U-space ConOps Ed 5.0

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Abstract

This document describes SESAR Solution 0512: “Development of an integrated U-space / ATM CONOPS”.

The CORUS five project is a research initiative dedicated to evolving the European U-space Concept of Operations (ConOps) and informing the U-space regulatory direction. Building on the foundations of previous CORUS and CORUS-XUAM projects, CORUS five addresses the critical challenge of integrating U-space for Unmanned Aircraft Systems (UAS) and Innovative Air Mobility (IAM) with the existing Air Traffic Management (ATM) system. While the current vision is to have U-space operations largely restricted to Very Low Level (VLL) and segregated airspaces, the project has devised a stepwise approach toward full U-space and ATM interoperability, allowing diverse aircraft with varying degrees of autonomy and performance to operate safely and efficiently in shared airspace. One of the outcomes is an evolutionary shift towards a collaborative, highly automated, information-rich air navigation environment.

CORUS five adopts the Global Air Traffic Management Operational Concept (GATMOC) structure to achieve its vision for an interoperable U-space / ATM system. By aligning with the GATMOC, the project aims to build consensus while providing a framework of building blocks to ensure U-space can be evolved as an integral part of the ATM structure in which quality-assured and timely information is shared.

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CORUS five

CORUS FIVE DEVELOPMENT OF THE EXTENDED U-SPACE CONCEPT OF OPERATIONS CORUS V5.0

CORUS five

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1 Executive summary

The CORUS five project represents the next maturity tier in the European U-space concept, building upon the foundations of previous CORUS activities to inform future strategy, regulation, and standard development. This edition shifts the focus from developing Unmanned Aircraft System (UAS) and Vertical Take-off and Landing (VTOL) Vertical Capable Aircraft (VCA) operations to integrating U-space and ATM. It starts with the basic question, “How does U-space work?” to provide a baseline, followed by how it is expected to evolve over time to bridge the U-space and ATM network of services. The outcomes of CORUS five will be at various levels – scientific, conceptual, economic, technological, and societal, thereby addressing all elements of U-space/ATM integration. A new ConOps is critical as rising drone traffic makes current airspace segregation obsolete. Without it, segregation will prevent commercial scalability of UAS operations.

Since U-space is a branch of air traffic management, the ConOps follows the ICAO Global Air Traffic Management Operational Concept (GATMOC). That framework uses seven core building blocks to transition toward a more connected and collaborative aviation system. To keep things safe and manageable, the ConOps explores three clear phases (short, medium, and long term), showing how U-space and ATM will merge over time. Beyond the mechanics, the ConOps also addresses economic and societal issues.

Short-Term (Implementation & Maturation): Focuses on stabilising foundational U1 and U2 services under current EU regulations. Efforts are centred on maturing the regulatory framework by updating the Acceptable Means of Compliance (AMC) and Guidance Material (GM) to ensure consistent deployment across the European network.

Medium-Term (Operational Expansion): Introduces U3 services to support increased traffic densities and complex airspace environments. This phase prioritises the safe coexistence of manned and unmanned aircraft while bridging the interfaces among U-space, traditional ATM, and new infrastructure such as vertiports to create a unified mobility ecosystem.

Long-Term (Full Integration): Targets the realisation of U4, full-services, shifting toward highly automated management of all traffic benefiting from interoperable infrastructure. This horizon addresses open conceptual questions to fully embed U-space as a core component of the global Air Traffic Management network.

Scaling this new sector is only possible if the public accepts the balance between the benefits of new services and potential negative impacts. Public acceptance depends on balancing the benefits of new services against their potential impacts. To measure this, CORUS five is evolving previous indicators into a comprehensive assessment toolkit. Economically, the ConOps promotes an open-market ecosystem by prioritising stakeholder business models. It will identify viable approaches to cost recovery, access fees, and fairness principles to ensure commercial sustainability.

By progressing through these three horizons, CORUS five provides a transition roadmap for U-space, offering simultaneous directions for maturing technology, regulation, and trust, empowering Europe to a global lead in regulation, standards and future R&I.

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2 Introduction

2.1 Purpose of the document

A concept of operations (ConOps) is a document describing the characteristics of a proposed system from the viewpoint of an individual who will use or participate in the system. It is used to communicate the quantitative and qualitative system characteristics to all stakeholders[2].

This ConOps aims to answer the basic question, "How does U-space work?", and provides a common basis for discussing details. U-space is the European Union (EU) brand for Unmanned Aircraft System (UAS) Traffic Management (UTM) (IR (EU) 2021/664 [1] -/665 [2] & -/666 [3]), meaning a digitalised, highly automated service framework designed to provide safe, secure, and efficient airspace access for large numbers of UAS operations (which are governed by the EU UAS regulations [5], [6] and AMC/GM [7], [8]) and incorporating Innovative Aerial Mobility (IAM) in time. The ConOps provides a general view and further details of the U-space framework and how it is expected to evolve over time.

This document aims to be a reference manual for U-space, intended mainly for a knowledgeable audience seeking to better understand the U-space concept for Research and Innovation (R&I), or policy-making purposes. To achieve these goals, the ConOps begins with an overview of the U-space concept and then dives into perspectives on the evolution of the U-space framework, from its initial implementation to its ultimate target: seamless integration with ATM.

This document describes SESAR Solution 0512: "Development of an integrated U-space / ATM CONOPS" and presents the 5th Edition of the U-space ConOps builds on the previous editions [9] and the lessons learnt during initial U-space implementation and proposes a substantially enhanced ConOps that seeks to harmonise the current regulatory and R&I frameworks. For such purpose, this vision also considers developments in research projects, regulations, standards and the updated ATM master plan [10].

2.2 Intended readership

The intended readership includes a broad range of stakeholders (see section 3.4 for details) who will participate in, be affected by or need to understand the U-space system and its operation. The readership includes European and global user communities interested in the U-space, including implementors, users, regulators and those involved in aviation adjacent to U-space:

- The SESAR Joint Undertaking: as they manage existing and new R&I activities, including the ATM Master Plan. The ConOps seeks to be the central common reference for all U-space R&I activities, regarding how U-space works and how it should evolve.
- Rule-making bodies (e.g. EASA, UK CAA): as the ConOps includes perspectives on how the U-space system should evolve (i.e. a first reference to support the development of a new regulation).
- Practitioners, such as UAS and Vertical Take-off and Landing (VTOL) Capable Aircraft (VCA) operators, U-space Service Providers (USSPs), Common Information Service Providers (CISPs) and Air Traffic Control (ATC), may find some inspirational ideas.
- The R&I U-space community: the ConOps aims to be the central common reference for the R&I activities in U-space, which can use the ConOps as a reference when working on SESAR projects, to understand how their solutions integrate in the wider U-space context.

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

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- The overall UAS/U-space community: for airspace users, service providers or authorities alike, the ConOps can provide useful information regarding what to expect from U-space in the future. However, the reader should be mindful not to consider the ConOps as a regulatory document or an operational guide and instead refer to applicable regulations and standards.

2.3 Where is U-space today?

The need for a new version of the ConOps is essential, given the rapid growth in the number and complexity of UAS operations worldwide. Currently, European member states are laying the groundwork for U-space that includes processes and mechanisms for facilitating U-space airspace designation and certification of service providers.

At the time of writing this ConOps (October 2026), there is one operational U-space in Italy and several close to deployment in Spain, Belgium, and Switzerland, with many more under development in other countries. As the U-space regulation has been tested through certification, the industry is learning about shortcomings in the means of compliance, guidance and technical standards.

The slower-than-anticipated proliferation of designated U-space airspaces and certified service providers across Europe stems from interlocking regulatory friction, gaps in technical standardisation, institutional hesitation, and unproven business cases.

Becoming a certified USSP under Commission Implementing Regulation (EU) 2021/664 requires meeting rigorous safety management, cyber resilience, and financial oversight standards adapted from traditional ANSPs. For digital startups, software developers, and small tech firms, the compliance burden – spanning EASA oversight and National Supervisory Authority (NSA) auditing – incurs heavy Capital Expenditure (CAPEX) and Operational Expenditure (OPEX) before generating operational revenue.

Early certification efforts in pioneer member states have exposed practical gaps between high-level regulatory mandates and detailed engineering specifications:

- **Interoperability and Data Exchange:** While standards like EUROCAE ED-318 and ASTM F3548 provide structural frameworks, real-time USSP-to-USSP discovery, state vector exchange, and automated handover protocols still encounter synchronisation and latency challenges in multi-provider environments.

- **Tactical Conflict Resolution Service (TCRS):** Establishing a certified, automated separation algorithm that satisfies deterministic safety criteria without causing excessive false alarms or collision-avoidance ping-ponging remains a complex engineering challenge.

- **Ambiguities in the Acceptable Means of Compliance:** The initial release of EASA Acceptable Means of Compliance (AMC) and Guidance Material (GM) left several edge cases open to subjective interpretation by national authorities, requiring iterative clarification cycles during active applicant audits.

The Common Information Service (CIS) Implementation Dilemma: The architectural choice between a single (monopolistic) Common Information Service (CIS) provider, often assigned by default to the incumbent national ANSP, and a distributed CIS model has generated friction across Member States:

- **Monopoly Pricing and Conflicts of Interest:** When designated to legacy air navigation bodies, UAS industry stakeholders anticipate high access fee models and lengthy integration schedules.

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- **Procurement and Deployment Delays:** Several national governments have delayed designating formal U-space airspace because their legal decrees, state procurement frameworks, or tender processes for the national CIS platform remain stalled.

Manned Aviation Resistance and Electronic Conspicuity (ADS-L): Under Commission Implementing Regulation (EU) 2021/666, manned aircraft operating in designated U-space airspace must make themselves electronically conspicuous to USSPs:

- **General Aviation Pushback:** Recreational, sport, and general aviation pilots' representatives have voiced resistance to mandatory outfitting with dedicated avionics or tracking devices, raising concerns over equipment costs, spectrum clutter, and liability.

- **Cellular vs Radio Spectrum Harmonisation:** The dual-track approach of Automatic Dependent Surveillance - Light (ADS-L) over Short Range Devices (SRD) 860 direct broadcast versus ADS-L over commercial cellular networks requires complex ground gateways and data aggregation pipelines to ensure no traffic is hidden to UAS operations.

The Economic "Chicken-and-Egg" Volume Deficit: The financial viability of a U-space volume depends entirely on recurring, high-density flight operations paying micro-fees for U-space services:

- **Commercial Drone Scale:** The commercial UAS sector is still dominated by low-volume, single-drone operations authorised under the Specific Category via the Specific Operations Risk Assessment (SORA).

- **Lack of High-Density Demand:** Until large-scale autonomous Beyond Visual Line of Sight (BVLOS) Innovative Aerial Services (IAS) and passenger Innovative Air Mobility (IAM) operations achieve commercial scale, the revenue generated from flight transactions rarely covers the infrastructure and maintenance costs of operating a certified USSP.

Institutional Disparity and Fragmented National Airspace Policies: Airspace sovereignty remains strictly under the jurisdiction of individual European Union (EU) Member States. Consequently, criteria for conducting local airspace risk assessments, reserving dynamic airspace corridors, and integrating military airspace users vary widely by country. Rather than a frictionless Single European Sky (SES), developers navigate a patchwork of national regulatory speeds, with only a few proactive states having established the inter-agency coordination needed to establish operational U-spaces.

Progress depends on refining EASA's U-space regulatory framework and accompanying AMC/GM materials, creating lower-friction certification pathways for USSPs, harmonising pricing frameworks, and broadly authorising scalable BVLOS operations. The next section provides a more detailed overview of the associated challenges.

2.4 Challenges

To further develop the U-space concept and its integration with ATM, the following challenges need to be resolved:

Integration of operations: The transition from segregation to shared airspace operations of different types of aircraft must resolve technological, operational and organisational issues. Some of these issues are related to the flight rules and solutions developed for manned aviation.

Flight rules and airspace management: Integration will require the development of a flight rule that can be flown by UAS that is compatible with the operation of manned aircraft. The impact of this flight rule on the

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definitions of airspace classes needs to be explored to ensure the number and variety of airspace classes remain manageable.

Separation: The definition of separation standards that includes new airspace users and accounts for different operating performance and equipage standards. Separation standards should also account for navigation performance, surveillance and telemetry quality, communication capability, traffic density, operational volumes and allocation of separation responsibility.

Ground infrastructure: Future UAS and VCA operations, whether passenger-carrying or not, will require designated ground infrastructure to ensure safe operations. This infrastructure will vary depending on the specific use case and operating environment.

Integrated CNS: Communication is not only a link between aircraft and between them and the ground, but it is also a digital backbone connecting operational stakeholders, which sets high requirements for availability, reliability, and real-time data exchange. The navigation systems used for U-space operations must function at low altitude, and procedures and separation standards must make provision for the performance of the CNS systems of unmanned aircraft, which will differ from that of other airspace users. Reliable surveillance is paramount for tactical conflict resolution, while it is challenging in complicated environments.

Vertiports: As part of ground infrastructure, vertiport integration is crucial. Vertiports include airside infrastructure such as take-off and landing pads, parking stands and gates, whether on land or water, as well as digital and engineering infrastructure, including power supply. Vertiports provide the crucial link between (urban) airspace and the ground, and their placement must transcend operational viability, specificity and safety of aircraft operations, spatial constraints, environmental considerations, and sociopolitical acceptance.

Common altitude reference systems: Ensure that manned and unmanned aircraft can operate in the same airspace and navigate with a consistent altitude reference. This integration is a requirement due to the coexistence of barometric and GPS-based altitude measurement systems.

Economic aspects: Rules and procedures must be designed in such a way that they do not undermine the economic attractiveness for new entrants, including UAS operators and USSPs. Fairness of access to all airspace users must be ensured. The costs of establishing and implementing U-space will have to be shared in an as-yet-undetermined manner.

Regulatory framework: Creating new or amending existing aviation regulations to accommodate new approaches will have to be addressed and consulted upon. These take time.

2.5 Structure of the document

This document is organised as follows:

Introduction and references

Serves as the user manual for the document

- **Section 2** describes the purpose of the document, the intended readership, background, structure of the document, and the glossary of terms and acronyms.
- **Section 9** contains the references used during the development of this document.

Foundations

Baseline and elements that do not change over time

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- **Section 3** outlines the generalities of the U-space concept, covering the high-level aspects of the concept and the time-invariant aspects.

Implementation horizons and evolution

This section tracks the evolution moving from the current reality to the ultimate goal of full integration.

- **Section 4** describes the **short-term horizon**, covering what U-space is today according to the existing EU regulatory framework.
- **Section 5** describes the **medium-term horizon**. This covers the expected evolution of the U-space concept in order to satisfy emerging needs and developments, while aligning the concept towards an eventual integration with ATM.
- **Section 6** describes the **long-term horizon**. This section outlines the key areas to be developed in order to achieve the ultimate goal of seamless integration of U-space into the wider ATM framework.

Impact and assessment

This section moves beyond technical mechanics to evaluate the feasibility and consequences of the ConOps.

- **Section 7** details the methods developed by the CORUS five project to assess the public acceptance of U-space implementation.
- **Section 8** outlines the economic aspects of the U-space implementation and operation, as a complement to the technical approach followed in the rest of the document.

Appendices

Two appendices follow after the last numbered section of the document. These do not fit into the flow of the document but provide additional information. The appendices are:

- **Mapping between Edition 4 and Edition 5 services:** describing in detail how the long list of services described in previous editions became the fewer number of services proposed in Edition 5.

- **Advanced DCB and traffic synchronisation:** exploring RTTA as an alternate means to execute the demand and capacity balance and traffic synchronisation functions in high-density scenarios, considering fairness aspects and the challenges of distributed architectures. (In future version)

- **What is RTTA:** describing Reasonable Time to Act (RTTA), which is a concept of delaying conflict management actions as much as reasonably possible before the flight, to benefit from the reduction in uncertainty closer to the flight and thus increase efficiency. The concept has been described in earlier versions of the ConOps, but this appendix presents an update and addresses some confusion in the research community.

Annexes

Three documents are annexed to the ConOps. These are longer than Appendices.

- Annex A, Simulation Results. This document is a report on some simulations carried out in the project to assess U-space performance, focusing on the interdependence between safety, capacity, and efficiency.

- Annex B, Social acceptance performance framework. Based on the work of three research projects, this annex presents a unified social acceptance performance framework for U-space.

- Annex C is a review of recent studies on the social acceptance of UAS flight.

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2.6 Glossary of terms

Term	Definition	Source / Remarks
3D volume	A volume of airspace defined in terms of latitude, longitude, and altitude.	ASTM F3548-21
4D trajectory	The 4D trajectory describes a series of one or more 4D volumes, each with entry and exit times.	AMC/GM to IR (EU) 2024/664
4D volume	A 3D volume plus a start and end time for the volume.	ASTM F3548-21
Aerodrome	A defined area, on land or on water, on a fixed, fixed offshore or floating structure, including any buildings, installations and equipment thereon, intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft;	IR (EU) 2018/1139
Aircraft	Any machine that can derive support in the atmosphere from the reactions of the air other than reactions of the air against the earth's surface;	IR (EU) 923/2012
Aircraft operator	Any legal or natural person operating or proposing to operate one or more aircraft;	IR (EU) 2018/1139
Altitude	The vertical distance of a level, a point or an object considered as a point, measured from mean sea level (MSL)	IR (EU) 923/2012
Autonomous operation	An operation during which an unmanned aircraft operates without the remote pilot being able to intervene;	IR (EU) 2019/947
Beyond Visual Line of Sight (BVLOS) operation	A type of UAS operation which is not conducted in VLOS;	IR (EU) 2019/947
Common Information Service (CIS)	A service consisting in the dissemination of static and dynamic data to enable the provision of U-space services for the management of traffic of unmanned aircraft;	IR (EU) 2021/664
Conflict	A situation where there is a risk of collision between aircraft and/or vehicles. ICAO Doc 9426 provides the following definition: predicted converging of aircraft in space and time which constitutes a violation of a given set of separation minima. The more generic definition from Skybrary is used instead, as the 9426 definition is made from the ATC perspective, and may not be applicable in the U-space context.	Skybrary
Conflict horizon	The extent to which hazards along the future trajectory of an unmanned aircraft are considered for separation provision.	ICAO doc 9854 (GATMOC)
Conspicuous	Visible to or able to be detected by some implied or identified observer.	also *Conspicuity*

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Term	Definition	Source / Remarks
Control and Monitoring Unit (CMU)	The equipment to control and monitor unmanned aircraft remotely as defined in point (32) of Article 3 of Regulation (EU) 2018/1139;	IR (EU) 2024/1110
Deviation thresholds	The maximum acceptable deviation from the intended UAS flight path, to be considered by the USSP when processing a flight authorisation or to generate a non-conformance alert to the UAS operator;	AMC/GM to IR (EU) 2024/664
Digital Flight Rules (DFR)	A new hypothetical set of flight rules applicable to both manned and unmanned aircraft. Operations under DFR are characterised by high levels of digitalisation and automation of functions.	Our definition
Drone	Informal synonym for Unmanned Aircraft	Our definition
Dynamic Airspace Reconfiguration (DAR)	The temporary modification of the U-space airspace in order to accommodate short-term changes in manned traffic demand, by adjusting the geographical limits of that U-space airspace.	IR (EU) 2021/664
Equipment to control unmanned aircraft remotely	Any instrument, equipment, mechanism, apparatus, appurtenance, software or accessory that is necessary for the safe operation of an unmanned aircraft, which is not a part, and which is not carried on board of that unmanned aircraft;	IR (EU) 2018/1139
Geographical zone or Geozone or UAS Geographical Zone	A portion of airspace established by the competent authority that facilitates, restricts or excludes UAS operations in order to address risks pertaining to safety, privacy, protection of personal data, security or the environment, arising from UAS operations.	AMC & GMs to IR (EU) 2019/947
Hazard	Any condition, event, or circumstance which could induce a harmful effect;	IR (EU) 2017/373
Height	The vertical distance of a level, a point or an object considered as a point, measured from a specified datum;	IR (EU) 923/2012
Helicopter	A type of rotorcraft supported in flight chiefly by the reactions of the air on up to two power-driven rotors on substantially vertical axes;	IR (EU) 2024/1111
Human-on-the-Loop	Automation which executes most tasks independently, and humans monitor overall system performance but only intervene occasionally (for example in off-nominal scenarios).	Our definition
Human-in-the-Loop	Execution of a function in a manner that involves continuous human intervention, possibly supported by tools or subsystem automation.	Our definition
Innovative air mobility (IAM)	A holistic term that describes the safe, secure and sustainable air mobility of passengers and cargo enabled by new-generation technologies integrated into a multimodal transportation system;	EASA

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Term	Definition	Source / Remarks
Innovative Aerial Services (IAS)	A holistic term that describes operations that are enabled by new airborne technologies including surveillance, inspections, mapping or telecommunications networking	EASA
Remote pilot	A natural person responsible for safely conducting the flight of an unmanned aircraft by operating its flight controls, either manually or, when the unmanned aircraft flies automatically, by monitoring its course and remaining able to intervene and change the course at any time;	IR (EU) 2018/1139
Restricted area	An airspace of defined dimensions, above the land areas or territorial waters of a State, within which the flight of aircraft is restricted in accordance with certain specified conditions	ICAO Annex 2
Rotorcraft	A power-driven, heavier-than-air aircraft that depends principally for its support in flight on the lift generated by rotors	IR (EU) 2024/1111
Separation minima	The minimum displacement between an unmanned aircraft and a hazard that maintains the risk of collision at an acceptable level of safety.	Our definition
Separation mode	An approved set of rules, procedures, and conditions of application associated with separation minima.	ICAO doc 9854 (GATMOC)
U-plan	U-space equivalent of a flight plan. Used in the context of the UAS flight authorisation service.	Our definition
U-space airspace	A UAS geographical zone designated by Member States, where UAS operations are only allowed to take place with the support of U-space services;	IR (EU) 2021/664
U-space service	A service relying on digital services and automation of functions designed to support safe, secure and efficient access to U-space airspace for a large number of UAS;	IR (EU) 2021/664
U-space Service Provider (USSP)	U-space service provider' means any legal person providing U-space services	IR (EU) 2021/664
Vertical Take-Off and Landing (VTOL) Capable Aircraft (VCA)	A power-driven, heavier-than-air aircraft, other than aeroplane or rotorcraft, capable of performing vertical take-off and landing by means of lift and thrust units used to provide lift during take-off and landing';	IR (EU) 2024/1111
Vertiport Operator	An accountable entity responsible for ground movements, pad allocation, local flow management and coordination of surface operations. May be delegated responsibility for the controlled portion of a VTZ.	EUREKA project
Vertiport Traffic Zone (VTZ)	An airspace construct around a vertiport, conceptually similar to an Aerodrome Traffic Zone (ATZ). It may include: a monitored zone,	EUREKA project

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Term	Definition	Source / Remarks
	and a managed zone, where the designated manager (vertiport operator or other) may approve access for VTOL aircraft. VTZs do not constitute a new ICAO airspace class.	
Vertiport	An area used for the take-off and landing of vertical take-off and landing (VTOL) aircraft;	IR (EU) 2024/1679
Very Low Level (VLL)	The airspace below the minimum heights applicable to VFR flights as defined in SERA.5005(f). It is the primary layer for U-space deployment in the short-term and the main domain for early BVLOS operations.	UAS ATM Common Altitude Reference System (CARS), EUROCONTROL
Visual Line Of Sight (VLOS) operation	A type of UAS operation in which, the remote pilot is able to maintain continuous unaided visual contact with the unmanned aircraft, allowing the remote pilot to control the flight path of the unmanned aircraft in relation to other aircraft, people and obstacles for the purpose of avoiding collisions;	IR (EU) 2019/947

Table 1: Glossary of terms

2.7 List of Acronyms and Abbreviations

Term	Definition
4G/5G/6G/	$4^{th}/5^{th}/6^{th}$ generation 3GPP cellular technologies
xG	Next generation 3GPP cellular technologies
ARC-b, ARC-c	Air Risk Class b, Air Risk Class c – from SORA
ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-L	Automatic Dependent Surveillance - Light
AGL	Above Ground Level
AIRM	Aeronautical Information Reference Model
AIXM	Aeronautical Information Exchange Model
AMC	Acceptable Means of Compliance
ANSP	Air Navigation Service Provider
AO	Aerodrome Operations
AOM	Airspace Organisation and Management
API	Application Programming Interface
ARA	Airspace Risk Assessment
ASTERIX	All Purpose Structured Eurocontrol Surveillance Information Exchange
ASTM	A standards organisation – see https://www.astm.org/
ATC	Air Traffic Control service
ATM	Air Traffic Management

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Term	Definition
ATS	Air Traffic Services
ATSP	Air Traffic Service Provider
AUO	Airspace User Operations
AUSA	ATM U Space Shared Airspace
BVLOS	Beyond Visual Line Of Sight
C-UAS	Counter-Unmanned Aircraft System
CA	Collision Avoidance /
CA	Competent Authority
CAPEX	Capital Expenditure
CATM	Collaborative Air Traffic Management
CCIS	Communication Coverage Information Service
CDM	Collaborative Decision Making
CDR	Conflict Detection and Resolution
CIS	Common Information Service
CISP	Common Information Service Provider
CM	Conflict Management
CMS	Conformance Monitoring Service
CMU	Control and Monitoring Unit
CNS	Communication Navigation Surveillance
CTR	Control Zone – ICAO. Previously *Control Traffic Region*
DAA	Detect and Avoid
DAR	Dynamic Airspace Reconfiguration
DCB	Demand and Capacity Balancing
DFR	Digital Flight Rules
DoS	Denial of Service
DPIA	Data Protection Impact Assessment
DSS	Discovery and Synchronisation Service
EASA	European Union Aviation Safety Agency
EEAT	Earliest Expected Activation Time
EU	European Union
EVTOL	Electric Vertical Take-Off and Landing
FAS	Flight Authorisation Service
FATO	Final Approach and Take-off [area]
FCFS	First Come, First Served. (usually meaning first planned has priority)
FF-ICE	Flight and Flow Information for a Collaborative Environment

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Term	Definition
FIXM	Flight Information Exchange Model
FPV	First-Person View
FTE	Flight Technical Error
GANP	[ICAO] Global Air Navigation Plan
GAS	Geo-Awareness Service
GATMOC	[ICAO] Global Air Traffic Management Operational Concept
GDPR	[EU] General Data Protection Regulation
GCS	Ground Control Station
GM	Guidance Material
GNSS	Global Navigation Satellite System
HEMS	Helicopter Emergency Medical Service
HPL	High-Performance Layer
IAM	Innovative Air Mobility
IAS	Innovative Aerial Services
iARC	Initial Air Risk Class – from SORA
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IM	Information Management
IMC	Instrument Meteorological Conditions
IP	Internet Protocol
IR	Implementing Regulation
ISO	International Organisation for Standardisation
IXS	Information Exchange Service
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
JSON	JavaScript Object Notation
LTH	Long-Term Horizon
MLAT	Multilateration, sometimes written Multi-lateration
MSL	Mean Sea Level
MTCD	Medium Term Conflict Detection
MTH	Medium-Term Horizon
NAA	National Aviation Authorities
NGO	Non-Governmental Organisation
NIS	Network Identification Service
NSA	National Supervisory Authority
NSE	Navigation System Error

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Term	Definition
NTN	Non-Terrestrial Network
OEM	Original Equipment Manufacturer
OPEX	Operational Expenditure
PDE	Path Definition Error
PIC /PICs	Pilot/Pilots in Command
PINS	Point In Space
PNT	Position, Navigation and Timing
R&I	Research and Innovation
rARC	Residual Air Risk Class – from SORA
RNP	Required Navigational Performance
RPAS	Remotely Piloted Aircraft System
RRI	Responsible Research and Innovation
RTCA	Radio Technical Commission for Aeronautics
RTTA	Reasonable Time To Act
RWC	Remain Well Clear
SAIL	Specific Assurance and Integrity Level – from SORA
SAIL III, SAIL IV	Specific Assurance and Integrity Level three, Specific Assurance and Integrity Level four
SATCOM	Satellite Communication
SCM	Strategic Conflict Management
SDM	Service Delivery Management
SDO	Strategic Deployment Objectives
SDOs	Standards Development Organisations
SERA	Standardised European Rules of the Air
SESAR (JU)	Single European Sky ATM Research (Joint Undertaking)
SLA	Service Level Agreement
SNI	Simultaneous Non-Interfering
SORA	Specific Operation Risk Assessment - from JARUS (jarus-rpas.org)
SP	Service Provider(s)
SRD	Short Range Devices
SRL	Societal Readiness Level
STCA	Short Term Conflict Alert
STH	Short-Term Horizon
TBO	Trajectory Based Operations
TCAS	Traffic alert and Collision Avoidance System
TCP	Transmission Control Protocol

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Term	Definition
TI	Technical Infrastructure
TIS	Traffic Information Service
TN	Terrestrial Network
TRL	Technology Readiness Levels
TS	Traffic Synchronisation
TSE	Total System Error
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
UASO	UAS operator
UML	Unified Modelling Language
USSP	U-space Service Provider
UTC	Coordinated Universal Time
UTM	UAS Traffic Management
VAS	Vertiport Automation Systems
VCA	Vertical Capable Aircraft
VCTM	Vertiport Collaborative Traffic Management
VFR	Visual Flight Rules
VIS	Vertiport Information Service
VLL	Very Low Level
VLOS	Visual Line Of Sight
VTOL	Vertical Take-off and Landing
VTZ	Vertiport Traffic Zone
WGS-84	World Geodetic System 1984
WIS	Weather Information Service

Table 2: List of acronyms and abbreviations

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3 Generalities

3.1 The U-space concept

U-space establishes a federated, interconnected airspace management system specifically designed to support large numbers of highly automated UAS operations. It creates a digital shared information environment based on interoperability and standardised protocols, with ongoing data exchange between service providers and airspace users. As an expandable set of services and functions, it creates an interoperable network of service providers supporting a safe operational environment. Thus, the U-space concept may be considered as a regulatory, operational, service and architectural framework designed to enable the safe, secure, and efficient integration of UAS and IAM into the airspace.

The U-space service framework is characterised by a novel set of services based on digitalisation and automation of functions, tailored to the needs of new airspace users and the challenges present in new environments, such as the very low-level airspace over urban areas. Initially, this framework is implemented in segregated airspaces labelled as U-space airspaces, and the starting level of integration between U-space and ATM is limited. The long-term goal is to eventually integrate the U-space concept into the wider ATM framework, enabling safe and efficient shared airspace use between manned and unmanned aviation.

At its core, the concept exercises highly automated risk management, supported by the digitalisation of functions and characterised by a minor human role when compared to traditional ATM. In its current scope, U-space focuses on supporting the mitigation of risks related to collisions with other conspicuous aircraft, whether manned or unmanned. This scope may be extended in the future.

3.2 Evolving Airspace Management

Both U-space and Innovative Air Mobility bring new elements into aviation that have triggered a shift in airspace management when both occur at scale and include low-level operations, operators using automation, electric power and digital data links. This transition in traditional ATM and convergence with U-space is captured by the 2025 European ATM Masterplan [10] and illustrated in Figure 1 that addresses the need to mature and advance both U-space and IAM first.

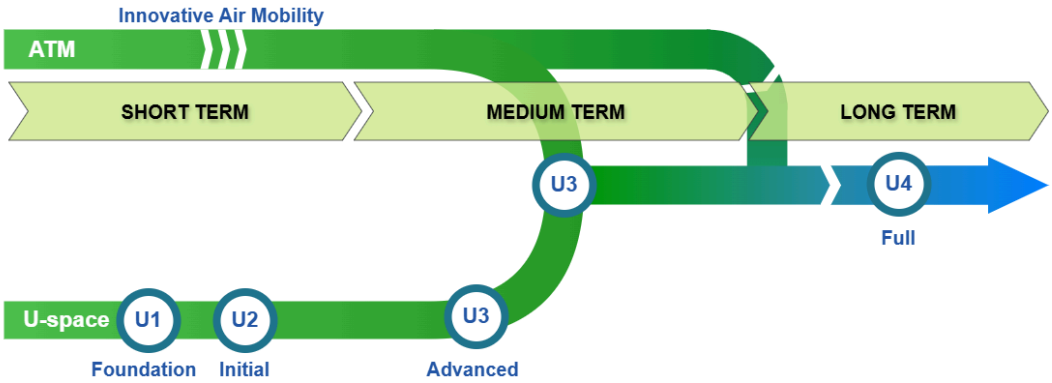


Figure 1: U-space ATM Convergence, from the ATM Master Plan

From the beginning, there has been an aspiration that U-space's automation and digital collaboration will progressively integrate with the European ATM system, leading to a safe and efficient coexistence of manned and unmanned traffic. The steps to this goal have previously been referred to as U1, U2, U3 and U4. The U terminology was an expression of how U-space would evolve that appeared in earlier editions of this ConOps. U1 was "U-space Foundation Services", U2 is "U-space Initial Services", U3 will be "U-space Advanced

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Services", and U4 will be "U-space Full Services". This edition of the U-space ConOps describes three time horizons spanning the evolution from U1 to U4.

In the short term, the current landscape is defined by the successful rollout of foundational aspects (**U1**, implemented via the EU UAS regulations [5], [6]), and the active deployment of the EU U-space regulations 10.1, [2] & [3]covering the initial **U2** services. This ConOps assumes the short-term phase will focus on implementing and maturing this existing framework across the EU and beyond, supported by revisions to the **Acceptable Means of Compliance (AMC) and Guidance Material (GM) [4]**.

The medium term includes advanced U3 services and functionalities, building upon current research to allow operational expansion. First, it introduces support for larger traffic densities, allowing for a higher concentration of UAS within a specific volume of airspace by scaling the capability of U-space to safely and efficiently manage traffic. Second, it significantly improves the integration of manned aircraft, ensuring more robust and safer coexistence within shared environments. Finally, U3 facilitates a more seamless interface between U-space, traditional ATM, established aerodromes, and emerging infrastructure such as vertiports, creating a unified ecosystem that integrates innovative air mobility into the U-space framework.

The longer term is less mature and consists of a collection of open questions and some ideas and proposals that might answer them. U4 is meant to represent a leap into highly automated traffic management within which U-space is an interoperable component. This progression is illustrated using the ATM Masterplan diagram (Figure 2).

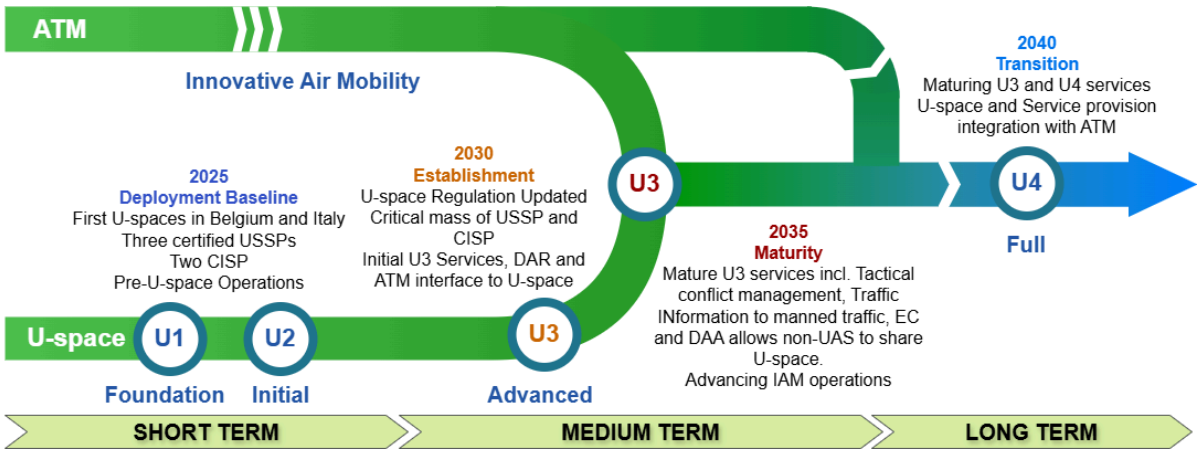


Figure 2: U-space ATM Convergence, from the ATM Master Plan

It is important to note that, although the ATM Master Plan includes a temporal prediction on the evolution of U-space, this document follows a more generic approach and instead links the different time horizons to a series of triggers, which may occur at different times than predicted by the ATM master plan. The following table outlines the strategic evolution of U-space, mapping out the specific triggers and objectives that define each temporal horizon from initial deployment to full integration.

Horizon	Trigger	Objective of U-space	Objective of this ConOps
Short U1, U2	Adoption of the current EU regulatory framework	Enable the first implementation of U-space	Bridge the gap between SESAR activities and the current EU implementation

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Horizon	Trigger	Objective of U-space	Objective of this ConOps
Medium U3	Updated EU regulatory framework with a new iteration of the U-space concept	Satisfy emerging needs, including high-capacity U-space airspaces and IAM operations Improve integration with the ATM framework	Guide U-space R&I activities and inform an eventual update to the EU regulatory framework
Long U4	Provision of digital services integrated in the ICAO framework (incl. airspace classification, flight rules, and air traffic services)	Seamless integration with the ATM framework	Highlight strategic actions needed to achieve integration

Table 3: Time Horizons and their objectives

3.2.1 Integration according to the EU ATM Master Plan

While this ConOps presents a view from the U-space standpoint, the ATM evolution perspective provides some clues to potential approaches for integration. In the first instance, much of the EU ATM Master Plan addresses the evolution of ATM to achieve European performance objectives through the Strategic Deployment Objectives (SDO), which provide checkpoints for activities relating to high maturity within the time horizons, while this ConOps can be viewed as providing an extra level of detail on gaps or opportunities for further action.

UAS and innovative air mobility (IAM) enablers in the Master Plan are captured in SDO 10, which states:

- (10.1) Implement system support and procedures to integrate instrument flight rules (IFR) RPAS and IAM in airspaces A to C, which are required to have detect and avoid (DAA) systems that perform at least as well as TCAS II (traffic alert and collision avoidance system) and see and avoid.
- (10.2) Implement foundational (U1) and initial (U2) U-space services as established by the regulatory framework for U-space (Commission Implementing Regulation (EU) 2021/664).
- (10.3) Implement a common ATM–U-space interface and dynamic airspace reconfiguration service to help ATC actors in charge of airspace reconfigurations to increase safety, keeping manned and unmanned aircraft segregated within the designated U-space airspace.
- (10.4) Implement simultaneous non-interfering (SNI) operations (e.g. parallel or convergent point-in-space (PinS) procedures) and capabilities (i.e. GNSS and the RNP navigation specification) allowing airspace users (e.g. rotorcraft, VCA, etc.) to operate to and from airports, vertiports and TMAs without conflicting with other traffic or requiring runway slots.

It is well known that manned VCA will be flown under current rules, which require modification, as addressed in 10.1 and 10.4. The remaining two items address the implementation of U-space, and the development of an initial data exchange between U-space and ATM. This is where CORUS five provides value, and it outlines the following steps.

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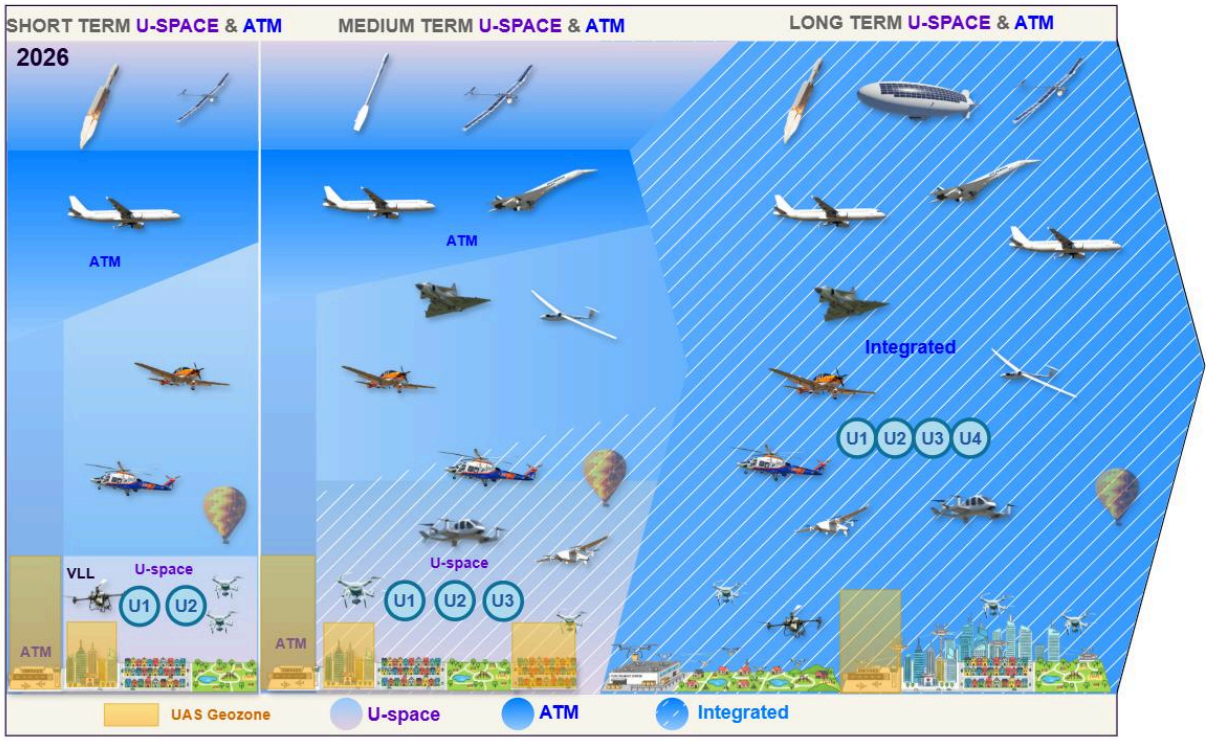


Figure 3: Evolution of U-space and ATM integration

3.3 ATM functions according to ICAO GATMOC

As U-space is part of air traffic management, this ConOps is structured in line with the ICAO's Global Air Traffic Management Operational Concept (GATMOC) 10.1. The GATMOC defines seven basic components of ATM designed to transition global aviation from a legacy ATC model to a collaborative ATM system. This makes the GATMOC an excellent baseline from which to address U-space integration into the broader ATM environment (Figure 4).

A core tenet of digital transformation in aviation is a shift from a product-centric model (PDF, paper documents and voice/radio) to a data-centric model (machine-readable data, digital services). The GATMOC provisions the core concepts (information management, ATM Service delivery management and balance of demand and capacity) for collaborative management that would apply to shared airspace development. This is realised using automated services that generate appropriate data exchanges between service providers. Critically, due to the localisation of drone operations, much of the information exchange necessary may occur; however, a digital collaborative network requires all service providers to be considered and to have role-based access, a key element of any digital infrastructure.

For Collaborative Air Traffic Management (CATM) to work effectively, all parties must have access to a single version of information to create a well-defined airspace environment. This includes real-time constraints, weather and aircraft. Thus, effective and seamless Information sharing requires interfaces, services and role definitions to cover both strategic and tactical operations.

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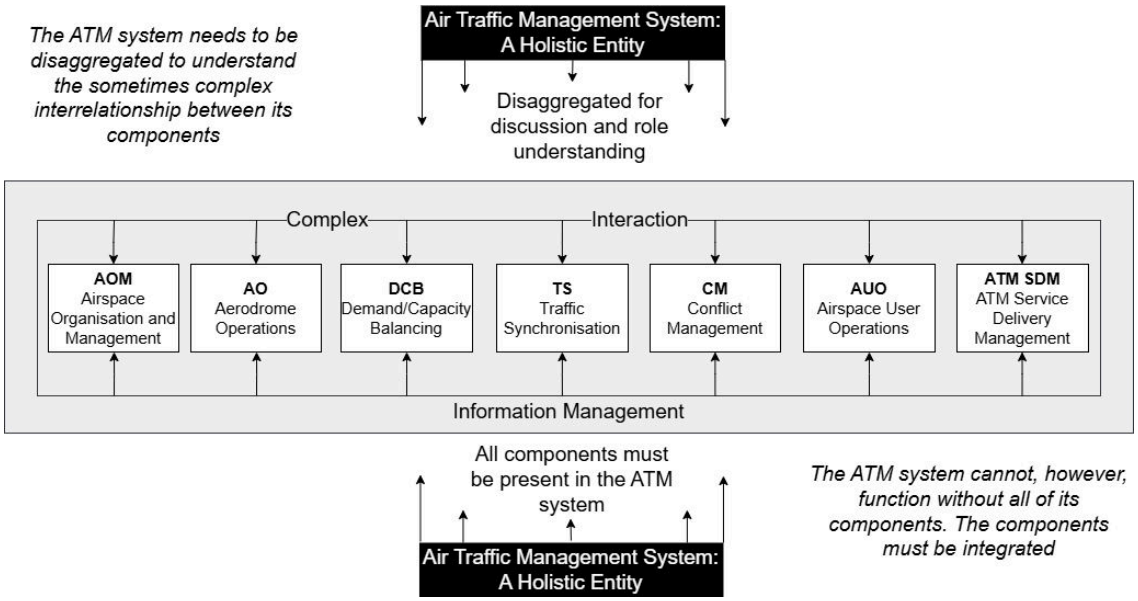


Figure 4: Airspace management environment according to the ICAO GATMOC Doc 9854 (reprinted from [12]).

