAO) Discovery and Synchronization Service (DSS)	NASA	December-24		Architecture	Yes	https://ntrs.nasa.gov/api/citations/20240016328/downloads/HAO%20DSS%20whitepaper.pdf
[65] Cooperative Upper Class E Airspace: Concept of Operations and Simulation Development for Operational Feasibility Assessment	NASA	August-21	Presentatio n	Conops	Yes	https://ntrs.nasa.gov/api/citations/20210017270/downloads/20210017270_Yoo_Aviation2021_Slides.pdf
[66] High Altitude Platform System (HAPS) Communication Support for Wildland Firefighting	NASA	December-23	Report	Use Case	Yes	https://ntrs.nasa.gov/api/citations/20230018267/downloads/NASA-TM-20230018267.pdf
[67] Study of Pairwise Deconfliction Metrics to Analyze Air Traffic Complexity in Upper Class E Airspace	NASA	June-23	Conference Paper	Conops	Yes	

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[68] A Web-Based Negotiation Tool for Conflict Resolution in Upper Class E Traffic Management	NASA	June-24	Conference Paper	Conops	Yes	https://ntrs.nasa.gov/api/citations/20240007850/downloads/AIAA_experiment_paper_2_party.pdf
[69] Cooperative Separation in Upper Class E Airspace Baseline Functional Requirements for Enabling Cooperative Separation	NASA	October-22	Report	Conops	Yes	https://ntrs.nasa.gov/api/citations/20220015612/downloads/NASA-TM-20220015612.pdf
[70] High-Altitude ADS-B Flight Tests on a NASA ER-2 Research Airplane	NASA	April-22	Report	CNS	Yes	https://ntrs.nasa.gov/api/citations/20220014456/downloads/20220014456FINAL.pdf
[71] Upper Class E Traffic Management: NASA's Collaborative Research and Technical Development to Enable Routine, Safe, and Scalable High Altitude Operation	NASA	November-24	Presentation	Conops	Yes	https://ntrs.nasa.gov/api/citations/20240014042/downloads/HAPS%20Alliance%20Bonn%20Germany.pdf
[72] Airspace Operations Lab - ETM	NASA	June-24	Website	General	Yes	https://hsi.arc.nasa.gov/groups/aol/research/etm.php
[73] A Guide to Commercial Suborbital Flight Providers for Flight Opportunities	NASA	January-21	Paper	General	Yes	https://www.nasa.gov/wp-content/uploads/2021/11/flight-providers-guide-2021-08.pdf
[74] ATM strategies for, and impacts of, space launches	N Robson, T Bolic and A Cook - Journal of Physics	September-23	Article	Conops	Yes	https://iopscience.iop.org/article/10.1088/1742-6596/2716/1/012083/pdf
[75] Higher Airspace operations A41-WP85	ICAO	July-22	WP	Regulatory	Yes	Higher Airspace operations A41-WP85
[76] AN-Conf/14-WP/110 OPERATIONS TO AND FROM OUTER SPACE	ICAO Chile	June-24	WP	Regulatory	Yes	https://www.icao.int/Meetings/anconf14/Documents/WP/wp_110_en.pdf

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[77] AN-Conf/14-WP/058 HIGHER AIRSPACE AND TRANSIT OF SPACE OPERATIONS	ICAO European States	June-24	WP	Regulatory	Yes	https://www.icao.int/Meetings/anconf14/Documents/WP/wp_058_en.pdf
[78] AN-Conf/14-WP/072 COMMERCIAL SPACE OPERATIONS	ICAO IATA IBAC IFALPA	June-24	WP	Regulatory	Yes	https://www.icao.int/Meetings/anconf14/Documents/WP/wp_072_en.pdf
[79] AN-Conf/14-WP/131 HIGHER AIRSPACE OPERATIONS (HAO)	ICAO Saudi Arabia	July-24	WP	Regulatory	Yes	https://www.icao.int/Meetings/anconf14/Documents/WP/wp_131_en.pdf
[80] AN-Conf/14-WP/162 THE EXPERIENCE OF SPAIN WITH A PROTOCOL FOR SPACE ALERTS	ICAO Spain	July-24	WP	Regulatory	Yes	https://www.icao.int/Meetings/anconf14/Documents/WP/wp_162_rev1_en.pdf
[81] AN-Conf/14-WP/205 COORDINATION REQUIREMENTS FOR RE-ENTRY OF SPACE OBJECTS AFFECTING INTERNATIONAL AIR NAVIGATION	ICAO South Africa	July-24	WP	Regulatory	Yes	https://www.icao.int/Meetings/anconf14/Documents/WP/wp_205_en.pdf
[82] NACC/DCA/11 — IP/36 ICAO'S ROLE IN THE SAFE INTEGRATION OF SPACE ACTIVITIES INTO THE AIRSPACE SYSTEM	ICAO	June-23	Paper		Yes	https://www.icao.int/NACC/Documents/Meetings/2023/NACCDCA11/NACCDCA11IP36.pdf
[83] AN-Conf/14-WP/213 REPORT OF THE COMMITTEE ON AGENDA ITEM 3	ICAO	September-24	WP	Regulatory	Yes	https://www.icao.int/Meetings/anconf14/Documents/WP/wp_213_en.pdf
[84] CATS Concept of Operations (ConOps) for Future Skies	CANSO	April-25	Report	Conops	Yes	https://www.futureskyvision.com/cats-conops
[85] CANSO ANSP CONSIDERATIONS FOR MANAGING SPACE OPERATIONS	CANSO	January-24	Report	Conops	Yes	https://canso.fra1.digitaloceanspaces.com/uploads/2024/02/ANSP-Considerations-for-Managing-Space-Operations.pdf