The seven components rely on the Information Management service to fulfil their functions as described below:

The **Airspace Organisation and Management (AOM)** function provides the strategies, rules and procedures by which the airspace will be structured to accommodate the different types of air activity, volume of traffic, and differing levels of service and rules of conduct.

Airspace management (ASM) is the process by which airspace organisation options and other options in the provision of services will be selected and applied to best meet the needs of airspace users. ASM level will no longer be Civil vs. Military and will have to include Unmanned vs. Manned.

Aerodrome operations (AO) describe the aerodrome functionality within the ATM system in terms of such factors as information acquisition and delivery, facility access, demand on airspace, and limits on usability.

The function of **Demand and Capacity Balancing (DCB)** is to minimise the effects of system constraints. DCB ensures that airspace users can optimise their participation in the ATM system (or U-space, in this case) while mitigating conflicting needs for airspace and aerodrome/vertiport capacity.

Traffic Synchronisation (TS) refers to the tactical establishment and maintenance of a safe, orderly and efficient flow of air traffic. TS, AOM, conflict management and DCB are interrelated and will become fully integrated, leading to a continuous and organised flow of traffic.

Conflict Management (CM) aims to **limit the risk of collision between aircraft and hazards to an acceptable level**. This function ensures that unmanned aircraft systems (UAS) operate safely and efficiently within a shared airspace environment. The CM process is structured into **three layers**, applied progressively along the conflict horizon – from flight planning to real-time operations:

- **Strategic conflict management** is the first layer of conflict management and is achieved through the airspace organisation and management, demand and capacity balancing and traffic synchronisation components.
- **Separation provision** is the second layer of conflict management and is the tactical process of keeping aircraft away from hazards by at least the appropriate separation minima. Separation provision will only be used when strategic conflict management cannot be used efficiently.

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- **Collision avoidance** is the third and final layer of conflict management and must activate when the separation mode has been compromised.

Airspace user operations (AUO) refer to the ATM-related aspect of flight operations and seek to accommodate diverse types of airspace user missions, with mixed capabilities. AUO includes mission planning, operational control, and flight operations.

The **ATM Service Delivery Management (SDM)** component addresses the balance and consolidation of the decisions of the various other processes/services, as well as the time horizon at which, and the conditions under which, these decisions are made. Flight trajectories, intent, and agreements will be important components in achieving a balanced set of decisions. Unlike the other components that manage specific functions, ATM-SDM has the coordinating role to ensure the system operates as a whole.

The function of **information services** is to deal with the exchange and management of information used by the different processes and services. It will ensure the cohesion and linkage between the seven concept components described above.

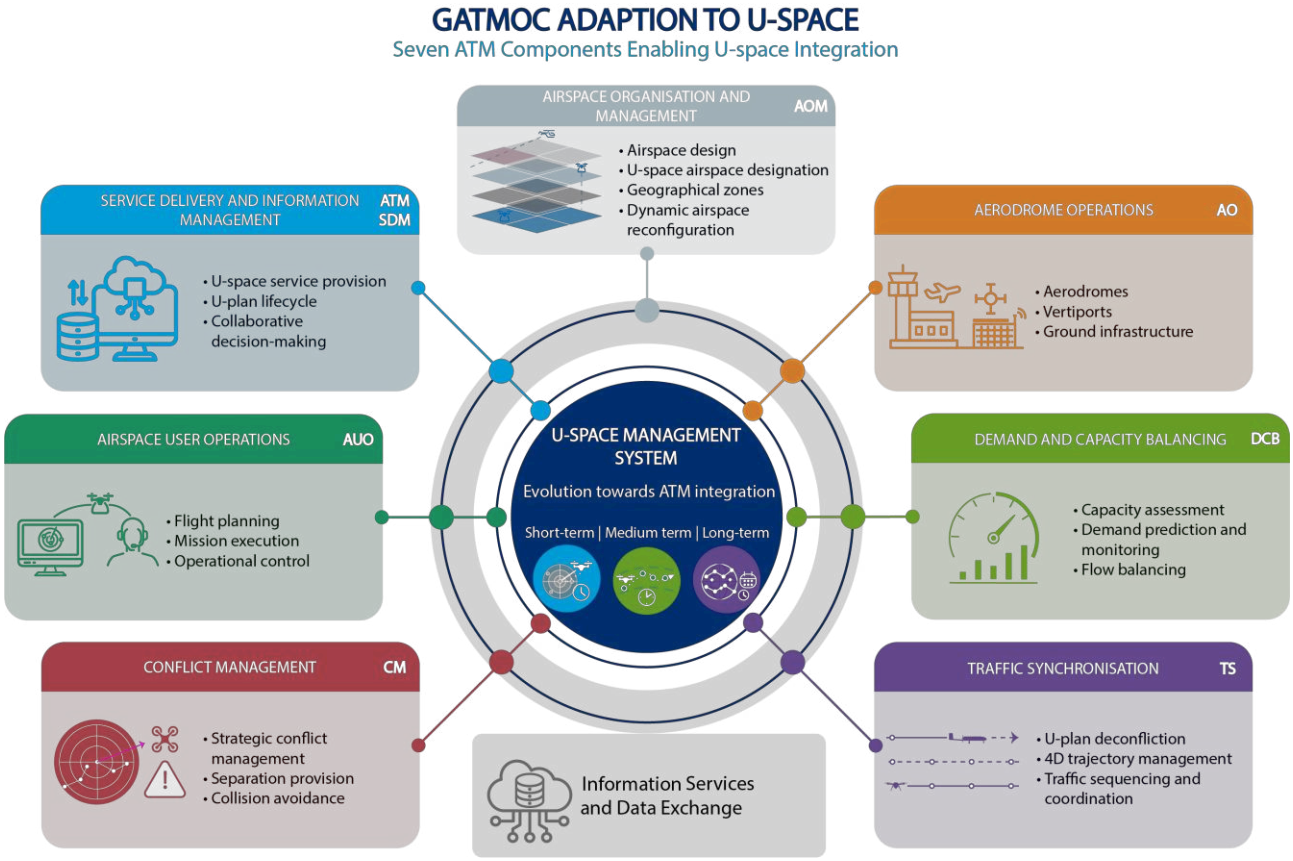


Figure 5 The areas of the CORUS five U-space ConOps based on GATMOC

3.4 The U-space Stakeholder Ecosystem

The operationalisation of Innovative Air Mobility (IAM) relies on a federated architecture, oriented to services, which differs significantly from the monolithic nature of traditional ATM. U-space acts as the enabler for this ecosystem, as a competitive marketplace of automated services designed to manage high-density operations in complex environments. To systematically analyse this interconnected environment, stakeholders are categorised into seven distinct groups based on their operational proximity to the flight and their function.

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The first three categories represent the operational core – entities that directly execute, support, or consume U-space services. The subsequent four categories constitute the strategic and governance framework that enables and oversees the market.

3.4.1 Direct Operational Stakeholders

3.4.1.1 Group 1. Beneficiaries

The first category encompasses the ultimate recipients of value within the U-space ecosystem. This group is bifurcated into direct consumers and the broader societal base.

- **Consumers and End Users:** This subgroup includes the commercial clients and consumers, the end users of U-space operations, such as aerial work or logistics. Their demand drives the economic viability of the U-space market.
- **General Public**: While not always direct users, the public is a critical stakeholder whose endorsement serves as the requisite societal mandate for operational deployment. They are the primary subjects of operational externalities (e.g., acoustic impact, visual intrusion, and privacy concerns). Consequently, their engagement is essential for defining the societal constraints under which U-space operations must function.

3.4.1.2 Group 2. U-space Users

The second category comprises active participants who conduct flight operations, either physically or digitally, within the U-space volume or that may potentially enter it.

- **Airspace Users:** The legal entities responsible for the flight, such as Commercial and Enterprise UAS Operators, State and Authority Operators. While U-space is designed for UAS, manned aircraft of Helicopter Emergency Medical Services (HEMS), General or Commercial (e.g., Dynamic Airspace Reconfiguration (DAR) cases) Aviation, and State and Military Aircraft that approach or enter U-space volumes also belong to this subgroup.
- **Operational Personnel:** Currently, this set includes Pilots in Command (PICs), crew members, and airspace observers. These actors are the primary interface for real-time decision-making and are legally required to comply with flight authorisations and U-space instructions. The roles and responsibilities of operational personnel will evolve as UAS operations increase in automation. Responsibility for operations will remain with the aircraft operator. The distribution of responsibilities of the aircraft operator will always need to be agreed with their regulator, either by following the “standard model” with key actors, such as the Pilot in Command, trained and licensed in accordance with defined norms, or otherwise as agreed.

3.4.1.3 Group 3. Service Providers and Infrastructure Operators

The third category comprises digital and physical infrastructure providers responsible for ensuring safe separation and efficient flow management.

- **Mandated Service Providers:** This includes U-space Service Providers (USSPs), which deliver mandatory and optional as well as non-regulated services, and Common Information Service Providers (CISPs, see details in section 3.5.1), which act as the single source of truth for each element of U-space data. Whenever U-space airspaces are located close to or within the controlled airspace (e.g., DAR cases), Air Navigation Service Providers (ANSPs) are to interact with USSPs. Aeronautical Information Service Providers (AISPs) are to ensure that aeronautical data (e.g., airspace structures, restricted zones, and static obstacles) is not only available for manned aviation via the Aeronautical Information Publication (AIP), but is also formatted and disseminated in a digital, machine-readable format suitable for the Common Information Service (CIS).

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- **Physical and Digital Infrastructure:** Stakeholders such as Vertiport Operators, Communication, Navigation, and Surveillance Service Providers (CNS SPs), and supplemental data providers (e.g., weather, geospatial, population, or environmental data providers) form the backbone of the ecosystem.

3.4.2 Strategic, Industrial, and Governance Stakeholders

3.4.2.1 Group 4. Economic and Civil Society Stakeholders

This category captures the broader ecosystem that supports the economic and societal sustainability of unmanned aviation and aerial services.

- **Civil Society & Advocacy:** This includes Non-Governmental Organisations (NGOs), environmental groups, and specialised media that scrutinise the ecological and societal impact of IAM.
- **Industrial Support:** This subgroup includes Original Equipment Manufacturers (OEMs), technology vendors, and maintenance providers. While they do not manage airspace, they are critical for exchanging technical performance data with operators and USSPs to ensure airworthiness and service reliability.
- **Research & Academia:** Universities and research institutions play a fluid role, often transitioning into operational actors during validation trials and pilot projects.

3.4.2.2 Group 5. Standardisation and Industrial Alignment Bodies

This category serves as the technical engine of the U-space ecosystem, translating high-level regulatory safety objectives into actionable engineering specifications. It is composed of two distinct but complementary sub-groups:

- **Standards Development Organisations (SDOs**): These are the consensus-based bodies responsible for publishing the technical standards (e.g., Minimum Operational Performance Standards - MOPS) that regulators adopt as Acceptable Means of Compliance (AMC). Among such organisations are EUROCAE, the International Organisation for Standardisation (ISO), ASTM International, Radio Technical Commission for Aeronautics (RTCA), and Society of Automotive Engineers (SAE International).
- **Industry Associations and Alliances:** These organisations represent the collective voice of the industry. While they do not publish "standards" in the regulatory sense, they develop pre-standardisation requirements, interoperability blueprints, and policy position papers that guide the work of SDOs and regulators. Among such organisations are the Global UTM Association (GUTMA), Aerospace, Security and Defence Industries Association of Europe (ASD), Alliance for New Mobility Europe (AME), Joint European Drone Associations (JEDA), European Association for Unmanned Aviation (UAV DACH), European network of U-space stakeholders, European UAS Test Centre Alliance, etc.

3.4.2.3 Group 6. Multi-State Governing Bodies

The sixth category comprises agencies and institutions that establish and steer the harmonised legal and strategic frameworks.

- **European Union Aviation Safety Agency (EASA):** The primary rulemaking body for aviation safety and environmental protection in Europe.
- **EUROCONTROL:** Facilitates the integration of U-space into the broader European ATM network.
- **SESAR 3 Joint Undertaking:** Drives the research and innovation agenda (such as the Digital European Sky strategy and the European ATM Master Plan) to accelerate market uptake.

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3.4.2.4 Group 7. National, Regional, and Local Authorities

The final category encompasses the entities responsible for enforcement, designation, and local implementation.

- **National Aviation Authorities (NAAs):** Entities such as national Civil Aviation Authorities (CAAs) are responsible for certifying USSPs, designating U-space airspaces, and overseeing compliance.
- **Local Authorities and U-space Coordinator**s: Local municipalities play a pivotal role in establishing the U-space geographical zones by enforcing local constraints – such as noise and visual pollution abatement, privacy restrictions, and temporal limits – thereby aligning U-space operations with urban planning policies and community needs. The U-space Coordinator is to facilitate the establishment and monitoring of U-space airspace, and thus to act as the liaison between the CAA and local stakeholders, including municipalities, city councils, and the general public.

Note on Convergence: As the market matures, significant functional overlap is anticipated. Entities such as software vendors, service providers, aerodrome operators, booking platforms, and large-scale UAS operators may vertically integrate, requiring distinct regulatory approvals for each function they perform. For example, an entity designing and developing the U-space system, or an entity acting as a fleet operator, may obtain certification and serve as the USSP.

3.5 Provision of services in U-space

3.5.1 Common Information Services

Common Information Services (CIS) consist of the aggregation, harmonisation and dissemination of static and dynamic data required for the provision of U-space services. Currently, CISPs are not required to perform any operational decision-making or traffic management functions. Instead, they enable USSPs to deliver operational U-space services by providing a single source of truth regarding airspace structure, operational constraints and applicable requirements, as well as relevant information concerning manned aircraft shared by an ANSP when applicable.

The CIS function can be designated for a single exclusive provider for a given U-space airspace[3], in which case a single CISP is certified, or as a multi-provider CIS capability in which different providers will provide elements of U-space data which is assured by the provider. No duplication of data is allowed, meaning it's a single source of truth for each U-space data except for electronic conspicuity data

3.5.2 U-space services

U-space services are regulated services provided by USSPs, certified legal entities that are responsible for maintaining safety standards. Multiple USSPs can provide their services in any U-space airspace as long as they have undergone an onboarding process, so as to demonstrate compliance with the local requirements established by the member state. The primary goal of U-space services is to enable safe, secure, and efficient access to the airspace for UAS operations.

The U-space ecosystem functions through a structured digital workflow where UAS operators interact with certified service providers to ensure safe and coordinated access to the sky. For any given U-space airspace,

[3] A single CISP may be designated for one or all of the U-space airspaces in a Member State. A member state can also choose a distributed approach in which U-space data is provided by multiple providers.

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the Common Information Service maintains an official registry of authorised **U-space Service Providers (USSPs)**, allowing operators to select and contract with a provider that best suits their operational needs.

To facilitate state operations of UAS (such as by police or military), which may be sensitive in nature, Member States may operate their own services to facilitate access to U-space for such operators whilst maintaining safety, security and confidentiality requirements.

3.5.3 Non-regulated services

Non-regulated services encompass a diverse suite of supplementary offerings that fall outside the formal U-space regulatory mandates. To maintain the integrity of the ecosystem, these services must operate under strict conditions: they shall not interfere with, substitute for, or negatively impact the safety, security, and efficiency aspects managed by U-space services. Instead, their primary role is to provide added-value functionalities that assist operators in the logistical planning and execution of their missions. These tools often range from supporting regulatory compliance checks – such as population density and noise maps for SORA risk assessments—to high-resolution terrain and obstacle data used to ensure 4D trajectories remain within authorised "above ground level" (AGL) limits and clear of physical obstructions.

Beyond mission preparation, non-regulated services facilitate the administrative side of flight operations. They offer specialised tools for generating compliant 4D trajectories tailored to specific UAS performance metrics and streamline the acquisition of permissions for restricted geographical zones. Furthermore, they may bridge the gap between operators and authorities by providing verification tools that allow service providers to confirm an operator's legal standing, such as the necessary permissions or authorisations to conduct operations. These services may also extend to non-operational stakeholders, information sharing or situational awareness capabilities for authorised public authorities, subject to applicable legal and access control requirements, or enabling public authorities to manage awareness and establish localised flight restrictions.

These services exist outside the mandatory regulatory core, and may be provided by any service provider, including certified service providers in addition to their regulated services.

3.6 Safety, capacity, and efficiency in U-space

3.6.1 What is capacity in ATM and U-space?

The core goal of ATM is to ensure the **safe** and **efficient** flow of air traffic. These same precepts are also applicable to the U-space concept. According to the ICAO GATMOC [12], airspace capacity is the maximum number of aircraft that can be accommodated within a defined airspace volume or at an aerodrome over a given period of time, consistent with the required level of safety. This ATM notion of capacity is rooted in the capability of a human actor, the air traffic controller, in managing a given amount of traffic.

In addition, the following metrics are related to capacity:

- The **airspace demand** is defined as the number of operations that intend to use the U-space airspace. Demand can also be expressed as a rate of operations per hour, as the number of simultaneous operations, and/or as airspace occupancy.
- The **traffic load** is defined as the actual number of operations that are allowed to operate after the risk mitigation barriers impose constraints on operations to ensure safe flights. Traffic load can also be measured as a rate of operations per hour, as the number of simultaneous operations, and/or as airspace occupancy.

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Considering the above, **the capacity of a U-space airspace** can be defined as the amount of traffic that can be **safely** and **efficiently** handled by the U-space airspace. The main difference between traditional ATM and the U-space approach in this regard is that the capacity limits of U-space airspaces are no **longer bound by the performance of a human** in charge of providing separation. The U-space framework allows **automated and digital functions** to take a **central role** in the mitigation of the risk of collision, thus unlocking new ways of safely managing air traffic.

This ConOps describes what safely and efficiently mean in the following manner:

- **Safety** means that the flights should be conducted in a safe manner. This is achieved by identifying and mitigating hazards to acceptable levels. In the provision of ATS, the most relevant hazard is the risk related to a mid-air collision. Thus, the main goal to achieve safe flights from a traffic management perspective is to ensure that the risk of mid-air collision is mitigated to acceptable levels.
- **Efficiently** refers to the efficient use of the airspace. Airspace is a limited resource whose efficient management is paramount. Airspace efficiency can be understood as the difference between the ideal 4D flight trajectory as desired by the airspace user, compared to the actual flown trajectory that was allowed after the necessary risk mitigations are applied. Additionally, efficiently also means that no unnecessary workload is imposed on the involved stakeholders.

Whether an acceptable level of safety can be met under a given traffic load depends on the effectiveness of the risk mitigation barriers in reducing the risk to the acceptable level. The mitigation strategy can be understood as how the different barriers corresponding to the three layers of the conflict management process are implemented. The capacity of the mitigation strategy in reducing the risk to an acceptable level depends on the performance of the different barriers considering nominal and non-nominal situations.

When the traffic load is higher than the defined capacity, the safety performance of the separation provision barrier may drop below the acceptable margins. Within the conflict management continuum framework, the role of traffic synchronisation functions is to ensure the traffic load is arranged in such a manner that the limits of the separation provision barrier will not be exceeded, and thus perform as expected. In a similar fashion, the goal of DCB is to ensure the adequate working of the traffic synchronisation function by adjusting the demand according to capacity considerations.

However, the implementation of DCB and TS measures introduces constraints on operations, such as delays, which can negatively impact the efficiency of the U-space airspace. In addition, tactical measures implemented during the flight to solve or prevent conflicts can also impact the efficiency of the flight, for example, resulting in larger trajectories. Hence, there is an inherent challenge in achieving both safe and efficient flights.

3.6.2 Capacity thresholds in U-space

Safety, capacity, and efficiency are strongly interrelated. This assertion leads to the definition of two different capacity thresholds:

- The **safety-capacity threshold** refers to the level of traffic load that can be safely handled by the system. This refers strictly to the residual risk at the tactical level associated with the traffic load, including the potential negative impacts of high local traffic densities on tactical barriers. Hence, this threshold is primarily related to the capabilities of the separation provision phase.
- The **efficiency-capacity threshold** refers to the level of demand that can be efficiently handled by the system. This threshold is primarily related to the capabilities of the traffic synchronisation phase.

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Ultimately, this threshold is also linked to safety, as the constraints that impact the flight efficiency are a direct consequence of the mitigation strategy.

Additional capacity limits related to societal indicators, such as noise or visual pollution, could be defined (see Section 7 regarding public acceptance).

The actual capacity of the U-space airspace is the lowest of all the defined thresholds. From this, it can be stated that, ideally, all thresholds should have similar values whenever possible, to ensure a balance between the requirements and constraints imposed by the system during the different phases of the conflict management continuum.

The time horizons described in the following chapters adopt different mitigation strategies to meet an acceptable level of safety according to the objectives and needs particular to each time horizon.

To achieve an acceptable level of safety, the near-term mitigation strategy conservatively relies on significant constraints to UAS operations in the pre-flight phase, as the tactical performance of U-space systems is not yet well understood including the capabilities of UAS operators to fly according to the U-plan, and their capabilities to effectively remain well clear of other traffic. Appendix B provides a high-level estimation of impact of strategic conflict resolution in the short term and identifies the primary factors limiting the efficiency-capacity thresholds. In the medium term, the goal is to find a different mitigation strategy that imposes strategic constraints in a more effective manner, allowing larger traffic loads to be met, for which a larger residual risk of conflict is effectively mitigated using improved tactical capabilities. This is the argument used by CORUS five towards unlocking high-density U-space airspaces.

3.7 Other relevant aspects

3.7.1 Flight rules

Flight rules are defined in the International Convention on Air Navigation (aka the Chicago Convention) Annex 2 [15] and have been developed into the Standardised European Rules of the Air (SERA), IR (EU) 923/2012 [16]. Annex 2 describes Right of Way, which gives some rules, priorities and manoeuvres that reduce the risk of collision. Visual Flight Rules (VFR) require that pilots see other aircraft and avoid them following Right of Way. Instrument Flight Rules (IFR) allow flight when the pilot cannot see other aircraft, but such conditions require Air Traffic Control to maintain separation. Today, some UAS are operated IFR in controlled airspace.

UAS cannot be operated under VFR (which requires “see and avoid” capabilities), while IFR is not possible in U-space airspace, as there is no service from ATC to maintain separation. Flight rules and rights of way will have to be addressed in the medium and long term to facilitate the transition from segregated airspace. Digital Flight Rules (DFR) have been proposed as an alternative for highly automated operations of unmanned systems leveraging connected digital systems.

In the short term, UAS fly in U-space without following VFR or IFR flight rules. Allowing UAS and manned aircraft to fly together in the same airspace will require UAS to follow a flight rule. This is explored in the long-term horizon section and may require some preliminary steps in the medium-term horizon

3.7.2 Coordinate reference systems

Regarding the use of coordinate reference systems in the U-space context, the ICAO Annex 11 provisions are considered:

- The WGS-84 (ellipsoid) is used as the horizontal reference system.
- The MSL (geoid) is used as the vertical reference system.

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- The Gregorian calendar and Coordinated Universal Time (UTC) are used as the temporal reference system.

The reference systems outlined above should be used in U-space, with the exception of particular cases, as necessitated by the circumstances.

It is important to note that barometric and geometric (i.e. using GNSS) altitude measurements cannot be directly compared. GNSS generally measure height above the WGS-84 ellipsoid, which can be converted to altitude by using the geoid undulation (i.e. the height of the ellipsoid compared to the geoid surface at a given point). Barometric altimetry systems do not actually measure altitude but instead predict the altitude according to pressure measurements and using an atmospheric model.

Therefore, if U-space is established to support operations using geometric and barometric altitude measurements, additional services must be in place to convert such measurements to a common altitude reference system.

If a single type of altitude measurement system is prescribed, authorisations issued to, and telemetry information coming from, any aircraft flying within U-space (manned and unmanned) must apply the same altitude reference system.

GNSS technologies become a critical component supporting navigation and coordinate referencing and, together with timing synchronisation between systems, Position, Navigation and Timing (PNT), is viewed as critical infrastructure in a digital, connected network of systems.

3.8 Assumptions

When considering the long-term integration of U-space and ATM, certain time-invariant assumptions must remain constant to maintain the system's integrity. The following non-exhaustive list is designed to steer the discussion to ensure the principles of U-space align with the first principles of safety, economics and equity, regardless of aircraft or automation.

- Automation, digital services and unmanned aircraft technologies do not degrade accepted system-wide safety levels.
- UAS operators comply with the requirements set out in the EU UAS regulatory framework, i.e. 2019/947 and 945. This means UAS operations follow a risk-based classification scheme: Open, Specific, Certified. It is assumed that these regulations will evolve over time, but the core elements, such as the risk-based classification, will remain.
- Airspace change and risk assessment remain an integral regulatory process that will become more agile with an increase in information and automation.
- U-space services remain market-driven and competitive to prevent monopolistic practices and to drive innovation.
- Common information is supplied to all. USSPs are regulated businesses and compete with one another, but at the same time cooperate to make the system work - in a similar manner to telephone service providers.
- Long-term integration assumes that rules are based on outcomes, not specific technologies.
- Performance-based approach assumes that airspace will shift from static segregation to flexible airspace usage with associated real-time risk assessment.
- Humans in supervisory roles remain a necessity to deal with system-level failures in ATM, even when high automation levels are used.
- An aviation communication network provides an interoperability infrastructure. This does not mean that a single network is required. However, interoperable and secure data exchange infrastructure exists between relevant actors.

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4 Short-Term Horizon

The Short-Term Horizon (STH) describes U-space in the near term according to the existing EU regulatory framework that includes U1 and U2 services. These are based on the requirements of Regulations 2019/947 and 2021/664, respectively.

The goal within this horizon is to get the initial concept of the U-space off the ground. During implementation, the expectation is to prioritise safety and security over high traffic or efficiency. This approach builds trust in the system and gives the entire ecosystem room to grow and mature over time.

The **goal** of this ConOps, regarding the **near term**, is to **align the current SESAR U-space framework with the regulatory framework**. While the current R&I references are anchored in the SESAR U-space Blueprint and the previous editions of the CORUS ConOps, today's U-space implementation is driven by an evolving EU regulatory framework and a domain evolution grounded in operational reality.

Therefore, to achieve this goal, Edition 5 of the CORUS ConOps must break with the approach followed in previous editions. This means that the regulations are used as the starting point from which the R&I opportunities are explored. Compared to previous editions, relevant concepts (incl. definitions and even the services) are aligned with the current regulatory framework, while keeping the essential parts of the overall U-space concept. The scope here is not to mimic the U-space regulations (which the reader is kindly invited to read 10.1), but to explain how the main ATM functions are implemented in U-space under the framework provided by these regulations.

As a secondary goal, the short-term horizon also aims to provide meaningful feedback regarding how supporting materials to the regulation can be developed to boost the implementation of U-space. Examples of such supporting materials could include an update to the AMC/GM or the development of U-space standards.

The short-term spans from the time marked by the adoption of the EU U-space regulatory framework, complemented by the publication of AMC/GM by EASA, until the medium-term begins.

4.1 Assumptions

In the short-term, the ConOps makes the following assumptions:

- **Isolated Airspaces**: The U-space concept is assumed to be in the first stage of implementation, meaning U-space airspaces will generally be standalone rather than adjacent to a network of other U-space airspaces.
- **Localised Management:** The focus is on managing flights within a specific U-space area rather than coordinating complex, system-wide interactions between U-spaces across large geographical regions.
- **Limited Data and Maturity**: There is currently a lack of operational data regarding capacity, efficiency, performance, and safety, reflecting an overall limited maturity in UAS traffic management.
- **Exclusion of High-Risk Operations:** Certified category operations, such as passenger transport, are not expected to be managed by the U-space framework.
- **Human intervention**: While the long-term goal is a high level of automation, human intervention is expected to remain common during this initial stage.

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- **Restricted geographical scope:** U-space airspaces will be limited to the very low-level airspace and situated at a sufficient distance from controlled aerodromes used by manned aircraft.
- **Minimal Manned-Unmanned Interaction**: Due to the geographical restrictions, encounters with manned aircraft within U-space airspaces are expected to be rare.

4.2 Overview of services provided in the short-term

The EU regulatory framework assigns Member States the responsibility of ensuring that a set of critical common information is made available to all relevant stakeholders. **Common Information Services (CIS)** constitute the foundational information layer of the U-space ecosystem. Their purpose is to ensure that all U-space Service Providers (USSPs) and UAS operators operate based on a shared, authoritative and up-to-date view of the airspace, thereby preventing information asymmetry and enabling safe, fair and interoperable U-space operations. The information provided as part of CIS includes geographical information (operational conditions and airspace limitations), terms and conditions for the provision of U-space services, and traffic information regarding relevant manned traffic in the vicinity of U-space airspaces, among others.

The USSPs must provide at least the following U-space services in a bundle:

1) **Network Identification Service (NIS)**, which allows the continuous processing of the remote identification of UAS and the provision of this information to relevant stakeholders.
2) **Geo-Awareness Service (GAS)**, which provides the UAS operator with information relative to applicable operational conditions and airspace constraints, UAS geographical zones, and temporary restrictions that are applicable to the U-space airspace.
3) **UAS Flight Authorisation Service (FAS)**, which guarantees that planned individual UAS flights are strategically de-conflicted and comply with applicable airspace restrictions and temporary airspace limitations.
4) **Traffic Information Service (TIS)**, which provides UAS operators with information on any other conspicuous air traffic that may be near the position or intended route of the UAS flight.

In addition, where mandated by the competent authority based on the outputs of the Airspace Risk Assessment (ARA) performed during U-space designation, USSPs may also be required to provide one or both of the following optional U-space services:

5) The **Weather Information Service (WIS)**, which provides USSPs and UAS operators with reliable up-to-date weather information and forecasts.
6) The **Conformance Monitoring Service (CMS)**, which alerts UAS operators if they, or other nearby UAS operations, deviate from the assigned flight authorisation thresholds.

4.2.1 A typical flight example

The following is a typical sequence of actions for a flight. *This is a fictional example about delivering bananas. It could be about delivering anything: prescription drugs, a set of strings for a guitar, an engagement ring, a woolly hat…*

The **UAS Operator (UASO)** is providing a delivery service to the rural region surrounding a city. The UASO has a base on the edge of the city and is continuously flying in this region. The UASO has an approved operational authorisation for this type of operation in this region.

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An order is received to deliver bananas to a house several km from the base. The UASO accesses the Common Information Services and determines that the entire flight will be within one U-space airspace.

The UASO prepares a U-plan using geozone data provided by its USSP through the Geo-awareness service. The U-plan is consistent with the performance capabilities of the selected UA, and the flight duration is determined according to the intended speeds along the trajectory. The UASO uses a dedicated weather forecast service to obtain a forecast and see whether the UA can safely fly in those weather conditions.

The UASO uses an interface provided by its USSP to access the Flight Authorisation Service. A Flight Authorisation Request is created for the U-plan and submitted for automatic processing. The USSP coordinates with other USSPs to check for conflicts with already authorised flights. A conflicting U-plan is found. The USSP determines that a 30-second delay to the take-off time will solve the problem. The USSP communicates this back to the UASO. The UASO checks geo-awareness and weather conditions, updates the flight plan with a later take-off time, and submits a new request through the FAS. The USSP authorises the flight as it is now conflict-free.

The ground crew of the UASO loads the bananas onto the UA and does the pre-flight checks. The remote pilot checks the system airworthiness, loads the U-plan into the aircraft's flight control system, and then, once within the activation time window, uses the USSP's Flight Authorisation service to request activation of the flight. The USSP makes a final check through CIS for Dynamic Airspace Restrictions, checks with the other flights, its own and those of other USSPs, to ensure there are no conflicts, and, if no issues are found, confirms the flight activation. Those checks are performed automatically. The UA takes off.

Through the U-space system, the flight is automatically connected to the USSP's Network Identification Service. The NIS allows the current position and motion of the flight to be updated frequently. During the operation, the UASO will monitor geo-awareness, Network identification, traffic information and conformance to the U-plan. All these services are provided by the USSP.

During the flight, the USSP continuously checks, in an automated mode, that the UA flight is proceeding according to the approved U-plan using the CMS.

Once the bananas are delivered, the aircraft returns to base, and the flight is completed.

The UASO informs the USSP through the Flight Authorisation Service that the flight has now ended. The connections to NIS, TIS, GAS, and CMS are terminated, and the flight data is recorded by the USSP.

In the countryside, the customer eats a banana.

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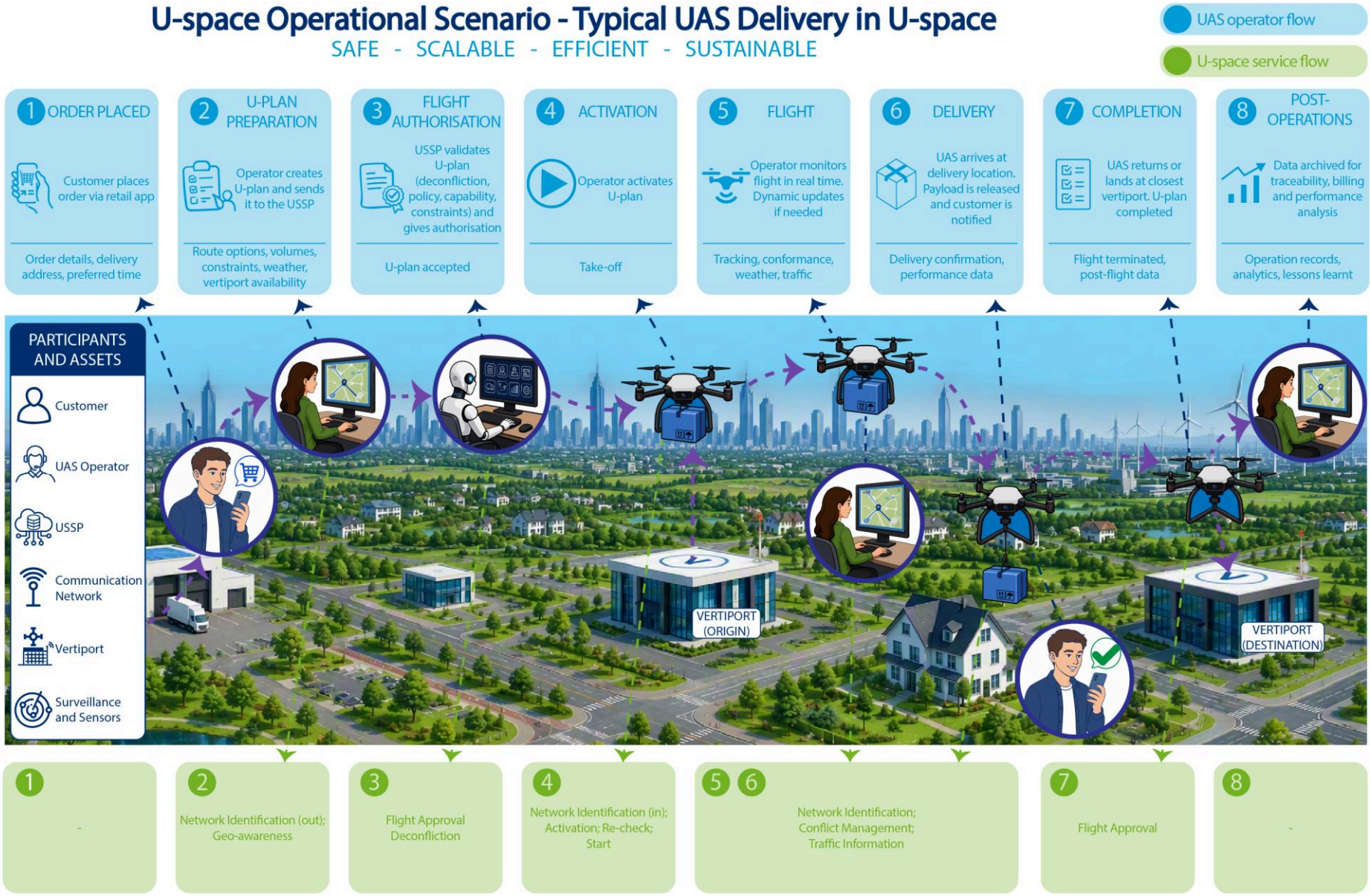


Figure 6. U-space operational scenario - delivery case

4.3 The core functions in U-space during the short-term horizon

This section details how each of the different ATM system components described in Section 3.3 are implemented in the U-space concept for the near term.

4.3.1 Airspace organisation and management

4.3.1.1 Airspace organisation

Limited geographical deployment

U-space in the short term is characterised by a **limited geographical deployment** designed to support the safe scaling of initial BVLOS operations under the current regulatory framework. This is achieved through the designation of U-space airspaces, intended to be primarily used by unmanned aircraft.

It is assumed that, in general, U-space airspaces will be designated in areas with high demand for BVLOS operations and/or in areas adjacent to the Control Traffic Region (CTR), provided they are sufficiently distant from controlled aerodromes, to relieve ATC from having to manage UAS operations. U-space airspaces will generally not be adjacent to other U-space airspaces.

Although not limited to this, U-space airspaces are generally expected to be established within the **VLL airspace environment**, **below the minimum heights applicable to VFR flights** defined in SERA.5005(f). This reduces interaction with conventional aviation and enables UAS trajectories to be managed in a domain largely unused by manned traffic. U-space airspaces are designated **at a sufficient distance** from known VFR routes, ensuring that airspace restrictions to accommodate manned aircraft via Dynamic Airspace Reconfiguration (DAR) remain infrequent and predictable.

A single class of U-space airspace

In the short term, the **U-space airspaces** are envisaged, as stated in Regulation (EU) 2021/664, to be supported by the provision of CIS and the four baseline mandatory U-space services, with the possibility of the competent authority requiring up to two additional services based on the Airspace Risk Assessment. This results in a setup where strategic deconfliction is provided, but UAS operators remain responsible for preventing collision hazards.

Internal structure

The internal structure of U-space airspaces relies heavily on **UAS Geographical Zones**. These zones introduce **localised operational constraints or conditions** – such as altitude limits, speed restrictions, local prohibitions, or mandatory equipment levels – that supplement the requirements associated with the U-space airspace itself. An individual U-space airspace may contain several of these internal zones, enabling fine-tuned management of safety, security, privacy, and environmental risks in specific areas without fragmenting the airspace into multiple separate volumes.

Structured route systems are not expected in the short term. Instead, U-space airspace is organised to support **dynamic, free-route UAS trajectories**, with strategic conflict management ensured through the UAS Flight Authorisation service. Operators submit a **U-plan**, which is assessed for compatibility with applicable constraints, surrounding geographical zones, and the plans of other users. In this horizon, the emphasis is on predictability achieved through **pre-tactical deconfliction**, rather than constraining traffic into predefined corridors.

The needs or capabilities of ATC regarding the use of dynamic airspace reconfiguration (DAR) may also influence the internal structure of the U-space airspace, for example, leading to predefined areas that can be independently activated/deactivated.

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Finally, it is expected that U-space airspaces within controlled airspace will also include internal protection buffers to ensure UAS operations remain properly segregated from operations conducted in the vicinity of the U-space airspace.

Environment with Multiple Service Providers

Even in early deployments, service provision within U-space airspaces is expected to involve **multiple service providers,** including multiple **USSPs**, one or more CISPs, and possibly even ATSPs (who may make certain common information available). These service providers must share information effectively to ensure the safe provision of services to UAS operators. This marks a key difference from the traditional ATM domain, where a single ATS service provider is designated to provide their services in a given airspace. The quality and interoperability of the provision of services are ensured through the certification and onboarding processes followed by service providers against common standards. This topic is explored in section 4.3.7, Service delivery management.

4.3.1.2 Airspace management

Airspace management approach

In the near term, airspace management focuses on enabling the safe and predictable use of U-space airspace as a **restricted, digitally supported environment** in which access is conditional upon compliance with specific operational, performance, and capability requirements. The goal is to establish a **conservative but robust baseline** from which more sophisticated, flexible and performance-driven airspace management mechanisms can evolve in the medium and long-term horizons.

Over this time frame, **airspace management relies on largely static airspace volumes**, through the definition of UAS geographical zones (incl. U-space airspaces) for safety, security, privacy, or environmental reasons. The use of dynamic UAS geographical zones is foreseen, but it is expected to be limited to exceptional situations.

U-space airspace designation

Each State has the sovereignty to designate U-space airspaces where deemed necessary, after the execution of an ARA supporting the designation process. The ARA process includes an assessment of safety, security, privacy, and environmental hazards and will determine the services to be provided and the airspace limitations, operational constraints, and capability and performance requirements (for UAS and service providers) to ensure that operations within the U-space airspace will be acceptably safe.

Before providing their services in a U-space airspace, a certified USSP or single CISP needs to pass an onboarding process to demonstrate to the relevant authority that they meet the local requirements for the provision of U-space services, as determined by the ARA. This ensures that all USSPs operating in the same U-space airspace provide their services with a consistent level of quality and reliability.

Access conditions for different airspace users

U-space airspaces in the short term remain a form of **restricted airspace**, in the sense that specific entry conditions apply:

- UAS operator within the scope of the Regulation (see [1] for further details) must:
    - submit a U-plan,
    - receive U-space services from a USSP, and
    - comply with the capability, performance and operational limitations defined for that airspace.

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- **Manned aircraft not provided with an air traffic control service** may only enter if they are **electronically conspicuous** to the U-space system, enabling USSPs to maintain situational awareness and protect active UAS operations.
- **Manned aircraft provided with an air traffic control service** remain segregated from UAS by temporarily adjusting the boundary of the U-space airspace through **Dynamic Airspace Reconfiguration (DAR)**. To avoid unnecessary workload and operational impact, predefined structures – such as corridors aligned with established VFR transits, HEMS corridors or permanent buffers around IFR arrivals and departures – may be used to limit the scope and frequency of such activations.

Dynamic airspace reconfiguration

Dynamic airspace reconfiguration (DAR) is the main tactical airspace management mechanism in the short term. DAR is expected to be used occasionally to manage short-term changes in manned traffic demand which is provided with an ATC service and intends to access the airspace where U-space airspace is designated. DAR allows the temporary modification of the boundaries of the U-space airspace to ensure manned traffic receiving ATC service and UAS remain segregated throughout the duration of the flight. DAR functions in a very similar way to ATM's flexible use of airspace (FUA) airspace management level three (tactical) but is managed by a local ATSP rather than an airspace management cell. When a DAR is triggered, an alert is communicated via the CIS to the affected USSPs. The USSP is required to update affected flight authorisations, alert pilot(s) of the DAR, and offer flight authorisation modifications to coordinate a safe landing or alternative path.

The U-plan in airspace management

The UAS Flight Authorisation service checks each plan and informs the UAS operator regarding all relevant restrictions and conditions, including temporary restrictions imposed through dynamic UAS geographical zones. Operators must declare, before obtaining flight authorisation, that they have acquired any required permissions to operate in these restricted areas—for example, by coordinating with the entity responsible for security or sensitive-site approvals. Consequently, the **U-plan** is also a relevant element of airspace management in the near term. The U-plan is not merely an expression of flight intent but the mechanism through which **access to U-space airspace is requested, evaluated and authorised**.

4.3.2 Aerodrome operations

An aerodrome is an umbrella term for any defined area of land or water intended for the arrival, departure, and movement of aircraft. Examples include airports in controlled airspace, airports in uncontrolled airspace, airstrips, lakes used for waterplanes, heliports, helipads, vertiports and more.

Aerodromes not yet integrated into U-space

In the short-term horizon, aerodrome operations remain largely **independent from the U-space environment**, reflecting both the early stage of U-space deployment and the predominance of manned aviation around controlled aerodromes.

While U-space may be created in controlled airspace adjacent to existing manned aerodromes, U-space airspaces are assumed to be **geographically apart from controlled aerodromes**, and therefore no dedicated U-space service is required to manage the integration between aerodromes and U-space.

Nevertheless, early interactions between both environments are emerging, preparing the ground for future coordination. Where UAS operations do occur close to aerodromes, they do so **outside U-space airspace**, enabled through local geozones and direct coordination mechanisms already in place in several States (e.g. local NOTAM-based procedures, airport-specific UAS restrictions, or interoperable UTM/aerodrome systems).

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Nature of UAS operations and ground facilities

Most UAS activities in the short-term horizon can be conducted **without dedicated ground infrastructure**. Small UAS can take off and land from flexible or ad-hoc locations, reducing the need for facilities comparable to aerodromes such as vertiports.

Some specialised operations – particularly logistics and delivery – may use **simple ground facilities** for charging or loading/unloading, but the limited scale of U-space airspace deployment means that **demand for such facilities remains modest** and does not yet drive dedicated aerodrome-U-space integration services. In addition, it is expected that such ground facilities will generally be used by a single UAS operator and therefore managed internally, without the need for the provision of dedicated U-space services.

UAS access conditions around aerodromes

Given the physical separation between controlled aerodromes and U-space airspaces in this horizon, UAS access rules to aerodromes remain governed by:

- **Prohibitions and restrictions** established through UAS geographical zones,
- Local operational procedures at aerodromes,
- The UAS flight authorisation service, which **ensures that UAS do not enter prohibited areas** and communicates any conditions applicable to restricted areas (e.g. the need for prior permission).

These mechanisms, combined with operator accountability and training, remain sufficient for the scale and type of operations expected in the short term.

4.3.3 Demand and capacity balancing

In the short term, we assume U-space is atomised, and isolated U-space airspaces are designated in areas with UAS traffic demand. Therefore, DCB focuses on the management of traffic within a U-space airspace, not yet considering system-wide traffic flows and capacities. It is expected to be implemented in phases as described below.

Strategic phase

At the strategic stage, the relevant authorities are expected to continuously evaluate the existing and predicted demand for UAS traffic and compare these to the available capacity of each U-space airspace, defined upon airspace designation, according to the results of the ARA.

When necessary, authorities may run a re-assessment (i.e. review the ARA) to improve the capacity of a U-space airspace, along with the necessary performance and capability requirements and airspace limitations and operational constraints.

Pre-tactical and tactical phases

The **UAS flight authorisation service** is employed to ensure that capacity/density limits are not exceeded, rejecting U-plan requests when the demand exceeds the available capacity, as determined for each U-space airspace.

It is important to note that, when temporary airspace restrictions are active, the effective capacity of a U-space airspace may be momentarily reduced.

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4.3.4 Traffic synchronisation

Traffic synchronisation based on 4D strategic deconfliction

In the near term, traffic synchronisation is materialised via the strategic deconfliction of U-plans, to ensure UAS flights are free of conflicts in space and time. To do so, the UAS flight authorisation service checks for overlaps between U-plans.

Each U-plan is represented as a 4D trajectory describing a flight's intent and including a protection volume that accounts for both time and position uncertainties inherent to the operation. This includes mission-level temporal uncertainty, considering pre-flight (e.g., take-off time uncertainty) and in-flight (e.g., inaccuracies in maintaining a desired ground speed) aspects, as well as system spatial uncertainties.

In a more formal approach, the system spatial uncertainties can be described as the Total System Error (TSE), which is a combination of the Navigation System Error (NSE), Flight Technical Error (FTE) and Path Definition Error (PDE). When these errors are considered at 2σ, they describe a 95% confidence that the aircraft will be located within the described margins, thus serving as an acceptable means to describe the flight's intent.

However, characterising the TSE for a given operation requires some effort, and it is expected that in many cases UAS operators will rely on more informal approaches, such as experience, to determine the margins within the 4D trajectory.

On top of the 4D trajectory, deviation thresholds are added before checking for conflicts. Deviation thresholds are spatial and temporal buffers considered for the purposes of strategic deconfliction and conformance monitoring and are defined for each U-space airspace as part of common information.

FCFS as prioritisation scheme

The prioritisation mechanism follows a first-come, first-served principle, whereby the earliest submitted U-plan retains priority in case of a conflict. Special UAS operations (see 4.3.5) may, however, be of a higher priority than regular operations and may therefore be accepted even when conflicting with previously submitted U-plans, meaning that the latter must then be amended or withdrawn.

The simplest method would be to consider a binary priority scheme, in which high-priority operations retain priority over all other flights submitted later. It is, however, expected that some States may implement more sophisticated schemes where different kinds of special operations may have different priority levels, as reflected in implementing regulation (EU) 2021/664 Article 10 (8-9).

FCFS is a simple approach that provides accepted UAS operations with a certainty that the flight will be conducted, unless some unplanned situation occurs. However, FCFS may also be perceived as unfair to airspace users who cannot plan their flights well in advance (see 7 for further details on fairness aspects).

Conflict resolution

A strategic conflict arises when any of the resulting 4D volumes (i.e. 4D trajectory + deviation thresholds) of a new or amended U-plan overlap with an already accepted or active flight. Considering flights of equal priority, newly proposed flights must be rejected or modified to resolve the conflict. Only a U-plan without conflicts (of equal or higher priority) can be accepted.

In the short term, there is no regulatory requirement on how to resolve a strategic conflict. The simplest approach is for the USSP to reject the U-plan request and notify the UAS operator of the reasons, but the regulation also allows USSPs to propose an alternate, involving a change to the 4D trajectory to one without

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conflicts. In this case, the UAS operator must ensure they have all necessary authorisations/permissions to conduct the new operation before accepting the proposed change, or generate a new U-plan request if not.

Regarding the formulation of alternates, this ConOps assumes that delaying the flight (i.e. postponing the entry/exit times of the 4D volumes by increasing amounts until there are no conflicts) will be the preferred option by USSPs and UAS operators since it does not change the spatial footprint of the operation and is less likely to result in an unacceptable flight by the UAS operator. Nonetheless, it is expected that UAS operators and USSPs may develop other means to resolve strategic conflicts in a manner acceptable for both stakeholders.

Live U-plans

Traffic synchronisation covers both establishing and maintaining a safe and expedient flow of traffic. UAS operators are required to conduct their flights following the conditions established in the U-plan, including keeping the aircraft within the 4D volumes described therein. These conditions are initially established upon acceptance of a U-plan.

Additional mechanisms are put in place to ensure that the U-plan is updated whenever the conditions require. For example, in case of dynamic airspace restrictions or in contingency situations. USSPs must continually check accepted and active U-plans against dynamic changes to ensure they remain free of conflict with airspace restrictions and potential new high-priority operations and must take the necessary action to amend or withdraw conflicting U-plans, coordinating with UAS operators as necessary.

4.3.5 Airspace user operations

Unmanned airspace users

Regular UAS operations within U-space airspaces must be conducted according to the EU regulatory framework for UAS and U-space. Among other requirements, this means that UAS operators must be duly registered, and that they must comply with the applicable conditions for the category of the operations they intend to conduct, such as the limitations for Open subcategories, or the conditions established in an operational declaration or authorisation for the Specific category.

In addition, to operate in a U-space airspace, UAS operators must make sure that the UAS complies with the applicable capability and performance requirements established for the U-space airspace, and that they are in receipt of U-space services provided by a certified USSP during the operation. UAS geographical zones may impose additional conditions to UAS operations performed therein, which operators must also adhere to. The UAS operator must include any mitigations for geographical zone conditions in the U-plan before submitting it to the USSP.

U-space services are for all UAS flying in U-space airspace, apart from very few exceptions. During the short term, it is expected that open category UAS operations, which are VLOS, will be regularly conducted within U-space airspaces. However, it is expected that the primary users of U-space airspace will be BVLOS operations in the specific category, given that one of the main goals of U-space airspace is to provide the necessary mitigation means to enable BVLOS operations[4]. Certified category operations are not foreseen inside U-space airspaces during the initial implementation in the short term. Further, the conflict

[4] In the context of the SORA method, adopted as AMC by EASA to authorise UAS operations in Specific category, U-space airspace is beneficial to UAS operators intending to fly in BVLOS conditions, as the SORA air risk assessment is partially covered by the airspace risk assessment and the mitigations provided by U-space.

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management scheme assumes that UA-UA collisions will have limited impacts, and further mitigations may be necessary to enable safe high-risk UAS operations.

Special UAS operations (i.e. those outside the scope of the EU UAS regulatory framework, such as customs, police, etc.) are expected to be conducted within U-space airspaces under the applicable conditions as defined by national rules. These conditions are expected to be specific to each State, and possibly also vary among different types of special operations and may range from having the same obligations as regular operations, to having certain privileges (e.g. higher priority, exemption from given requirements), to being completely outside the scope of the provision of U-space services. In summary, it is the role of each State to determine how to best handle special operations in their national airspace. Therefore, this ConOps focuses on describing the conditions applicable to regular UAS operations.

Finally, the operation of aircraft models in the framework of authorised clubs and associations may happen within U-space airspace, but those are not subject to U-space requirements. These flights are expected to be 'segregated' from regular U-space flights via a dedicated restriction (UAS geographical zone), which may require permission to enter and/or be dynamically managed (e.g. deactivated when not used by aircraft models). Some additional specific flights may also be exempted from the U-space requirements, such as the operation of C0 UAS in the A1 Open subcategory. It is expected that Member States may use the means at their disposal (e.g. UAS geographical zones) to establish conditions or limitations to these flights to ensure a safe integration with other flights subject to the U-space framework.

Manned airspace users

During the short term, the primary users of U-space airspaces will be UAS operators. However, it is expected that manned aircraft may occasionally need to access these restricted airspaces. The process to be applied depends on whether the manned aircraft is being provided or not with ATC service:

- Manned aircraft not receiving ATC service can enter U-space airspace if they are electronically conspicuous, meaning that they must broadcast relevant information for USSPs to include in the traffic information provided to UAS operators.
- Manned aircraft receiving ATC service cannot enter U-space airspace. Dynamic airspace reconfiguration by ATC is required to modify the limits of U-space airspace to ensure safe segregation.

In any case, there is no provision of U-space services to manned aircraft or direct communication between manned aircraft operators and USSPs.

The typical manned operations within U-space airspace will be operations exempted from SERA VFR minimum heights (e.g. HEMS operations, state operations of manned aviation such as police or military helicopters). In addition, on some occasions, uncontrolled aerodromes may be located within the U-space airspace boundaries. Depending on the frequency and predictability of such operations in VLL airspace, it is preferable to adjust the design of U-space airspace boundaries around frequently traversed routes to limit the need for manned aircraft to enter U-space airspace as much as possible.

Commercial manned traffic is not expected in the VLL except for take-off and landing purposes, and U-space is expected to be designated at a safe distance from controlled aerodromes. This means that commercial manned traffic will not generally be users of U-space airspace. Nonetheless, the DAR mechanism could be applied to accommodate commercial traffic demand as a response to short-term contingency situations, ensuring a safe segregation of manned and unmanned traffic.

Mission planning and flight operations

Each UAS flight conducted within a U-space airspace requires a UAS flight authorisation (U-plan). UAS operators plan their flights and submit U-plan requests to USSPs for each individual flight. The U-plan request

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contains the necessary information describing the UAS operator, the aircraft, and the intended flight. The intended flight is described as a 4D trajectory, which is comprised of one or more overlapping or contiguous 4D volumes. The content pertaining to the U-plan is outlined in Annex IV of (EU) 2021/664 10.1.

UAS operators are allowed to fly user-preferred trajectories (i.e. the 4D trajectory as defined in the U-plan request), unless in conflict with previously accepted U-plans or no-fly areas (see 4.3.4).

U-space plays no role in mission planning for manned aircraft operations, other than the need for manned aircraft operators to know when they plan to operate within U-space airspace, and take necessary actions in advance (e.g. equip e-conspicuity devices, request DAR).

During the short term, it is assumed that the definition of the 4D trajectories by UAS operators may be imprecise, overly conservative, and highly inefficient in terms of airspace usage. Operators will define volumes that are larger than operationally necessary and reserve temporal intervals longer than realistically required. The combined effect will be a rapid artificial saturation of airspace capacity, not driven by traffic density itself, but by excessive reservation margins embedded in U-plans.

Operational control

Operational control refers to the formal authority and responsibility for initiating, conducting, and terminating a flight, including the ability to respond to abnormal situations and to modify mission execution when required.

UAS operators have the authority (and responsibility) over the initiation, conduct, and termination of a flight. As described above, UAS operators must have a U-plan for each flight, which will describe the terms and conditions for the flight, in addition to any other required processes or authorisations. Then, operators must conduct the flight following such terms and conditions, including adherence to the 4D trajectory. When operators cannot comply with the U-plan, they must cancel the plan or request a U-plan amendment to their USSP.

USSPs manage U-plans (see 4.3.7) according to the UAS operator requests and may propose changes to the U-plans whenever necessary. Changes may be proposed due to dynamic changes, such as new airspace restrictions or high-priority flights. USSPs cannot terminate an active U-plan but may withdraw an accepted one.

An expected challenge for the near term is the amendment of active U-plans (i.e. during flight), where swift, effective coordination between USSPs and UAS operators is needed to react to dynamic situations.

4.3.6 Conflict management

In the short-term horizon, **conflict management focuses exclusively on hazards posed by other conspicuous air traffic**, both manned and unmanned. The objective is to maintain an acceptable level of safety by preventing collisions through a layered approach, as described in Section 3.3.

In the short term, most collision risk is expected to be mitigated through the **strategic layer**, with ‘basic’ tactical measures acting as a backup and collision avoidance being minimal and optional.

Conflict management in U-space for the near term follows the **three-layer approach** in the following manner:

Strategic conflict management

Strategic conflict management is the **primary means of conflict management in this time horizon**. It aims to prevent conflicts from happening and relies on three key mechanisms already covered in previous sections:

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- **Airspace Organisation and Management**: U-space airspace design and Dynamic Airspace Reconfiguration (DAR) procedures are implemented to minimise encounters with manned traffic. See section **4.3.1** for further details.

- **Demand and Capacity Balancing**: The UAS flight authorisation service ensures that the capacity of the U-space airspace is not exceeded, as described in section **4.3.3**.

- **Traffic Synchronisation:** The flight authorisation process ensures that there is **no overlap** between accepted U-plans, preventing conflicts at the strategic stage (see section **4.3.4**).

Strategic measures aim to reduce the need for tactical intervention to a level determined by the Airspace Risk Assessment (ARA) conducted prior to designating a U-space airspace.

It is expected that, whenever a strategic action is required during the STH, the solution will require a change of one or multiple U-plans (e.g. amendment, withdrawal), after a coordination process involving USSPs and UAS operators.

Separation provision

If strategic measures fail or unexpected situations arise, separation provision is applied tactically during flight to keep aircraft away from hazards (i.e. in the near term, other conspicuous aircraft). It is expected that the **separator is the UAS operator**, who relies on traffic information provided by USSPs to take appropriate action.

As the separator is the airspace user, the separation provision phase can also be described as the remain well clear (RWC) phase. Traditionally, RWC has been associated with the capability of an onboard pilot in visually detecting nearby traffic and acting according to such visual perception, without a defined separation minima. In the case of UAS, however, the RWC function is performed with the support of digital tools, meaning that there is a need to quantify what it means to be well clear of, or in conflict with, other nearby traffic. It is assumed in the STH that the Deviation Thresholds, established during ARA, are an expression of the acceptable clearance.

Therefore, the separation provision process steps are:

1. **Conflict detection**: in the U-space, the detection of a conflict is under the responsibility of the UAS operator, based on the information received from the **Traffic Information Service (TIS).** Therefore, U-space airspace users must be conspicuous.

   To enable the conflict detection function to be performed sufficiently in advance, a parameter described as ‘proximity’ is defined for the TIS, so that each flight receives traffic information regarding all other conspicuous traffic in proximity. Proximity describes horizontal and vertical distances and may have different values for UAS-UAS and UAS-manned pairs.

2. **Solution formulation**: As per EU IR 2021/664 [1], the UAS operators shall take the relevant action to avoid any collision hazard. Therefore, UAS operators are expected to formulate a solution within the authorised 4D volume whenever possible (i.e. 4D trajectory + deviation thresholds). This way, tactical actions should result in a trajectory change most of the time, not requiring a U-plan amendment.

   As the definition of *relevant action* is not clear and is open to interpretation, in the near term, UAS operators should decide the best solution based on the right of way defined by ICAO Annex 2 [12]. At a later stage, this term must be clarified, and it should be supported by operators’ manuals or standardised through AMC/GMs.

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3. **Solution implementation**: The UAS operator executes the trajectory change within the authorised 4D volume, if possible. A short entry into the deviation thresholds is considered acceptable. However, in case the UAS operator is unable to remain in conformance with the accepted U-plan, the U-plan must be amended by the USSP in coordination with the UAS operator. In addition, this new U-plan must be deconflicted again, taking priority over flights that have not yet been activated.

4. **Execution monitoring:** The UAS operator monitors that the manoeuvre or trajectory change effectively resolves the conflict. Additionally, the operator checks that the aircraft returns to conformance with the planned 4D trajectory after the manoeuvre. This feedback loop ensures both conflict resolution and adherence to the authorised U-plan.

Overall, there is no explicit requirement regarding the level of automation a UAS operation can employ for the different functions listed above.

Collision avoidance

In the short term, **there are no regulatory requirements for collision avoidance**. The primary layer of conflict management, strategic, is expected to mitigate most collision risks, with residual risk mitigated by the tactical layer, leaving collision avoidance as an optional safety net rather than a core function. During the Airspace Risk Assessment (ARA) process, collision avoidance capabilities should not be considered when determining UAS performance and capabilities or U-space service performance requirements.

Visual line-of-sight (VLOS) operations can rely on the traditional “see and avoid” principle and be considered a collision avoidance capability, but its effectiveness is limited to short ranges. For beyond visual line-of-sight (BVLOS) operations, methods such as first-person view (FPV) are generally considered unreliable unless integrated into a certified collision avoidance system.

As U-space evolves, most operations are expected to be BVLOS, which further limits the applicability of visual-based collision avoidance techniques. Therefore, collision avoidance in the short-term horizon remains a supplementary measure, primarily dependent on operator choice rather than regulatory obligation.

While UAS operators may choose to equip their aircraft with collision avoidance systems, these systems must operate independently of U-space services and act solely as an additional layer of protection.

4.3.7 Service delivery management

The U-plan as the centrepiece

The service delivery management component is arranged around the U-plan. The U-plan describes the UAS operator’s intent and establishes an agreement between the operator and USSP for each individual flight. The provision of U-space services begins with the U-plan submission, and the provided services evolve according to the U-plan status. USSPs only provide services to flights for which they have issued a UAS flight authorisation (U-plan).

In an automated digital air traffic management system, predictability is a key aspect. In the near-term, predictability is achieved through the UASO’s commitment to operate in accordance with the terms and conditions specified in the U-plan, including the 4D trajectory described therein. As described in Section 4.3.6, conflict management in the near term relies primarily on strategic deconfliction and thus is reliant on the operator’s capability to fly according to the U-plan.

In the near term, there are no explicit clearances granted by USSPs to UAS operators. Instead, certain mechanisms can trigger an update to the U-plan in response to dynamic situations, such as DAR. The role of the USSP in this regard is to continuously monitor dynamic conditions and restrictions so that U-plan withdrawals (applicable only before activation) or amendments can be issued as needed. The scope of

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amendments under 2021/664 is bounded by what triggers them, such as new dynamic airspace restrictions and manned traffic or emergency information, and covers changes to the trajectory, timing, and conditions of the previously accepted flight authorisation. Unlike withdrawal, amendment isn't restricted to the pre-activation phase, as the USSP can amend an authorisation at any point, including in-flight, and must inform the operator when it does.

The scope of what can trigger an amendment is tied to two specific categories of dynamic information that the USSP must continuously monitor:

1. New dynamic airspace restrictions and limitations that include newly published or updated static/dynamic airspace restrictions, changes to UAS geozones or temporary limitations affecting the previously accepted U-plan.

2. Manned aircraft traffic information shared by ATS, including general aviation operations conflicting with the planned UAS operation, or manned aircraft known or believed to be in a state of emergency.

What an amendment can therefore change is whatever the original UAS flight authorisation request contained under Annex IV, since it's that content being re-checked and re-issued:

- The 4D trajectory, i.e., the horizontal/vertical/time profile of the flight
- Mode of operation, type of flight, or applicable authorisation deviation thresholds (Article 10(2)(d))
- Any other term or condition of the flight authorisation originally granted under Article 10(1)

In addition, when the conformance monitoring service is provided, the execution of the flight is continuously monitored against the U-plan, so that early warnings can be issued to UAS operators in case of non-adherence.

The lifecycle of the U-plan

From the perspective of the UAS flight authorisation service, from the submission of a U-plan request to the completion of the flight, the U-plan status transitions between different states, as shown in below.

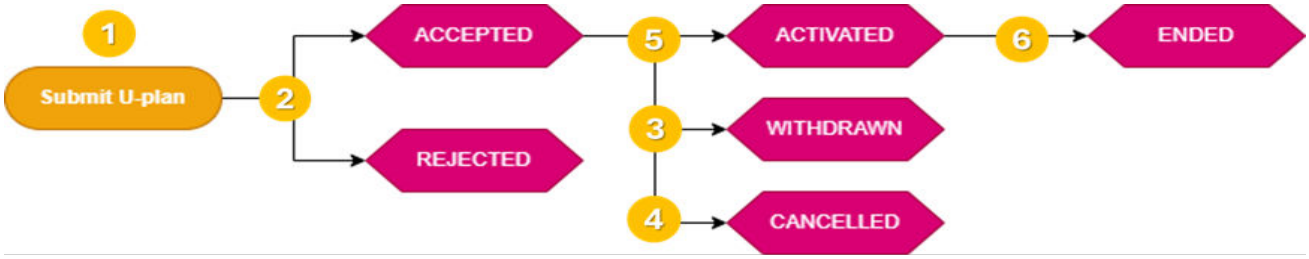


Figure 7: U-plan lifecycle

The relevant decision-making points are described as follows:

1) The Flight Authorisation Service receives a Flight Authorisation Request (submission of a U-plan) from the UAS Operator (UASO).

2) The Service performs a comprehensive assessment of the request, including syntactic and semantic validation, verification of operator registration, airspace capacity checks, verification against Dynamic Airspace Reconfiguration (DAR) or other restrictions, and conflict detection with already authorised flights of equal or higher priority.

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a) If any of these checks fail, the request is rejected, and the UASO is informed of the reasons. In case of a conflict, a modified proposal may be suggested.

b) If all checks are successfully passed, the flight authorisation is accepted, assigned a unique identifier, and the UASO is informed, together with the applicable Terms and Conditions.

3) After acceptance and before activation, the authorisation may be withdrawn if a higher-priority flight intersects with the operation or if the airspace becomes subject to DAR or new restrictions.

4) Prior to activation, the UASO may cancel the flight (e.g., if they assess they cannot conform to the accepted U-plan) and submit a new request if needed.

5) Shortly before starting the flight, the UASO requests the U-plan activation. A final verification is performed to ensure that no withdrawal conditions apply; if successful, the flight becomes active, and the USSP provides in-flight services, such as the NIS and the TIS.

6) After completion of the operation, the UASO ends the U-plan by informing the Flight Authorisation Service that the flight is no longer active.

The UASO may end the flight before the planned end should the need arise. The UASO may update the U-plan after activation if necessary. An update may be triggered by DAR.

Provision of U-space services according to the U-plan status

The regulated U-space services are used by the UAS operator at different stages of a flight's lifecycle, as shown in the following table.

U-space Service	Always available	While the U-plan is active
Network Identification Collection		✓
Network Identification Distribution	✓	
Geo-Awareness	✓	✓
Flight Authorisation	✓	✓
Traffic Information		✓
Weather Information*	✓	✓
Conformance Monitoring*		✓
* Optional U-space services are only provided if required for each instance of U-space airspace.		

Table 4: Flight stages in which U-space Services are used.

The so-called 'tactical services', i.e., Network Identification (collection), Traffic Information, and Conformance Monitoring, are only provided during the flight execution. The remaining services play a key role in preparing the flight and therefore become relevant at earlier stages of the flight.

Note that the Network Identification Service has two aspects: Collection and Distribution. Distributed NIS is unfiltered and general. In contrast, Traffic Information is in proximity to one flight.

Common Information is expected to be used by the UASO during the initial stages of flight planning, before submitting the U-plan to their USSP. For example, to determine whether the airspace is effectively U-space, or to check whether their UAS meets the applicable capability and performance requirements. Later in the process, it is expected that the UASO will directly consume the services through their USSP. The USSP continuously accesses common information as an input for the provision of U-space services such as Geo-

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Awareness and Traffic Information, meaning the relevant common information is routed to the UAS operator via their USSP.

Although not currently considered in the U-space regulatory framework, a potential enhancement identified by the ConOps is to extend the scope of U-space service provision so that geo-awareness, flight authorisation, and weather information services can be provided at a stage before the submission of the U-plan: during the U-plan preparation. This would give UASOs access to relevant information they can use when planning the flight, such as the 4D trajectories of other U-plans that could cause conflicts. This would greatly reduce the frequency of rejected U-plans and the workload for operators and USSPs, thereby improving the efficiency of the flight authorisation process.

Information sharing in U-space

U-space relies on the provision of U-space services by potentially multiple USSPs that provide services in a shared U-space airspace. USSPs are at the same time competitors and collaborators. Each USSP manages only the flights for which it has issued an authorisation, but it relies on information from other USSPs and CIS to do so.

IR (EU) 2021/664 Article 10 (6) states “U-space service providers shall establish proper arrangements to resolve conflicting UAS flight authorisation requests received from UAS operators by different U-space service providers.”

The decision by a USSP to accept (authorise) or activate a flight authorisation request (U-plan) depends on the U-plan being free of intersection with other accepted or active flight authorisations of the same or higher priority. These flight authorisations may be known to the USSP itself or any other USSPs. The USSPs must collaborate to discover conflicts. Thus, sharing the U-plans enables collaborative decision-making by USSPs in the joint management of flight authorisations for each U-space airspace.

By the Network identification service, the USSP collects current position and motion information for each active U-plan for which the USSP has issued the authorisation. This information is shared with other USSPs so that every USSP can supply Traffic Information to every active U-plan for which that USSP has issued the authorisation. Traffic Information also includes any relevant Common Information. Therefore, UAS operators may only have a complete traffic picture when all USSPs effectively communicate among themselves and collect the relevant common information before aggregating traffic information for each flight.

Finally, the Conformance Monitoring Service, as described in the U-space Regulatory Framework, works in a similar manner. In case of non-conformance, USSPs must alert the non-conforming operator, as well as other nearby operators. To achieve this, the USSP will first warn the other USSPs, who in turn will alert the operators they manage, in case they are in the proximity of a non-conforming flight.

4.3.8 Information services

Because airspace management is distributed among multiple SPs and stakeholders, sharing all relevant operational data among all actors is key to enabling safe operations. Information services support decision-making but do not make decisions.

4.3.8.1 Common information services

Coordinated use of CIS is essential to maintain a shared, consistent, and up-to-date operational picture while avoiding information asymmetry across the airspace. CIS provide the digital backbone for UA operating in U-spaces, collating and distributing static, dynamic, and operational data originating from Member States, ATSPs, and certified USSPs. Crucially, the substantive contents of common information are independent of the CISP. To accommodate diverse national environments and administrative frameworks, Member States

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may implement the exchange of common information through either a centralised model or a distributed and decentralised model.

The Centralised Architecture (Single CIS Provider Model).

In a centralised architecture, a Member State appoints a single organisation as the sole CIS provider within a given U-space airspace. In this case, the designated single CISP must hold a dedicated certificate under Annex VII of Regulation (EU) 2021/664. Acting as the exclusive operational conduit, the single CISP must collect, validate, and distribute authoritative static and dynamic common information to all operational stakeholders. It is legally bound to preserve data integrity, accuracy, traceability, and timeliness without altering the underlying information or assuming tactical operational control, while adhering to strict delivery thresholds such as publishing dynamic restrictions within 5 seconds. In this case, CAA feeds its sovereign datasets directly upstream to the certified single CISP, which serves as the airspace's exclusive digital gateway. The CAA coordinates operational airspace classifications with the ANSP, requiring it to stream its dynamic airspace restrictions, DAR messages, and manned traffic surveillance feeds directly into the CIS. Certified USSPs do not establish individual data links with the CAA or the ANSP for common information; instead, they consume this consolidated, authoritative stream from the single CIS via a single standardised API.

The Distributed or Decentralised Architecture (Multi-Provider Model).

When a Member State does not appoint a single entity, it adopts a distributed or decentralised model without a central intermediary. Instead, the Member State determines which stakeholders provide the various pieces of common information. These entities provide common information without needing separate CIS certification, operating instead under their existing institutional oversight. Each individual provider, including the Member State, ATSPs, and USSPs, must directly expose and exchange its allocated data elements via open, interoperable interfaces, with data integrity, strict latency thresholds, and cybersecurity. When multiple providers are involved, the Member State must ensure all published information is consistent and non-contradictory, creating a single source of truth for any part of common information. Without a central intermediary, the CAA acts directly as an authoritative provider of common information, exposing its state datasets to operational stakeholders through its own open digital access point or API. At the same time, the ANSP operates independent digital endpoints to distribute dynamic airspace restrictions, DAR activations, and manned traffic data directly to active USSPs. To avoid discovery bottlenecks and fragmented integration, the CAA must publish an official allocation directory that clearly identifies each data originator's digital network addresses and technical protocols, requiring each certified USSP to establish and maintain direct, concurrent point-to-point connections with both the CAA and the ANSP.

Both models serve the same safety objective: ensuring every operational actor navigates with verified, identical airspace awareness, while balancing technical integration against institutional simplicity and guaranteeing non-discriminatory access. The centralised model streamlines connectivity by giving service providers a single certified interface but introduces a commercial monopoly and a single technical point of failure. Conversely, the distributed model eliminates single-entity bottlenecks and aligns with federated data standards but places the responsibility on Member States to maintain strict governance so that multiple data sources remain completely harmonised. Ultimately, regardless of the architecture chosen, the regulatory framework ensures that common information functions strictly as a transparent, authoritative single point of truth, entirely separated from commercial flight authorisation decisions.

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Across both models, the CAA remains the sole authoritative originator of sovereign airspace baseline data, and the substantive content of this information is identical regardless of the distribution model. Whenever a model is deployed, the CAA provide the following information:

- **Horizontal and Vertical Limits:** The CAA defines the geographic boundaries and vertical limits of the U-space volume and coordinates with ANSP to establish the boundary interface with surrounding controlled or uncontrolled airspace.
- **UAS Geographical Zones:** The CAA validates, digitises, and publishes all permanent and temporary geographical zones in JavaScript Object Notation (JSON) compliant with EUROCAE standard ED-269.
- **Safety Requirements from the ARA:** The operational rules resulting from the ARA, such as mandatory service capabilities, weather limitations, aircraft connectivity thresholds, and electronic conspicuity mandates, must be made available to USSPs to be programmatically encoded into their automated flight authorisation systems.
- **Static and Dynamic Restrictions:** Static airspace restrictions originating from the CAA must be distributed within 30 seconds for at least 99% of the time, while tactical dynamic restrictions originating from the ANSP must reach USSPs within 5 seconds for at least 99% of the time.
- **List of USSPs and Oversight:** The CAA maintains the definitive list of certified USSPs permitted to operate in the U-space volume and conducts continuous regulatory oversight to verify data provenance, non-discriminatory access, and cybersecurity resilience across all exposed interfaces.

In the case that U-space Airspace is created inside Controlled Airspace, Common Information includes information about aircraft in proximity to the U-space airspace that are known to Air Traffic Control.

Under the U-space regulatory framework, two CISPs cannot operate concurrently within the same designated U-space airspace. Consequently, the framework prohibits overlapping mandates, such as a national provider publishing static data while a local provider distributes dynamic restrictions within the same geographical boundaries, because operational stakeholders require a single, legally accountable point of truth. Nevertheless, two specific cases are possible.

Airspace-by-Airspace Differentiation and Hybrid Deployments. A Member State may establish differentiated single CISPs across distinct, non-overlapping U-space airspaces. Article 5(6) permits designating a single CIS provider for all or only some of the airspaces under a Member State's responsibility. This allows a national ATSP to serve as the certified single CIS provider across standard regional sectors, whilst a dedicated local authority or private operator is certified as the exclusive single CIS provider for a specific complex volume, such as an industrial seaport or vertiport hub. Furthermore, States can implement a hybrid framework, deploying certified single CIS providers in controlled or complex sectors whilst leaving remaining airspaces under the distributed or decentralised model without any single intermediary.

Local Integration via Upstream Data Provision. Where a national single CISP is designated to cover all U-space airspaces across an entire territory, a local entity cannot act as a parallel certified CIS provider, but it can operate as an authoritative data originator. In this arrangement, the local entity (such as a municipality, port authority, or vertiport operator) defines and manages local UAS geographical zones and temporary ground restrictions, feeding them upstream directly into the national single CIS provider. The national

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provider then consolidates, validates, and distributes these feeds to active USSPs, preserving institutional exclusivity whilst accommodating localised operational needs.

CIS includes information on:

- Airspace Organisation (horizontal and vertical limits of U-space airspace, adjacent U-space airspace(s), static and dynamic airspace restrictions, and UAS geographical zones)
- Operational requirements (UAS capabilities and performance requirements, U-space services performance, applicable operational conditions and airspace constraints)
- Registry of Active USSPs (Including Legal identification and operational contact information, details on the bundle of U-space services provided, specific certification conditions or operational limitations of those services, as well as access rules, technical interface requirements, and commercial terms and conditions established by each active USSP for UASOs.
- Static and dynamic airspace restrictions and tactical modifications (permanent and temporary restrictions, aeronautical information and warnings, and DAR data whenever appropriate)
- ATS and manned aviation operational data (mandatory in CTR and supplementary in non-controlled airspace).

In accordance with Article 5(2) of IR (EU) 2021/664, Air Traffic Service Providers (ATSPs) are responsible for making available, as part of the common information services, the relevant operational data referred to in point ATS.OR.127 of IR (EU) 2021/665, as well as the data resulting from the dynamic airspace reconfiguration referred to in point ATS.TR.237 thereof.

GM1 Article 5(b)(2) [4] further clarifies that ATSPs are a main source of common information and are responsible for transmitting manned traffic information and information related to the application of dynamic airspace reconfiguration, which is then provided through common information services to the relevant operational stakeholders within the U-space airspace.

4.3.8.2 USSPs information exchange mechanism

4.3.8.2.1 Operational Data Shared Among Peer U-space Service Providers (Inter-USSP Exchange)

This operational data flow enables multiple competing service providers to maintain a synchronised, unified picture of the shared airspace without creating safety blind spots. Because different USSPs use U-space platforms of different commercial providers, these platforms must continuously stream real-time operational states to execute strategic deconfliction, tactical tracking, and immediate contingency handling. The specific pieces of information and data exchanged comprise:

- **Network Remote Identification Telemetry:** Dynamic broadcast tracks containing the operator registration number, the unique serial number of the UA (or broadcast add-on module), live geographical position (latitude and longitude), altitude referenced to mean sea level, operational height above the ground or take-off point, ground speed, track bearing measured clockwise from true north, real-time coordinates of the remote pilot or launch point, emergency status indicators, and time of message generation.

- **Flight Authorisation Statuses:** Strategic planning records detailing unique flight authorisation identification numbers, submitted flight intents, planned 4D volumes with associated lateral and vertical deviation thresholds, and instantaneous state transitions (accepted, activated, updated, withdrawn, or ended) to verify that prospective trajectories remain free of spatial and temporal intersections.

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- **Tactical Traffic Data:** Aggregated traffic tracks, including the detected positions of electronically conspicuous manned aircraft acquired through privately deployed ground receiver grids.
- **Non-Conformance Alerts:** Automated deviation notifications broadcast when an aircraft strays outside its cleared 4D operational volume or exceeds defined deviation thresholds for more than an agreed percentage of time, including timestamp, location, and the nature of the excursion.
- **Contingencies and Emergencies:** Time-critical status alerts indicating a pilot-declared emergency, a loss of the Command and Control (C2) link, critical battery depletion, propulsion failure, unexpected obstacles, or the selection of emergency diversion sites.
- **Service Degradation Notifications:** Immediate system notices reporting planned or unplanned downtime, network outages, communication link failures, or compromised quality of service within a provider's infrastructure.
- **Complementary Interoperability Data:** Supplementary local airspace constraints, priority handling declarations, or coordination tags agreed among the active service providers.

4.3.8.2.2 Services and Technical Interfaces Shared Among USSPs

This category constitutes the shared digital infrastructure, open architectures, data models, and interface contracts that allow disparate software systems to interoperate seamlessly. Rather than representing the dynamic operational data itself, it provides the standardised channels, semantic definitions, and validation frameworks through which information is transferred. The specific technical elements, data structures, and services shared include:

- **Service Profiles and Descriptions:** Publicly documented service descriptions formulated according to System-Wide Information Management (SWIM) standards, defining available Application Programming Interfaces (APIs), operation methods, input and output payload structures, association rules, and dynamic life-cycle behaviours.
- **Transport Protocols and Infrastructure:** Technical baseline profiles mandating communication over open Internet Protocol (IP) networks using the Transmission Control Protocol (TCP), conforming to technical infrastructure yellow profile specifications.
- **Agnostic Data Models and Payloads:** Technology-agnostic structural models defined using Unified Modelling Language (UML) and encoded in open serialisation formats, specifically JavaScript Object Notation (JSON) or All Purpose Structured Eurocontrol Surveillance Information Exchange (ASTERIX), ensuring identical data interpretation across systems.
- **Standardised Machine-to-Machine Interfaces:** APIs structured in accordance with global consensus specifications, including technical endpoints for network remote identification streaming and automated multi-provider strategic conflict resolution.
- **Testing and Validation Sandboxes:** Common testing environments and digital test beds equipped with predefined test datasets, enabling providers and oversight bodies to verify interface compliance, message parsing, and end-to-end latency before live operational deployment.

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- **Performance and Security Specifications:** Machine-readable indicators defining service availability metrics, latency budgets, data protection rules, encryption handshakes, and identity management credentials.

4.3.8.3 Information Shared with Air Traffic Service Providers and Air Traffic Control

This information exchange bridges U-space systems with conventional ATM, establishing the coordination necessary to guarantee separation between unmanned and manned aircraft operations. The flow supports situational awareness in controlled environments and facilitates urgent tactical adjustments. The specific pieces of information and data shared include:

- **DAR Acknowledgements:** Formal electronic execution notifications returned to the air traffic control unit confirming that a requested portion of airspace has been completely cleared of UAS operations following a deactivation instruction.
- **Special Operations Advisories:** Immediate operational notifications alerting air traffic controllers to the presence and active trajectories of UA performing state or high-priority public-interest missions, such as police, emergency medical delivery, search and rescue, or firefighting operations.
- **Controlled Airspace Incursion and Threat Alerts:** High-priority safety warnings transmitted directly to air traffic control when UA experiences an uncontained non-conformance event, breaches the outer boundary of the U-space volume, infringes active protection buffers, or approaches protected arrival and departure flight paths.
- **Communications Link Status:** Instantaneous diagnostic alerts sent to air traffic units if the digital communication link connecting the U-space platform to ATM degrades or fails.
- **Joint Emergency Response Procedures:** Bilateral coordination protocols, direct operational telephone lines, points of contact, and documented emergency response plans establishing shared responsibilities during unexpected air incidents or severe airspace disruption.

4.3.8.4 Information Shared with Common Information Services

Commercial service providers supply this data stream to the central or federated common information function, ensuring the overarching administrative layer maintains full transparency on market participants and data integrity. The specific pieces of information and data supplied comprise:

- **Commercial Terms and Conditions:** The transparent commercial terms, access rules, technical user prerequisites, subscription costs, and digital connectivity requirements that the service provider establishes for operators seeking access to its platform.
- **Data Quality Feedback and Anomaly Reports:** Systematic reports highlighting discrepancies, corrupt data, format non-compliance, missing entries, or excessive latencies identified within the authoritative airspace, obstacle, geographical zone, or meteorological feeds distributed by the common information system.
- **Provider Profile and Service Scope:** The legal entity name, corporate address, principal place of business, authorised managerial points of contact, certified bundle of service offerings, and any operational constraints or geographic limitations associated with the service provider's operational status.

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4.3.8.5 Information Shared with Competent Authorities and Authorised Public Entities

This information channel provides civil aviation oversight authorities, law enforcement, and emergency response bodies with the transparency and evidence needed to monitor safety compliance, maintain public security, and investigate incidents. The data encompasses real-time situational feeds alongside extensive historical registries. The specific pieces of information and data made accessible include:

- **Aggregated Live Remote Identification Feeds:** Continuous, real-time UA telemetry, including operator registration numbers, serial numbers, live positions, geometric altitudes, ground speeds, remote pilot positions, and emergency statuses, made available to aviation inspectors and security agencies, with filtered subsets exposed to the general public.
- **Operational Audit Records and Flight History:** Traceable logs maintained for at least thirty days (and up to five years for significant events), recording all submitted flight authorisation requests, timestamps of receipt, approval notices, reasons for rejections, and assigned unique authorisation numbers.
- **Flown Trajectories and Conformance Data:** Chronological records of the actual 4D trajectories flown by UA, deviation metrics, conformance alerts, and recorded instances of over-conformance where excessively conservative deviation thresholds wasted available airspace capacity.
- **Safety Incidents and Proximity Encounters:** Comprehensive occurrence files documenting air-proximity situations between UA, conflicts with manned aircraft, detected rogue or non-cooperative aircraft, system outages, and formal emergency declarations.
- **Operational Status and Readiness Notifications:** Formal administrative notices submitted at least three months in advance regarding the scheduled commencement, temporary suspension, or cessation of service provision in any designated airspace, accompanied by verified evidence of management capacity and financial continuity.

4.3.8.6 Inter-USSP data exchange

At the moment of writing this ConOps, two main technical approaches have been developed to support inter-USSP data exchange:

- **Distributed inter-USSP exchange**, based on the ASTM F3548-21 standard:
  This standard defines a so-called federated, peer-to-peer inter-USSP data exchange model supported by the Discovery and Synchronisation Service (DSS). The DSS enables USSPs to discover other relevant participants and the information they manage within a given scope. Once discovered, USSPs exchange operational information directly through standardised APIs, using pull-based requests and subscription-based notifications. Each USSP remains responsible for the data it creates and exposes, while interoperability is ensured through commonly agreed interfaces and discovery mechanisms.

- **Indirect inter-USSP exchange**, described in EUROCAE ED-339 standard:
  In this model, inter-USSP data sharing is performed through a common Information Exchange Service (IXS) that acts as an intermediary for information exchanged among USSPs. Each USSP publishes the information it produces to the IXS using standardised provision interfaces. The IXS aggregates this information and redistributes it to other USSPs and authorised users through subscription-based distribution interfaces, defined according to spatial and temporal criteria. This indirect approach reduces the need for direct peer-to-peer interfaces between USSPs, simplifies interoperability, and

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provides a single exchange point for shared information while maintaining a consistent, up-to-date view of information relevant to U-space service provision.

While both data exchange models provide structured mechanisms for inter-USSP communication, each has inherent limitations under the current EU regulatory framework.

- The ASTM F3548 framework is tailored to the United States airspace and UTM concept. The core function of the DSS, i.e., the 'discovery', becomes redundant under the EU framework, in which U-space airspaces are clearly defined, and a complete list of service providers is known beforehand and provided as common information. Furthermore, the current model has limitations in synchronising a large number of DSS instances and sharing information between different DSS regions, which may lead to interoperability issues in EU airspace, where cross-border operations are expected.
- ED-339 on indirect exchange models simplifies connectivity but creates a dependency on a shared intermediary service whose availability, performance, and regulatory alignment become critical. The need for an additional intermediary creates further risks and delays that could affect the safety of service provision.

Furthermore, recognising two different approaches as acceptable will necessarily affect interoperability at the EU level, as different states may choose one approach or the other. This will require USSPs to choose between limiting their scope or interfacing with both approaches, adding cost and complexity to the certification process.

As a result, neither approach should be considered a definitive solution for U-space in the STH. Thus, the identification of a new, single approach fully aligned with the EU U-space framework is encouraged. To ensure full alignment with the current regulatory framework and interoperability of USSPs across the EU, a single inter-USSP information exchange mechanism should be established that allows direct USSP-to-USSP communication without intermediaries, whether a DSS instance or an information exchange service.

4.3.8.7 Connection between the UASO and the USSP

The connection between the UASO and the USSP is a digital, connected environment that operates primarily over public IP-based wireless communications. Under the regulatory framework, this connection is characterised by specific operational duties, interface architectures, and performance guarantees:

- **Interface Modalities:** The USSP provides the UASO with interfaces delivered either as human-machine interfaces, such as mobile, web, or personal computer applications, or as direct machine-to-machine APIs integrated directly into the Ground Control Station (GCS) or autopilot software. When an operator develops a proprietary API connection, it remains accountable for ensuring that its custom software layer does not degrade system performance or introduce communication latency.