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[86] SESAR 3 ER 1 Green-GEAR D3.1 – Initial OSED – Geometric Altimetry June 2024	SESAR Green-Gear	June-24	Report	CNS	Yes	https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e50ebaf98b&appId=PGMS
[87] JARUS CS-HAPS, Airworthiness recommendations for HAPS	JARUS	July-24	Report	Regulatory	Yes	https://jarus-rpas.org/wp-content/uploads/2024/07/CS-HAPS-Rev.-1.0.pdf
[88] ED-102B Minimum Operational Performance Standard (MOPS) for the 1090 MHz Extended Squitter ADS-B and TIS-B Datalink for ADS-B Version 3	EUROCAE	December-20	MOPS	Standard	No	www.eurocae.net
[89] EUROCAE Technical Work Programme 2025	EUROCAE	December-24	Report	Standard	Yes	https://www.eurocae.net/media/2354/eurocae-twp-2025.pdf
[90] WRC-23 Final Acts	ITU	August-24	Report	Spectrum	Yes	https://www.itu.int/dms_pub/itu-r/opb/act/R-ACT-WRC.16-2024-PDF-E.pdf
[91] HAPS – High-altitude platform systems	ITU	January-25	Web page	Spectrum	Yes	https://www.itu.int/en/mediacentre/backgrounders/Pages/High-altitude-platform-systems.aspx
[92] Environmental sustainability of future proposed space activities	Loïs Miraux, Andrew Ross Wilson, Guillermo J. Dominguez Calabuig, ESA Clean Space Industry Days	October-22	Presentation	Environment	Yes	https://indico.esa.int/event/416/contributions/7277/attachments/4845/7531/CSID_1_Presentation_Environmental_sustainability_of_future_proposed_space_activities.pdf
[93] Montreal Recommendations on Aviation Safety and Uncontrolled Space Object Reentries	Outer Space Institute (OSI)	February-23	Conference Paper	Safety	Yes	https://outerspaceinstitute.ca/osisite/wp-content/uploads/Montreal-Recommendations-on-Aviation-Safety-and-Uncontrolled-Space-Object-Reentries.pdf
[94] Applying for a licence under the Space Industry Act 2018	UK CAA	May-24	Regulatory	Regulatory	Yes	https://www.caa.co.uk/publication/download/18919