- **Operational Information Exchanged:** Across this digital link, the UASO submits its 4D flight authorisation requests, contingency landing locations, and aircraft performance parameters. In return, the USSP transmits real-time flight authorisation approvals, unique authorisation numbers, and operational deviation thresholds. During flight, the link supports immediate pre-flight activation requests, real-time traffic information alerts, geo-awareness updates, conformance alerts, and contingency or emergency declarations.

- **Continuous Monitoring and Link Integrity:** UASOs are required to maintain digital connectivity throughout the duration of the flight. Because situational awareness relies on this connection, a loss

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of link between the operator and the USSP is considered a safety issue in itself, as it severs the remote pilot from vital airspace alerts and tactical traffic feeds.

- **Performance and Service Level Agreements:** UAS operators must demonstrate that the required service performance level can be achieved throughout the flight, typically underpinned by a Service Level Agreement (SLA) or formal contractual arrangement with their chosen certified USSP. Operators are advised to retain a single USSP service bundle throughout an activated flight to maintain consistent operational data.

4.3.8.8 Connection between the CIS and the UASO

The CIS are not typically connected directly to the aircraft in flight. Instead, the USSP functions as the operational intermediary that ingests, harmonises, and filters CIS data before delivering it to the UASO. The connection between the operator and the provider utilises the CIS in several distinct operational capacities:

- **Supplying Authoritative Airspace Data for Flight Planning and Geo-Awareness:** The USSP continuously ingests static and dynamic airspace data from the CIS, including the horizontal and vertical limits of the U-space airspace, adjacent airspaces, and UAS geographical zones published under EUROCAE standard ED-269. When the UASO plans a flight over the USSP connection, the USSP checks the requested trajectory against this CIS data. The USSP then feeds these geographical limits and active restrictions directly to the operator through the geo-awareness service.

- **Executing DAR:** When an ATC unit needs to segregate manned aircraft from unmanned traffic in controlled airspace, it publishes a temporary dynamic restriction into the CIS. The single CIS provider or distributed CIS node must distribute this dynamic restriction within 5 seconds for at least 99% of the time. The USSP ingests this modification from the CIS, immediately alerts the connected UASO via the geo-awareness and flight authorisation services, and instructs the operator to alter the flight path or land safely. Once the UA vacates the volume, the USSP acknowledges the deactivation back to ATC.

- **Relaying Manned Air Traffic Data in Controlled Airspace:** Under point ATS.OR.127 of Commission Implementing Regulation (EU) 2017/373 (amended by Regulation (EU) 2021/665), ATSPs must feed surveillance and operational flight data regarding manned aircraft into the CIS. The USSP pulls this manned traffic feed from the CIS, processes it alongside unmanned traffic data, and streams the compiled, real-time traffic information service directly to the UASO to prevent mid-air collisions.

- **Enforcing Weather and Operational Constraints:** Member States publish environmental limitations (such as maximum wind gusts or visibility minima) and aircraft capability requirements into the CIS. The USSP uses these CIS parameters to validate the operator's flight authorisation request and to issue alerts across the USSP–UASO connection if localised weather thresholds are breached.

Direct UASO Discovery and Onboarding via CIS: While the USSP routes tactical flight management, UASOs also use the CIS directly during the pre-operational phase. Under Article 5(5) of Regulation (EU) 2021/664, UASOs have non-discriminatory access to the CIS. UASOs can access published CIS user instructions and public registries to identify certified USSPs active in a particular U-space airspace, review their certified service capabilities, and examine their commercial terms and conditions before establishing an operational data link.

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4.3.8.9 Security considerations regarding the CIS

Security considerations for the CIS, and specifically the single CIS within a centralised architecture, focus on safeguarding data integrity, ensuring high availability, and shielding open digital interfaces from cyber threats. Because the CIS serves as the authoritative single source of truth for airspace structure, dynamic restrictions, and manned traffic, any security breach, data corruption, or denial of service directly induces an unsafe condition across the entire airspace.

Information Security Management System (ISMS) and Regulatory Certification

- **Aviation-Grade Security Architecture:** Under Article 15(1)(f) of Regulation (EU) 2021/664, a certified single CIS provider must implement and maintain an information security management system aligned with ATM/ANS requirements (specifically point ATM/ANS.OR.D.010 of Regulation (EU) 2017/373 and the management of information security risks under Part-IS).
- **Security Risk Assessment (SRA):** Guidance Material (GM) GM5 to Article 15(1)(b) requires providers to execute structured security risk assessments to evaluate the confidentiality, availability, and integrity of all functional systems. This methodology is derived from EUROCAE standards ED-201A and ED-202A / RTCA standard DO-326A. They identify threat conditions, potential attack vectors, and operational severities across connected digital architectures.

Mitigation of Intentional Unauthorised Electronic Interactions (IUEI)

- **Threat Surface Protection:** Annex III, Point B of Regulation (EU) 2021/664 requires CIS providers to protect open, interoperable communication protocols against Intentional IUEI that could lead to an unacceptable communications breakdown or system corruption.
- **Robustness and Penetration Verification:** Under AMC2 to Article 15(1)(b), the applicant must prove that the functional system contains no exploitable vulnerabilities. The applicant must substantiate the effectiveness of security safeguards through security-oriented robustness testing, refutation and penetration testing, and continuous auditing agreed with the competent authority.
- **Protection Against Denial of Service (DoS):** Because the CIS must distribute dynamic airspace changes within 5 seconds for at least 99% of the time, the infrastructure must deploy specialised defences against distributed Denial of Service (DoS) attacks to prevent service starvation during tactical airspace reconfigurations.

Preservation of Data Integrity, Authenticity, and Traceability

- **Non-Alteration and Authenticity:** Under AMC3 to Article 5(7), the CISP must ensure it does not alter the substance of information received from originators, preserving completeness, accuracy, resolution, timeliness, and logical consistency. Data transfers must be governed by authentication mechanisms that verify data provenance from authorised originators.
- **Cryptographic Transport Controls:** Point 3 of Annex V and the EUROCONTROL *Specification for SWIM Technical Infrastructure (TI) Yellow Profile* mandate recognised encryption standards, specifically Transport Layer Security (TLS), over open TCP/IP networks to prevent eavesdropping and man-in-the-middle data alterations.
- **Tamper-Evident Record Keeping:** Under Article 15(1)(g) and AMC15 to Article 15(1)(e), operational transaction logs must be retained for at least 30 days (and up to 5 years for safety-critical

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investigations) with backup systems updated within 24 hours, incorporating technical safeguards that prevent unauthorised manipulation or deletion.

National Security, Defence, and State Services Interoperability

- **Sovereign Defence Compliance:** GM1(f) to Article 5 emphasises that to achieve seamless data exchange with state services, such as military commands, police, and border control, the CIS must comply with national security and defence requirements.
- **Protection of Sensitive Airspace Data:** In accordance with GM1 to Article 1(1) and GM5 to Article 3(1), the CIS often distributes restrictions over sensitive physical sites, critical infrastructure, VIP protection details, and military flight zones. The CIS data architecture must ensure that tactical deactivations are distributed to certified USSPs without leaking classified operational details regarding state missions.

Data Privacy, Confidentiality, and Commercial Protection

- **Data Protection and Privacy by Design:** While basic airspace data is public, the CIS environment may handle operator registration identities and commercial service attributes. GM8 to Article 3(1) and GM1 to Article 5(6) require strict adherence to the General Data Protection Regulation (GDPR), including completing a Data Protection Impact Assessment (DPIA) under Article 35 of the GDPR when handling data concerning natural persons.
- **Commercial Confidentiality:** Under Article 5(5) and Annex III, Point B, the CIS must grant non-discriminatory access while simultaneously shielding the proprietary business terms, sensitive telemetry, and intellectual property of commercial operators from unauthorised disclosure.

Infrastructure Resilience, Supply Chain, and Insider Threat Control

- **Hosting and Supply Chain Governance:** CIS providers must ensure that third-party cloud hosting facilities and commercial data centres comply with European data storage mandates and verified cybersecurity baselines.
- **Continuous Threat Intelligence and Insider Controls:** In accordance with Annex III, Point B, the CIS provider must implement internal security awareness training, deploy solutions that augment automated threat intelligence, and monitor user and network behaviours to detect internal anomalies and prevent insider sabotage.

4.4 The limitations of the short-term horizon

It is assumed that U-space in the Short-Term will be limited in terms of capacity, and thus not capable of fully achieving the stated goal in the definition of U-space services: “large number of UAS”. This limitation comes from caution, a lack of experience, and a deliberate choice to establish U-space with a minimum viable implementation. In the Short-Term, U-space will be operated with fully deconflicted 4D trajectories for each UAS flight authorisation, including the deviation thresholds. These deviation thresholds currently make a generous allowance for the uncertainty in the observed position, horizontally, vertically, and longitudinally. As experience grows, some of this uncertainty and allowance can be reduced, but the fundamental Short-Term limitations remain. Transition to the Medium-Term will be marked by the changes that increase capacity. There are four main groups of drivers for this change:

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1. Traffic scalability:

- Increase in traffic density and operational complexity, exceeding what can be managed with strategic deconfliction through flight authorisation.
- Need for scalable mechanisms to manage multiple simultaneous operations and actors (including several USSPs).
- Increasing need for automation in conflict prediction and resolution as traffic density grows.
- Operational need to support trajectory-based operations and conditional-access volumes to optimise airspace usage.

2. Traffic heterogeneity:

- Emergence of mixed-performance traffic (simple drones, high-performance drones, VCA, and manned aviation) sharing portions of airspace.
- Need for a performance-based airspace organisation where access to certain volumes requires minimum operational capabilities.
- Requirement for greater automation to verify the suitability of the aircraft and operator performance for the intended airspace.
- Need to manage interactions between UAS and manned aviation in airspace layers above basic U-space volumes.

3. Integration with ATM, aerodromes and vertiports:

- Increasing demand for operations closer to aerodromes and within complex controlled environments.
- Integration of vertiports and advanced air mobility infrastructure requires coordination between vertiport operators, USSPs, and ATM actors.
- Need for clear definition of operational responsibilities regarding air traffic transitioning between controlled airspace (ATC-domain), U-space (USSP domain) and aerodrome/vertiport traffic zones (infrastructure operator domain).
- Need for flow management and slot allocation mechanisms around vertiports to support safe arrival and departure of VTOL aircraft.
- Emergence of Vertiport Traffic Zones and network-level coordination between multiple vertiports.

4. Automation and flexible airspace management:

- Limitations of static geozones to manage evolving operational constraints and traffic demand.
- Need for smarter, more dynamic, data-driven airspace reconfiguration as a tool for systematic airspace management.
- Need for systematic conformance monitoring and enforcement mechanisms in denser traffic environments.
- Requirement for real-time digital information sharing between operational stakeholders and aircraft systems.

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5 Medium-term horizon

The medium-term horizon (MTH) describes what the next iteration of the U-space concept could be in the future. Considering the U-space 2.0 roadmap described in the European ATM Master Plan 2025[5], the MTH includes the roadmap objectives up to 2035. The MTH includes the provision of advanced (U3) services.

5.1 Goals of the medium-term evolution of U-space

The goal of U-space in the MTH is to build on the confidence and experience gained through the STH and adapt the initial concept to cater to emerging needs arising from increased ecosystem maturity levels. Such emerging needs include:

- **High-capacity U-space airspaces.** The U-space concept definition relies on enabling airspace access to **large** numbers of UAS operations, which is a limitation of the STH. The MTH will allow the ecosystem to scale up, enabling profitable models that can provide new services to a large portion of the EU population.
- **Enable new modalities of air mobility**. The MTH seeks to integrate the new e-VTOL/VCA models into the U-space airspace, which are not included in the STH primarily due to safety considerations. The MTH includes provisions about how to safely manage operations with different performance levels.
- **Streamlined interaction with the ATM.** The MTH serves as an intermediate step towards full interaction. The U-space framework becomes better connected with the ATM framework, while the joint management of manned and unmanned traffic evolves towards 'smart segregation'. Under this scheme, new mechanisms are put in place to facilitate and improve communication and coordination between U-space and ATM stakeholders. U-space services start to be used by manned traffic in some circumstances.
- **Expanded geographic limits of U-space airspaces**. In the STH, the U-space airspace is limited to the VLL in areas where manned traffic demand is low. The MTH expands the coverage of U-space airspace beyond the VLL and in areas where manned traffic demand is more frequent. The MTH also aims to make U-space airspaces ubiquitous in the VLL by facilitating the designation of U-space airspaces with proportional requirements in areas where UAS traffic demand may be low but relevant enough to justify the need to enable BVLOS flights.

The goal of the ConOps in the MTH is to provide a clear description of how the U-space concept should evolve to tackle the emerging needs. This description starts at a low maturity level and aims to inspire future waves of research projects, which will further mature the concept, therefore laying the ground for an R&D roadmap. The ultimate goal of the MTH description in the ConOps and the related developments is to eventually feed a new U-space model that will lead to a new EU U-space regulatory framework formally implementing this updated model.

The start of the MTH is therefore not a precise date but rather a milestone: the MTH begins with the entry into force of a hypothetical new European regulation that amends or supersedes Commission Implementing Regulation (EU) 2021/664 and expands the U-space concept with new services and functionalities, as described in this chapter. The MTH spans from this moment until the LTH begins.

[5] https://www.sesarju.eu/node/4821

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5.2 Assumptions

In the medium-term, the ConOps makes the following assumptions:

- **Greater level of maturity.** In the MTH, U1 and U2 services will be completely implemented and well tested, and the industry will have achieved a minimum level of maturity, meaning that competent authorities are familiar with the U-space framework, plenty of USSPs and CISPs are certified, operators are familiar with operating in U-space, standards are readily available, the performance of the U-space services is well understood, etc.
- **U-space is governed by a new/updated regulatory framework.** It is assumed that the U-space, as defined by the medium-term horizon, will be governed by a regulation other than EU IR 2021/664, or an update to 664, considering additional services, functionalities, users, and requirements.
- **Advances in the UAS regulatory framework.** Adjustments to UAS regulations (i.e. Commission Implementing Regulation (EU) 2019/945 and 2019/947) standards are expected to support the increased level of digitalisation that advanced U-space services require (e.g. through digitalisation of SORA processes, adaptation of UAS operator requirements for conducting flights within U-space or advances in dynamic management of UAS geographical zones).
- **Exponential increase in UAS traffic demand and operation complexity.** According to available estimates, it is expected that the demand for UAS operations will greatly increase, as well as the need to conduct more complex (and riskier) operations.
- **Generalised designation of U-space airspaces**. In this term, it is expected that the number of designated U-space airspaces will greatly increase, leading to a scenario where U-space airspaces are generally adjacent to others. As a result, traffic management schemes should consider the management of flights across multiple U-space airspaces.
- **U-space services to Manned/IAM traffic:** by the time the MTH arrives, a new mobility paradigm of remotely piloted, electrified and urban flight will be mature enough to start regular operations. We assume that these airspace users will benefit greatly from having access to U-space airspace and the services provided therein. There will also be some manned flights accessing U-space airspaces that take advantage of U-space services.
- **Detect and Avoid systems:** DAA systems will be standardised and begin to be generally adopted. These systems will be able to perform Remain Well Clear (RWC) and Collision Avoidance (CA) functions with high levels of performance, relying on automation and digitalisation. The use of these systems will enhance the UASOs' capabilities to remain well clear of, or avoid collision with, other airborne hazards.

5.3 Overview of the services provided during the MTH

5.3.1 Regulated services

This table lists the regulated services expected in the medium term. Further details appear below.

Service	Short Term	Medium Term
Common Information	✓	✓
Network Identification	✓	✓
Geo-Awareness	✓	✓
UAS Flight Authorisation	✓	✓
Traffic Information	✓	✓
Weather Information	(✓)	?

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Service	Short Term	Medium Term
Conformance Monitoring	(✓)	✓
Separation Service *in U-space Z*		✓

Table 5: Short-term and Medium-term regulated services

The initial regulatory framework during the STH describes weather information and conformance monitoring as optional services, identified as (✓) in Table 5. However, given the addition of different categories of U-space airspaces in the MTH (see Section 5.4.1.1), a different approach is proposed to reduce complexity. In the MTH, the expectation is that, for each category of U-space airspace, there is a clearly defined set of mandatory services.

The weather information service is tagged in the Table 5 with a question mark, due to an open question regarding whether this service should be considered necessarily as being regulated under the provision of a certified USSP. Other UAS Traffic Management approaches, such as in the USA or the UK, consider weather information to be part of supplementary services, rather than being a core UTM service.

Hence, the only proposed new U-space service in the MTH is the Separation Service, which, when in use, effectively transfers the responsibility for managing the separation provision phase from operators to USSPs.

5.3.1.1 Separation Service

The Separation Service can be thought of as consisting of Tactical Conflict Detection and Tactical Conflict Resolution functions:

The Tactical Conflict Detection function predicts conflicts, based on Traffic Information, plus, as appropriate, other data that may include intent, weather information, aircraft performance, airspace structure and constraints. When feasible, detected conflicts should be shared with all the USSP and/or UASO involved.

The Tactical Conflict Resolution function proposes changes to the trajectory (U-plan or current motion vector) of a UAS to reduce the risk of conflict. When feasible, the resolution manoeuvre should be coordinated between all the USSP and/or UASO involved.

5.3.1.2 Changes to existing services in the medium term

U-space is expected to be used in some instances for passenger-carrying operations. This will impact the associated level of risk and certification required for USSP and aircraft operators, possibly others.

5.3.1.2.1 Common information services

In the medium term, common information is enriched with additional data to support the execution of safe operations in a more complex environment. At least the following additions are expected:

- Common information will include the vertiport availability information. The Vertiport availability information shares the current and (near-term) planned availability of a Vertiport, where the availability indicates the ability of the Vertiport to accommodate an aircraft movement (i.e. landing, take-off). This information is made available by vertiport operators, either by providing the information to a CISP or by being CISPs themselves. The vertiport availability information is based on the findings of the EUREKA project [43].

- Common information will also include separation management information. This information describes the applicable rules regarding separation, such as the separation minima and modes. The purpose is to ensure that, in a distributed separation model, where operators or USSPs act collectively as separators, there is a common set of rules to be followed that ensures the successful

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implementation of the separation provision barrier. The separation management information is based on the findings of the BUBBLES project [43] and SPATIO project [45].

Additional sets of data may be regarded as relevant to be provided as common information in the MTH, according to how the concept evolves.

5.3.1.2.2 Weather information

It is expected that weather forecasting will be considerably finer-grained, with information available at a level currently referred to as "microweather". In addition, and as mentioned above, weather information may change from being a certified service provided by USSPs to supplementary information.

5.3.1.2.3 Flight authorisation service

U-Plan format and lifecycle in the Medium Term Horizon

In the Short Term Horizon, the format of the U-plan is regulated in Annex IV of EU IR 2021/664. This format includes the airspace required for the flight as a series of 4D volumes. In the Medium Term, it is expected that, in the interest of convergence with ATM, U-plans could be expressed using Flight and Flow Information for a Collaborative Environment (FF-ICE). FF-ICE expresses the flight trajectory as a line. It is expected that the 4D volume considered to be occupied by the flight will be that resulting from adding the Required Navigational Performance (RNP) of the U-space airspace applied to the linear trajectory expressed in the FF-ICE. *Work is needed to make practical implementation of this, including for "area" trajectories.*

U-plans should express preferences of the aircraft operator in case the flight is not authorizable as is, for example whether the rerouting is preferable to delayed take-off.

The lifecycle of the U-plan, which impacts the FAS, is also expected to evolve. This matter is discussed in sections 5.4.7 and 5.4.5. *FF-ICE is not expected to support updates in flight without a major update. Update of trajectory in flight is required in U-space to facilitate DAR.*

Fairness

"First Come First Served" (FCFS) or, more accurately, prioritisation of first-to-plan, systematically puts operations that cannot plan in advance, such as on-demand delivery, at a disadvantage to those that can, such as infrastructure inspection. The strategic conflict detection and resolution processes, as well as the demand capacity balancing, are expected to evolve from FCFS to something more fair. *See Appendix B.*

Airspace access

It is expected that permission to enter "restricted" regions will be standardised in a way that allows USSP to easily confirm that the UAS operator has appropriate permissions in order to give more relevant responses. To support this, the Flight Authorisation Service should check "tokens" in the U-plan. Like digital signatures, airspace access permission tokens should be verifiable by third parties but resistant to falsification.

FAS could also confirm whether the U-plan is consistent with the (EU IR 2019/947) flight authorisation for the flight, if the U-plan can contain digital CAA permissions (facilitated by concepts such as eSORA) interpretable by U-space (Services). USSP could confirm U-plans conform to digital versions of permits and their constraints, in terms of permitted area of operation, maximum operating altitude, allowed UAS types, mitigation measures, permit validity periods, and even ground risk.

EU IR 2021/664 suggests this behaviour in Article 10(2a), but the absence of relevant information in Annex IV currently restricts implementation.

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Demand Forecasting, Collaborative Decision Making

Within FAS is Demand Capacity Balancing. As described in section 5.4.3, DCB is expected to advance in MTH. FAS also includes Traffic Synchronisation and parts of Conflict Management. See sections 5.4.4 and 5.4.6 respectively for more details.

5.3.1.2.4 Traffic Information Service

Traffic information in the short term is based on Network ID, electronic conspicuity or ATS surveillance. In the medium term, other surveillance means may be used depending on the risk associated with the operations and the performance required. Individual detected or reported positions of the aircraft are referred to as "observations". Observations are always from the past. Tracking is the statistical process of using observations to estimate the current position and motion of an aircraft. In the medium term, higher performance traffic information could result from tracking and even multi-sensor fusion tracking in which observations from different sources are combined. Tactical conflict "detection" or "prediction" is usually based on tracking to estimate future positions of aircraft.

5.3.2 Non-regulated services

In the short term, it is possible to imagine many unregulated services in the medium term. Some are described here in their canonical form, but in practice, valuable services might combine elements listed here.

Flight planning aid services are expected to increase in number. Already (now) they exist, giving geographic, often dynamic, information about

- Mobile network performance
- GNSS performance degradation
- Ground risk

More will be developed as ingenuity allows and the market demands.

Infrastructure monitoring services, giving alerts before and during flight, may also become more numerous.

The ICARUS project [42] proposed the Vertical Alert Service, which gives the UAS operator warnings if the UAS comes close to terrain or obstacles. The vertical alert service will require a terrain obstacle database (map). As this data may be costly to obtain and maintain, the Vertical Alert Service might not be offered to a uniform level of performance, but rather with a precision in function of the cost - and because of this variable performance, it may not be a regulated service.

5.4 The core functions in U-space during the MTH

5.4.1 Airspace organisation and management

Airspace Organisation is about the nature, shape and rules-of-use of airspaces. Airspace management is the process of applying the rules defined by airspace organisation to satisfy the needs related to the use of airspace.

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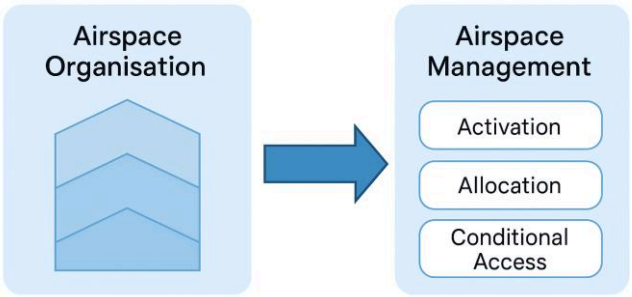


Figure 8 Airspace Organisation in contrast with Airspace Management

5.4.1.1 Airspace organisation

U-space in the medium-term is expected to extend to a much wider geographical range than in the short-term. In particular, the following are expected:

5.4.1.1.1 U-space airspaces above VLL

U-space up to 3000 or even 4000ft AGL has been suggested in research related to VCA flight. Any U-space airspace's upper limit will be determined when the U-space Airspace is created in the same way that the airspace's horizontal bounds are determined; by considering the needs of the flights within U-space and balancing these with the impact of creating the U-space airspace. U-space airspaces for VCA and other certified category UAS may be a *high-performance layer,* as suggested by AMU-LED [46]. These airspaces are designed to accommodate higher-risk operations that regularly carry people on board, and thus entry into these airspaces should be subject to the demonstration of a higher level of performance.

U-space airspaces considered in the STH in the VLL are expected to be classified as ARC-b according to the SORA air risk classification scale. However, U-space airspaces above the VLL are expected to be classified as ARC-c, due to the higher probability of encounters with manned aircraft. Operations in the Specific category in ARC-c airspaces result in at least a SAIL IV for Specific category flights, meaning a limited certification is necessary (design verification report), ensuring a minimum level of performance. For higher-risk operations (more than SAIL IV or Certified category), a full certification is necessary. It is important to remember that Open category operations would not be allowed over the VLL limits.

There is an open question about U-space airspaces above VLL when in controlled airspace: should these airspaces be subject to DAR, or should these be the starting point towards integration? In the sense that, since we expect aircraft operating here will have a high level of performance, it should be possible to safely integrate them with manned aircraft (similar levels of performance) given that a minimum set of services is provided (e.g. traffic information that includes a common vertical reference system).

U-space airspaces above VLL may be entered by manned traffic more often than those in VLL. The risk represented by the amount of manned traffic and its nature should be taken into account during the airspace risk assessment for the U-space airspace. U-space airspaces within airport environment

In the medium term, it is expected that U-space airspaces will be designated next to controlled aerodromes, when so necessitated by demand (e.g. shuttle services with VCA use of UAS to support aerodrome operations). In these airspaces, the high risk of collision is mitigated through smart segregation processes, such as the ATM U Space Shared Airspace (AUSA) concept suggested by AURA [50], refined in ENSURE [47]. Instead of simultaneous cohabitation, the model is based on dynamic allocation of airspace to users (and responsibilities to service providers), based on demand.

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From a SORA perspective, these zones could be considered as having an intrinsic ARC-d (highest risk, somewhat prohibitive), and thus strategic mitigations by smart segregation can serve as the means to reduce to ARC-c for UAS operators for a much more manageable setup.

5.4.1.1.2 Ubiquitous U-space airspaces in the VLL in low-risk environments

The designation of U-space airspaces is presented as the tool to enable ubiquitous BVLOS operations by providing a known traffic picture. These airspaces are designed to support low-risk operations in rural/suburban areas in uncontrolled airspace (ARC-b), where the presence of manned aircraft is expected to be minimal. To ensure a proportional approach, these airspaces are subject to a reduced list of performance and capability requirements, as well as services provided.

5.4.1.1.3 Two dimensions of U-space airspace

Airspace organisation can be based on two dimensions:

- the number and nature of U-space services provided
- performance and capability requirements

The number and nature of services are expressed in X, Y, Z, following the spirit of previous editions of the ConOps. As before, these classes reflect increasing levels of complexity and interaction, and are associated with different roles in strategic conflict management and separation provision. However, the definitions of each class are updated in this version of the ConOps, the 5th edition:

U-space X

U-space airspace X can be understood as a 'light' implementation of U-space meant to be used in low-risk VLL airspace (i.e. low ground risk – low population – and low air risk – little flying)[6]. In U-space airspace X, the demand and the resulting risk of mid-air collisions is considered low enough that the implementation of DCB and TS functions is not deemed necessary. Hence, safety is ensured by the execution of the remain well clear (spacing) function by airspace users, which may be supported in certain cases by collision avoidance capabilities. The core services are network ID + traffic information services (incl. information about manned aircraft based on e-conspicuity).

- Common Information is provided as always.
- Geo-awareness service could also be provided, optionally.
- Either no flight authorisation service, or flight authorisation with no strategic deconfliction. In the latter case, U-plans are generated by the airspace users that intend to consume U-space services, to support some basic checks such as identity confirmation and airspace availability (e.g. to check that the airspace is not closed). However, the U-plans may not even include a 4D trajectory for strategic deconfliction and conformance purposes.

[6] During the development of this document, EASA published a regulatory proposal (NPA 2026-103) which includes an 'intermediate' level of U-space airspace, described by the proposal as U-space level 1. It should be noted that EASA's proposed 'level 1' and CORUS 'X' U-space airspaces are strikingly similar in terms of scope, objectives, and services provided, and could perhaps be considered equivalent. In addition, it should be considered that, depending on how EASA's proposal develops, 'X / level 1' airspaces may eventually be implemented during the short term, much earlier than other elements described in this Chapter.

Nonetheless, within the scope of this document, class X remains within the medium-term horizon, and the EASA proposed terminology is not used, given that the final publication of this document precedes any potential regulatory updates resulting from EASA's proposal.

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- No conformance monitoring service.

X U-space airspace is meant to facilitate the ubiquitous implementation of U-space airspaces, which is one of the goals stated in Section 5.1. To the question: **how about providing U-space services outside U-space airspaces?** This ConOps provides the following answer: **how about facilitating the designation of U-space airspace in a larger geographical scope?** It is important to consider that the actual benefits of using the U-space services can only be reaped when all (with a few exception) airspace users cooperate. U-space airspace imposes requirements such as the mandatory receipt of U-space services, or having electronic conspicuity capabilities, as requirements to use the airspace (except via segregation), and provides a standardised and certified regulatory framework that ensures the quality in the provision of services. Together, these elements provide the necessary framework to ensure safe operations, even with a minimal set of services. However, outside U-space airspaces, these benefits simply do not exist.

X proposes a proportional implementation that is adjusted to scenarios where Y U-space airspace might be too much (i.e. too expensive, too complex, or too constraining). In X, airspace users have greater freedom, not having to define a 4D trajectory with which to comply during the operations. Less services are used, meaning that certification and operations should be cheaper when compared to Y U-space airspaces. However, this also means that the complete weight of risk mitigation lies on tactical capabilities, limiting the total amount of risk that can be mitigated, and hence the achievable airspace capacity. These limitations may be somewhat lifted once a new generation of advanced DAA capabilities is developed, ensuring a robust tactical mitigation of the mid-air collision risk.

U-space Y

U-space airspace Y is the most similar to the current implementation in the STH. The same suite of services is provided, meaning strategic deconfliction by USSPs and traffic information to enable operators to remain well clear of other traffic.

U-space Y airspaces rely on UAS operators to manage the separation provision phase of conflict management, meaning the implementation of remain well clear (spacing) capabilities. These capabilities may be initially implemented considering different levels of automation, ranging to a human operator using traffic information, to advanced DAA capabilities[7] performing the RWC function, where. The 'detect' and 'feedback loop' subfunctions are supported by the U-space services (traffic information), but the operator remains responsible for the rest (i.e. decide, command, execute). DAA capabilities are expected to support the operator in one or several of these subfunctions by automating actions.

U-space Z

U-space airspace Z includes the provision of a separation service by the U-space ecosystem (in principle, managed collectively by USSPs), which take responsibility for separating traffic. This is the primary difference between Y and Z U-space airspaces. At this point, it is not possible to confidently claim that putting the separation provision responsibilities on USSPs instead of on airspace users will lead to an implementation that is safer, more efficient, or with a higher capacity than having airspace users perform such functions supported by advanced DAA systems. In the end, it will be a matter of the performance that may be achieved for the implemented systems (be it through USSPs, or DAA systems).

The discussion on whether airspace users should retain the responsibility to remain well clear from other traffics, or whether they should be separated by another agent, is currently an open one. Hence, this ConOps

[7] DAA capabilities should be understood as defined in the ICAO RPAS manual, Doc 10019, section 10.12.3. This definition focuses on capabilities and is agnostic regarding the particular implementation of such capabilities via a DAA system, that may be on-board, ground-based, satellite-based, or any combination of the previous.

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describes both U-space Y and Z as possible implementations for the medium term, considering that both are equally possible, and both may be implemented in the future, without having any preference at this moment.

In U-space Z airspaces, a DAA-RWC function is not necessary, as the separation function is managed by the USSPs, but a DAA-CA function may still be required (see conflict management), depending on the desired level of overall performance and capacity (see below).

SPATIO [45] has developed SESAR Solution 0461: "Tactical conflict prediction, resolution and implementation with onboard extension". As of today, it remains an open question whether a distributed separation provision service could achieve the level of performance/assurance necessary to safely enable high-risk operations, such as those where people are carried by aircraft. Therefore, an alternative solution could be a centrally provided separation service, but to consider this option, multiple aspects of U-space must be reviewed (e.g. what "central" means; a new stakeholder must be defined with clear roles and responsibilities).

Performance – the other dimension

In addition to the distribution in X, Y, Z classes as described above, a secondary classification is proposed, according to the required performance and capabilities. The goal of this secondary classification is to enable a proportional standardised implementation, according to the needs to achieve a certain capacity in a given scenario.

U-space airspace is structured according to a limited number of performance categories, identified by roman numbers (Categories I, II, III, etc.), increasingly supporting the integration of larger amounts of more complex traffic across the U-space airspace classes defined (Classes X, Y and Z). Performance categories here may be in terms of navigational performance, speed of response, etc., or in terms of the presence of equipment or features such as a collision avoidance system or tracking in the traffic information service. As the required performance and capabilities increase, so does the amount of risk that can be safely and efficiently mitigated, thus enabling larger demands to be met. The increase of performance levels is aligned with the implementation of the measures described in this chapter for the medium-term, which focus on smarter strategic actions and more robust tactical capabilities as the way to increase the capacity of U-space airspaces.

Ideally, these performance category / feature combinations will be standardised across XYZ and across all implementations. (Category II is the same whether flown in X, Y or Z. Category II is the same from Finland to Greece.)

Quantised performance categories can simplify U-space Airspace designation and USSP certification, as the performance requirements are standardised. They also allow aircraft, ground equipment, pilot training and so on to be characterised as compliant with a particular numeric performance.

Two dimensions

Combining XYZ with performance categories results in a table, where the possible U-space airspaces are defined as X-I, Z-II, Y-III, etc. As the numbers increase, higher levels of performance and operational capability are required, reflecting the transition from environments with limited capacity to environments with higher traffic density supported by greater levels of performance and capabilities. (Three categories are mentioned here, but there may eventually be as many as necessary.)

The XYZ forms of U-space must be clearly defined, including which services are provided, the roles and responsibilities of the different actors, and so on. Ideally, this will be part of the regulation developed in the future once a sufficient maturity is reached. The numbered performance and capability requirements should also be defined as well, in a manner that can be easily standardised, supporting manufacturers, service providers, and operators, as well as interoperability at the EU level (and beyond).

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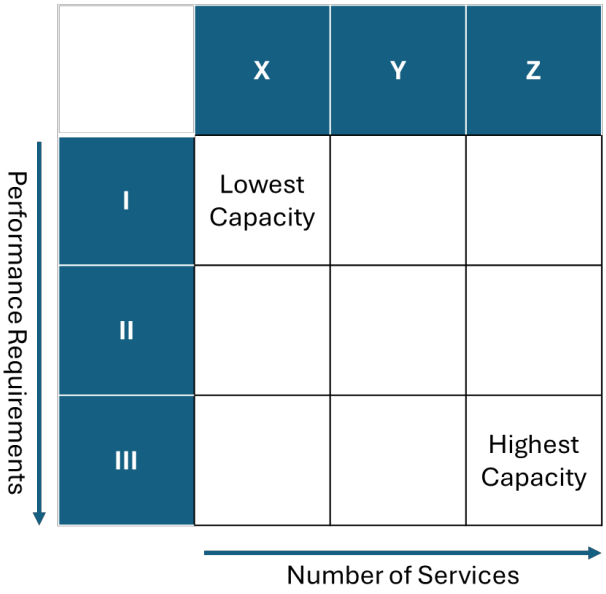


Figure 9 Two dimensions of U-space airspace characteristics

The following examples are provided to illustrate how the two-dimensional classification may be employed and some of its benefits:

- A U-space airspace in uncontrolled airspace, in the VLL, over a rural area, and supporting a low demand, may be initially designated as X-I. After a few years, to accommodate the increase in demand as the industry consolidates, the U-space airspace is reassessed and assigned a classification of X-II. This allows the larger level of demand to be met, but also imposes greater requirements on aircraft (e.g. enhanced positioning accuracy) and USSPs (e.g. increased availability of traffic information).
- U-space airspaces that are located beyond the limits of the VLL may require a minimum performance category (e.g. III). These airspaces are characterised by a larger presence of manned aircraft that carry people on board, and hence a greater risk to be mitigated.
    - Similarly, a U-space airspace that is located within an airport environment (e.g. to provide shuttle services with VCAs) may require a minimum performance level, due to the presence of on-board people.
- A U-space airspace designated over a populated area in the VLL is Y-II. To enable VCA operations, a high-performance layer is designated over the vertical limits of this first U-space airspace. The high-performance layer is designated as Y-III. In order for UAS to enter the high-performance layer, they must meet the associated performance requirements for Y-III.
- When performance category is larger than given values, certain functionalities could be required, such as:
    - tracking, as part of the traffic information service.
    - an independent collision avoidance capability (i.e. that retains its functionality in case of complete loss of connexion with the USSP)
    - DCB functions as described in 5.4.3
    - In general, any of the functionalities described in this Chapter for the medium term. This allows the gradual implementation of the described features in a manner that is proportional to the evolution of needs and aligned with the technological developments.
- A UAS that complies with the capability and performance requirements for performance category II (e.g. through class-marking, design verification report, or certification) can operate in U-space airspaces with category II and below.

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- A USSP certified to provide their services in class Z can provide their services in X and Y. A USSP certified for Y can also provide their services in X. Similarly, a USSP certified for performance level III can also provide their services in U-space airspaces with performance categories I or II.

The detailed analysis of exactly which performance and capability requirements should be associated to each of the airspace performance categories is left as an open question for future research activities, in case this proposal is considered relevant enough.

5.4.1.1.4 Managing interaction by means of airspace structures

Airspace organisation is part of a layered conflict management approach and provides an initial layer of conflict mitigation by structuring traffic. Airspace structures (e.g. performance-based layers, corridors, access routes) are defined in a way that supports the different operational logics of U-space X, Y and Z. In particular, the goal of airspace structures in the MTH is to minimise, as far as reasonably practicable, the level of interaction between traffic with different levels of performance. The underlying reason is that the efficiency of tactical conflict mitigation barriers is limited when attempting to separate traffic with different performance: such as cruise speed, manoeuvrability, level of assurance, or the target level of safety.

At the same time, structures may be permeable to allow operational flexibility, with crossing possible under defined conditions.

Additional structuring mechanisms may be introduced in higher-density environments (typically U-space Y and Z).

- Conditional corridors can be defined to support trajectory-based operations and connect key nodes (e.g. vertiports) to ensure minimal to higher-performance airspace.
- Performance-based layers (e.g. high-performance layer) can be introduced to organise traffic with different capabilities and reduce interaction between aircraft with very different performances (and safety targets) – traffic types.

5.4.1.2 Airspace Management

Airspace Management in the medium-term horizon is expected to be largely as in the short-term horizon but with the difference that U-space Airspaces become more integrated and dynamic.

Airspace designation

Airspace Designation continues to involve Airspace Risk Assessment (ARA), but with additional aspects to consider. The Competent Authority (CA) determines if the U-space airspace is X, Y, or Z, and also the performance number. These options are taken from a list of standard values.

Airspace access conditions

Airspace access conditions are defined through performance and capability requirements. Access to U-space airspace is determined based on the performance and capability requirements associated with each airspace volume: numeric performance category (I, II, III) and class (X, Y or Z), reflecting the level of service and separation expected. Aircraft, system and other performance requirements should match the airspace performance.

Dynamic Airspace Reconfiguration

The AURA and ENSURE projects introduced and developed the concept of ATM U-space Shared Airspace (AUSA), an enhanced form of DAR. In the medium term, it is likely that there will be dynamic allocation of responsibilities for service providers, based on AUSA. When in controlled airspace (e.g. airport environment), the management of traffic in the airspace can be delegated to U-space (i.e. USSPs) or ATM (i.e. ATC units).

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UAS geographical Zones as airspace management tools for non-operational stakeholders and state operators

Non-operational stakeholders of U-space (such as government agencies and local authorities), and state UAS operators (such as police or military) may impose additional restrictions on UAS operations within U-space in the form of static or dynamic UAS geographical zones issued within U-space airspace. By applying standardised use of UAS geographical zones conditional language (as provided by the ED-318 standard), USSPs can consider them directly as part of the flight authorisation and conformance monitoring processes, without the need for human interpretation. An example of this could be the issuance of a dynamic UAS geographical zone which only authorises state operations in a given area due to security requirements by the police, by identifying which UAS operation plans are submitted with the appropriate operator classification or flight purpose. These processes will allow non-operational stakeholders to have a say in U-space operations without needing to be active participants in airspace management.

5.4.2 Aerodrome operations

Two aspects are considered. The Vertiport as the U-space aerodrome, both for VCA and smaller UAS, and U-space at airports.

5.4.2.1 The VCA vertiport as the U-space aerodrome

5.4.2.1.1 VCA needs that impact Vertiport operations

Currently, VCA are novel aircraft designs (multi-rotor, tilt-rotor, tilt-wing) with novel systems (variable-speed electric motors, fixed-pitch rotors, high levels of automation, etc.) and usually with novel power sources (battery, hydrogen fuel cell, hybrid). IAM is expected to use VCA for commercial transport at relatively low altitude, including in areas of dense population.

Battery-powered aircraft currently have limited flight duration. VCA flight is currently expected to be organised to minimise holding or hovering. Vertiport operations should ideally enable an incoming VCA flight to land without any delay. To this end, landing is expected to be precisely organised before take-off.

Continued Safe Flight and Landing is a capability of an aircraft to remain operable in the presence of system failures or adverse conditions. It is expected that VCA flight will include continuous planning of possible diversion. Hence, it is expected that Vertiports will continuously make known their availability to accommodate a landing, now and in the near future. This is the “Vertiport Information Service”

VCA are expected to take off and land vertically from FATO. Some lack wheels and will require ground handling equipment to be moved. FATO will be occupied for a noticeable time before take-off or after landing, even if the VCA are usually at parking places.

5.4.2.1.2 Vertiport Information Service

Vertiports will exist inside and outside U-space. The EUREKA project has studied their integration into U-space. In that situation, the Vertiport Information Service (VIS) is part of Common Information. For Vertiports outside U-space, the VIS should be shared with appropriate actors by some means equivalent to U-space Common Information.

Vertiport information includes

- static elements:
    - location,
    - contacts,
    - access conditions,

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- capabilities, limitations
- associated airspace structure, including Vertiport Traffic Zone if any
- any related ATC or Tower
- arrival and departure procedures
- surface guidance
- landing and navigation aids
- hazards

- Dynamic information
    - slot availability
    - weather conditions
    - airspace restrictions
    - arrival and departure procedures in use

Slot reservation needs to be coordinated with the U-plan. A flight between Vertiports purely in U-space needs to coordinate three constraints: Departure vertiport availability, strategic deconfliction of flight, and arrival vertiport availability. The EUREKA project has studied a solution for this known as Vertiport collaborative traffic management (SESAR Solution 0349), which can also accommodate constraints imposed by adjacent manned airport operations. Other options include use of a strategic deconfliction process for the FATO as an element of the route.

5.4.2.1.3 Vertiport Manager

The Vertiport Manager (VM) controls access to the Final Approach and Take-Off Area (FATO) of the Vertiport. The VM collects the information necessary to feed the VIS. If the Vertiport is at an airport or has a remote tower, Air Traffic Control are likely to be informed by the VM of the current and future state of the FATO.

The level of automation of the vertiport manager is likely to be a balance between technical capabilities and the level of risk implied by the flights concerned. For passenger transport in the medium term, human oversight seems likely.

5.4.2.1.4 Vertiport Traffic Zone

The Vertiport Traffic Zone is a generalisation of a region around a Vertiport with a single control to facilitate sequencing of traffic into/out of the FATO. When the Vertiport is at an Airport in controlled airspace, the VTZ is controlled by the tower. If there is no tower, sequencing might be achieved “mechanically” by deconflicting time slots at the FATO, giving the USSP FATO-to-FATO responsibility.

Within a VTZ:

- the vertiport operator may be delegated responsibilities for ground movements, slot allocation and local flow management,
- after which the USSP assumes responsibility for the airborne segment.

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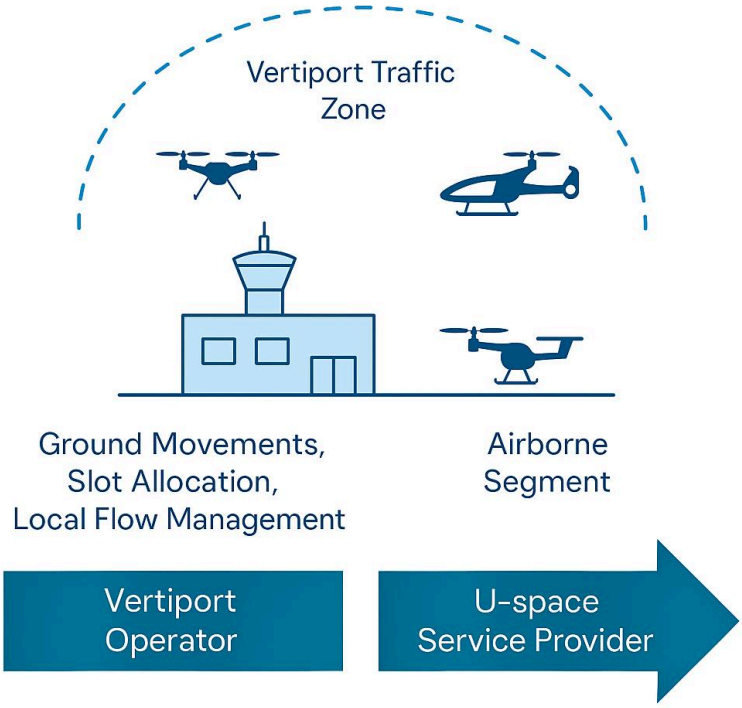


Figure 10 Vertiport Traffic Zone

5.4.2.1.5 Vertiport Collaborative Traffic Management (VCTM)

A flight which is subject to Strategic Deconfliction (i.e. in U-space Y or Z) from one Vertiport to another must reconcile three constraints.

- The availability of the take-off FATO
- A conflict-free 4D trajectory
- The availability of the landing FATO

The EUREKA project generalised the solution to this problem into a collaborative decision-making process (Vertiport collaborative traffic management – VCTM; SESAR Solution 0349) that could accommodate other aspects such as dependence on a runway nearby the FATO.

5.4.2.1.6 Vertiport (Local) Network Management

There may be cases where a single operator is operating an isolated network consisting of a number of vertiports and a fleet of aircraft. The EUREKA project [43] showed how such a network can be managed optimally.

5.4.2.2 Vertiports for UAS smaller than VCA

Vertiports for UAS which are smaller than VCA, for example those currently used in delivery, have been less studied in European research projects. They operate as Vertiports for VCA with a few key differences. Notably, Continued Safe Flight and Landing is not required for small UAS, and the operator of the Vertiport is the aircraft operator. Hence

- The Vertiport is only used by aircraft from that operator.
- There is no Vertiport Information Service

There are likely to be more FATO than a VCA Vertiport, as the small size (and downwash) of the aircraft allows close spacing of FATO.

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- FATO allocation is simplified and under the control of the aircraft operator
- FATO may be used as parking stands and might be assigned to an aircraft over many flights

5.4.2.3 U-space at "current" aerodromes

In the Medium Term, as in the Short Term, U-space is only likely to be created at aerodromes in regions where manned aircraft seldom fly. For occasional UAS flight in areas like the runway and apron – for inspection, bird scaring or calibration activities – concerns like containment will be paramount and are out of the scope of U-space.

U-space in the CTR can aid identification of "friend or foe" when rogue drones are observed / detected. U-space non-conformance warnings could also be relayed to ATC for cases when "friend becomes foe."

In the Medium-term Horizon, as in the Short-term Horizon, Dynamic Airspace Reconfiguration of U-space in controlled airspace is expected to continue to be used – see 4.3.1.2.

The Medium Term is not currently expected to bring new U-space services aimed particularly at mitigating risk at aerodromes in uncontrolled airspace. Even if all manned aircraft are electronically conspicuous, U-space is not aware of the intent of the flights, and there is little USSPs can do to make a BVLOS operation safe among many manned aircraft.

The EUREKA project has studied co-location of vertiports at airports in controlled airspace. It showed that distinct arrival & departure routes for U-space traffic and manned aviation can be configured at airports, allowing relative independence. The sensitivity of VCA to wake vortices from airliners - and other factors – influences the choice of vertiport location, VCA arrival and departure procedures and whether or not the movements were independent. It is expected that with increasing automation and experience, handling of U-space in the medium term will be more dynamic than in the short term. The unpredictability of manned aviation today is much greater than the precision expected of U-space and VCA flight.

Instead of simultaneous unrestricted coexistence of all traffic types, the system increasingly relies on dynamic allocation of airspace volumes and responsibilities. Dedicated structures such as corridors, flyways or performance-based layers may be introduced to support VCA operations in the vicinity of aerodromes and may be activated dynamically depending on demand. Consequently, portions of airspace may temporarily transition between ATM-managed and U-space-managed environments. Allocation is adapted according to demand, traffic flows and operational priorities. This is particularly relevant in the vicinity of controlled aerodromes with high traffic density, as the expected density and tempo of UAS operations make traditional tactical control approaches difficult to scale. Automated agents and digital coordination mechanisms are expected to support sequencing, flow management and trajectory coordination. Human operators progressively move towards supervisory and exception-management roles. Conformance monitoring plays a key role in ensuring safe transitions and airspace reuse.

This higher level of dynamic assignment of roles and responsibilities requires U-space services to remain accessible outside the geographical limits of U-space airspace to support continuity of operations.

5.4.3 Demand and capacity balancing

Compared to the short-term horizon, DCB is one of the components that is expected to experience the most changes during the medium-term horizon. As stated, one of the primary goals of the foreseen evolutions during the medium-term horizon is to enable high-density U-space airspaces. This means that the DCB mechanisms should be able to efficiently manage large numbers of operations, in scenarios with aircraft subject to different performance requirements, and contemplating the need for coordination between multiple USSPs.

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5.4.3.1 DCB Phases

DCB retains the same phases as in the short-term, although the actions performed during each phase are expected to change. The sections below describe the expectations for each DCB phase in the MTH.

5.4.3.1.1 Strategic DCB

Strategic DCB in the medium term is unchanged from the short term. It mostly consists of the long-term regular assessment to review limitations/constraints and requirements to define capacity (ARA re-assessment) according to demand evolution. When the U-space Airspace is created or modified, the Airspace Risk Assessment (ARA) considers an expected traffic level and composition. Strategic DCB involves checking that the actual traffic is the expected traffic, and if not, revising the ARA and the Concept of Operations for the U-space airspace.

Strategic DCB considers the monitoring of trends and future events that may impact the demand or the capacity, resulting in the allocation of additional temporary measures. Examples might include seasonal variations in traffic, closures of airspace due to accumulations of people, etc. Strategic DCB links to AOM and includes the setting of geo-zones to impose temporary airspace limitations and/or operational conditions.

Thus, Strategic DCB actions are performed by authorities and/or designated entities in charge of airspace governance. USSPs/CISPs do not take an active role in the definition of Strategic DCB actions but are conditioned by them (e.g. a CISP publishes airspace limitations derived from Strategic DCB actions, while a USSP must ensure flights comply with such limitations).

5.4.3.1.2 Pre-tactical and Tactical DCB

While in the ATM environment Pre-tactical and Tactical DCB are described separately, it is expected that in the U-space environment these two phases will be executed in a continuum, the interface between them being barely noticeable. This trend described in the short term is expected to be maintained in the medium term.

Pre-tactical and Tactical DBC use known demand – actual U-plans –, complemented with traffic forecasts. Generally, the goal during these phases is not to modify the capacity, but rather to focus on regulating demand (see 5.4.3.3 for further details). Therefore, these DCB actions start from the moment a U-plan is known and can be implemented until a reasonable time before the start of the flight. These DCB actions are implemented collectively by USSPs, who must share the relevant U-plan information and coordinate effectively to ensure appropriate decision-making.

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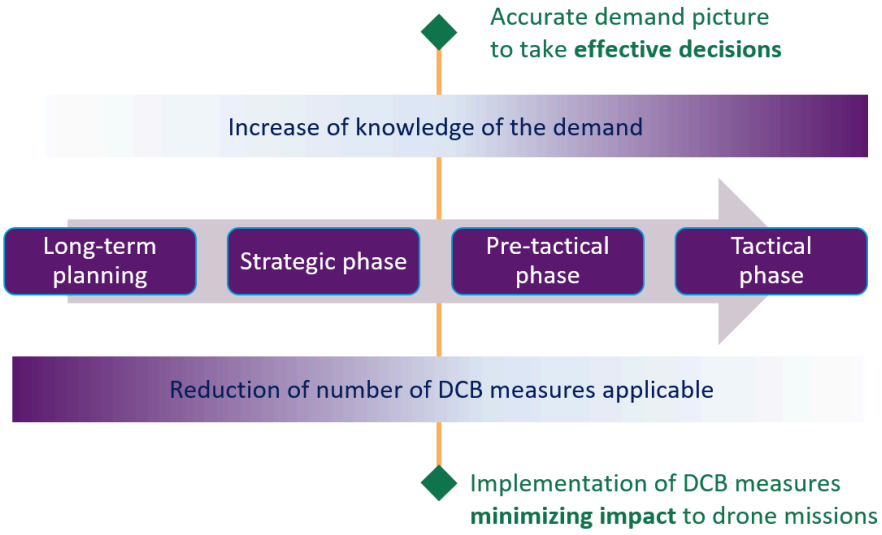


Figure 11: Conceptual representation of the time horizon of the U-space DCB process (source: DACUS D1.2)

Pre-tactical and Tactical DCB in the medium term are completely overhauled compared to the short-term horizon. Although these processes remain dominated by the UAS flight authorisation service, it is expected that multiple new functionalities will be added to the service to cater for the emergence of new needs during the medium term.

The sections below describe a series of functionalities that are expected to be included within the UAS flight authorisation service to effectively perform Pre-tactical and Tactical DCB actions.

The topic of 'how DCB works in U-space' is complex and needs further development. Complementing the sections below, Appendix B describes a potential method to execute DCB measures that considers the key aspects detailed in these sections.

5.4.3.2 Demand forecast

Demand forecasting is necessary to allow DCB other than at the very last minute, giving additional flexibility to service providers and airspace users. Demand forecasting combines already known flights (USSPs must share U-plans in advance) with a prediction based on historical data, which may include both manned and unmanned traffic.

Different options exist for implementing a demand forecast function. The implementation chosen for each case should consider market competence and separate making the prediction from making decisions based on such predictions. This ConOps remains agnostic as to which implementation is used. Some options are:

- Each USSP makes their own predictions for all traffic, based on the shared U-plans and historical data.
- Each USSP makes their own predictions for their own traffic (based on known U-plans and historical data) and shares with others. Then, predictions are aggregated.
- There is a single forecast service for each U-space airspace, provided as part of the common information services.

5.4.3.3 How DCB regulates demand in the MTH

To understand the goal of DCB actions, these must be addressed considering the complete context in which they are implemented. The conflict management phase executed immediately after DCB is traffic synchronisation (TS). This phase is described in additional detail in Section 5.4.4 below. In summary, the core

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function of TS is to arrange traffic in a manner that prevents tactical conflicts from occurring, while ensuring the expediency of traffic. Colloquially, this is referred to as Strategic conflict resolution (SCR).

In the medium term, strategic conflict resolution is done a few moments before the flight starts[8], meaning there should be a high degree of certainty that an effective solution to any conflict will be found, and that such a solution will be acceptable to the UAS operator. Hence, the goal of DCB as the process before TS is not to resolve strategic conflicts, but to preprocess the U-plans, introducing the necessary changes that lead to an outcome that is manageable by the TS function (i.e. to ensure a safe and efficient strategic conflict resolution). Hence, the goal of DCB functions is to ensure that the efficiency-capacity thresholds described in Section 3.6.2 are complied with.

DCB actions should only be performed when necessary, as any deviation from the airspace user's original plan is understood as an efficiency loss[9]. For this purpose, **Hotspots** are areas defined in time and space where capacity limits are or could be exceeded.

In ATM, the capability of a human controller to safely and efficiently manage traffic within a given sector configuration is a thoroughly studied topic, and the resulting airspace capacity is well identified. Generally, airspace capacity is described in terms that are easy to understand and implement by humans, such as a given number of flights happening during a given time interval (e.g. X flights per hour). However, U-space is characterised by reduced human intervention and the allocation of tasks to automated systems. Hence, it is expected that capacity limitations in the medium term are described in a manner that is consistent with the highly automated system that will manage such limitations, and which may not be easily interpreted by humans.

Therefore, a Hotspot is an area where, for a given portion of time, it is foreseen that due to the high density of traffic (known + predicted demand), any of the following conditions may occur:

- The Strategic conflict resolution function will not be able to find a solution in time (e.g. due to the complexity of computing a solution exponentially scaling with the density of traffic in close proximity).
- The Strategic conflict resolution function will not be able to find solutions that are acceptable to operators (e.g. requiring large deviations from the plan that are incompatible with the expressed user preferences).
- It is predicted that any other capacity limitation unrelated to conflict resolution (e.g. noise) may not be respected.

At the moment, it is not possible for this ConOps to explicitly state the precise indicators that may trigger the previous conditions (e.g. density of simultaneous flights, U-plan 4D volume size and granularity, level of proximity between flights). Furthermore, the acceptable magnitude of these indicators will depend on many different aspects, such as:

- How the U-plans are defined and what parameters are included in them (e.g. user preferences)
- What algorithms are used to perform the strategic conflict resolution function
- The available computational capability to execute such algorithms

[8] It is important to highlight that this poses a major difference compared to the short term, in which the strategic conflict resolution is performed almost immediately after a U-plan request is made.

[9] It is assumed that airspace users will plan their flights in the most efficient manner for them. This generally means that a certain metric of interest is optimised. For example, flight duration, fuel consumption, etc. Any chance introduced to the U-plan may negatively impact such metrics.

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- The acceptable level of residual risk to be mitigated by later actions

As there is no simple way to express these notions, the following characterisation for hotspots is recommended to support decision-making and human interpretation:

- Green: there is no foreseen DCB issue. No DCB measures required.
- Yellow: congested airspace (close to capacity limits). DCB measures are recommended.
- Red: over capacity limits. DCB measures are mandatory.

Once the necessary algorithms and supporting systems are developed, standardised and implemented, experience will lead to a more concise identification of the efficiency-based capacity limitations and how these should be communicated to and used by both humans and machines.

The DCB measures, focused on regulating demand, include, but are not limited to, the following:

- **Reduce the 'footprint' of a flight by imposing constraints.** For example, by splitting the U-plan into more, smaller 4D volumes, or by reducing the temporal uncertainty by allocating a stricter U-plan activation window. These actions do not change the flight 4D trajectory, but impose constraints on the execution of the flight, forcing a more accurate execution of the flight in the 4D space. The footprint reduction facilitates the execution of the strategic conflict resolution function, at the cost of requiring a more precise action by the airspace user.
- **Move the flight outside a hotspot.** This can be done by implementing changes to the 4D trajectory (i.e. the path and/or the timing components) to reduce the number of flights planned to operate within a hotspot, thus alleviating the DCB issue.

Since DCB actions are performed sufficiently in advance before the U-plan activation, it is expected that, in case of need, there will be enough margin for airspace users to react to DCB measures and propose alternatives. Nonetheless, DCB actions should consider the user preferences expressed in the U-plan to minimise the need for iterative changes to the U-plans.

Figure 12 describes at a high level the different steps taken during the Pre-tactical & Tactical DCB process.

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Figure 12: High-level schematic representation of the U-space dynamic capacity management processes

5.4.3.4 DCB priority principles

During the medium term, it is expected that solutions other than the FCFS paradigm will be implemented. FCFS is understood to penalise airspace users that cannot request their U-plans in advance, and thus is seen as an unfair method. A different approach is necessary, based on the continuous exchange of information among USSPs, and considering user preferences, to ensure coordinated actions are distributed among different airspace users, rather than penalising a flight with smaller. DCB collaborative decision-making is critical to ensure coordination and avoid “gaming the system”.

Another notion related to the topic of priority is **virtue points**. Virtue points were proposed in previous CORUS projects and have been mentioned in earlier U-space ConOps. The problem they seek to solve is a fairness problem: DCB measures penalise the aircraft operator subject to those measures. Historically in ATM, the same flights tend to be repeatedly picked by DCB measures, leading to an ‘unfair’ distribution of nuisances among airspace users.

Assuming every UAS operator files the U-plan closest to their ideal flight, any deviation is a penalty. If in an airspace there are, say, ten flights and DCB requires one to be (re)moved, then the operator of that flight suffers while the others do not. The aim of the Virtue points notion is to spread this penalty around between aircraft operators in a manner that is fair. Virtue points can be awarded at the same time as a flight is subject to a DCB measure, and then these points can be used in future to give another flight by that operator a slight priority in the selection process to avoid their flight being penalised.

Virtue points could also be awarded for behaviour that maximises capacity, for example by planning well in advance, and describing U-plans that use the minimum airspace necessary for the flights. The problem is to design a system that is fair and robust against “gaming”.

Plenty of open questions remain related to this topic. Further research is necessary to determine whether virtue points are a desirable feature and how such a feature may be implemented.

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5.4.4 Traffic synchronisation

Compared to the short term, Traffic Synchronisation (TS) must evolve during the medium term to accommodate high-density scenarios. A key factor constraining airspace capacity is the uncertainty embedded in the definition of the U-plan, leading to inefficient strategic conflict resolution. In the medium term, TS optimises the use of airspace by establishing mechanisms to leverage the uncertainty reduction based on temporal and operational flexibility.

A core principle to improve the efficiency of the TS process is to delay the application of TS measures as much as reasonably practicable before the start of the flight, to benefit from the progressive reduction in uncertainty as time passes. This marks a difference with the STH approach, where TS is applied upon U-plan request (filing), where uncertainty may be high. In addition, TS in the MTH benefits from in-flight mechanisms such as the U-plan uncertainty re-assessment after take-off, as described in AUO.

The sections below address the functioning of TS during the MTH, beginning with the definition of what is a strategic conflict, and continuing with the pre-flight and in-flight TS phases. These are complemented by additional notions addressing collaborative decision-making and fairness issues.

5.4.4.1 What are strategic conflicts in the MTH?

TS is the action to resolve strategic conflicts, ensuring that the residual[10] risk of collision for accepted U-plans is acceptable (i.e. below a specified threshold). In this scope, the term 'strategic' refers to the conflict management continuum. It means 'before tactical', which is translated to anything that happens before the separation provision phase. In the context of U-space, strategic conflict management acts according to the information contained in the U-plans, rather than on the traffic information (which is used for separation provision purposes). Hence, strategic conflict resolution is achieved by adjusting the U-plan (e.g., trajectory, temporal shifts, mission description discretisation) in accordance with the strategic conflict particularities and the operator preferences described in the U-plan.

In the STH, it is considered that the residual risk of collision is acceptable when the U-plans, with the deviation thresholds added, do not overlap in time and space. In this case, the overlap of 4D volumes is defined as a strategic conflict, and thus the TS function aims at resolving such conflicts. A similar process is followed when, instead of deviation thresholds, other metrics are used to define 4D volumes, such as the protection volumes described by SPATIO [45]. The methods described in ASTM F3548 [26] also rely on this classification, in which 4D volumes are checked for conflicts, without added deviation thresholds or protection volumes.

These methods have two elements in common: the U-plan is expressed as a series of 4D volumes, and the strategic conflict is defined as a deterministic yes/no choice depending on the overlap of 4D volumes, which are expected to contain the various aircraft within a certain level of confidence.

This is an indirect, **volume-centric approach**: 4D volumes are defined as proxies for the actual flight, with the goal of capturing the flight uncertainty, and the risk mitigation barrier seeks to prevent the overlap of such volumes. It is assumed that if 4D volumes do not intersect, the residual risk of conflict will be acceptable.

A **trajectory-centric approach** is also possible, in which U-plans are modelled using 4D trajectories with uncertainties directly added on top of the 4D trajectory and the level of overlap between any pair of flights is estimated as a direct function of these 4D trajectories and the uncertainties, without the need to explicitly define a series of 4D volumes. The main advantage of trajectory-centric approaches is that they allow a

[10] This term should be understood as 'after the application of strategic actions'

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granular representation of a flight with a reduced computational load compared to volume-centric approaches [41].

The transition from volume-centric approaches to trajectory-centric implementation is expected to occur during the medium term, as described in Section 5.4.5.4. This is also seen as a necessary alignment towards an eventual full integration with ATM, by incorporating concepts similar to and compatible with FF-ICE developments in ATM.

In addition, the very definition of the strategic conflict is also expected to change. The current approach relies on the overlap of volumes as the yes/no criteria to trigger a conflict. Effectively, it is assumed that the aircraft is equally likely to be in any part of the 4D volumes, leading to an inefficient usage of the available airspace.

A different approach is possible. Instead of checking for yes/no overlaps, the residual risk between any pair of trajectory-centric U-plans can be directly estimated using a probabilistic approach by estimating the probability of collision[11], given the two 4D trajectories and their temporal and spatial uncertainties. The residual risk of collision will be considered acceptable when the probability of collisions (or acceptable safety-related proxies) for each pair of flights is reduced below a defined threshold[12]. This method allows a more accurate (and less conservative) risk estimate, as the statistical nature of uncertainties is directly embedded into the model. Hence, the medium-term definition of a strategic conflict eventually evolves from the STH's binary description (whether there is any overlap) to a detailed model that allows decisions to be made based upon a quantified estimation of risk.

5.4.4.2 Pre-flight Traffic Synchronisation

Pre-flight traffic synchronisation is then the process to resolve strategic conflicts before the start of flights. In the Medium Term, the pre-flight TS process may allow a certain degree of overlap/proximity between U-plans, given that the residual risk of conflict is acceptable. This residual risk will be mitigated later by other Conflict Management functions available.

There is a need to determine two temporal thresholds:

- One that marks the boundary between DCB and pre-flight TS measures. Before this moment, DCB actions can be implemented. After this moment, TS takes over. It is expected that a measure relative to a certain amount of anticipation before the expected start of the operation will be used. This ensures decisions are made at the correct moment (benefiting from the uncertainty reduction as time passes) and that both conflict management components work and coordinate effectively without overlapping.
- A second one that forbids further application of pre-flight TS measures, and 'freezes' the status of the U-plan. Again, it is expected that this measure will be defined relative to the expected start of the operation. This is to ensure that the operator receives a 'final' version of the U-plan well in advance, so that they can finalise flight preparations in time.

Given that pre-flight TS is expected to happen shortly before the start of the flight, the prescribed changes to the U-plans are expected to be communicated to operators at short notice. It is imperative that such changes are provided with enough anticipation, are as small as possible (while ensuring an acceptable mitigation of risk), and are acceptable for UAS operators. The changes to the DCB process described above,

[11] Acceptable safety-related proxies may be used instead, such as the probability of loss of well clear or separation

[12] Regarding the methods to define such thresholds, consider the safety-related capacity threshold as described in Section 3.6.2 and further detailed in **Error! Reference source not found.**.

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as well as the evolution of the U-plan model described in 5.4.5.2 support the effective implementation of pre-flight TS measures.

5.4.4.3 Collaborative decision making based on batch processing

In the STH, strategic deconfliction is performed on a case-by-case basis, which limits the scope of the process to a single flight. To improve the efficiency of the process, the MTH considers batch processing, meaning that decisions regarding strategic deconfliction must consider multiple flights and find an efficient solution that minimises the overall impact. This batch-based approach shall not only prevent overlaps between U-plans (above a given threshold) but also enable the optimisation of system-level variables, such as maximum airspace occupancy, compliance with noise constraints, and the assurance that the total impact applied to a given operator remains within an acceptable threshold. Optimisation algorithms address the mitigation of conflicts among U-plans by maximizing/minimizing the value of the selected system variables.

Selection of the system-level optimisation objective, including whether the objective should prioritise capacity, noise, efficiency, or a multi-objective combination of both. This also entails defining whether individual USSPs may generate solutions based on their own optimisation criteria, and the extent to which operators' preferences should be incorporated into this process. Alternatively, the optimisation objective may be centrally defined by the U-space airspace governance (and made available as common information) to ensure consistency, uniform application, and operational coherence across all USSPs operating within the designated U-space airspace. Batch processing allows the distribution of the impact among different airspace users, producing 'fairer' results than other binary schemes such as FCFS.

It shall be necessary to define how such batch-based deconfliction is to be implemented in a multi-USSP environment, including the interoperability requirements, safeguards, and data-exchange mechanisms that enable the Collaborative Decision Making (CDM) process to function effectively.

5.4.4.4 In-flight Traffic Synchronisation

In-flight TS manages plan updates during flight execution, leveraging the progressive reduction of uncertainty. The in-flight TS functions are not considered part of separation provision. It is expected that USSPs provide advisory guidance to operators regarding potential modifications of the planned 4D trajectory (and thus, of the U-plan) to resolve potential conflicts well in advance.

After take-off, operators send a U-plan update message with reduced temporal uncertainties (as detailed in Section 5.4.5.5, the take-off time uncertainty reduces to zero once in flight). Then, the updated U-plan is rechecked against other potentially overlapping U-plans. The more accurate timing information enables a more precise conflict prediction. If a conflict is still predicted, in-flight TS applies corrective measures with enough anticipation (i.e. before aircraft are considered to be 'in proximity'), such as minor speed adjustments (e.g., a 5% ground speed change). This approach is conceptually similar to Medium-Term Conflict Detection (MTCD) as currently applied by air traffic controllers, although in the U-space concept this remains part of SCM rather than separation provision.

In the case of longer flights, where the final legs of the flight may be subject to high temporal uncertainty, periodic U-plan update messages can progressively reduce the uncertainty, allowing USSPs to periodically re-check for potential conflicts with higher confidence, triggering corrective actions (as above) whenever necessary.

To ensure the effective utilisation of these functions, appropriate 4D navigation capabilities are necessary, so that the predicted 4D trajectories are accurate, and there is high confidence that the aircraft will follow the planned path.

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5.4.5 Airspace user operations

The evolution of U-space in the MTH should be driven by two complementary objectives: increasing the flexibility available to operators and improving the overall efficiency of airspace use. Achieving these objectives will require a more dynamic interaction between operators and U-space services, allowing flight intentions to be expressed, updated, and managed in a way that better reflects operational needs and changing circumstances.

From a flexibility perspective, the management of U-plans is expected to become significantly more dynamic than in the STH. Operators will need greater visibility of existing and predicted airspace demand, as well as enhanced capabilities to adapt their plans before and during flight. Mission planning will therefore evolve from the current “fire-and-forget” paradigm towards a collaborative process, where operators and U-space service providers continuously exchange information and participate in collaborative decision-making to optimise operations.

At the same time, U-space must become more efficient in its ability to accommodate a larger number and wider variety of airspace users. The MTH is expected to see the integration of VCA operations, introducing new operational requirements and constraints, such as the use of vertiports. Beyond VCA traffic, an open question is the extent to which certain categories of manned aviation could also become recipients of U-space services, for example, VFR flights operating in uncontrolled airspace or aircraft operating under Digital Flight Rules (DFR).

Supporting this more diverse and denser operational environment will require both the U-space framework and the aircraft themselves to evolve. U-space services must be capable of accommodating different aircraft characteristics, performance capabilities, and operational needs. In parallel, aircraft will need to comply with specific equipage and performance requirements, such as electronic conspicuity, digital communication capabilities, 4D trajectory management, and appropriate Detect-and-Avoid (DAA) functions.

5.4.5.1 Awareness of the level of demand to support flight planning

Currently, UAS operators submit U-Plan requests without knowing the expected level of airspace occupation. This reflects the operational approach envisaged for the STH, where current traffic levels allow operators to plan with limited awareness of competing demand. However, this lack of information can lead to unnecessary deconfliction actions and inefficient use of the available airspace. As U-space evolves towards the MTH, higher traffic densities are expected to increase competition for airspace resources, making strategic planning progressively more challenging.

To support efficient operations, operators should have access to a minimum level of information regarding expected airspace demand before submitting a U-Plan request. This information could combine historical data, providing insight into typical demand patterns for specific locations and time periods, with real-time indicators of airspace occupancy and capacity utilisation. Although the nature of conflict management is expected to evolve from the STH to the MTH, such information would be valuable under both deconfliction schemes, helping operators to assess the feasibility of their intended operations and adapt their flight plans accordingly.

To preserve operational confidentiality, the information should be provided in an aggregated and anonymised form, indicating the expected availability of airspace rather than the details of individual operations. High-level metrics, such as occupied areas, capacity utilisation, or congestion, would support better planning decisions, reduce unnecessary deconfliction and iterative replanning, and contribute to a more efficient use of airspace.

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5.4.5.2 Include user preferences in the 4D trajectory

To support the deconfliction process in a fair and efficient manner, U-Plans should allow operators to express their operational preferences and constraints as part of the submitted 4D trajectory. Rather than treating a flight plan as a rigid object, different levels of flexibility could be associated with different parts of the operation. This capability is expected to become increasingly important in the MTH, where higher traffic densities will lead to a greater number of interactions between competing U-Plan requests.

Current conflict management approaches assume that all elements of a trajectory have the same operational importance. As a result, when conflicts arise, alternative routes or schedules may not adequately reflect the operator's mission objectives. Allowing operators to declare their preferences would enable the deconfliction process to distinguish between critical and negotiable aspects of a flight. Such preferences could describe both temporal flexibilities, such as acceptable departure windows, and geographical flexibility, including tolerances for route, altitude, speed, or timing modifications along different flight segments.

By explicitly representing operational preferences within the U-Plan, conflict management processes could generate solutions that better preserve mission intent while making more efficient use of the available airspace. This approach would improve the fairness and effectiveness of airspace allocation, reduce unnecessary rejections and replanning cycles, and support the advanced conflict management techniques envisaged in the MTH.

5.4.5.3 Continuous U-Plan Feedback

The FCFS framework envisaged for the STH provides operators with a high degree of certainty that an accepted U-Plan will be executed as approved. In the MTH, however, more advanced Strategic Conflict Management (SCM) mechanisms are expected to increase the dynamic nature of airspace allocation, making it more likely that accepted U-Plans may be adjusted before activation to accommodate changing traffic conditions.

This evolution requires a more fluid interaction between operators and the U-space ecosystem. Operators should be able to monitor the status of their accepted U-Plans at any time, understand the differences with respect to the originally requested operation, and receive indications of the likelihood of future changes. Such continuous feedback naturally complements other MTH capabilities, including awareness of expected airspace demand, the declaration of operational preferences and constraints, and trajectory-centric flight management. Together, these mechanisms support a more collaborative and adaptive approach to conflict management, improving planning efficiency while preserving operator confidence in the U-space system.

5.4.5.4 Trajectory-based U-plans

Advanced conflict management mechanisms envisaged for the MTH require a richer description of intended operations than is currently available. Efficient deconfliction depends not only on identifying the airspace that may be occupied but also on understanding the planned 4D trajectory and its associated operational characteristics. While the current regulatory framework, based primarily on operational volumes, provides an appropriate solution for the STH, it offers limited support for the more sophisticated conflict management techniques expected in the MTH. As U-space evolves, U-Plans should progressively transition towards a trajectory-centric approach, where the intended 4D trajectory becomes the primary representation of airspace demand.

Such an evolution should be consistent with broader ATM developments. Aircraft capabilities should support the accurate execution of user-preferred trajectories, enabling advanced deconfliction while improving airspace efficiency. This naturally aligns the evolution of U-space with concepts such as Trajectory Based Operations (TBO) and Flight and Flow Information for a Collaborative Environment (FF-ICE), facilitating the long-term integration of U-space and conventional ATM. In the interests of commonality with ATM, the U-

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plan may be expressed using FF-ICE and the volume occupied by the aircraft estimated from the linear trajectory, and a required navigational performance figure for the U-space airspace.

5.4.5.5 Dynamic Uncertainty Management and U-plan Adherence

In the STH, strategic conflict management relies on conservative assumptions regarding the uncertainty associated with U-Plans. Protection buffers are introduced on top of the natural uncertainties associated with the departure time, navigation performance, and flight execution, ensuring that strategic conflicts are avoided. While this approach provides a robust safety strategy, it also reserves a significant amount of airspace capacity that may never actually be used, limiting the scalability of U-space airspace.

The MTH scope provides the opportunity to manage uncertainty in a more dynamic and risk-informed manner. Rather than assuming worst-case conditions throughout the entire flight, uncertainty can be progressively reassessed as the operation evolves. For example, uncertainty associated with departure time largely disappears once the aircraft takes off, releasing previously reserved capacity that may be allocated to other operations. Likewise, the availability of tactical conflict management capabilities reduces the need for overly conservative strategic protections. Rather than treating every interaction between protection buffers as an unacceptable conflict, advanced deconfliction mechanisms may consider the geometry, duration, and probability of potential interactions. Short-lived or low-probability overlaps may be operationally acceptable, particularly when additional tactical safety barriers are available, whereas persistent or higher-risk interactions would continue to require strategic resolution.

This dynamic approach also changes the interpretation of U-Plan conformance. Small deviations from the planned trajectory, whether caused by normal operational variability or recoverable contingencies, should not necessarily be treated as breaches requiring immediate replanning. As long as the operation can safely return to the intended trajectory and maintain an acceptable level of safety, these deviations may be managed through tactical mechanisms without modifying the original U-Plan. Only when the flight can no longer achieve its planned objectives or timing constraints would a revision of the U-Plan become necessary. By continuously reassessing uncertainty and the associated level of risk throughout the flight lifecycle, the MTH can improve airspace utilisation while maintaining the required level of operational safety.

5.4.5.6 Advanced Planning Feature - U-plans crossing multiple U-space airspaces

As the number of U-space airspaces increases, future operations are expected to involve flights that cross several U-space service areas, potentially managed by different USSPs. In addition, operations may temporarily leave U-space airspace altogether before re-entering either the same or another U-space airspace. Consequently, the management of U-plans spanning multiple service areas will become an increasingly important aspect of Mid-term Horizon (MTH) operations.

One possible approach is to consider these transitions as operational discontinuities. Under this view, a U-plan could enter a "suspended" state when the aircraft leaves U-space airspace and later return to an "active" state upon re-entry. During the suspended period, the provision of certain U-space services, such as network identification or conformance monitoring, could be interrupted until the aircraft requests reactivation. This approach is conceptually close to the way trajectory continuity is managed in TBO and FF-ICE, where temporary discontinuities may arise during planning and tactical phases and are progressively resolved through negotiation and trajectory updates.

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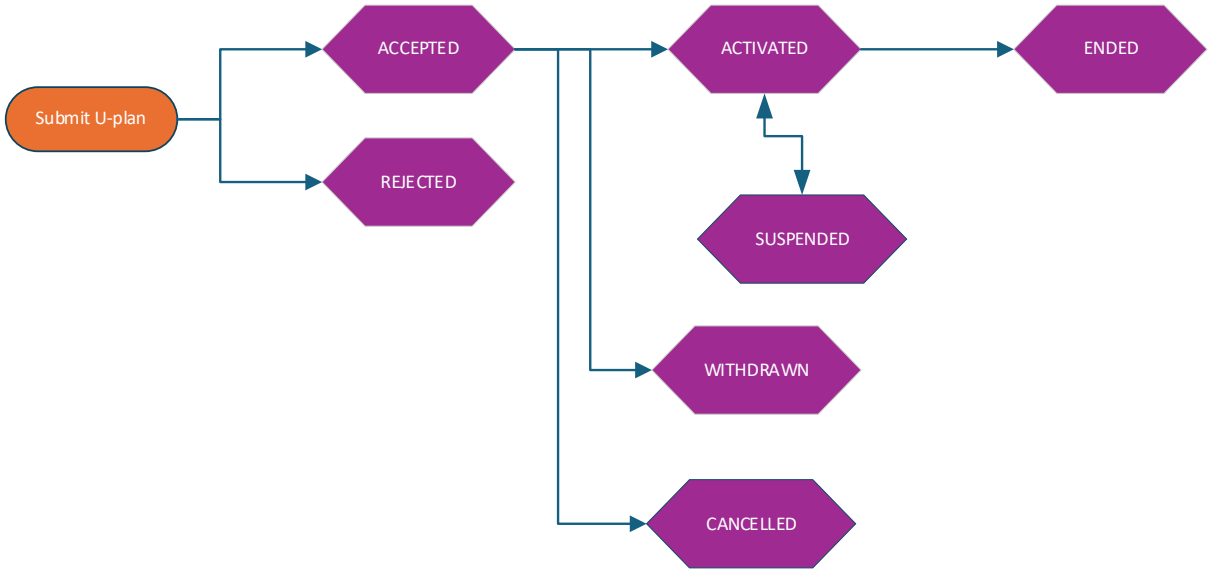


Figure 13 States of a U-plan that can exit U-space

An alternative perspective is to distinguish between the continuity of the flight itself and the continuity of the services supporting that flight. From the operator's viewpoint, the mission remains a single continuous operation, represented by a single U-plan covering the complete trajectory from departure to destination, irrespective of the number of U-space airspaces or non-U-space segments crossed during the flight. In this sense, the trajectory itself does not exhibit operational discontinuities; only the provision of U-space services may start, stop, or transfer between different providers.

This second approach is conceptually similar to the Flight Object used in European ATM. A single trajectory is maintained for the entire flight, while different service providers are responsible for managing the portions that fall within their respective areas of responsibility. Applied to U-space, a drone operator could submit a single U-plan to the relevant USSP(s), which then identify and process only those segments that lie within their operational domains. This allocation could be performed implicitly, based on predefined service areas, or explicitly, by allowing the operator to identify the intended transfer points between service providers. In either case, the partitioning of responsibilities would not require splitting the U-plan into independent operational entities.

Such an approach would transfer much of the complexity from the operator to the service architecture. The operator would remain responsible for obtaining all the necessary authorisations associated with the complete mission, potentially by submitting the same U-plan to multiple USSPs and consolidating their responses. Situations in which authorisation is granted for some segments but denied for others would require additional coordination and decision-making by the operator but would not invalidate the concept of a single mission-level U-plan.

Both approaches present advantages and challenges. The discontinuity-based model naturally extends certain TBO and FF-ICE concepts, including shadow trajectories, transition points, and collaborative negotiation mechanisms. The Flight Object-inspired approach emphasises trajectory continuity and operator simplicity while treating changes in service provision as implementation details of the underlying U-space architecture.

Further investigation is required to determine which of these paradigms, or which combination of them, provides the most effective balance between operational simplicity, scalability, interoperability, and compatibility with future ATM and U-space integration concepts.

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5.4.6 Conflict management

Conflict management in the medium term must manage traffic with different performance – size, speed, turn rate, etc. This heterogeneous traffic will include UAS as today and new users such as VCA, more manned traffic and even remotely piloted adaptations of manned aircraft. The conflict mitigation strategy must be proportional to risk and make use of different tools according to the needs for each airspace.

5.4.6.1 Strategic Deconfliction in MTH

Strategic Deconfliction is part of the Flight Authorisation Service.

In the U-space Y, Deviation Thresholds are added to the U-plan before strategic deconfliction. This "buffer" gives some margin for differences between the planned flight and the executed flight. Tactical separation in Y is an exceptional event.

In U-space Z, Tactical Conflict Management is much more prominent. A separation service is provided. The uncertainty buffers of U-space Y can be replaced by actions during the flight. Because of this, U-plans are deconflicted without the addition of Deviation Thresholds. While strategic deconfliction requires that U-plans cannot intersect, they can be immediately adjacent to each other. Deviation Thresholds still have a role in other services such as conformance monitoring.

More flexible strategic deconfliction is expected in the Medium Term compared to the Short Term. In order to efficiently accommodate larger densities of traffic, strategic deconfliction processes must evolve. Possible approaches to be explored include:

5.4.6.1.1 Improve the definition of the plan.

Methods to describe more accurate 4D volumes that better predict and represent the trajectory. One particularly interesting approach is explored in [51]. The line string-based representation provides the same performance efficiency-wise as using infinite 4D volumes (for deconfliction) but at a fraction of the computational cost. However, to use this model, U-space needs to switch from the current definition of the plan that explicitly uses 4D volumes as an approximate representation for a 4D trajectory and instead use a new definition based on the actual 4D trajectory, towards transitioning to full integration with TBO or similar (e.g. FANS).

5.4.6.1.2 Use different models for conflict detection

There should be a comparison of numerical vs analytical methods. The current approach of detecting overlapping volumes can become quite compute-intensive as the number of flights increases and the size of distinct volumes decreases.

5.4.6.1.3 Make use of additional strategic conflict management options.

These are explored in the other GATMOC components in this ConOps but can be briefly referenced here:

- Airspace structures (part of AOM) are put in place to minimise the interaction between traffic with different performance characteristics (e.g. a typical passenger-carrying VCA and a low-cost UAS). It is important to note that this is not segregation. Airspace structures must be porous (i.e. allow traffic to cross) but should allow for a limitation in risk exposure to be mitigated with appropriate tactical means. Examples can be the high-performance layer (HPL) or corridors linking vertiports to the HPL.
- Advanced DCB.
- In-flight traffic synchronisation. A measure akin to MTCD used by controllers today, which can be used to modify active U-plans long before a conflict happens.

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5.4.6.2 Tactical conflict mitigations.

To safely manage larger densities of traffic, more robust tactical mitigations are needed. Separation provision must be reinforced. There are two main possibilities, each with its own pros and cons:

- **USSP as separator – U-space Z**: will require effective coordination means, additional liability, new certification, etc.
- **UAS operator as separator – U-space X and Y**: will require advanced DAA capabilities (see below). This option keeps responsibilities at a very similar level as in the STH, meaning the impact on USSP certification and liability is smaller.

Two open questions about separation are: 1) whether a (tactical) separation provision can be reliably provided in a distributed system (multiple actors are separators). 2) at which level of required assurance it becomes no longer feasible to have a distributed system providing (tactical) separation.

Hence there may be a third possibility which relies on ATC-like systems in which a single entity is providing separation for all users in a given airspace volume. In principle, this is not the goal for U-space, but it is perhaps worth mentioning.

Adherence to the U-plan may be less strict in the MTH, as we now have tactical means to mitigate residual risk (as opposed to the STH where strategic deconflictions are the primary means and leaving the plans means unacceptable risk). Due to the nature of the aircraft involved, resolutions may not be limited to horizontal changes but also speed and vertical

5.4.6.3 Advanced detect and avoid capabilities

DAA capabilities with automation in key functions (e.g. levels 3-4) will be necessary to support at-scale operations (e.g. typical case of a small team of 1-3 operation supervisors managing a fleet of hundreds of aircraft)

RWC by airspace users should be supported by advanced DAA systems when required. These systems' collision avoidance capabilities, independent of U-space service provision, can be required as a safety net to accommodate high-risk airspace users.

An open question is the level of assurance/certification that would be necessary for these DAA systems, especially for low-performance and low-risk operations. Perhaps not at the level of current certified aviation for most cases, but a minimum will be necessary to enable integration with high-risk flights (i.e. ensuring the risk posed by small UAS to passenger-carrying VCA is manageable).

5.4.6.4 Enhanced surveillance

No matter if the separator is the USSP or operators, higher performance – higher traffic density, reduced separation – means that **tracking** will be necessary for the separator to act on the prediction of the current location rather than acting on data describing a reported past location.

In addition, to ensure a common altitude reference for the separator (USSPs or operators), vertical positioning data referring to barometric measurements are converted to geometric references before being provided to the separators. This is the vertical conversion as identified by ICARUS [42].

5.4.6.5 An initial set of right-of-way (or similar) rules will be necessary

If USSPs are separators, we need a common set of rules so that USSPs always find the same solution in the same scenario (deterministic). Having a distributed system respond to a tactical situation with limited reaction time will not allow for extensive discussion/negotiation among USSPs. Instead, a deterministic

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model is preferred. [note: a lot can be taken from BUBBLES' separation management service, which defines the rules for USSPs to follow in deconflicting].

If UAS operators are separators, it is still a similar picture. DAA systems will have to be interoperable and lean on the same set of common rules for conducting well-clear or avoidance manoeuvres.

5.4.7 Service delivery management

In the short term, SDM was focused on single operation management where each USSP checks a U-plan against everything it knows from the CIS and peer USSPs. The MTH changes the scale of the problem: Multiple USSPs, UAOs and the first VCA/manned participants need their actions reconciled against each other in multiple categories of airspace and U-space airspace (X/Y/Z).

5.4.7.1 Federation

SDM ensures the system operates as a coherent system capable of balancing and consolidating decisions, behaving as a single system from the airspace user's perspective, even though no single entity holds all the information. The MTH changes the scale of the problem in four ways that need careful consideration.