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[95] Guidance for spaceport licence applicants and spaceport licensees	UK CAA	May-24	Regulatory	Regulatory	Yes	https://www.caa.co.uk/publication/download/18913
[96] Spaceport brochure	UK Space Agency	April-23	Brochure	Market	Yes	https://assets.publishing.service.gov.uk/media/643e6a4222ef3b000c66f3d1/Spaceport_brochure_17.4.23.pdf
[97] The UK Space Industry	UK House of Commons , Claire Housley, Elizabeth Rough	April-21	Briefing Paper	Market	Yes	https://researchbriefings.files.parliament.uk/documents/CBP-9202/CBP-9202.pdf
[98] EU Space Act Factsheet	European Commission	June-25		Regulatory	Yes	https://defence-industry-space.ec.europa.eu/document/download/540afc7b-dd3d-4b8c-96f1-bf8e861ec23c_en?filename=EU-Space-Act-factsheet.pdf
[99] EU Space Act proposal	European Commission	June-25		Regulatory	Yes	https://defence-industry-space.ec.europa.eu/document/download/0adeee10-af7a-4ac1-aa47-6a5e90cbe288_en?filename=Proposal-for-a-Regulation.pdf
[100] Annexes to the EU Space Act proposal	European Commission	June-25		Regulatory	Yes	https://defence-industry-space.ec.europa.eu/document/download/2257596a-0485-465a-8031-a5d43eb5190f_en?filename=Annexes-to-the-proposal-for-a-Regulation.pdf
[101] Spectrum Sharing between High Altitude Platform Network and Terrestrial Network: Modeling and Performance Analysis	Zhiqing Wei, Lin Wang, Zhan Gao, Huici Wu, Ning Zhang, Kaifeng Han, and Zhiyong Feng	June-23	Research	Spectrum	Yes	https://arxiv.org/pdf/2306.04906
[102] UK, USA, Canada, EU and its member states and Japan joint statement calling on the ICAO to work towards global standards	EU, USA, CA, JP, UK	December-23	Policy Paper	Regulatory	Yes	https://transport.ec.europa.eu/news-events/news/joint-statement-higher-airspace-operations-hao-2023-12-18_en

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[110] Air Traffic Control in the Upper Reaches	Flight Safety Foundation	October-24	Web page	Conops	Yes	https://flightsafety.org/asw-article/air-traffic-control-in-the-upper-reaches/
[111] Sharing airspace: Simulation of commercial space horizontal launch impacts on airlines and finding solutions	Embry-Riddle Aeronautical University,	March-21	Web article	Conops	Yes	https://www.sciencedirect.com/science/article/abs/pii/S2468896721000070?via%3Dihub
[112] High-Altitude Platform Systems Alternative, Supplement, or Competition to Satellites?	JAPCC Joint Air Power Competence Centre	July-22	Article	Technology	Yes	https://www.japcc.org/articles/high-altitude-platform-systems/
[113] Between Air and Space –Zephyr and the Future of High Altitude Pseudo-Satellites within Defence	RAF	January-23	Article	Defense	Yes	https://www.raf.mod.uk/what-we-do/centre-for-air-and-space-power-studies/aspr/aspr-vol22-iss2-5-pdf/
[114] Higher Airspace Operations (HAO) Overview	ENAC (Italy)	April-22	Presentation	General	Yes	https://anacna.it/uploads/files/353302610.pdf
[115] FLIGHT TERMINATION SYSTEM FOR AERIAL VEHICLES	Loon LLC	March-21	Patent	Technology	Yes	https://patentimages.storage.googleapis.com/ba/b0/21/027bc9cfa3e65e/US20210061436A1.pdf
[116] ENVIRONMENTAL DETECTION SYSTEMS AND METHODS FOR HIGH ALTITUDE PLATFORMS	Loon LLC	August-21	Patent	Technology	Yes	https://patentimages.storage.googleapis.com/88/2c/83/2510fe12e20839/US20210242931A1.pdf
[117] TERMS OF REFERENCE RTCA Special Committee 228 Minimum Performance Standards for Uncrewed Aircraft Systems	RTCA	June-24	ToR	Standardisation	Yes	https://www.rtca.org/wp-content/uploads/2024/07/SC-228-TOR-Rev-18-Approved-2024-06-27.pdf