- multiple USSPs operating concurrently in shared airspace
- multiple categories of U-space airspace (X/Y/Z) with differing service obligations
- the introduction of the Separation Service, which shifts separation responsibility from the operator to the USSP
- the arrival of vertiports and the first regular VCA operations, which couple airspace decisions to ground constraints.

While the federated model supports resilience and redundancy arguments, architecting common CDM processes requires every USSP in shared U-space to participate and expose a minimum common information to its peers. Additional requirements include

- Common responsibilities to publish information considered necessary by consensus.
- Decisions and rules to include priority principles, DCB measures and separation rules to allow USSPs to reach decisions without reverting to negotiations. Simply put, a user should be able to predict the outcome using the system.
- Service equivalence within a given airspace category means an operator's experience of what is authorised, based on which terms and any priority is needed, should not vary by choice of USSP. This could be the criterion for a practical test of whether SDM is working.

While federation in the STH is acceptable, it should be noted that bilateral integration across n providers grows quadratically, creating scalability issues in the MTH. e.g., if every USSP has to connect directly to every other USSP to exchange U-plan status, intent and conformance data, the number of connections is $n(n-1)/2$, growing with the square of the number of providers.

If instead the USSPs build one interface that publishes to and subscribes from a common set of described services, each provider does one integration regardless of how many others exist. The total grows in a straight line with n. The SWIM mechanism that makes this achievable includes discoverable, registry-published information services with standardised descriptions, so that a USSP can meet its federation duty by publishing a described service rather than negotiating a bespoke integration with every counterpart.

In the STH, USSPs are negotiating and building custom integrations with national CISPs before they can operate. CISPs may decline, delay or price the integration efforts, creating structural barriers to Market Entry. Under a standardised EU registry model, a new entrant builds one interface against a published standard and is interoperable on day one.

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A bilateral connection degrades unevenly if the link between two particular USSPs fails, as they may have an inconsistent view of the airspace. A publication model degrades more visibly and more uniformly, because a provider that stops publishing is detectable by every consumer rather than by one counterpart.

5.4.7.2 Collaboration

CDM in the STH rests on a single regulatory obligation and a single information mechanism. IR (EU) 2021/664 Article 10(6) requires USSPs to establish proper arrangements to resolve conflicting UAS flight authorisation requests received from different USSPs. The mechanism is U-plan sharing: a USSP can only accept or activate an authorisation if the U-plan is free of intersection with other accepted or active authorisations of equal or higher priority, and those may be held by any USSP, so USSPs must collaborate to discover conflicts. USSPs are simultaneously competitors and collaborators. Each manages only the flights it has authorised but depends on information from other USSPs and from CIS to do so. This limited form of CDM works in the STH because the decisions are strategic, pre-flight, and reversible. CDM in the MTH cannot be a USSP-only process and will have to include ATSP, Vertiport managers and UAS/VCA operators.

This model is structurally weak for the short term due to the introduction of separation services, which introduces decisions that are tactical, time-critical and non-reversible. U-space X/Y/Z means the participants in a given decision may be operating under different separation responsibilities. And vertiports introduce ground constraints that bind airspace decisions, owned by a party that is not a USSP at all. Thus, CDM in the medium term operates in two distinct modes: a deliberative mode for strategic and pre-tactical decisions (DCB measures, U-plan deconfliction, vertiport slot allocation) and a deterministic mode for tactical decisions, where the collaboration consists of having agreed the rules in advance and sharing the data they operate on.

Compared to the STH, the Medium term includes new aircraft such as VCA, even manned. Liability will necessarily be shared as all stakeholders play a relevant role, whether in providing information or acting based on the available information.

Where more than one USSP serves a given U-space airspace, the USSP that has authorised a flight retains decision authority over it but must resolve conflicts and coordinate separation with the USSPs managing the other involved operations. This mirrors the short-term non-conformance alert chain but now applied to tactical separation, not just strategic deconfliction. Roles and liability follow the party issuing the instruction: a USSP issuing a resolution manoeuvre is accountable for that instruction’s safety; the operator remains accountable for its execution. CDM decision processes (who resolves what, and when) are kept distinct from execution (who flies the resolution), so that liability can be traced.

The MTH alert chain resulting from Tactical conflict detection predicts conflicts from traffic information plus intent, weather, aircraft performance, and airspace structure, and tactical conflict resolution proposes trajectory or motion-vector changes, with the resolution coordinated between the USSPs and operators involved where feasible.

- Detection. A USSP's tactical conflict detection predicts a conflict. It may involve flights it authorised, flights authorised by peers, manned traffic notified by ATS, or a non-conforming flight. The detecting USSP is not necessarily the USSP of any involved flight.
- Publication of the prediction. The prediction is published to the shared picture rather than sent point-to-point, so every USSP with an involved or nearby flight learns of it in one step.
- Determination of the resolution. Each involved USSP applies the common rule set to the shared data. Because the rules are deterministic, they converge on the same resolution without an exchange. Where time permits (strategic or pre-tactical conflicts), a deliberative coordination step may substitute.
- Issue of the instruction. Each involved USSP issues the resolution to the operator it authorised. The instruction travels one step, from the responsible USSP to its own operator and is never relayed through

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a peer. The USSP issuing the instruction is accountable for it, while the operator is accountable for executing it.

- Publication of the mitigation. The accepted resolution and the resulting revised intent are published back to the shared picture, so that other USSPs' conflict detection operates on post-resolution trajectories rather than the original ones. Without this step, peer USSPs continue predicting against stale intent and may generate cascading secondary alerts, a failure mode worth naming explicitly in the text.
- Proximity advisory. Operators not party to the resolution but nearby are alerted by their own USSPs, in the STH pattern. This is advisory, not instructional, and its latency budget is correspondingly relaxed. The role of aircraft operator.

Determining whether USSP services should feed data directly to aircraft or remain an operator-level issue is an open mid-term question. The SPATION project has developed SESAR Solution 0461: “Tactical conflict prediction, resolution and implementation with onboard extension” which is proposing that in some cases separation instructions should go directly to the aircraft for automatic execution.

In the MTH, the default remains that USSPs deliver instructions to the operator, who retains responsibility for execution consistent with the STH. Direct-to-aircraft delivery (bypassing the operator, as explored in SESAR Solution 0461: “Tactical conflict prediction, resolution and implementation with onboard extension”) is treated as an emerging option for specific, tightly bounded use cases e.g. automated resolution manoeuvres within U-space Z, where response time is critical rather than the default model, pending clarity on liability and certification implications.

5.4.8 Information services

The architecture governing future information exchanges builds upon established SWIM principles, incorporating an interoperable framework split across information exchange services, exchange models, and technical infrastructure. Information exchanges are characterised across three core dimensions: the specific information type, the required performance level, and the operational actor role. This will allow data models, such as Flight Information Exchange Model (FIXM) and Aeronautical Information Exchange Model (AIXM), to evolve, ensuring global cohesion while accommodating rapid technological advancements.

CIS is expanded to include additional information, such as

- Common rules / principles to be followed for separation provision (applicable both to RWC by UAS operators and a separation provision service by USSPs)
- Vertiport Information
- QNH and similar reference information.

In the short term, the Common Information Service (CIS) functions as a single, largely undifferentiated pool of data that USSPs consume. As the number of USSPs, U-space airspace categories, and data domains grows in the MTH, this model needs to evolve from one service into a family of discoverable services consistent with the SWIM architecture that ICAO Doc 10039 [52] and PANS-IM (Doc 10199) [53] define for the wider ATM system, of which U-space/UTM is a part.

Clearly, accommodating U-space services into the SWIM approach will require updates to the governance, interoperability and software elements of the SWIM Technical Infrastructure to allow hosting, communication and consumption of information services over an IP-based network. Elements that will have to be updated include services, service exchanges for unmanned systems, information discoverability and use of open standards. Interoperability will necessitate extending the European Aeronautical Information Reference Model (AIRM) before technical interoperability consensus is achieved on exchange models such as FIXM.

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U-plan evolution

Given ICAO's objective is for all ANSPs to have moved to electronic FPLs (eFPL) by 2034, there will be a need to evolve and transition U-plan taking advantage of FIXM's layered structure. The core of FIXM contains

- Basic flight data that is globally applicable and endorsed by a Configuration Control Board.
- FF-ICE application layer sits above the core and governs context-specific messaging structures (such as filing, planning and notification message formats) required to execute specific FF-ICE operational workflows.
- Extensions support localised requirements from particular communities of interest, enabling extension of basic flight data and/or applications.

Today, regional extensions already exist in practice; e.g. EUROCONTROL's Network Manager extension covers European specificities, and there is a US extension. A U-space/UTM community of interest is necessary to enable the U-plan evolution.

Flight plan identity as the reconciliation mechanism will necessitate that the U-space/UTM interest group develop alignment between SWIM's Globally Unique Flight Identifier (GUFI) as a single reference and the U-plan identifiers used. U-space permits version 4 (randomly generated) and version 5 (namespace/name-based with a hashed value) of the Universally Unique Identifiers (UUIDs) for flight authorisations.

FF-ICE/R1, which has to be implemented by 2034, covers the pre-departure phase only. In-flight revision and updates map to FF-ICE/R2, which can only be available in the longer term, given it requires adoption of R1 and there are no implementation dates yet.

The gap between U-plan and eFPL is not small and requires assessment. For example, the content of a U-plan does not include a command pilot on board, DAA/RWC capability, non-ICAO vertiports or a mission- maybe an area operation with no trajectory. This technical mismatch may be overcome by extending FIXM with extra fields, however, it will require attention. However, there is a divergence risk in that with each year the cost of convergence rises.

From CIS to discoverable information services integrated with ATM

Rather than a separate CIS, information in the medium term should be organised as a set of individually described registry-discoverable Information Services aligning with SWIM's definition of an information service being a type of service in a service-oriented architecture that provides an ATM information sharing capability. Each USSP, CISP, or other provider publishes a standard service description for the data it holds, allowing any authorised consumer to discover and subscribe to it without a bespoke point-to-point integration. This is the mechanism that makes the federation obligation described in section 5.4.7.1 practically achievable, meaning a CIS or USSP can expose the minimum common data set to its peers via a described, discoverable service rather than a custom interface per counterpart. Ultimately, the goal would be to achieve a common AIS, flight information, meteorological and traffic information Service. Common in this case refers to the pooling of information in a service with discovery and registry allowing role-based access. Common doesn't mean a centralised service provider. Instead, information is contributed by multiple service providers.

Publish/subscribe as the standard exchange pattern

The Network Identification and Traffic Information sharing described in the STH (section 4.3.7) extends in the MTH to cover Separation Service coordination and vertiport status. This may be best supported by a publish/subscribe exchange pattern, i.e. a provider publishes updates once, and every authorised subscriber (other USSPs, vertiport managers, ATSPs) receives them without the provider needing to know who all its consumers are in advance. This scales far better than the STH's implicit model of direct USSP-to-USSP notification as the number of participants grows.

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New information domains

The scope of exchanged information should be expanded to include:

- Common rules and principles for separation provision (applicable both to Remain Well Clear by UAS operators and to a separation provision service delivered by USSPs)
- Vertiport information (status, capacity, scheduling constraints)
- Standardising weather information and other environmental information.

None of these yet has a standard exchange model equivalent to the FIXM/AIXM/IWXXM families used elsewhere in ATM and is flagged as an open standardisation need for the medium horizon. Specifically, a common U-space or UTM data model (or a UTM-specific extension to an existing ICAO model) has to be developed before these can be exposed as proper SWIM-aligned information services rather than proprietary formats.

Information security

The digital tokens and permissions introduced in Airspace access (section 5.3.1.2.3.3) intended to be verifiable but resistant to falsification should be grounded in the information security framework such as the PANS-IM, which defines for SWIM: an end-to-end, certificate-based, scalable approach to protecting information regardless of who is consuming it. Adopting this framework rather than a bespoke U-space security model keeps U-space's access-control mechanism interoperable with the wider ATM information environment from the outset.

5.5 U-space processes supported by increased digitalisation

The maturation of U-space services and processes in the medium-term will benefit from greater (machine-readable) digitalisation of regulatory (i.e. Regulation (EU) 2019/945 and Regulation (EU) 2019/947) and operational constraints which shape UAS operations, such as:

- **Digital CAA permissions which can be interpreted by U-space (Services):** Depending on the established preconditions for operating within a defined U-space, flights under the "open" UAS category may also be subject to prior CAA approval. Developing additional digital versions of permits and their constraints (in terms of permitted area of operation, maximum operating altitude, allowed UAS types, mitigation measures, permit validity periods, etc.) would also assist USSPs in meeting their requirement as per Article 10(2a) of the U-space regulation to check if the UAS flight authorisation request is complete and correct. This would require all authorities and actors which can limit UAS operations to follow a common format when issuing digital permissions.

- **UAS geographical Zones as airspace management tools for non-operational stakeholders and state operators:** Non-operational stakeholders of U-space (such as government agencies and local authorities), and state UAS operators (such as police or military) may impose additional restrictions on UAS operations within U-space in the form of static or dynamic UAS geographical zones issued within U-space airspace. By applying standardised use of UAS geographical zones conditional language (as provided by the ED-318 standard), USSPs can consider them directly as part of the flight authorisation and conformance monitoring processes, without the need for human interpretation. An example of this could be the issuance of a dynamic UAS geographical zone which only authorises state operations in a given area due to security requirements by the police, by identifying which UAS operation plans are submitted with the appropriate operator classification or flight purpose.

- **Higher fidelity UAS operation plans:** Operator metadata, 4D flight route, contingency scenarios, equipage, UAS limitations, etc.

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To achieve this level of digitalisation, adjustments to non-U-space regulations (i.e. Regulation (EU) 2019/945 and Regulation (EU) 2019/947) on UAS and standards (such as ED-318) may be necessary.

5.6 A Typical Medium Term Flight Example

The flight from section 4.2.1 is updated here to the Medium Term Horizon. This is a fictional example.

The UAS Operator (UASO) is one of a number of operators providing delivery services in and around a city. The UASO has a base on the edge of the city and is continuously flying in this region. The UASO has an approved operational authorisation for this type of operation in this region.

An order is received to deliver bananas to a house several kilometres from the base. The UASO accesses the Common Information Services and determines that the entire flight will be within one U-space airspace.

The UASO's system prepares a U-plan using geozone data provided by its USSP through a Geo-awareness service, and consults the forecast traffic using an unregulated forecasting service provided by its USSP. The UASO system (or an unregulated route planning service provided by the USSP) calculates a route that is acceptably efficient and likely to be conflict-free. A U-plan is generated that is consistent with the performance capabilities of the selected UA, and the flight duration is determined according to the intended speeds along the trajectory. The UASO's system uses a dedicated weather forecast service to obtain a forecast and see whether the UA can safely fly in those weather conditions.

The UASO uses an interface provided by its USSP to access the Flight Authorisation Service. A Flight Authorisation Request is created for the U-plan and submitted for automatic processing. The USSP coordinates with other USSPs to check that capacity is not exceeded and that there are no conflicts with already authorised flights. The USSP authorises the flight.

The ground crew of the UASO supervise the automatic loading of bananas onto the UA. The aircraft carries out pre-flight checks. The remote pilot system checks the aircraft systems and loads the U-plan into the aircraft's flight control system, and then, once within the activation time window, uses the USSP's Flight Authorisation service to request activation of the flight. The USSP makes a final check through CIS for Dynamic Airspace Restrictions, checks with the other USSPs to ensure there are no conflicts, and, if no issues are found, confirms the flight activation. Those checks are performed automatically. The UA takes off. The UASO's system starts sending position reports via NIS. The conformance monitoring service detects takeoff, and the USSP refines the U-plan in the FAS with the precise takeoff time. The USSP's separation service starts monitoring the flight for potential conflicts using the precise takeoff time and other traffic information service inputs. A risk of conflict is detected towards the end of the flight. The USSP sends a proposed updated U-plan to the UASO with a slight reduction in speed that reduces the conflict risk to an acceptable level. The UASO's flight management system determines that the delivery time is still acceptable and updates the plan in the aircraft avionics without warning the piloting team.

Through the U-space system, the flight is automatically connected to the USSP's Network Identification Service. The NIS allows the current position and motion of the flight to be updated frequently. During the operation, the UASO systems will monitor geo-awareness, network identification, traffic information and conformance to the U-plan. All these services are provided by the USSP.

During the flight, the USSP continuously checks, in an automated mode, that the UA flight is proceeding according to the approved U-plan using the CMS.

Once the bananas are delivered, the aircraft returns to base, and the flight is completed.

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The UASO informs the USSP through the Flight Authorisation Service that the flight has now ended. The connections to NIS, TIS, GAS, and CMS are terminated, and the flight data is recorded by the USSP.

In the countryside, the customer eats the banana.

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6 Long-term Horizon

In the long term, the distinction between U-space and ATM begins to dissolve as we move towards greater interoperability and integration of the digital service framework to support a greatly diverse range of airspace users and aircraft types than today. In this scenario, unmanned and manned aircraft are able to share low-altitude airspace supported by U-space services, without the restrictions in the previous horizons. A greater number of automated U-space services will support unmanned and manned users as part of the services framework. To baseline the viewpoint, it is helpful to provide assumptions and beliefs for this evolution.

- **Digital Bridge**. The U4 evolution of the U-space service framework acts to bridge the gap between U-space and ATM. It provides the sophisticated digital infrastructure required to link U-space protocols with legacy ATM systems, allowing for automated collaborative airspace management. It is expected that interoperability will be developed and fully standardised.
- **Diverse Users.** As the system moves to support the wide spectrum of powered aircraft types, it is difficult to envisage commercial delivery drones (<20kg) requiring regular access to airspace above VLL just as we don't expect large commercial traffic to operate differently from today's operations. The critical challenges of mixed operations occur in today's Class G airspace, where aircraft of different capabilities will co-exist, as well as the VCA that require access to controlled airspace. State operators will require knowledge of civil operations, while civil operators will require local knowledge of state training areas, live operations, as well as airspace constraints.
- **Airspace.** Manned aircraft transition from being visitors to regular participants. The operational restrictions and some of the segregations are removed with advanced U-space services and aircraft equipage that will allow some classes of aircraft traffic to co-exist. A wholesale change in airspace classifications is not expected; therefore, certain UAS/VCA operations will be able to routinely access Class C and D airports with the support of integrated U-space/ATM services.
- **Digital services** are still expected to provide timely, unified, machine-readable airspace constraints and Flexible airspace reconfigurations to users who will access this information through web and mobile applications used for managing the flight operation. There is expected to be a convergence between ATM and U-space. Digital services will increasingly be common to both. Aeronautical Information and Common Information converge in content and may be distributed through the same digital means.
- A **new Flight Rules** framework will have been established to govern unmanned, automated operations whilst the manned aircraft process the new rules automatically based on eligibility, service tiers and logic. Eligibility refers to which users are authorised or required to follow one or more digital rules. Tiered rules will be established to provide users options based on operation type and equipage, while the service logic provides standardised protocols for the interaction between operations.
- **Flight Plan Consistency.** The U-plan, representing a high-precision, 4D digital trajectory, will harmonise to become a new standard for a spectrum of aircraft. A critical requirement is the absolute consistency between the future U-plan and the traditional ICAO flight plan to facilitate strategic coordination. This ensures that a single flight can transition between zones without data loss or safety conflicts. Collaborative digital services are able to access and process manned or UAS flight plans to make decisions at a strategic or tactical level.
- **Conflict Management.** Strategic coordination of flight plans takes on significant importance in this horizon and includes the ability for in-flight checks of changing operational intents. Tactical conflict resolution will be supported using U-space services with onboard DAA systems and logic designed to be TCAS-aware, meaning the DAA logic is aware of TCAS resolution advisories, for example. Of

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course, rights of way will have to be updated to establish a new precedence hierarchy, with these updated responsibilities integrated directly into the automated conflict management services.

6.1 Assumptions

- **Shared Airspace** will mature with an interoperable U-space and ATM environment specifically at low altitudes. This system will rely on management by trajectory, using negotiated 4-D trajectories that are conflict-free and synchronised from start to end. Automated information management will ensure that the intent and position of manned or unmanned aircraft are known to the entire ATM community.
- **Collaborative Decision Making (CDM)** will serve as a bridge between U-space and the ATM community to transition towards a cooperative system by utilising the Information Services to balance the competing needs of airspace users while maintaining system safety and efficiency.
- **Conflict Management:** Safety in this horizon will be maintained through layered conflict management, prioritising strategic planning and electronic separation provision, using U-space services provided to both unmanned and manned systems, to minimise the need for tactical intervention.
- **Localised Management:** The focus is on managing flights within a specific U-space area rather than coordinating complex, system-wide interactions between U-spaces across large geographical regions.
- **In LTH, manned aircraft become regular users of U-space services**, without the restrictions in the previous horizons.
- Flight rules are a core element of the long-term horizon. New flight rules could cover aspects such as:
    - What airspace users can follow different flight rules
    - What services are provided to airspace users following different flight rules
    - How airspace users following different flight rules interact with each other
- In the long-term horizon, the U-plan becomes a possibility for manned aviation receiving U-space services.
    - The consistency between the future U-plan and the traditional ICAO flight plan should be assured.
- U4 services refer to
    - Digital services provided to airspace users, compatible with ICAO provisions
    - Digital services to interface with ATM

6.2 The core functions in U-space during the LTH

6.2.1 Airspace Organisation and Management

Tiered aircraft operations, meaning a class of automated UAS operations over built-up areas, remain separate from most users except for VCA and emergency service aircraft. Low altitude operations of helicopters are expected to interact with VCA operations and larger drones. When operating in rural areas or near aerodromes, the unified U-space service framework will support effective coordination.

Aerodrome traffic is also expected to segment based on airports supporting large commercial and military traffic for economic reasons, meaning certain controlled airspace classes (Class C, D and Class E) will remain. Lower airspace zones will be managed with dynamic reconfiguration facilitated by faster digital communications within the network, extending the AUSA concept of AURA [50] / ENSURE [47]

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Airspace organisation gradually transitions from layered or performance-based volumes into a single, adaptable architecture able to accommodate all types of aircraft, manned and unmanned, under harmonised **digital flight rules**. While performance requirements continue to exist, they are embedded within the flight rules and service levels rather than in permanent structural segmentation.

Airspace design becomes **service-oriented**, centred around system capabilities (e.g., trajectory management, advanced separation automation) rather than traditional classes or segregated zones. Only in remote or low-demand regions might unmanaged airspace persist, though even there basic electronic conspicuity and shared situational awareness remain expected.

Airspace management becomes **highly automated, predictive and continuously active**, relying on system-wide data sharing across all airspace users. Strategic and tactical functions are deeply integrated: boundaries and capacities are **reconfigured in real time** based on traffic flows; conditional or temporary structures are activated only when needed; equitable access is ensured through transparent, automated mechanisms.

- Safety assurance is supported by mandatory conformance monitoring and persistent electronic conspicuity.

The system orchestrates availability, demand and separation through **advanced automation** capable of forecasting and resolving complex interactions that exceed human cognitive limits. Human operators remain "on the loop", supervising operations and intervening only in non-nominal situations or exceptional cases.

6.2.2 Aerodrome operations

In the long-term horizon, aerodrome and vertiport operations reach a state of **high automation, seamless integration with U-space/ATM**, and coordinated management across networks of facilities. Routine surface and airborne processes are handled by **Vertiport Automation Systems (VAS)**, with human involvement shifting to supervisory roles and intervention only in exceptional or off-nominal conditions. This evolution from "human-in-the-loop" to **"human-on-the-loop"** reflects the maturity of automation and the need for consistent, scalable operations across dense VTOL and UAS environments.

Vertiports operate with **digital twins** that simulate and predict traffic flows, maintenance requirements, pad availability, energy loads, and adverse environmental conditions. This predictive layer allows both tactical and strategic optimisation: anticipating disruptions, reallocating resources, validating escape routes, and ensuring safe degraded-mode procedures before they are needed.

Operations scale from single-facility optimisation to **network-level coordination**. Vertiports participate in a **Network Collaborative Decision-Making (Network-CDM)** environment that manages shared scheduling, capacity balancing, real-time slot exchange, and dynamic rerouting across the network. **Remote or multi-site operations centres** replace local towers, supervising multiple vertiports and orchestrating overall flow efficiency. The "delta" is network-wide orchestration rather than local facility optimisation. This network-wide synchronisation supports equitable access, prioritisation for emergency missions, and optimised distribution of demand across the system.

6.2.3 Demand and capacity balancing

Within the U-space concept, Strategic Conflict Detection and Resolution (CDR) is one of the primary mechanisms for ensuring safety before any unmanned aircraft takes off. However, strategic deconfliction can only succeed if the mathematical and algorithmic complexity of the airspace remains manageable. This is precisely where Demand and Capacity Balancing (DCB) serves as the critical enabling layer. By actively managing air traffic flow before the activation phase, DCB inherently serves as a macro-level conflict-resolution tool. It prevents oversaturation by capping the total number of simultaneous operations in shared

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airspace, ensuring the airspace remains sparse enough for CDR algorithms to function efficiently. If the system predicts a spatial bottleneck, the DCB framework resolves the conflict by adjusting time slots or pathways well before individual trajectory conflicts trigger a localised CDR alert. This is especially crucial when the airspace volume is temporarily reconfigured by the authorities for any reason.

Building upon this need to manage both physical and digital capacity, DCB relies heavily on high-fidelity data to manage dense unmanned traffic. Traditional legacy airspace management systems introduce latency and uncertainty, forcing airspace managers to enact large, conservative separation buffers. By considering the operational domains as a harmonised framework, an Integrated Communication, Navigation, and Surveillance (ICNS) architecture currently fuses 4G/5G telemetry with established precision technologies – such as the Global Navigation Satellite System (GNSS) and Real-Time Kinematic (RTK) systems – to safely reduce those buffers. However, the long-term strategic vision is that next-generation 3GPP cellular technologies (xG) may eventually replace many of these standalone systems by delivering all CNS services through the exact same technology stack in an integrated manner. Until this fully xG-based integrated CNS replacement reaches the level of maturity and certification, a high-fidelity Air-to-Air surveillance layer should be supported by cooperative broadcasting technologies such as Automatic Dependent Surveillance-Broadcast (ADS-B), Automatic Dependent Surveillance-Light (ADS-L), and essential to UAS Remote Identification (Remote ID). Crucially, alongside physical air traffic density, the unified ICNS framework is expected to help the USSP actively monitor real-time network load and availability, e.g., via the Communication Coverage Information Service (CCIS). This enables the USSP to proactively apply DCB measures – such as restricting new UAS flight authorisations – if a local Terrestrial Base Station (TBS) cell approaches its data saturation point, preventing critical signal degradation before it occurs.

Even with robust strategic planning, when a DCB hotspot occurs tactically – such as a sudden airspace restriction or an unexpected weather event – a USSP must instantly issue simultaneous trajectory updates to multiple aircraft. An xG-based ICNS framework guarantees the ultra-low latency, high reliability and capacity required for these complex, multi-agent re-routings to succeed. However, resolving capacity bottlenecks in dense urban areas often requires shifting traffic into adjacent sectors, which risks creating secondary data congestion. To maintain safety during these tactical manoeuvres, 3GPP xG-based hybrid network architecture utilises Non-Terrestrial Network (NTN), especially Satellite Communications (SATCOM), to help offload traffic from the Terrestrial Network (TN), reducing congestion during peak hours. Furthermore, to prevent a single point of failure during extreme network stress, the aircraft systems currently rely on redundancy. If external signals are jammed or degraded in urban canyons, aircraft may navigate and maintain safe separation using onboard Simultaneous Localisation and Mapping or Inertial Navigation Systems. Simultaneously, backup data links via the L-band Digital Aeronautical Communications System or traditional Industrial, Scientific, and Medical radio bands ensure the Command and Control (C2) link survives. While legacy Primary Surveillance Radar struggles to detect small plastic airframes due to their low Radar Cross Section, the system can rely on specialised 3D holographic, Active Electronically Scanned Array, or passive radars. Furthermore, the transition to Integrated Sensing and Communications allows the 5G/6G network to dynamically switch between sensing topologies to maintain continuous surveillance. In dense U-space environments, the network utilises Multistatic Sensing, applying Multilateration (MLAT) techniques to process signals from multiple base stations simultaneously for high-precision 3D localisation. Conversely, in areas with sparse infrastructure, a single base station can revert to Monostatic Sensing, utilising Angle of Arrival and Time of Flight data to function as a standalone radar. This hybrid capability ensures that non-cooperative drones remain visible to the U-space Service Provider (USSP) even when traditional triangulation geometries are unavailable.

Ultimately, the evolution towards 5G Advanced, 6G, and further towards xG networks aims to phase out heavy and fragmented legacy redundancies. By combining and harmonising the CNS domains into a single system, a mature ICNS architecture powered by 3GPP xG will eventually eliminate the need for multiple onboard hardware devices entirely while maintaining vital redundancy using TN and NTN within the same

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architecture. This transition to a single, cost-effective integrated solution ensures vital service continuity for autonomous BVLOS operations even at absolute capacity, without the payload penalties of legacy systems.

6.2.4 Traffic synchronisation

Continuous sharing of intent is the key to improving traffic synchronisation. Aircraft and ground systems will form a network that allows sharing of intent and navigational performance. Synchronisation will converge with conflict management. Both will be a continuous process of checking for conflict, updating the trajectory and resharing the trajectory.

Protocols will be needed to prevent stalemate or gross inefficiency and to ensure fairness.

The necessary privacy can be assured by use of an agreed protocol. ASTM F3548 is one approach and might be further developed. Key to such protocols is agreeing the access conditions; for example, commercial aircraft operators may want to share the minimum with their competitors while states want to have a clear view of the operations in their sovereign airspace. State operations may be more secret than commercial ones, etc. There then needs to be some governance model that all participants trust that can operate the system and fund any necessary infrastructure.

Intent sharing may also be limited because the flight has no known intent, for example, a police flight following a stolen car. Such flights might be given a circular buffer around them with a radius of a few minutes of flight. This could then be continuously revised as the aircraft moves. In principle, as long as such flights are a small minority, their impact may be acceptable.

Digital Flight Rules are likely to appear to allow UAS to operate without requiring them to fly IFR. DFR may involve continuous intent sharing, as this would offer advantages over simply being electronically visible.

In this environment, the trajectory will evolve from being a plan that is authorised into a living digital object that is continuously negotiated and refined throughout its lifecycle. As execution approaches, traffic synchronisation will progressively refine the agreed trajectory. At longer planning horizons, synchronisation may rely on relatively coarse measures, such as capacity management, significant temporal shifts or route changes. As uncertainty decreases and increasingly accurate intent and performance information becomes available, finer-grained and less disruptive measures can be applied, including minor adjustments to timing, speed or trajectory. In the long-term horizon, the concept of a fixed RTTA may therefore evolve towards a more continuous, time-dependent process, in which the nature and granularity of the applicable measures depend on the time remaining to execution, the available information and the associated uncertainty. As execution gets closer, the scope for major changes would progressively decrease, while continuous intent sharing would enable increasingly fine adjustments, progressively blurring the boundary between traffic synchronisation and conflict management.

	TS measures
STH	Intent → deconflict → authorize → fly
MTH	Intent → wait/refine → RTTA → stabilise → update in flight
LTH	Intent → continously refine → execute → continuously refine

During flight execution, this continuous refinement process would benefit from increasingly accurate information on the aircraft state and capabilities. Improved navigation and tracking performance, together with a richer characterisation of aircraft performance, would provide a more precise understanding of the

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current aircraft state and its expected evolution. Combined with continuously shared flight intent, this information would enable increasingly accurate trajectory predictions and associated uncertainty estimates, feeding traffic synchronisation and conflict assessment to support trajectory refinement when necessary.

6.2.5 Airspace user operations

In the long-term timeframe, U-space is expected to have reached a significantly higher level of maturity, with established services supporting a broad range of commercial UAS operations. At the same time, the business models associated with these operations are expected to have matured, progressively increasing the number and frequency of flights and leading to a more intensive use of the available airspace. Under these conditions, the operational models used by UAS operators will necessarily evolve. Economic viability at scale will require not only higher levels of automation, but also a transformation of the way in which operational responsibilities are organised and distributed within UAS operating organisations.

One of the most significant changes is expected to concern the traditional one-to-one relationship between a remote pilot and an individual UAS. In large-scale operations, groups of operators are expected to supervise and manage fleets of UAS operating simultaneously over extensive geographical areas, potentially spanning different regions and the areas served by multiple U-space Service Providers (USSPs). Increasing levels of automation will allow individual operators to supervise multiple aircraft, while operational responsibilities may be dynamically distributed according to particular functions or geographical areas rather than assigning a single pilot to an aircraft for the complete duration of its flight. This evolution will require appropriate mechanisms to transfer operational responsibility between personnel or operational centres while maintaining an unambiguous identification of who is responsible for each aircraft at any given time.

Such operational models will have important implications for the interaction between UAS operators and U-space services. The relationship between an individual operator, a particular aircraft and a specific USSP can no longer be assumed to remain static throughout an operation. An operation may interact with different service providers during its execution, while operational responsibility may change as the flight progresses. U-space interfaces, information exchanges and responsibility-management mechanisms will therefore need to support these transitions in a consistent and transparent manner. This flexibility will be essential for enabling scalable end-to-end operations across large geographical areas.

A second major element of the long-term operational environment will be the increasing importance of **flight intent**. As traffic density and airspace utilisation increase, reliable knowledge of the intended evolution of each flight will become increasingly important for maintaining situational awareness and supporting conflict management. Flight intent is therefore expected to become an essential source of information throughout the operation, allowing U-space actors to anticipate traffic evolution rather than relying only on the current aircraft state. This will require mechanisms for sharing sufficient safety-relevant intent information among the appropriate actors, while preserving the confidentiality of commercially sensitive or otherwise protected operational data.

Finally, the progressive integration of UAS with conventional aviation will require greater interoperability between the flight-information models used in U-space and ATM. While the U-plan provides the basis for describing UAS operations and supporting strategic deconfliction, conventional ATM is evolving towards the use of Flight and Flow Information for a Collaborative Environment (FF-ICE). In the long term, convergence or interoperability between U-plan and FF-ICE should therefore be pursued, enabling U-space and ATM systems to exchange and process compatible flight and intent information and supporting the progressive integration of UAS and manned aviation within a common airspace environment.

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6.2.6 Conflict management

The long-term integration of Unmanned Aircraft Systems (UAS) and traditional Air Traffic Management (ATM) hinges on a fundamental evolution of Flight Rules. To safely scale operations – particularly in the busy airspace up to 5000 feet – the industry must move beyond the binary of traditional Instrument Flight Rules (IFR) and Visual Flight Rules (VFR).

The key aspect of Flight Rules is tactical conflict management. Today, in controlled airspace, a separation service is provided to IFR operations by Air Traffic Control, and in most classes of airspace, the VFR pilot is responsible for remaining well clear of other aircraft. The desire for a new flight rule is primarily driven by the need to integrate UAS and current aviation in airspaces up to 5000 feet.

The transition to data-driven Detect and Avoid requires a framework that defines how diverse airspace users interact, the services they receive, and who holds the ultimate responsibility for separation.

Flight rules are a core element of the Long-term Horizon. New flight rules should cover aspects such as:

- Which airspace users can follow different flight rules.
- What services are provided to airspace users following different flight rules.
- How airspace users following different flight rules interact with each other.

The **key** aspect of Flight Rules is tactical conflict management. Today in controlled airspace, a **separation service** is provided to IFR by Air Traffic Control. Today in most classes of airspace, the VFR pilot is responsible for maintaining **remain well clear** of other aircraft.

The desire for a new flight rule is primarily driven by the need to **integrate** UAS and current aviation in airspaces up to 5000 feet. Today, much aviation in that range is VFR. Any new flight rule used to integrate will need to be either

- Interoperable with VFR
- Usable instead of VFR by on-board pilots

Two options for a new flight rule might be

- A third instance of IFR that facilitates remote piloting:
    - New CNS allowing reduced separation minima
    - Digital communications allowing automation of piloting and controlling
    - More controlled airspace
    - ATC – with increased automation so as to scale economically
- A **Digital Flight Rules** (DFR) that replaces VFR and is usable by remote pilots.
    - Digital services provide situational awareness, replacing vision
    - Intent is shared – where known – allowing efficient deconfliction
    - Deconfliction manoeuvres are coordinated
    - The pilot may be remote and is supported by automation
    - Compatibility would require all aircraft to be digitally visible

Other options may be possible. New flight rules are being examined in the DiFeRent project [53]

In addition to conflict management, DFR and advanced automation will significantly enhance safety regarding human and environmental hazards, such as pilot incapacitation, spatial disorientation, emergency response,

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and adverse weather (IMC). Because automated self-landing and contingency recovery systems already exist, the long-term goal is their full integration into a networked digital service ecosystem.

6.2.7 Service delivery management

Through the STH and MTH, U-space SDM and conventional ATM SDM operate as two parallel governance layers: USSPs consolidate decisions for UA/VCA traffic within U-space airspaces, while ANSPs continue to consolidate decisions for manned traffic within the remaining airspace, with limited specific coordination at the boundary between the two. By the LTH, this separation is no longer sustainable as the goal is to evolve to an integrated airspace with Interacting manned and unmanned traffic share airspace. Once a meaningful share of both traffic populations occupies the same volume of airspace under the same operational rules, the presence of two separate SDM functions, one arbitrating trade-offs for unmanned traffic, and one for manned traffic over that shared airspace means two authorities making independent decisions (priority, capacity allocation, separation mode) with no guarantee they're mutually consistent. Convergence resolves this by making SDM a single function that balances and consolidates decisions across all GATMOC components for every aircraft in the airspace, regardless of whether it's flying under a legacy ICAO flight rule or one of the digital tiers introduced earlier as the New Flight Rules framework.

The U4 evolution of the U-space services framework will provide the digital infrastructure required to link U-space protocols with legacy ATM systems, allowing for automated collaborative airspace management. SDM is where that bridge is exercised operationally and represents the function through which decisions from two separate governance layers are actually reconciled into one, rather than just technically interconnected via the Information services layer that carries the data on which the decisions depend.

Examples of these convergences include updated AIS requirements which fold CIS information into it and present an all-inclusive service. Elements thereof could become a Pan-European Information service.

Network management

SDM's federation model matures from coordinating USSPs within a single environment into full Network-CDM, aligned with the network-wide vertiport coordination described in section 6.2.2 and the ICNS-based capacity management in section 6.2.3. A single flight's decisions (trajectory, separation mode, priority) are consolidated across U-space and ATM network layers simultaneously, not handed off between them. The shared technical infrastructure this depends on is explained in section 6.2.8 on Information Services.

Convergence of CIS and AIS

With U-plans harmonised against ICAO flight plans via FF-ICE (per the LTH assumptions), the distinction between U-space Common Information Services and traditional Aeronautical Information Services becomes largely administrative as AIS information has become digital and machine-readable, as explained by the information-services architecture (section 6.2.8) underpinning this convergence. The service will remain certified and the data assured; however, its delivery will adopt new digital techniques for consumers to verify the data.

Cross-border flight

As U-space airspaces become contiguous and traffic flows across USSP and national boundaries as a matter of course, SDM must define a formal handover protocol — analogous to ATC sector handover today, specifying what state (U-plan, separation obligations, conformance status) transfers between USSPs, and at what point liability transfers with it. See section 6.2.8 for the technical mechanism that carries out this handover.

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6.2.8 Information services

By the LTH, Information Services is expected to transition from an ATM adjacent U-space-specific function into a single, SWIM-based information environment shared by manned and unmanned aviation alike. This is the technical counterpart to the governance convergence described in section 6.2.7. The SDM function determines who has authority over a U-space operation, and Information Services provide the common infrastructure that makes those decisions actionable across both domains.

A single technical infrastructure for ATM and U-space

Collaborative decision-making depends on ATM and U-space sharing one SWIM technical infrastructure, including reference model (AIRM), messaging, security, mediation, interface management and enterprise service management, rather than two networks bridged by translation layers. For service delivery management to function seamlessly across a single aviation network is only as good as the shared infrastructure that transmits a U-space service flight object message from USSP to ANSP, or service providers use machine-readable AIXM information about a restriction or DAR. Unifying this infrastructure allows a UAS or VCA flight authorisation, separation mode, and priority to be resolved consistently regardless of which side of the ATM/U-space boundary it originates from.

However, research attention is needed to achieve the long-term vision on:

- **Scale and Participation.** SWIM's governance, registry and trust model was originally designed for a few dozen institutional, ANSP participants, some with links to government departments. U-space implies potentially hundreds of commercial USSPs with real market dynamics involving new entrants, exits and acquisitions. Whether SWIM's registry, access and certificate management scale to that population and how service continuity is assured when a participating USSP ceases trading will have to be resolved.
- **Certification and release-cycle mismatch.** ANSP systems are safety-certified with multi-year change cycles, while USSPs are expected to move faster, typically with cloud-native platforms and discrete but faster deployments. A shared infrastructure must tolerate both without forcing USSPs into ANSP change cadences or exposing ANSPs to uncontrolled changes from differing interface versions and conformance issues.
- **Latency and timescale mismatch.** SWIM's exchanges between ground-based systems were specified for ATM timescales. Tactical separation coordination between USSPs and dynamic reconfiguration propagation to drone operations run at substantially tighter timescales. Whether the same infrastructure serves both, or whether a performance-tiered approach is needed, should be posed rather than assumed.
- **Governance ownership.** It is currently unclear who owns the converged infrastructure's rules given the segmentation in SWIM and U-space policy. For example, ICAO is responsible at the semantic and procedural level, EASA at the regulatory level, and EUROCONTROL/SESAR at the specification level; then who funds USSP participation, given these are commercial parties whose costs must be recovered from end-users, while CIS integration is funded by the state? According to the GATMOC, the solution sits with SDM as a governance function, but the institutional mapping does not yet exist.

Convergence of CIS and AIS

U-space's Common Information Services and traditional Aeronautical/Meteorological Information Services operate as one family of SWIM information services, discoverable through a single registry and consumed by manned and unmanned traffic alike. The administrative distinction between U-space data and ATM data that persists through the MTH becomes largely irrelevant by the LTH. Instead, a single, layered set of information services differentiated by content and by access rights, not by which community historically produced them.

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FF-ICE-based flight data exchange

The LTH assumption of consistency between the U-plan and the traditional ICAO flight plan will have to be realised through a FIXM-based (or U-space-extended-FIXM) flight data exchange service published as a SWIM information service in the same way as ICAO's FF-ICE model. The U-plan effectively becomes a specialised instance of the same underlying flight data object, rather than a parallel structure that has to be reconciled with the flight plan after the fact.

Information Services and Real-Time Data Ecosystems

Future aircraft operations will depend heavily on advanced digital information services that replace legacy voice communication with automated, machine-to-machine data exchanges. Information services will aggregate and distribute real-time operational data, such as high-resolution micro-weather forecasts, digital Notice to Air Missions (NOTAMs), cooperative intent trajectories, and dynamic airspace constraints, directly to automated flight management systems and ground control stations. A shift from traditional ICT towards operating technologies may be observed. By utilising technology-agnostic data models, these services enable seamless interoperability across various platforms.

Information security at scale

It is believed that LTH's information security position should follow ICAO's Aviation Information Security Manual (Doc 10204), extending the certificate-based, end-to-end framework introduced in the MTH (section 5.4.8) to a system where safety-critical decisions increasingly depend on information originating outside any single provider's direct control.

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7 Public acceptance

To enable routine BVLOS operations and commercial UAS business models across Europe, it is essential that the public welcomes them. Commercial viability requires not only direct consumer demand for innovative air services, but also broad societal consent regarding operational externalities, specifically noise, visual intrusion, security, and privacy concerns. Therefore, achieving public acceptance is crucial.

Public acceptance is the collective approval or willingness of society to accept and support something. Since society is a very broad term, this chapter addresses the 'General Public' as citizens who are not necessarily direct service consumers or drone operators, but who reside, work, or interact within areas affected by low-altitude drone operations. They belong to the ‘beneficiaries’ stakeholder group as defined in section 3.4. Public acceptance is treated as a dynamic operational variable managed through structured governance, active transparency, and continuous impact monitoring throughout the U-space airspace lifecycle.

This ConOps is governed by the following principle: Public acceptance is an operational prerequisite for U-space airspace activation. Airspace managers must integrate community engagement and impact mitigation directly into routine airspace management protocols rather than treating public sentiment as a static post-deployment observation

7.1 Core principles

U-space public acceptance is built upon two foundational principles derived from state-of-the-art technology acceptance research: Transparency and Inclusiveness.