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[118] EUROHAPS demonstration Platform	European Defense Funds	March-23	Factsheet	General	Yes	https://defence-industry-space.ec.europa.eu/system/files/2022-07/Factsheet_EDF21_EuroHAPS.pdf
[119] kickoff of EuroHAPS project for the demonstration of stratospheric platforms	Thales Alenia Space	March-23	Press release	General	Yes	https://www.thalesaleniaspace.com/en/press-releases/thales-alenia-space-signs-contract-european-commission-and-announces-kickoff
[120] Main classes of Aerospace systems, Altitude-Velocity diagram	DGAC/DSAC	September-24	Presentation	Technology	Yes	https://salledelecture-ext.aviation-civile.gouv.fr/externe/DSAC/20241209_Diagram_ALT-V_main_aerospace_categ_1-1000km.pdf
[121] ESA Strategy 2024 - In depth	ESA	March-25	Report	Market	Yes	https://esamultimedia.esa.int/docs/corporate/ESA_Strategy_2040_InDepth.pdf
[122] Impact of Higher Airspace Operations on Air Traffic in Europe	DLR	September-23	Article	Conops	Yes	https://elib.dlr.de/197627/1/aerospace-10-00835-v2.pdf
[123] Ensuring the safety of aviation when there are uncontrolled space object reentries	Outer Space Institute (OSI)	July-23	Article	Safety	Yes	https://unitingaviation.com/news/safety/ensuring-the-safety-of-aviation-when-there-are-uncontrolled-space-object-reentries/
[124] Environmental sustainability of future proposed space activities	Space Generation Advisory Council, Loïs Miraux, Andrew Ross Wilson, Guillermo J. Dominguez Calabuig	August-22	Report	Environment	No	https://www.sciencedirect.com/science/article/abs/pii/S094576522003800?via%3Dihub
[125] CIRA High Altitude Platform Systems (HAPS)	Peter Lobner, CIRA	February-24	Article	Technology		https://lynceans.org/wp-content/uploads/2024/02/CIRA-HAPS.pdf
[126] Zephyr conducts stratospheric connectivity test in Kenya	AALTO	March-25	Press release	Technology	Yes	https://www.aaltohaps.com/wp-content/uploads/2025/02/Zephyr-conducts-stratospheric-connectivity-test-in-Kenya-connecting-4G-mobile-device-to-HAPS.pdf

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[127] Zephyr completes 13 days of stratospheric flight and testing, launching operations from Kenya base	AALTO	February-25	Press release	Technology	Yes	https://www.aaltohaps.com/wp-content/uploads/2025/02/Zephyr-completes-13-days-of-stratospheric-flight-and-testing-launching-operations-from-Kenya-base.pdf
[128] Stratospheric Flying Opportunities for High-Speed Propulsion Concepts - D6.2 Recommendation for future research	STRATOFly project	September-21	Report	Technology	Yes	https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5e8692b14&appId=PGMS
[129] Grottaglie Space port technical feasibility design for the Italian Spaceport	Aeroporti di Puglia	March-24	Presentation	Market	Yes	https://pugliasviluppo.eu/storage/news/application-pdf/2024/03/slide-progetto-spaziporto.pdf
[130] High-Altitude Pseudo-Satellite Market - By Platform (Unmanned Aerial Vehicles, Airships, Balloon Systems), By Payload, By Deployment (Land-based Operations, Maritime Operations, Polar Regions, Disaster-prone Areas), By Application & Forecast, 2024 - 2032	GMI Global Market Insight	July-24	Report	Market	No	https://www.gminsights.com/industry-analysis/high-altitude-pseudo-satellite-market
[131] LOI n° 2008-518 du 3 juin 2008 relative aux opérations spatiales	French State	June-08	General	Regulatory	Yes	https://www.legifrance.gouv.fr/loda/id/JORFTEXT000018931380/
[132] Arrêté du 28 juin 2024 application de la loi no 2008-518 du 3 juin 2008 relative aux opérations spatiales	French State	June-24	General	Regulatory	Yes	https://www.legifrance.gouv.fr/download/file/9JAiB7DYgU7L5db6l2juHxyq2uN_TKeBRRXw8U00MM=/JOE_TEXTE
[133] Space Alerts Protocol.	Spanish State	October-22	General	Regulatory	Yes	https://www.boe.es/buscar/pdf/2022/BOE-A-2022-18336-consolidado.pdf

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[134] High-Altitude Pseudo-Satellite platforms as support to air traffic management	Tomo Bagarić, Zvonimir Rezo, Sanja Steiner, ICTS 2024 Croatia	January-25	Conference Paper	Technology	Yes	https://doi.org/10.1016/j.trpro.2025.03.030
[135] Orbital and Suborbital Launch Sites of the World	Bryce Tech	December-24	Map	Market	Yes	https://brycotech.com/reports/report-documents/Bryce_Launch_Sites_2024.pdf
[136] Du ciel à l'espace. Nouveaux enjeux opérationnels à très haute altitude	Centre d'Études Stratégiques Aérospatiales	January-23	Conference paper	General	Yes	https://www.calameo.com/cesa/read/0069402882c38787bda4c
[137] STRATÉGIE DES ARMÉES POUR LA TRÈS HAUTE ALTITUDE	Ministère des armées France	June-25	Report	General	Yes	https://www.defense.gouv.fr/sites/default/files/ministere-armees/strat%C3%A9gie%20THA.pdf
[138] Regulatory perspectives on emerging higher airspace users	EUROCONTROL	October-21	Article	Regulatory	Yes	https://www.eurocontrol.int/article/regulatory-perspectives-emerging-higher-airspace-users



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