7.1.1 Transparency principle

Airspace management entities and USPs shall deliver timely, plain-language operational information to local communities. Technical jargon must be translated into standardised public-facing terminology (e.g., leveraging standardised U-space definitions). Transparency ensures citizens understand the purpose of UAS operations, while giving law enforcement and regulatory bodies clear mechanisms to verify and enforce compliance. By increasing public knowledge, transparency enforces trust. A notable initiative by ImAFUSA [19] is the U-space Wiki (https://www.uspacewiki.eu/), which provides clear definitions of technical terms about drones and low-flying aircraft in cities, making terminology accessible to citizens.

While providing transparent situational awareness through services such as the Network Identification Service and the Traffic Information Service is essential for the safe integration of UAS operations, this transparency must be carefully balanced against operational confidentiality, commercial sensitivities, and national security requirements. Widespread sharing of operational data and flight information can expose proprietary business information and commercial interests, or attract undesired public attention to accident areas, so controlled access models are needed to protect market confidentiality. At the same time, national security and defence obligations, including operations managed by military, police forces, and security agencies, often require strict secrecy to safeguard critical infrastructure and official operations from external threats or exploitation. Additionally, legal frameworks and data protection regulations govern how operators' and flight-related information is handled to prevent unwarranted intrusion into privacy. Consequently, robust governance structures, trusted identification policies, and role-based access controls must be implemented to ensure that operational transparency effectively supports safety without compromising security, privacy, or economic interests. U-space infrastructure shall support a dual-layer information architecture: general public tracking feeds will display authorised UAS flights, while dedicated high-security data links provide military and law enforcement authorities with a complete, unblinded awareness of any

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airspace operation. The latter also enables identification of non-cooperative or rogue drones for rapid Counter-Unmanned Aircraft System (C-UAS) actions.

7.1.2 Inclusiveness principle

In compliance with Article 18(f) of Regulation (EU) 2021/664, designating U-space airspace, establishing operational restrictions, and determining required services require mandatory coordination mechanisms between aviation authorities and local municipal/regional entities. Municipalities represent local public interests regarding land use, noise-sensitive zones, and community priorities. They must empower the public through consultations and involve them in decision-making on the rules governing U-space deployment.

7.2 From principles to action plans: Societal Readiness Level tool

The public acceptance principles increase public trust, which, together with clear accountability rules, lays the foundation for deploying U-space and UAS technologies. Societal Readiness Level (SRL) is a methodology for increasing public maturity with respect to a technological innovation [56, 57]. Just as the technology lifecycle moves through a sequence of Technological Readiness Levels (TRL), society's maturity in understanding, accepting, and using the technology also evolves through a sequence of SRLs.

SRL is a framework designed to help researchers, innovators, industry and politicians align their projects with societal values, needs, and expectations. SRL serves as a vital complement to the TRL framework. While TRL is used to quantify the technical maturity of an innovation (asking "will it work?"), SRL focuses on its societal desirability and ethical acceptability (asking "will it acceptably address broader, long-term societal concerns?").

The concept is operationalised through the Societal Readiness Thinking Tool (https://thinkingtool.eu/), which organises societal readiness into a stage-gate model that follows the typical lifecycle of a research project. This model divides a project into four distinct stages:

1. Design - Problem Formulation: The ideation and conceptual planning phase.
2. Implementation, Data Collection and Testing: The active research and experimental phase.
3. Data Analysis and Evaluation: The interpretation and evaluation of research results.
4. Launching and Dissemination: The phase where outcomes are shared with stakeholders and the public.

The SRL framework is built on four core "conditions" derived from Responsible Research and Innovation (RRI):

- Anticipation: Thinking ahead about both the intended and potentially unintended outcomes and applications of the technology.
- Reflexivity: Critically examining the underlying goals, motivations, assumptions, and worldviews that drive the work.
- Inclusion: Ensuring that diverse voices and stakeholder interests—including those whose interests might be overlooked—are involved in the design and development process.
- Responsiveness: Being prepared to change course or modify practices based on the insights gained through reflection and stakeholder engagement.

The primary purpose of maturing a project's societal readiness is to avoid the "cascading sets of undesirable effects" that often accompany new technologies. By encouraging double, the Societal Readiness Thinking Tool aims to ensure that scientific advances are properly embedded within the societal fabric.

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Beyond SRL, authorities and industry evaluation of the overall readiness of a national ecosystem for adopting IAM needs to assess other factors like government leadership, infrastructure readiness, and regulatory alignment. While distinct from the academic SRL framework, it similarly aims to measure the transition from "hype" to "reality". SRL is a tool to drive implementation rather than passive monitoring. At the EU level, and in particular under the SESAR JU umbrella, very large demonstration projects such as U-ELCOME, BURDI, ÁELÚ-AER, etc. have positioned U-space around SRL.

Continuous monitoring of a new technology's performance and deployment is part of the SRL methodology and of the transparency and inclusiveness principles. Performance monitoring also extends to regularly capturing the status and evolution of well-established technologies. In aviation, Europe supports continuous monitoring through the SESAR Performance Framework, with the PEARL project [17] responsible for its maintenance and evolution. The latest PEARL performance framework proposal includes a full chapter on U-space monitoring.

Exploratory research projects [19, 20] have proposed extensions to the SESAR official performance framework for U-space, particularly related to public acceptance and environmental impact. Annex B summarises the main contributions from SESAR projects to enlarge the U-space performance frameworks to measure public acceptance. The annex also details the method used to select a comprehensive set of indicators. The list is proposed as part of the CORUS five ConOps for the continuous monitoring of future established U-space airspaces. The aim is to bring objective data to the governance board to support informed decisions.

To complement the objective data captured by the set of indicators, we also propose to enrich them with subjective information. This is materialised in a normalised list of questions for deployed U-space airspaces. Periodic surveys of the population living in the areas where U-space traffic is becoming a daily experience will provide the governance board with a complete picture of public acceptance and its evolution over time.

Public surveys have been conducted over the years to assess both the potential of direct consumer demand and the public acceptance/acceptability. Annex C provides a summary of public surveys available since ConOps 4.0. It also presents the methodology used to propose the normalised list of questions.

Most recent surveys generally show positive opinion, especially because drones are perceived as fast, green, and improving connectivity. Emergency services and public benefit missions typically receive higher support than commercial flights. Acceptance tends to be higher among young, tech-savvy men compared to older populations, non-tech users and women. Most surveys show that key concerns are perceived safety, noise, environmental impact, privacy, security, and liability.

A relevant near-term topic for public acceptance is perception of safety and security, as drone sightings and subsequent disruptions at airports in Denmark and Germany in 2025 have shown. U-space services should therefore help to show the public that UAS operations are conducted safely, securely and in regulatory compliance, while providing a full airspace picture of collaborative UAS flights, so state authorities can more easily distinguish non-cooperative UAS.

C-UAS systems are being commercialised to protect sensitive areas and critical infrastructure such as public gatherings, airports and government buildings. C-UAS operations are structured around a comprehensive lifecycle of sequential phases designed to manage airspace security risks posed by unauthorised or hostile UAS.

The initial engagement phase forms the critical foundation of airspace defence, beginning with the detection stage, where multi-sensor architectures, incorporating radio frequency sensors, primary and secondary

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radars, acoustic monitors, and electro-optical/infrared cameras, identify the presence of an aerial intruder within a protected zone. This flows immediately into surveillance/tracking, which maintains continuous, real-time positional oversight, tracking the four-dimensional trajectory, velocity, and vector of the target. Finally, the identifying/classifying step evaluates sensor signatures, flight behaviours, and electronic emissions to determine whether the UAS represents a benign anomaly, a commercial operation, or a targeted security threat.

Once operations confirm a threat, they transition to the mitigation/neutralisation phase to terminate the risk. This phase includes repulsion, which uses non-kinetic countermeasures such as electronic jamming, GNSS spoofing, or command-and-control link disruption to deter the UAS, break its connection to the operator, and force it to abort its mission or return home. If non-kinetic deterrence is insufficient or the threat level is critical, interception is deployed, using active physical or directed-energy measures, including net-capture systems, kinetic interceptors, dedicated firearms, or high-energy lasers, to disable or destroy the target in a controlled manner.

The final post-actions phase ensures safety and data integrity following an engagement. This includes disarming any active payloads, ordnance, or self-destruct mechanisms to protect security personnel and first responders from physical or chemical hazards. Concurrently, recovery involves gathering physical debris, forensic electronic components, and onboard flight logs from the downed UAS to support rigorous incident investigations, forensic threat attribution, and the continuous refinement of security protocols.

With the deployment of U-space services, the detection component, which today cannot easily differentiate between authorised and non-authorised drones, will have a much easier task. Still, a gap exists for automating rogue drone identification and neutralisation.

7.3 Public acceptance assessment framework

Aligned with the ICAO Global Air Navigation Plan (GANP [18]) and the SESAR Performance Framework [17], the U-space governance ConOps uses a performance framework built on objective technical indicators, mostly derived from operational telemetry. These metrics are to be complemented with standardised subjective public surveys.

Current population surveys highlight several key determinants of public sentiment. A primary driver of public acceptance is the mission profile, with operations that offer a clear societal benefit, such as emergency medical services and disaster relief, yielding significantly higher approval rates than commercial passenger flights or private business operations. Demographic variation also shows that support currently trends higher among younger, male, and technologically literate populations. Regardless of demographics, public apprehension remains firmly concentrated within six critical externalities: safety, noise, environmental impact, privacy, security, and liability. Addressing these core concerns is essential to the public acceptance assessment framework and provides useful information about its evolution beyond the initial decision to deploy a U-space airspace.

Every designated U-space airspace volume shall establish a local Governance Board (GB) comprising civil aviation authorities, U-space service providers, local municipal representatives, and community stakeholders. The GB is empowered to conduct the public acceptance assessment framework, which includes collecting and monitoring acceptance metrics, conducting and evaluating surveys of local residents, and adjusting local airspace constraints accordingly.

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7.3.1 Key Performance Indicators (KPIs)

Objective indicators are continuously gathered from activated flight plans, telemetry, local environmental sensor networks, and citizen logging channels. The core monitoring areas and metrics are defined below, based on the most relevant performance areas selected in consultation with the Advisory Board: Acoustic Impact (Noise), Privacy & Security, and Socio-Economic Impact.

The KPI selection criteria require that all indicators be representative, applicable, understandable, and easy to obtain or calculate. The public acceptance performance framework includes a concise set of area-based indicators that isolate the deltas generated by U-space airspace traffic.

The following table lists the public acceptance indicators.

Table 6. List of selected indicators

Performance Area	Indicator Name	Operational Definition and Calculation Method
Acoustic Impact / Noise	Noisy Events Count	Total flight events exceeding specified dBA noise threshold, weighted by time-of-day and zone sensitivity factor.
Acoustic Impact / Noise	Noise Delta (L5 - L90)	Difference between overflying drone acoustic signatures (L5 peak) and ambient local background noise (L90).
Privacy & Security	Surveillance frequency	Frequency of low-altitude camera/sensor missions executed directly over residential land parcels.
Privacy & Security	Hovering Duration	Cumulative hover duration of unmanned aircraft within restricted proximity to residential buildings.
Privacy & Security	Citizen Incident Reports	Total volume of verified citizen privacy or security complaints logged via digital U-space reporting portals.
Socio-Economic Impact	Local Economic Growth	Percentage of local/regional GDP and economic productivity directly generated by IAM/UAS logistics services.
Socio-Economic Impact	Operational Time Efficiency	Average transit time savings achieved by UAS emergency/logistics missions relative to conventional road transport.

7.3.2 Standardised Public Perception Monitoring (Surveys)

To contextualise objective operational metrics, periodic population surveys must complement them. The proposed survey is grounded in a comprehensive state-of-the-art review of existing public perception studies, documented in Annex C. This review identifies seven distinct psychological and behavioural constructs as critical to public acceptance: Mission Support, General Attitude, Policy Support, Institutional Trust, Intention to Use, Willingness to Pay, and Automation Preferences. Each construct evaluates two vehicle scales—small delivery UAS (drones) and larger passenger aircraft (air taxis or VCA), supplemented by a third general baseline item to ensure construct validity. The survey utilises a forced-choice 4-point Likert scale, from 'Strongly Disagree' to 'Strongly Agree', to eliminate neutral fence-sitting and capture clear directional sentiment across the seven core psychological constructs.

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Underlying trends and correlated public sentiment can be linked to socio-economic factors if the survey includes a section on participant demographics (age, gender, education level, occupation, and salary). All data will be collected anonymously to protect participant privacy and encourage honest responses.

The questionnaire is divided into 3 parts: the third-party perspective, market adoption and automation preferences

Table 7. Survey questions for public acceptance

Construct	Item ID	Survey Question Text
Mission Support	(i)	I am in favour of UAS being utilised for emergency and medical support operations.
Mission Support	(ii)	I am in favour of UAS being utilised for commercial logistics and business operations.
Mission Support	(iii)	I am in favour of integrating UAS as a standard operational tool for public civil missions
General Attitude	(i)	Overall, I feel positive about the introduction of UAS technology in my municipality.
General Attitude	(ii)	I consider air taxis to be a beneficial innovation for society as a whole
General Attitude	(iii)	I consider delivery drones to be a beneficial innovation for society as a whole
Policy Support	(i)	I support local government investment in building dedicated UAS infrastructure (e.g., vertiports)
Policy Support	(ii)	I support city policies that facilitate commercial and emergency UAS to fly over my city
Policy Support	(iii)	I believe public authorities should actively foster and support UAS technological innovation
Institutional Trust	(i)	I trust aviation regulatory authorities to ensure the highest safety standards for UAS flights.
Institutional Trust	(ii)	I am confident that UAS operating companies will respect and safeguard citizen privacy.
Institutional Trust	(iii)	I trust law enforcement agencies to effectively protect society from malicious or rogue UAS

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Table 8. Survey questions for automation preferences

Construct	Item ID	Survey Question Text
Intention to Use	(i)	I would likely use a passenger air taxi service if offered at a reasonable price
Intention to Use	(ii)	I am willing to select drone delivery options for my routine online retail purchases.
Intention to Use	(iii)	I aim to try innovative aerial services provided by UAS
Willingness to Pay	(i)	I am willing to pay a premium fee to achieve faster delivery times via commercial drones.
Willingness to Pay	(ii)	I am willing to pay extra for rapid urban transit using air taxi passenger services.
Willingness to Pay	(iii)	I am willing to pay additional fees for specialised local aerial services.

The section on automation preferences is optional. Level of automation is a transversal concern that covers all areas of modern life, with U-space being just one element in the continuously automated aviation eco-system.

Table 9. Survey questions about public's automation preferences

Construct	Item ID	Survey Question Text
Automation preference	(i)	I would likely use a passenger air taxi service if offered at a reasonable price
Automation preference	(ii)	I am willing to select drone delivery options for my routine online retail purchases.
Automation preference	(iii)	I aim to try innovative aerial services provided by UAS

Public acceptance of Innovative Air Mobility is a dynamic variable that will naturally evolve over time. As flight density increases and citizens become more accustomed to seeing and hearing these aircraft, public sentiment will shift. To track and manage this evolution, it is critical to use a dual approach: calculating periodic objective indicators alongside regular public surveys.

7.3.3 Implementation Time Horizons

Using the same set of questions, the methods and focus over time are as follows:

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- Short-term: Indicators are computed primarily from approved flight plans (U-plans), telemetry logs, and initial citizen claims. Surveys focus on immediate safety perceptions and reactions to initial commercial rollouts and localised apprehensions as drones first enter the airspace.
- Medium-term: Indicators incorporate empirical dataset inputs from local acoustic and environmental sensor networks. Surveys shift to tracking routine operational exposure and community economic benefits.
- Long-term: Indicators integrate seamlessly into the annual European ATM performance reporting framework, embedding societal metrics into high-level ATM oversight. Surveys expand to capture public perception of all means of aviation, measuring foundational pillars like deep-seated societal trust, sustained institutional credibility, and enduring public policy support.

7.3.4 Summary of Strategic Recommendations

To ensure robust alignment with community expectations and operational transparency, the following recommendations to authorities are listed:

- Proactive Educational Campaigns: Deploy accessible digital outreach and media to familiarise and inform local communities regarding UAS operations, U-space safety features, and societal benefits.
- SRL Maturity Tracking: Apply SRL methodology as a mandatory gate check prior to scaling operational flight density in urban zones.
- Stakeholder Incident Reporting: Establish a centralised public reporting system (similar to frameworks like EUROCONTROL EVAIR available through the EUROCONTROL website https://www.eurocontrol.int/service/eurocontrol-voluntary-atm-incident-reporting) to collect a wide spectrum of operational safety concerns from U-space stakeholders.
- Governance Board Oversight: Establish a local Governance Board for every designated U-space airspace, responsible for continuously monitoring KPI data, executing periodic surveys, and enforcing operational mitigations.
- Physical & Digital Transparency Notices: Install physical informational signage along high-density flight zones and maintain open digital web portals detailing active U-space operational zones.
- Multi-Stakeholder Participation: Publish periodic acceptance reports and maintain open dialogue channels with municipal leaders, citizen groups, and industry representatives.

Ultimately, the successful deployment of U-space rests not only on technological readiness and regulatory compliance, but on the sustained cultivation of public trust and collaborative governance. By embedding these recommendations into national and regional implementation frameworks, authorities can ensure that U-space scales safely, transparently, and in harmony with the communities it serves.

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8 Economic aspects

Service Provision

The financial sustainability of U-space depends on balancing cost recovery with the need to encourage market growth. In the U-space ecosystem, the CISP and the USSP operate under different economic pressures. USSPs operate in a competitive market in which they have to differentiate themselves while adhering to regulatory guidelines such as those from ICAO on transparency and efficiency [56]. Meanwhile, the CISP may be viewed as a natural monopoly because a single CIS could be established to provide the single source of truth (static and dynamic data) for a volume of airspace. In a distributed CIS model, services have to be provided free to USSP at the point of use. This assumes that the necessary data is available to a USSP as it would be to a single CIS.

"*Prices of CIS should therefore be based on cost and a reasonable mark-up for profit and should be subject to approval by national supervisory authorities. Where CIS are not provided by a single CIS provider, the individual CIS should be provided for free.*"

With the lack of a significant base market, regions may adopt a phased recovery approach where the initial phase is pre-funded with state support. With market adoption and growth, the model transitions to full cost recovery. The other approach is to adopt a market pull in which the market provides distributed U-space and CIS services, placing the economic burden on the market. In this model, CIS provision would be free as it would be subject to EU 2024/2803.

U-space Implementation

The question of financing U-space implementation and growth will be an important one in the short term. Given the initial low flight demand from drone operators and comparatively high infrastructure development costs, initial U-space implementations will likely rely on a multitude of different external funding mechanisms before the ecosystem is able to financially sustain itself.

To avoid cost overruns, it is crucial that the U-spaces developed in the short term rely on the minimal viable complexity for sustained operations permitted by the established funding mechanisms. It is therefore expected that U-space will initially work within the regulatory framework with a few additional value-added services, flexibility in terms of communication latencies, position resolutions, longer processing times and an overall greater reliance on procedures and coordination required outside of the U-space service architecture.

Core Principles

U-space service delivery reveals a significant shift in aviation economics. Historically, Air Navigation Service (ANS) economics uses centralised monopoly-style cost recovery for manned aviation. The ATM Master Plan 2025 proposes a view of the entire ATM system as three layers of service delivery, with the business layer focused on business goals, processes, functions and organisational arrangements of all stakeholders concerned, including new entrants. This layer describes an open-market ecosystem for U-space as a more dynamic, market-driven and service-oriented economic model for service delivery and the specific roles, responsibilities and capabilities of each of these stakeholders.

Feature	Traditional ATM (ICAO 9082/9161)	U-space (ATM Masterplan 2025 Context)
Market Structure	Natural Monopoly (Single ANSP)	Competitive (Multiple USSPs)
Cost Basis	Infrastructure & Personnel (Fixed)	Software & Cloud Data (Scalable)

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Feature	Traditional ATM (ICAO 9082/9161)	U-space (ATM Masterplan 2025 Context)
Pricing Model	Cost-Recovery[13] / Regulated pricing mechanism based on Unit Rates	Subscription / Pay-per-flight / Tiered
Revenue Stream	Navigation Charges (En-route/Terminal)	Service Fees & Data Monetisation

Table 10: Comparison of the economic features of U-space and current ATM

CORUS five understands that delivering an open-market ecosystem is a fundamental principle, and that the ConOps shall support the business models of all stakeholders on this layer. A key element of this is U-space access fees. A second key element is the Fairness principle.

A key issue in ICAO9082 is avoiding undue cross-subsidisation and ensuring equitable access. The ATM Masterplan is clear that manned aviation should not pay for U-space infrastructure and vice versa. The use of services however remains chargeable e.g. drones operating in controlled airspace may contribute to terminal navigation charges if an ATC service is used. This is likely for larger drones and VCA in the medium term, but this raises questions on fee restructuring when U-space and ATM are integrated.

Calculation of fees

The number of flight hours of drone flights has increased by 29% from 2023 to 2024 (see https://droneii.com/global-drone-industry-review), more in VLOS than BVLOS operations. The aim is to increase the number of BVLOS operations thanks to U-space services and convert this increase in the expected economic benefits, as expected in the EU Drone Strategy 2.0, of the creation of 90,000 jobs and a €4.2bn market size, combined with the societal benefits such as 2-4 times faster transfers, 73% faster deliveries between hospitals, all with fewer accidents and less pollution.

It is a basic shared principle that end-users are the ones who shall pay for the services. In the long term, these payments shall cover the full cost of the operation, including U-space services, leaving also room for benefits. In the short term, this is not so obvious.

How the fees for the U-space services provision have to be calculated is the main focus of this subsection.

ICAO set out 2 key principles for calculating charges in ATM: users pay, and **fees must be closely linked to the cost of providing the services.**

Today ATM fees in Europe are proportional to the flight distance (every 100 km) and to the take-off mass (square root of half the MTOW) and are multiplied by a unit rate factor that considers the costs of the services in different countries (ranging from 28 euros to 120 euros). Aircraft with less than 2 tons are excluded.

Current U-space regulation (EU) 2024/2803 establishes the principles to apply to the CISP fees (Art 12), but not for USSP. This ConOps proposes to abandon the second ICAO principle for the calculation of the USSP fees, accepting benefits provided by USSPs determined by the value of services and accepting different rates depending on time or area (i.e. low/high density hours, to get a fixed schedule, etc.) but not to accept any payment to give flights higher priority during strategic deconfliction. The U-ELCOME project developed a forecast model in which the cost of the services provided by USSP is covered by the fees. In their prognosis, for 5 years from now [63], the fee calculations ranged from:

[1313]Most countries follow a cost recovery model using route & terminal charges; but not all countries, for example the USA does not.

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- More than 10 euros in a pessimistic scenario (18 flights per day)
- Less than 1 euro in an optimistic scenario (90 flights per day)

The cost of operating one flight today for an operator with 300 flights a day is between 3-6 euros. Clearly, fees shall not be more costly than the operation.

The CORUS five ConOps proposes that the USSP fees calculation should not be based on distance and aircraft size; instead, a variable rate, based on the 4D volume of the operation, should be used to encourage the reduction of airspace occupancy, together with a flat rate that supports the fixed cost of each flight authorisation and management. Additionally, the USSP fees shall be (partially) paid at flight authorisation approval and liquidated after the flight is terminated or cancelled.

Currently, there is little consensus on the convenience of exceptions for operations in support of the police or ambulance services.

The time horizon for the implementation of the above charging systems is over the mid-term. For the short-term, fees will need to be symbolic, given that the volume of the expected operations is still not enough to cover the costs of a USSP. For the long-term horizon, CORUS five proposes the integration of the ATM and U-space charges into a unique system.

Fairness principles

Fairness principles are established by the regulation with the aim of allowing access to the shared airspace to all. In particular, the fairness principles shall allow all business models to benefit from the U-space airspace. These business models' needs range from well-planned flights to last-minute operations.

Current regulation mentions fairness in the article 3(4)(b) of the EASA GM 2021/664 GM7:

> "to ensure efficiency as well as fairness (…) Member States may constrain (…) the maximum time a flight authorisation request may be sent in advance to ensure the effective implementation of the 'first in [come], first served' principle (...)."

which suggests a limit on the time in advance for booking airspace, so last-minute operations are not at a disadvantage compared with scheduled flights, but also establishes the first come, first served (FCFS) as the basic fairness rule.

But fairness is a much more complicated concept. In the dictionary, synonyms of **fairness** are **free from bias, dishonesty, or injustice; correctly or properly done according to the rules;** etc. Looking at the state of the art, Verma et al. (2018) provide 20 definitions of fairness, further classified into 3 types of fairness: statistical, similarity-based and causal reasoning. They show that the same decision can be fair and unfair depending on the definition used. For Saxena et al. (2019), there are 3 types of fairness, of which 'calibrated fairness' is demonstrated to be better accepted by citizens. The rules of calibrated fairness prioritise requests as a function of the self-merit versus the sum of everyone else's merits. The complication comes when selecting a good merit indicator. Chin et al. (2021) propose a flow management solution (delay assignment) for unmanned air traffic trying to balance efficiency and fairness. Efficiency is measured globally by counting the number of flight departure reversals, while fairness considers individual operator preferences, which can provide their own cost values for ground and airborne delay.

Several research projects such as SPATIO [45] and SAFIR-READY [64] have explored the fairness issue. SPATIO proposed a new U-space service, the **Fairness manager**, in which two separate FCFS queues manage the authorised flights and the non-authorised flights, which are temporarily waiting for the spare capacity that

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may allow the flights. The Fairness manager will try to select the most appropriate request from the waiting list using fairness as the selection criteria.

SAFIR-Ready proposed a Dynamic non-binary priority scheme that goes beyond the Flight Authorisation service and includes in-flight operations. In their scheme, priorities are given by values up to 72 as the result of the mission type and status (a number of conditions depending on whether the aircraft is flying or on the ground) and the level of priority in case of emergency flight (number of people, time to catastrophic event, etc.)

The CORUS five partners conducted a survey on fairness (Hlavatá and Kraus, 2025) whose results were discussed with experts and the Advisory body. As an outcome, the CORUS five ConOps is proposing the following fairness principles:

- Priority shall be given to urgent flights (blue lights).
    - The understanding is that urgent flights (i.e. ambulance) are generally accepted and of primacy in the public interest
    - Priority is declared at operation level, not at operator level
    - The operator of an emergency flight is recognised
- Access rules are known and are enforced
- Decision-making process is transparent and simple

With respect to the time horizons, the CORUS five ConOps recognises that the FCFS principle applied to non-urgent flight requests represents a viable solution for the short term, as it is easy to implement, is well-established and is an accepted rule to prioritise. Its application in the short-term horizon will help to obtain statistics about non-authorised operations, cancelled operations, delayed operations, etc. Knowing the magnitude of potential unfairness situations will help to propose new solutions or rules. Solutions found in the literature go from classifying the operators' requests according to their business model and implementing separate FCFS queues for their requests, to implementing collaborative decision-making, in which the concept of "Enhanced Strategic Flexibility through Advanced Tactical Management presented in section 5.3.4 could be applied.

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9 U-space ConOps in a nutshell



Figure 14. CORUS five ConOps in a nutshell

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10 References

10.1 Applicable documents

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

[2] Commission Implementing Regulation (EU) 2021/665 of 22 April 2021 amending Implementing Regulation (EU) 2017/373 as regards requirements for providers of air traffic management/air navigation services and other air traffic management network functions in the U-space airspace designated in controlled airspace. *Link*: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0665

[3] Commission Implementing Regulation (EU) 2021/666 of 22 April 2021 amending Regulation (EU) No 923/2012 as regards requirements for manned aviation operating in U-space airspace. *Link*: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0666

[4] Acceptable Means of Compliance and Guidance Material to Regulation (EU) 2021/664 on a regulatory framework for the U-space – Issue 1, December 2022. *Link*: https://www.easa.europa.eu/en/document-library/acceptable-means-of-compliance-and-guidance-materials/amc-and-gm-implementing

[5] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1560259925294&uri=CELEX:32019R0945

[6] Commission Implementing Regulation (EU) 2019/947 of 24 May 2019 on the rules and procedures for the operation of unmanned aircraft (Text with EEA relevance.) https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1560259925294&uri=CELEX:32019R0947

[7] Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Commission Implementing Regulation (EU) 2019/947
https://www.easa.europa.eu/sites/default/files/dfu/AMC%20%26%20GM%20to%20Commission%20Implementing%20Regulation%20%28EU%29%202019-947%20%E2%80%94%20Issue%201.pdf

[8] Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Part-UAS UAS operations in the 'open' and 'specific' categories
https://www.easa.europa.eu/sites/default/files/dfu/AMC%20%26%20GM%20to%20Part-UAS%20—%20Issue%201.pdf

[9] U-space Concept of Operations (ConOps), 4th edition, July 2023, CORUS-XUAM Consortium https://www.eurocontrol.int/project/concept-operations-european-utm-systems
https://www.eurocontrol.int/project/concept-operations-european-utm-systems

[10] SESAR JU 2025 Edition of the European ATM Master Plan, December 2024. https://www.sesarju.eu/masterplan.

[11] JARUS SORA package. http://jarus-rpas.org/content/jar-doc-06-sora-package

[12] Global Air Traffic Management Operational Concept (GATMOC), Doc. 9854, International Civil Aviation Organization (ICAO), 2005.

[13] Eurocontrol U-space Airspace Risk Assessment Method and Guidelines – Volume 1. April 2023

© –2026– CORUS five for SESAR JU

[14] Eurocontrol Expanded Safety Reference Material (E-SRM) Core Document. July 2024

[15] ICAO Annex 2 - Rules Of The Air. *Link*: Annex 2 - Rules Of The Air | ICAO Store.

[16] EU Regulation 2012/923, SERA, Standard European Rules of the Air - https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012R0923

[17] PEARL Deliverable D6.4 - DES Performance Framework. 2026. ICAO Global Air Navigation Plan (Doc 9750)

[18] ICAO Global Air Navigation Plan (GANP) Performance Ambitions https://ganpportal.icao.int/GanpDocument#/lessons/mjR-NvTw42AWIArqUwLYarQFkoUGNX_h?_k=2m03u4

[19] DES HE SESAR solution 0463 concept outline. ImAFUSA D2.2. December 2025. https://cordis.europa.eu/project/id/101114776

[20] Measuring UAM Social and Environmental Impact: Lessons learned from the MUSE project. M. Baena Botana, M. Alonso, D. Mocholí, O.G. Cantú-Ros; J. Kuljanin, C. Barrado; I. LeGriffon, E. Ruaud; E. Ganić, T. Krstić Simić, B. Mirković. SESAR Innovation Days, Bled, Slovenia, Dic 2025.

[21] SESAR Joint Undertaking: U-space Blueprint https://www.sesarju.eu/sites/default/files/documents/reports/U-space%20Blueprint%20brochure%20final.PDF

[22] SESAR Joint Undertaking: Roadmap for the safe integration of drones into all classes of airspace. 1st March 2018 https://www.sesarju.eu/sites/default/files/documents/reports/European%20ATM%20Master%20Plan%20Drone%20roadmap.pdf

[23] ICAO Annex 11 - Air Traffic Services https://store.icao.int/en/annex-11-air-traffic-services

[24] ICAO Annex 14, Aerodromes. https://store.icao.int/en/annex-14-aerodromes

[25] ICAO Heliport Manual – Doc 9261 https://store.icao.int/en/heliport-manual-doc-9261

[26] ASTM F3548-21 Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability – see https://www.astm.org/f3548-21.html

[27] European Union Aviation Safety Agency, 'Special Condition Vertical Take-Off and Landing (VTOL) Aircraft'. Jul. 02, 2019. Accessed: Oct. 22, 2020. [Online]. Available: https://www.easa.europa.eu/sites/default/files/dfu/SC-VTOL-01.pdf

[28] SESAR JU, "European Drones Outlook Study. Unlocking the value for Europe", Nov 2016.

[29] Clothier, Reece A and Greer, Dominique A and Greer, Duncan G and Mehta, Amisha M. 2015. Risk perception and the public acceptance of drones. Risk analysis, 35(6), p 1167-1183, Wiley Online Library.

[30] Hamilton, Booze A, 2018. Final Report Urban Air Mobility (UAM) Market Study, National Aeronautics and Space Administration (NASA).

[31] EASA, "Study on the societal acceptance of Urban Air Mobility in Europe", May 2021.

© –2026– CORUS five for SESAR JU

[32] Philip Butterworth-Hayes and Tim McCarthy. Accelerating the potential of drones for local government - International Best and Emerging Practice Report. Dublin City Council and Smarts Dublin. May 2022. Available at https://bit.ly/3QbSiB5

[33] Gonzalez P et al. AMU-LED – Air Mobility Urban – Large Experimental Demonstrations SESAR project. https://amuledproject.eu. Paper to appear at MPDI Aerospace 2023.

[34] Çetin E. et al, "Implementing Mitigations for Improving Societal Acceptance of Urban Air Mobility", MDPI Drones 2021.

[35] EASA Guidance Material for Design of VFR Vertiports - https://www.easa.europa.eu/document-library/general-publications/prototype-technical-design-specifications-vertiports

[36] ASTM F3411 Standard Specification for Remote ID and Tracking https://www.astm.org/f3411-22.html

[37] Commission Implementing Regulation (EU) 2016/1185 of 20 July 2016 amending Implementing Regulation (EU) No 923/2012 as regards the update and completion of the common rules of the air and operational provisions regarding services and procedures in air navigation (SERA Part C) and repealing Regulation (EC) No 730/2006 (Text with EEA relevance) https://www.easa.europa.eu/en/document-library/regulations/commission-implementing-regulation-eu-20161185

[38] EASA Prototype Technical Design Specifications for Vertiports https://www.easa.europa.eu/en/document-library/general-publications/prototype-technical-design-specifications-vertiports

[39] ICAO Annex 15, Aeronautical Information Services, https://store.icao.int/en/annexes/annex-15.

[40] ICAO Document 4444, Procedures for Air Navigation Services (PANS) - Air Traffic Management https://store.icao.int/en/procedures-for-air-navigation-services-air-traffic-management-doc-4444.

[41] Evaluation of U-plan representation impact on U-space capacity and computational needs. David Carramiñana, José M. Moline, Juan A. Besada. 2025 Integrated Communications, Navigation and Surveillance Conference (ICNS), April 2025. https://ieeexplore.ieee.org/document/10976951

[42] ICARUS project https://cordis.europa.eu/project/id/894593

[43] EUREKA project https://cordis.europa.eu/project/id/101114799

[44] BUBBLES project https://cordis.europa.eu/project/id/893206

[45] SPATIO project https://cordis.europa.eu/project/id/101114674

[46] AMU-LED project https://cordis.europa.eu/project/id/101017702

[47] ENSURE project https://cordis.europa.eu/project/id/101114732

[48] BURDI project https://www.burdi.eu/

[49] EALU-AER project https://research.dblue.it/ealu-aer/

[50] AURA project https://cordis.europa.eu/project/id/101017521

© –2026– CORUS five for SESAR JU

[51] Evaluation of U-Plan Representation Impact on U-space Capacity and Computational Needs, David Carramiñana, José M. Molina; Juan A. Besada https://doi.org/10.1109/ICNS65417.2025.10976951

[52] Manual on the System-wide Information Management Concept. ICAO Doc 10039. 1st Ed, May 2024.

[53] Procedures for Air Navigation Services-Information Management, (PANS-IM), ICAO Doc 10199. 1st Ed 2024.

[54] Different CORUS project https://cordis.europa.eu/project/id/101287635

[55] European Grid Declaration. Grid infrastructure communication toolkit. https://renewables-grid.eu/app/uploads/2025/08/EGD-Transparency-and-public-participation.pdf

[56] ICAO's Policies on Charges for Airports and Air Navigation Services. ICAO Doc 9082

[57] OECD, The Next Production Revolution. Implications for governments and business. Chapter on Public acceptance and emerging production technologies. DOI http://dx.doi.org/10.1787/9789264271036-en , 2017.

[58] J. Dore, L. Lebel, Gaining Public Acceptance: A Critical Strategic Priority of the World Commission on Dams. *Water Alternatives* 3 (2), 124–141. 2010

[59] Bernstein, M.J., Nielsen, M.W., Alnor, E., Brasil, A., Birkving, A.L., Chan, T.T., Griessler, E., de Jong, S., van de Klippe, W., Meijer, I. and Yaghmaei, E., 2022. The Societal Readiness Thinking Tool: A Practical Resource for Maturing the Societal Readiness of Research Projects: MJ Bernstein et al. *Science and Engineering Ethics*, *28*(1), p.6.

[60] Miller, Michael; Thomas, Seth; Rusnock, Christina. Extending System Readiness Levels to Assess and Communicate Human Readiness. Systems engineering: the journal of the International Council on Systems Engineering. , 2016, Vol.19(2), p.146-157

[61] Pricing the Sky: Analysing Real-World Demand for U-space Services. Anna Palaiologk, Mahdi Gholami, Nikoleta Krousouloudi, BURDI project. https://futureneeds.eu/wp-content/uploads/2026/05/2026-05-05-BURDI-White-Paper-WEB.pdf

[62] U-ELCOME project https://u-elcome.eu/

[63] U-ELCOME. Deliverable M30: Set of recommendations for U-space legal and financial aspects. July 2025

[64] SAFIR-READY project https://cordis.europa.eu/project/id/101114855

[65] U-AGREE project https://cordis.europa.eu/project/id/101167187

[66] C. C. Puchol, M. J. Navarta, P. Gascó and D. Phu, "ACUTE Project – Facts and Findings on UAS Traffic in European Cities," *2025 Integrated Communications, Navigation and Surveillance Conference (ICNS)*, Brussels, Belgium, 2025, pp. 1-15, doi: 10.1109/ICNS65417.2025.10976789

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10.2 Reference documents

EUROPEAN ATM Master Plan, 2020.

Commission Implementing Regulation (EU) 2021/664 of 22 April 2021 on a regulatory framework for the U-space, EASA, 2021.

U-space Airspace Risk Assessment, Method and Guidelines – Volume 1, EUROCONTROL, 2023.

Global Air Traffic Management Operational Concept (GATMOC), Doc. 9854, International Civil Aviation Organization (ICAO), 2005.

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Appendix A Mapping of ConOps Ed. 4 Services onto Ed. 5

The fourth edition of the U-space ConOps identified 36 services, shown in Figure 15. This fifth edition of the ConOps follows Implementing Regulation EU 2021/664 in identifying fewer services.

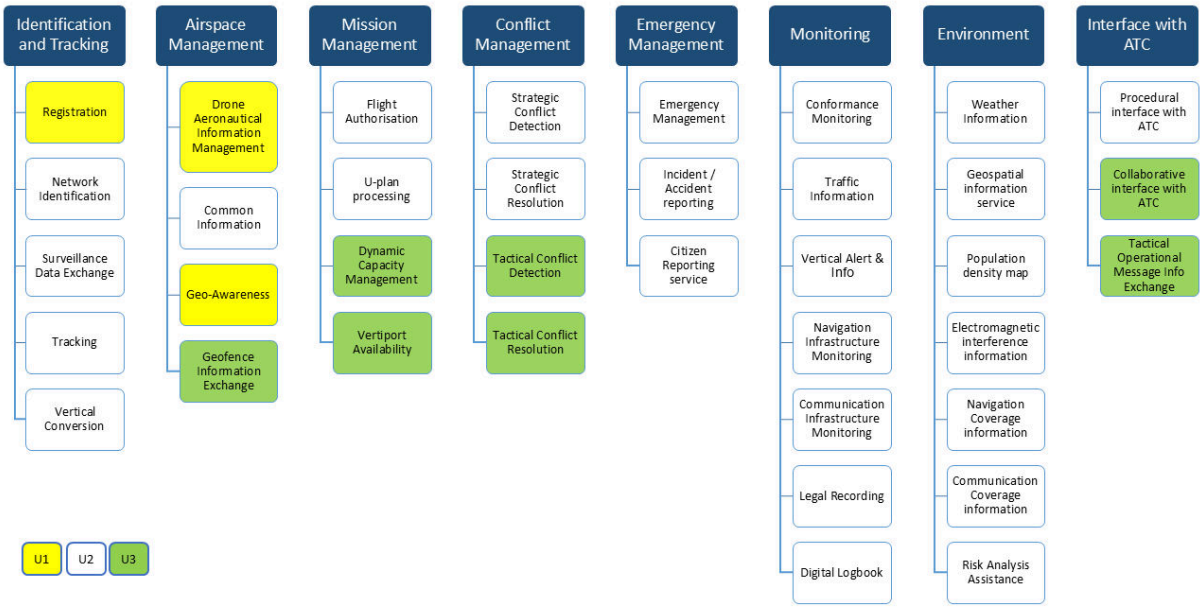


Figure 15: Services in U-space ConOps Ed.4

The U1, U2, U3 services are part of a progression described in earlier editions of the ConOps. Four U-levels were identified, each building on what came before.

U	Name
U1	U-space Foundation Services
U2	U-space Initial Services
U3	U-space Advanced Services
U4	U-space Full Services

Table 11 U levels

In practice, U1 has not been regulated as a set of *U-space Services; instead,* these services are implied by obligations within regulations for UAS operations, EU IR 2019/947. U2 equates to the set of services in EU IR 2021/664, 665 and 666, although the regulations identify fewer. U3 services are expected in the Medium Term and U4 in the Long Term.

U1 Services

The U1 Services that were foreseen in the earlier U-space ConOps are implied by obligations of UAS regulation EU IR 2019/947. In Edition 5, these are not referred to as U-space Services

- **Registration:** it is not a U-space service but an obligation for Member States to set up registration systems and for UAS operators to register (Regulation 2019/947), and could be mapped to U1. The registration number of an operator must be provided as part of the network identification messages

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and in the U-plan request. Finally, the USSPs must be given access to the UAS operator registration systems to verify the correctness of the data.

- **Drone aeronautical information management** is not a service in Edition 5. It is an obligation for Member States to make publicly available the information on UAS geographical zones. Regulation 2019/947, U1. The management of such information by Member States is implied in such obligation.

U2 Services

- **Network identification** is a U2 U-space service in Edition 5 as it was in Edition 4. Network Identification Service (NIS) is described in EU IR 2021/664.
- **Surveillance data exchange** is not considered a service in Edition 5, but a function embedded into the NIS. NIS requires that USSPs share information on their own flights with other USSPs, and in return will be informed about flights of other USSPs. This interchange is Surveillance Data Exchange.
- **Tracking:** the description in Ed.4 remains applicable, but tracking is now considered a 'function' rather than a service. In the 664 it is not mandatory, but we may find tracking is needed to achieve a minimum performance in the operators' remain well clear function. As described in 664, tracking could be performed at different stages (e.g. be a function of NIS, or of TIS, or even be applied in the CMU [minimum latency])
- **Common information services:** The Common Information Service is explicitly mentioned in EU IR 2021/664 and is thus a U2 service. The Edition 4 description continues to apply.
- **Geo-awareness:** the Ed.4 description was split into U1 and U2 parts. The U1 part is a function embedded into the Member State obligations regarding UAS geographical zones, listed in EU IR 2019/947 article 15. The U2 function remains applicable in Ed.5, as the Ed.4 description is based on 664.
- **Geo-fence information exchange service.** Not considered a U-space service but as part of the obligations of air traffic control units, as defined in Regulation 2021/665. Note that this is a re-classification from the previous Collaborative interface with ATC (U3) to the U2 horizon.
- **Flight authorisation service:** In Edition 5, FAS remains a U2 U-space service, with a minor change to the name compared with Edition 4. It is now 'UAS flight authorisation service'. The description of the U-plan has been updated (see U-plan section).
- **The U-plan processing service** has been embedded into the UAS flight authorisation service, as subfunctions performed by the FAS.
- **U-plan preparation/optimisation service:** In Edition 5, this is no longer considered as a U-space service. It can be regarded as a non-regulated service that USSPs could provide as an added value or may be even provided by third parties.
- **Strategic conflict detection** is embedded as a function into the FAS.
- **Strategic conflict resolution** is embedded as a function into the FAS, although in U2 the conflict resolution scheme is to reject the U-plan. Optionally, an alternate can be formulated, but there are no prescriptions.
- **Vertical alert and information:** in U2 it may be a non-regulated added-value service provided by USSPs. To be discussed whether U3 should include deconfliction from terrain within the scope of U-space services or whether this remains fully a responsibility of UAS operators.
- **Navigation infrastructure monitoring:** may be regarded as a non-regulated service in U2. Possibly included in U3 as a standalone service or a subfunction.
- **Communication infrastructure monitoring:** may be regarded as a non-regulated service in U2. Possibly included in U3 as a standalone service or a subfunction.

U3 Services

- **Dynamic airspace management** is U3 – The Dynamic Airspace Management of Edition 4 and previous is in Edition 5 now embedded within the Flight Authorisation Service as part of the DCB functionalities.

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- **Vertiport availability service** is U3 – In Edition 5, this is not a distinct service but a data element within common information. The function is unchanged.
- **Tactical conflict detection** is U3 – in Edition 5, it is not a distinct service but a function within the Separation Service.
- **Tactical conflict resolution** is U3 – in Edition 5 is not a distinct service but a function within the Separation Service.
- **Conformance monitoring:** continues as a U2 U-space service but only covers checking information against the U-plan terms and conditions and the applicable airspace limitations.
- **Traffic information:** continues as a U2 U-space service.
- **Weather information** continues as a U2 U-space service.
- **Vertical conversion:** This function is moved from U2 to U3 and is part of the Traffic Information service, which must provide a common vertical reference to airspace users.
- **Procedural interface with ATC.** In the U2 framework, there are a few obligations for U-space actors (CISPs, USSPs) and ATSPs to exchange information, such as network identification, manned traffic information, emergency statuses, and DAR activation. We can consider these as U2.

General Services

- **Incident/accident reporting** is a general obligation of USSPs (Article 15.1.d of 2021/664) rather than a U-space service.
- **Citizen reporting service** can be best understood as being part of the responsibilities of authorities, such as the coordination mechanism, ensuring public acceptance.
- **Emergency management** is a general obligation of USSPs (Article 15.2 of 2021/664) rather than a U-space service. It can materialise through different services such as the FAS (i.e. by updates to the U-plan) or the NIS (i.e. by indicating the emergency status of the aircraft), and also via USSP-ATSP interactions.
- **Legal recording** is a general obligation of USSPs (Article 15.1.g of 2021/664) rather than a U-space service
- **Digital logbook** is considered a non-regulated service. May be provided by USSPs as an added-value service, and also by third parties such as UAS manufacturers. Note that any information related to occurrence investigation should be part of the legal recording obligation listed above.
- **Geospatial information service** is a non-regulated added-value service.
- **Population density map** is a non-regulated added-value service.
- **Electromagnetic interference information** is a non-regulated added-value service.
- **Navigation coverage information** is a non-regulated added-value service.
- **Communication coverage information** is a non-regulated added-value service.
- **Risk analysis assistance** is a non-regulated added-value service.
- **Collaborative interface with ATC** is not a U-space service but rather an obligation for USSPs and/or ATSPs. Since this is U3, the precise mapping from Ed.4 to Ed.5 is not yet assessed
- **Tactical operational message information exchange**, as in Ed.4, is considered a sub-part of the collaborative interface with ATC.

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Appendix B U-space capacity limits in the short term

B.1 Scope and objectives

This appendix seeks to provide a high-level estimate of the expected capacity indicators of U-space airspaces considering the operational conditions as described in the short term (Chapter 4). The goal is to identify the limitations of the existing U-space capabilities and use this information to support the necessary developments during the medium term (Chapter 5) to achieve the stated goal of enabling high-density U-space airspaces.

As described in Section 3.6.2, there are different thresholds for capacity in U-space airspaces. The estimation of the safety-capacity thresholds is described in detail the U-AGREE project [65] OSED (Deliverable 2.6). These thresholds depend primarily on the performance of the mitigation barriers allowing the TLS to be met and can be measured through a series of risk-related mathematical equations, as described by U-AGREE.

This Appendix focuses on the efficiency-capacity thresholds, which are not as straightforward to quantify. These thresholds are related to the acceptability of the changes imposed by DCB and pre-flight deconfliction processes on the U-plans submitted by airspace users. The acceptability of such changes depends on multiple parameters and may vary depending on the kind of mission performed by each airspace user.

Hence, this appendix uses the necessary delays to resolve conflicts[14] as a proxy indicator of the impact associated with the strategic deconfliction processes. It is assumed that, as the average delay increases, less airspace users will consider the delay to operate as acceptable. Hence, large average delays are considered as indicators for a low acceptability, and a demand that is over the efficiency-capacity thresholds of the U-space airspace. However, this Appendix does not attempt to quantify the exact relationship between the magnitude of the delays and the percentage of UAS operators that may consider such delay inacceptable, nor to determine the exact resulting efficiency-capacity thresholds. These activities are considered as relevant for future research, in which the involvement of relevant stakeholders is necessary.

For the above purposes, a simple simulation tool has been developed to assess the impacts of volume-based strategic deconfliction using a FCFS prioritisation scheme. The tool has been used in different representative scenarios, changing a series of relevant parameters. Then, the results have been evaluated to identify the key factors driving the strategic deconfliction impacts on U-plans.

B.2 The tool

This section describes the simulation tool used to evaluate the impact of strategic deconfliction on U-plans, considering the conditions established for the short term in this ConOps.

The tool considers an airspace region of defined dimensions and generates a given number of U-plans that represent flights within the airspace region, during a given day (i.e. a continuous 24-hour period). Flight locations are randomly generated and thus homogeneously distributed in space. Regarding the temporal distribution during the day, the flights are distributed according to the patterns described in [66], based on the monitoring of actual UAS flights conducted in European cities.

For each flight, the tool generates a simple, straight 4D trajectory defined by two waypoints, which are randomly located within the airspace volume, at different locations and heights. Certain rules are defined to ensure that flights have a minimum size, to avoid extreme cases. In addition, when multiple 4D volumes are used per flight, intermediate waypoints are generated and used as reference to determine the location and

[14] Note this is the assumed strategy during the short term to resolve strategic conflicts. Others may be employed.

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duration of each individual 4D volume. These intermediate waypoints are located at equal intervals (space and time), to split the 4D trajectory into a series of identical segments.

Each pair of consecutive waypoints is used as the baseline to determine the boundaries and the start/end times of individual 4D volumes. These are created by adding the temporal and spatial uncertainties and margins (including the deviation thresholds) to the 4D coordinates of each waypoint. The resulting 4D volumes are rectangular prisms, with flat lower and upper surfaces, aligned with the principles described in [26].

Regarding the conflict detection algorithm, an analytical algorithm using the separating axis theorem (SAT) has been implemented to determine whether any pair of 4D volumes overlap in time and space. The conflict check is performed following the FCFS approach: whenever a new flight is generated (simulating the submission of the U-plan request), its 4D trajectory is compared against all the previously existing flights. In case of a conflict, an algorithm identifies the minimum delay necessary to resolve such conflict, without generating any other conflict. The modified (delayed) new U-plan is then added to the list of existing U-plans used to check for future conflicts with newly submitted plans.

The process follows a Montecarlo approach, simulating for each scenario a total of n iterations, each representing an operational day (24-hour cycle), and then produces an outcome based on the aggregation of the results from individual iterations.

The inputs for the simulation tool are:

- Airspace dimensions
- Number of flights per day
- Number of individual 4D volumes per flight
- U-plan uncertainty (horizontal, vertical, and temporal)
- Deviation thresholds (horizontal, vertical, and temporal)
- Ground speed
- Number of Montecarlo iterations

Outputs:

- Average U-plan delay (necessary to resolve strategic conflicts)
- Average percentage of U-plans that had a conflict upon request
- Time used by the tool to simulate a complete day (computational cost)

B.3 Use cases

The following use cases have been considered for simulation:

A. **Pessimistic scenario**. Conservative temporal uncertainties are used to evaluate the impact on typical levels of demand for the short term. Different numbers of 4D volumes are considered to evaluate the impact of the granularity of the U-plans.
B. **Changes in demand.** Scenarios subject to an increasing level of demand are addressed, to evaluate how the strategic deconfliction impact related to demand. Moderate temporal uncertainty.
C. **U-plan granularity.** The evolution of the impact and computation cost as the number of 4D volumes is evaluated, considering a moderate temporal uncertainty.
D. **Reduced uncertainties.** The impact of the reduction of uncertainties and margins is evaluated, considering different scenarios where the spatial or the temporal uncertainties are reduced.

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E. **Combination of C and D.** The combined impact of the reduction of uncertainties and margins and the number of 4D volumes is evaluated.

These scenarios are defined by a set of fixed parameters, common to all of them:

- Airspace dimensions: 10,000 x 10,000 x 100 m
- Ground speed: 16.67 m/s (60 km/h)
- U-plan horizontal uncertainty (95%): 10 m
- U-plan vertical uncertainty (95%): 10 m
- Vertical deviation thresholds: 18 m
- Montecarlo iterations: 100

The following variable parameters are used to configure the different use cases:

- Number of flights per day: [10, 50, 100, 250, 500, 750, 1000]
- Number of individual 4D volumes per flight: [1, 5, 15, 25, 35]
- Horizontal dimension of the deviation thresholds (m): [50, 150]
- U-plan total temporal uncertainty, incl. deviation thresholds (s): [30, 90, 300]

B.4 Results

The common input produce flights of varied length and duration, with an average of approximately 5800 m and 348 s. These values are constant for all scenarios. The results obtained for each scenario are described in the following sections.

B.4.1 Case A: Pessimistic scenario

In this scenario, operations have a temporal uncertainty of +/- 5 minutes. Table 12 below describes the results for the different combinations between 100 and 250 operations per day, and 1, 5, or 35 individual 4D volumes per U-plan.

It can be appreciated that the impact is less than 7.5 minutes on average for 100 daily flights, even with a single 4D volume. This impact decreases moderately (down to about 55%) by using more 4D volumes) However, under higher demand (250 daily flights), the impact with a single 4D volume is quite large (over 34 minutes, on average), reduced down to 20 minutes (about 60% of the previous value) with the use of multiple 4D volumes.

Table 12. Impact of strategic conflict resolution in a pessimistic scenario

Daily flights	DT_h (m)	T_unc (s)	4D_vols	Average delay (s)	% of delayed plans	Comp. cost (s)
100	150	300	1	449,88	45,43%	2,19
250	150	300	1	2065,25	78,31%	6,43
100	150	300	5	298,99	36,81%	2,28
250	150	300	5	1642,32	72,58%	7,54
100	150	300	35	242,36	32,33%	3,82
250	150	300	35	1214,6	68,98%	36,76

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B.4.2 Case B: changes in demand

In this second exercise, a reduced temporal uncertainty of +/- 90 seconds (arbitrarily distributed between the 4D trajectory and the deviation thresholds) is considered to evaluate the impact of strategic deconfliction as demand increases, from very low levels up to 1000 flights per day.

Table 13. Impact of strategic conflict resolution when varying demand

Daily flights	DT_h (m)	T_unc (s)	4D_vols	Average delay (s)	% of delayed plans	Comp. cost (s)
10	150	90	25	4,14	2,00%	0,24
50	150	90	25	14,46	6,44%	1,3
100	150	90	25	31,35	12,09%	2,59
250	150	90	25	91,3	28,60%	8,59
500	150	90	25	256,84	52,65%	34,54
750	150	90	25	625,77	70,86%	103,67
1000	150	90	25	1332,19	80,05%	226,47

The results show a reduced impact when compared to the first case, with the impact for 1000 daily operations under this reduced uncertainty being comparable to 250 daily operations under a larger uncertainty.

To provide additional insights regarding how this impact is distributed to operations conducted at different times during the operational day, Figure 16 and Figure 17 below display the demand (black line) and the resulting traffic load (bars) in two different scenarios: 250 and 1000 daily operations. The bars are coloured according to the impact of strategic deconfliction: blue in case of no conflicts, orange for smaller impacts (less than 15 minutes of delay), and green for larger impacts (more than 15 minutes of delay).

In the first scenario, it can be observed that the system can effectively absorb the demand under this setup. The demand is consistently met throughout the day, and most flights are not affected by strategic deconfliction. Among those which are, the vast majority experiences only minor impacts below 15 minutes. On average, the peak demand consists on 5-6 simultaneous UAS operations in the 100 km^2 area assessed. This environment can be qualitatively understood as a ‘low density’ airspace.

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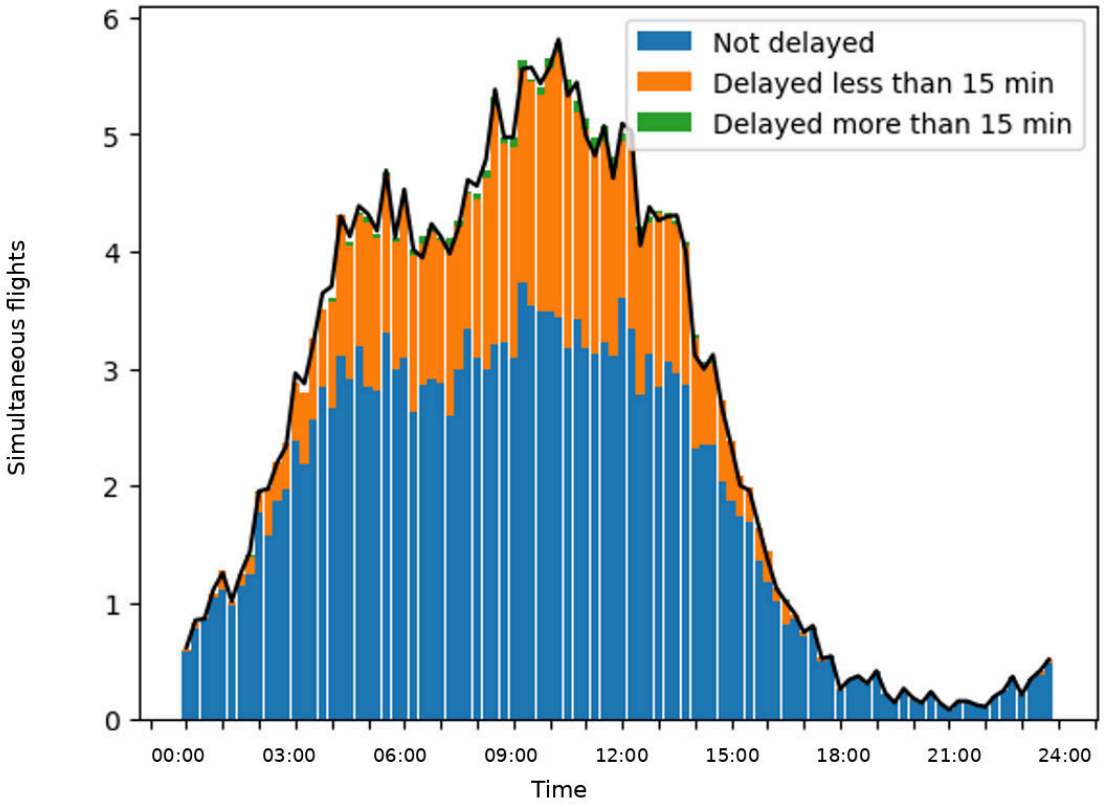


Figure 16. Impact of strategic deconfliction with 250 daily flights

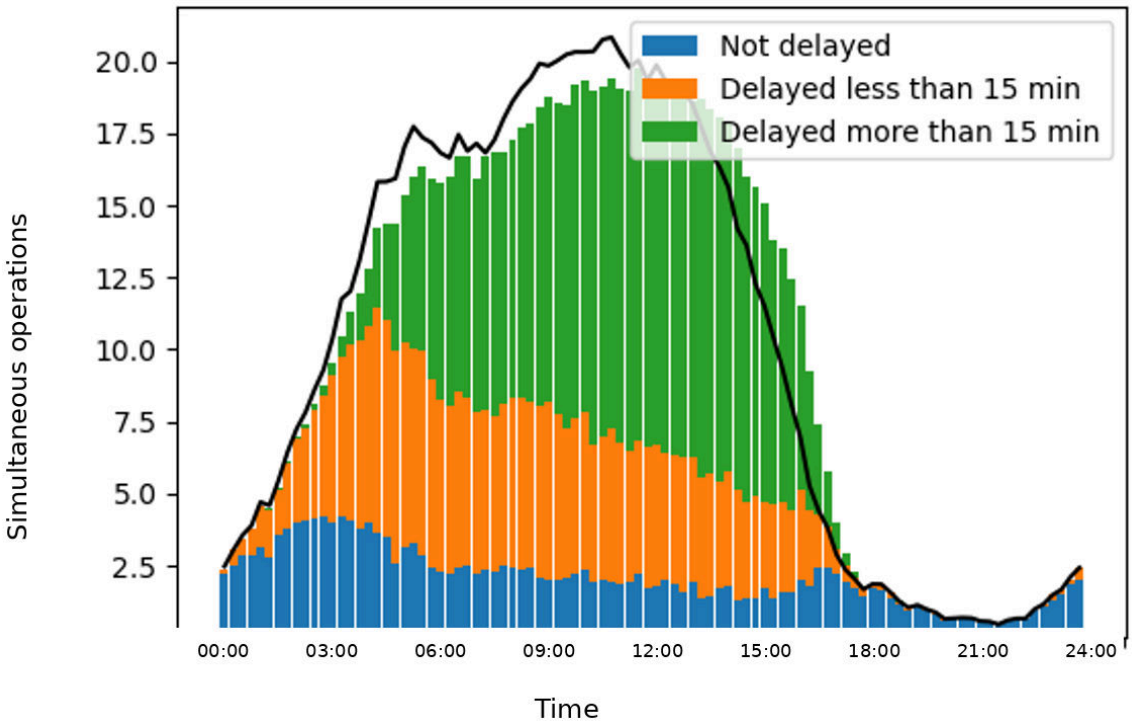


Figure 17. Impact of strategic deconfliction with 1000 daily flights

However, when the demand increases by a factor of four, the results are completely different. Compared to the previous figure, the traffic load does not actually reach the peak demand levels (bars do not meet the black line), and many operations are delayed cumulatively, with the impact persisting for a few hours after

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the traffic peak. It can be appreciated how, as the day progresses, a larger proportion of flights is delayed more than 15 minutes, due to the the FCFS approach and the 'waiting queue' that is created as operators are not allowed immediate airspace access. This scenario, which could be described as a medium-density airspace, cannot effectively meet the demand expressed by airspace users.

B.4.3 C: U-plan granularity

For the next exercise, we consider the highest level of demand evaluated, 1000 daily operations, and we estimate the strategic deconfliction impact according to the U-plan granularity. This is, the amount of 4D volumes used to define each individual U-plan. Results are shown below.

Table 14. Impact of strategic conflict resolution according to the U-plan granularity

Daily flights	DT_h (m)	T_unc (s)	4D_vols	Average delay (s)	% of delayed plans	Comp. cost (s)
1000	150	90	1	6728,45	91,73	82,82
1000	150	90	5	3037,27	85,07%	99,88
1000	150	90	15	1623,54	81,71%	163,95
1000	150	90	25	1332,19	80,05%	226,47
1000	150	90	35	1232,38	79,49%	463,05

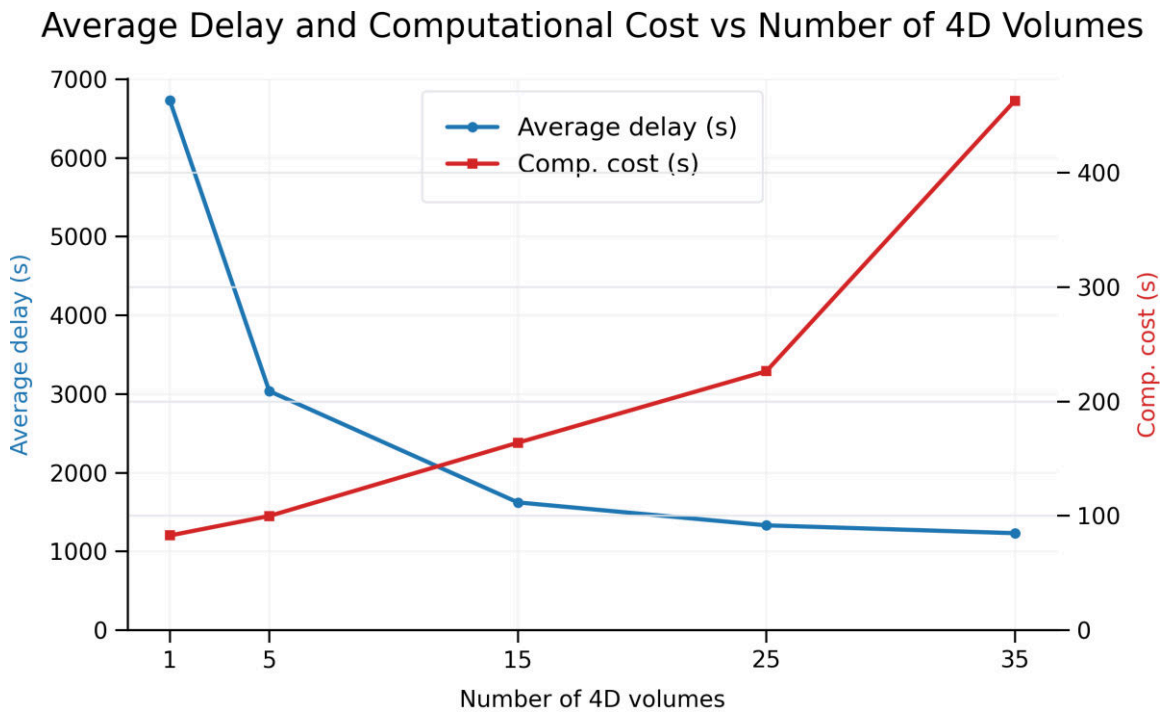


Figure 18. Evolution of strategic deconfliction impact and cost according to the U-plan granularity

The trend clearly shows how the strategic deconfliction impact is large when a single 4D volume is used; then decreases quickly until it reaches a plateau. On the other hand, the computational cost exponentially increases with the number of 4D volumes. These data suggest that there is a sweet spot regarding the U-plan granularity that provides a good enough impact reduction at an acceptable cost.

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B.4.4 Case D: uncertainty reduction

The next aspect to explore is how the reduction in the uncertainty margins reduces the impact of strategic deconfliction. Four scenarios are considered in this case. The first considers the baseline uncertainties from the previous scenario. The second considers a reduced horizontal dimension for the deviation thresholds by a factor of 3, which is often perceived as one of the more limiting factors. A third case considers a reduced temporal uncertainty by a factor of three. Finally, the fourth case considers both reduced spatial and temporal uncertainties, to evaluate the combined impact.

Table 15. Impact of strategic conflict resolution when reducing uncertainty margins

Daily flights	DT_h (m)	T_unc (s)	4D_vols	Average delay (s)	% of delayed plans	Comp. cost (s)
1000	150	90	35	1232,38	79,49%	463,05
1000	50	90	35	471,95	67,33%	115,8
1000	150	30	35	122,3	47,84%	128,28
1000	50	30	35	51,2	33,36%	53,56

The results show that, while a certain benefit can be achieved by reducing the physical spacing between flights, the largest benefit can be achieved when the temporal uncertainty is minimised. When both temporal and spatial uncertainties are reduced, the strategic deconfliction impact can be further reduced.

B.4.5 Case E: U-plan granularity and reduced uncertainties

The last experiment involves the assessment of how much reduction is achieved by splitting the U-plans into multiple 4D volumes for different levels of uncertainty. Table 16 below collects the results by addressing the scenarios from the previous exercise with 1 and 25 4D volumes per U-plan.

Table 16. Impact of strategic conflict resolution with different U-plan granularity and uncertainties

Daily flights	DT_h (m)	T_unc (s)	4D_vols	Average delay (s)	% of delayed plans	Comp. cost (s)
500	150	90	1	2079,85	82,25%	14,74
500	150	90	25	256,84	52,65%	34,54
500	50	90	1	1473,57	76,93%	12,43
500	50	90	25	144,47	40,58%	22,75
500	150	30	1	1119,7	76,40%	12,01
500	150	30	25	51,17	27,90%	20,63
500	50	30	1	821,12	69,42%	13,73
500	50	30	25	24,63	19,48%	13,63

It can be appreciated that, for reduced levels of uncertainty, the benefits of using multiple 4D volumes increase.

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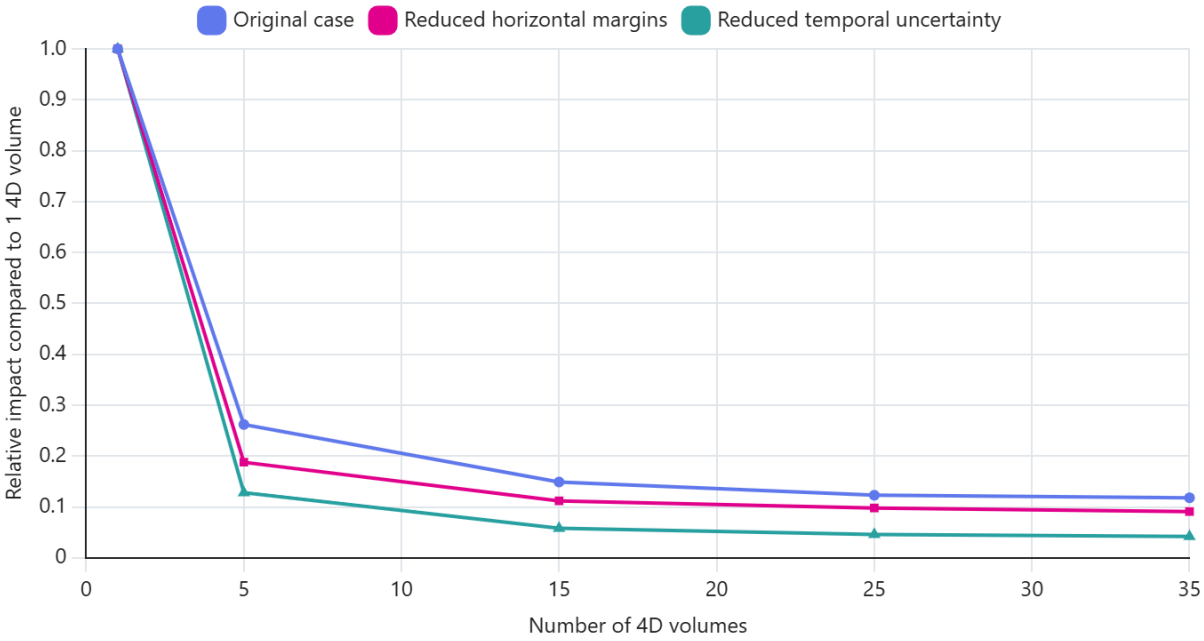


Figure 19. Reduction in impact of strategic deconfliction for different U-plan granularity and uncertainties

This effect can be explained by the relative size of each individual segment of the 4D trajectory that conforms to the 'skeleton' of the U-plan. Uncertainties are added to all segments to create each individual 4D volume. Hence, uncertainties drive the minimum size that can be achieved for each 4D volume, when the number of 4D volumes tends to infinity. As the uncertainties decrease, so does the relative size of the buffers compared to individual segments, leading to larger benefits being reaped when smaller segments are used. When using 35 volumes, each individual segment has an average length of 165 m and a duration of about 10 seconds. Once the spatial and temporal uncertainties reach a similar order of magnitude compared to the segments underlying the 4D trajectory, the benefits reaped from increasing U-plan granularity quickly vanish.

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B.5 Conclusions

Based on the results of the simulated scenarios in this Appendix, the following conclusions are drawn:

- U-space implementations that are limited to the use of a single 4D volume per U-plan are limited in terms of capacity. These may be accepted during the initial phases of the short-term but should rapidly adapt to the use of multiple 4D volumes to accommodate the expected growth in demand.
- Increasing the number of 4D volumes in each U-plan provides large benefits at the beginning, but a plateau is quickly encountered, while the computational cost increases exponentially. Trajectory-centric models described for the medium term, such as the linestring model explored in [51] are considered a potential upgrade, benefiting from the same improvement as using large numbers of 4D volumes without the associated computational cost.
- Reducing the horizontal deviation thresholds provides moderate benefits, but at the cost of increased performance requirements to maintain the TLS with reduced spatial margins. In particular, this impacts the maximum acceptable reaction time for UAS operators, which affects refresh rates for traffic information, system latency, and also the level of automation required to support UAS operators (facilitating a faster reaction). Thus, the reduction of this margin should be considered carefully. Thus, the potential safety impact of reducing the deviation thresholds is large compared to a moderate gain in capacity. Furthermore, in the medium term, it is expected that formally defined separation minima, or well-defined spacing, will substitute the deviation thresholds as the criterion to safely space U-plans.
- The factor that has the most impact on strategic deconfliction is the reduction of the temporal uncertainties. A moderate reduction (e.g. down to 90 seconds) can be achieved by careful planning and execution of the operations. However, the STH approach of performing strategic deconfliction upon U-plan submission does not allow us to benefit from the inherent reduction of uncertainty as time passes, including the collapse of uncertainty upon take-off. Hence, the strategies described in this ConOps for the medium-term to enable high-density U-space airspaces[15] focus on the smart management of uncertainties, to allow the temporal margins to be reduced down to a few seconds. An example approach for the smart management of uncertainty is the RTTA model detailed in Appendix C below, which should be complemented by in-flight traffic synchronisation as described in Section 5.4.4.4.
- There is a synergy between the reduction of uncertainty margins (temporal and/or spatial) and the use of a greater quantity of more compact 4D volumes: the more uncertainties are reduced, the larger the benefit that can be achieved by using increasingly smaller 4D volumes. Trajectory-centric models inherently benefit from this synergy, as these are equivalent to using an infinite number of 4D volumes.

[15] An initial qualitative description of high-density U-space airspaces may be those that can effectively support more than 1000 daily flights per 100 km^2 (considering operations in the VLL). Following this trend, a medium-density U-space airspace may support between 100 and 1000 daily operations, while a low-density U-space airspace would support less than 100 daily operations. Do note this is a high-level qualitative description that should be further assessed in future research activities.

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Appendix C What is RTTA?

C.1 Explanatory note

Previous editions of this ConOps have explored a new concept, branded as Reasonable Time to Act (RTTA), used within the wider U-space model to support unmanned traffic management. This term stems from the core principle behind the concept: delaying conflict management actions as much as reasonably possible before the flight, to benefit from reduced uncertainty and increase efficiency.

However, it has been noted that the high-level description and uses of RTTA in previous editions may have proven insufficient and/or unclear. Although the RTTA concept has been used in multiple research activities (journal papers, projects, etc.), which is kindly appreciated by the authors, it has been observed that the concept has often been misinterpreted, either regarding how the model is supposed to work or regarding the context in which it is supposed to be implemented.

Hence, this appendix has been developed with the purpose of clarifying what the RTTA concept is, what functions are executed by the model, and the context in which it is expected to operate.

C.2 RTTA scope and objectives

ICAO's GATMOC [12] is a core reference for this document. As described in the GATMOC, traffic synchronisation, conflict management and demand and capacity balancing are interrelated and will eventually become fully integrated, leading to a continuous and organised flow of traffic.

RTTA is a conflict management concept formulated to cover the safe, efficient and fair implementation of the pre-tactical and tactical DCB and pre-flight TS processes in U-space airspaces as described in the MTH (Chapter 5). DCB and TS are both key components of the ATM operational concept, each with different goals, that are integrated together in the RTTA concept. The RTTA model also describes the interface between DCB and TS functions, spanning the final stage of DCB and the pre-flight TS activities.

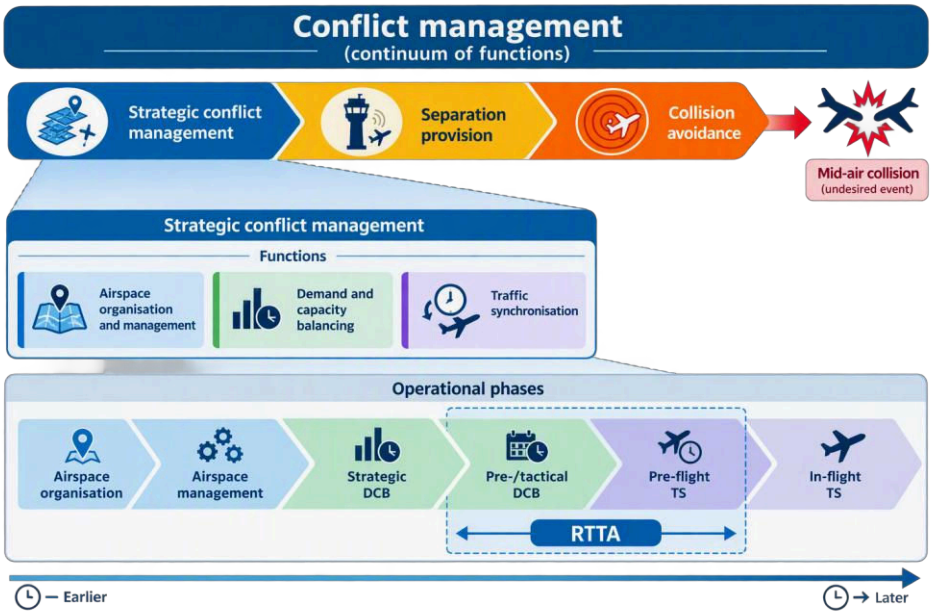


Figure 20. RTTA as part of the conflict management continuum

In the fourth Edition of the CORUS ConOps, two variations of the RTTA model are discussed, referred to as the 1-parameter and the 3-parameter models. The former is a simplified version of the model which

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addresses each flight individually, while the latter tackles the flights in batches, providing a framework for USSP coordination. The comparison between both models is detailed in Section C.5.

Another relevant aspect of the RTTA concept is the allocation of roles and responsibilities. From the service provision perspective, U-space is regarded as a federated system, in which multiple USSPs concurrently provide services to different aircraft in a shared airspace. Reliable communication links, together with digitalisation and automation of tasks, enable multiple USSPs to perform their functions in a coordinated manner.

Therefore, the RTTA concept is formulated with the intention for DCB and TS functions to be performed collaboratively by USSPs. The concept includes the necessary tools to facilitate coordination and minimise the issues related to the need for continuous synchronisation among USSPs. When any common reference is necessary, such information should be made available to all USSPs as part of the CIS. This includes information related to the acceptability of residual risks, the criteria used to define well clear distances or separation minima, or certain high-level rules defining the overall process, such as the RTTA parameters described in Section C.5 below.

Nonetheless, it could also be possible to implement the RTTA model in a centralised configuration, in which a single entity performs the necessary DCB and TS actions, and informs USSPs of the modifications to be implemented in the U-plans. However, this is not the preferred implementation, and the distributed model should be prioritised when possible.

Additionally, the model may benefit from an arbitration mechanism to solve potential disputes among USSPs. Such an arbitration mechanism could be distributed among USSPs or allocated to another entity. The establishment of an arbitration mechanism goes beyond the scope of RTTA and is not explored in this Appendix.

Finally, it is important to note that the RTTA concept as described in this Appendix is merely one of the many ways in which DCB and TS functions may be implemented, considering the stated goal of the medium term regarding enabling high-density U-space airspaces. The content of Chapter 5 is described in a manner that is aligned with the core principles and objectives of RTTA, but that does not prescribe the use of RTTA to achieve the desired outcomes. Therefore, the authors note that the development of new methods is considered as important as the further refinement of the RTTA concept.

The following sections describe what stages of DCB and TS are considered to be part of the RTTA process, what their goals are, and which measures can be implemented to safely, efficiently, and fairly manage air traffic within this context.

- **Section C.3** illustrates the goals of pre-flight TS in the RTTA model.
- **Section C.4** describes how DCB acts before TS as a ‘preprocessing’ stage that ensures that the TS function is provided with a set of inputs that allows an effective and efficient strategic conflict resolution.
- **Section C.5** describes the timeline of the RTTA process and how it ensures that U-plan changes are communicated with enough anticipation.
- **Section C.6** describes a method for synchronous collaborative strategic conflict resolution that may be applied in the context of RTTA.

C.3 Pre-flight TS in RTTA

Pre-flight TS aims at **establishing a safe, orderly, and efficient flow of air traffic**. The goal of TS measures in RTTA is to implement the necessary changes in the U-plans to reduce the residual risk of collision below the acceptable level, while minimising the impact on mission efficiency. This process is also known as strategic conflict resolution (SCR). These actions are performed after DCB measures, but before the start of each

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individual flight. It is important to note that further TS measures could be implemented on ongoing flights to ensure the safe, orderly, and efficient flow of air traffic established before flight **is maintained during the flight**. The implementation of such measures is **not** within the scope of RTTA.

Pre-flight TS measures are applied on U-plans when they are 'at RTTA'. Section C.5 below describes exactly what being 'at RTTA' means. These measures generally consist of what is understood as 'strategic conflict resolution', or 'pre-flight deconfliction': to introduce changes to the U-plans before the flight starts, to mitigate the residual (tactical) risk below the acceptable level.

The RTTA model supports binary or quantitative definition of strategic conflicts and for volume-centric or trajectory-centric U-plans, as described in Section 5.4.4.1. It is expected that the RTTA model will be initially implemented with the currently available approaches, before eventually transitioning to a quantitative trajectory-centric approach.

Furthermore, the changes to the U-plans coming from TS in RTTA are expected to be communicated to operators shortly before the earliest expected activation time[16] (EEAT) of the U-plan. It is imperative that such changes are provided with enough anticipation, are as small as possible, and are acceptable for UAS operators. DCB functions act as a 'pre-processing' filter to ensure these requirements are met.

C.4 DCB in RTTA

In the RTTA model, DCB actions can be implemented from the moment a U-plan is known until the flights are at RTTA. The main goal of DCB in RTTA is not to resolve strategic conflicts but to protect the boundary conditions in which the TS function can effectively perform strategic conflict resolution. In this sense, DCB actions within RTTA act as a first coarse filter before other functions refine the results. The RTTA model provides a structured timeline, as described in Section C.5 in which the time for application of DCB measures is well established. In the RTTA scheme, pre-tactical and tactical DCB measures are expected to be implemented according to the principles described in Section 5.4.3.3.

C.5 The RTTA timeline

C.5.1 The 1-parameter RTTA model

This is the original RTTA model as described in previous editions of this ConOps. The logic of the model is simple: to delay the strategic conflict resolution to benefit from the reduction of uncertainty as time naturally passes. How much to delay? Until we achieve a reasonable balance between how much uncertainty is reduced and how much time is left for the system to act (i.e. resolve strategic conflicts, communicate the solution to UAS operators, and allow UAS operators to implement the solution before the scheduled flight start). This reasonable balance is where the name of the model originates.

Hence, the single parameter in this model is the RTTA, i.e. the **reasonable time to act**. RTTA describes the time before the activation of the U-plan where there is a reasonable balance between the diminishing uncertainty and the time needed to make the necessary arrangements to ensure the residual risk of collision is reduced to an acceptable level. DCB measures are implemented before RTTA, and pre-flight traffic synchronisation happens at RTTA. After the pre-flight deconfliction, the U-plan is frozen and does not generally accept any changes (apart from exceptional cases such as contingencies or new high-priority

[16] In a volume-centric approach, the EEAT is the entry time of the first 4D volume (i.e. the one with the earliest entry time) described in a U-plan, consider the provided uncertainties. In a trajectory-centric approach, the EEAT considers the timing of the first waypoint defined in the U-plan, plus uncertainties.

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flights). It is important to emphasise that the 1-parameter RTTA model does not include any priority rules, which must be defined in addition to the RTTA.

An example case is illustrated in Figure 21 below. In this example, flights A, B and C are requested in order. However, B is planned to start earlier. This example showcases the following findings:

- The model allows for a time window to implement DCB measures before SCR. In the STH model, all DCB and SCR measures are implemented immediately upon U-plan request.
- The SCR of flight C is delayed after the expected activation of flight B, compared to the STH. Following FCFS rules, flight B retains priority over flight C in case of a strategic conflict. However, thanks to the dynamic uncertainty management of flight B (e.g. uncertainty collapse upon take-off), the footprint of flight B is reduced, and the possibility of a conflict between B and C is reduced, compared to the STH case.
- Although flight B will pass through SCR before flight A does, the latter maintains the priority in a FCFS scheme (first one to request the U-plan). Therefore, in case of an A-B conflict, flight B does not benefit from the RTTA model during SCR, as the uncertainties in flight A have not yet been subject to refinement.

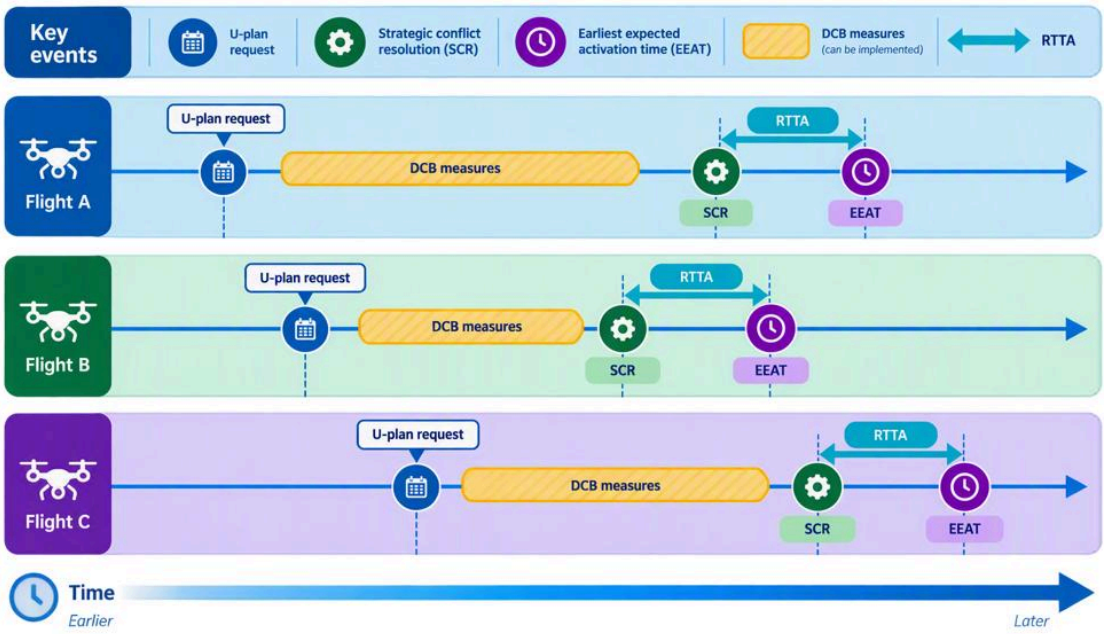


Figure 21. Example case of 1-parameter RTTA

Other approaches than FCFS could be used. For example, giving priority to the flights that are scheduled to be activated earlier. However, in such a scenario, flight A would be penalised against flight B and would not be able to benefit from dynamic uncertainty management, as the SCR of flight A happens before the activation of flight B.

This model has been tested via simulations in the 4th ConOps Edition, which showed a reduced impact of strategic deconfliction (i.e., fewer delays and less impacted flights) compared to the STH approach, when dynamic uncertainty management processes such as the ones described in Section 5.4.5.5 are implemented.

However, the 1-parameter model has multiple limitations:

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- It does not allow batch processing. Strategic conflicts are resolved for each individual flight when at RTTA. This focuses on a local solution and prevents finding solutions that achieve desired system-wide performance targets (e.g. less overall impact on airspace users).

- It does not resolve the fairness issues due to prioritisation, as showcased in the example above. The model changes when the strategic conflict deconfliction is performed but does not change the prioritisation logic. Even if the deconfliction is not performed upon U-plan submission, additional criteria are needed to determine who has priority (e.g. FCFS, first to activate).

- It does not address USSP coordination and synchronisation aspects. The model does not resolve what happens when two flights are at RTTA at the same time (I.e. exact or very similar), and different USSPs must simultaneously take decisions and communicate the results.

Therefore, the further development of this model is not considered within the scope of CORUS five. Instead, the development efforts have focused on the more complex model described below.

C.5.2 The 3-parameter RTTA model

The 3-parameter RTTA model proposes a different approach. This implementation of the model is based on a continuous process that is executed iteratively at specific time intervals (i.e. a sliding window), designed to ensure that all operations pass through the DCB and TS processes in batches.

This RTTA model is described by the following three temporal parameters:

- α: is the RTTA, i.e. the **reasonable time to act**. RTTA describes the time before the activation of the operations where there is a reasonable balance between the diminishing pre-flight uncertainty and the time needed to make the necessary arrangements to ensure the residual risk of collision is reduced to an acceptable level. DCB measures can be applied only before RTTA.
- β: is the RTTF, i.e. the **required time to freeze**. RTTF describes the latest time before the activation of flights at which the final solution for the mitigation of conflicts should be known by all involved stakeholders, so that it can be properly implemented in time. Pre-flight TS measures are identified between RTTA and RTTF and must be communicated to stakeholders at RTTF.
- γ: is the **width of the RTTA slot**. In each RTTA iteration, the RTTA process considers for pre-flight TS measures all the operations in the area for which the earliest expected activation time (EEAT) is within the RTTA slot. γ also describes the periodicity of the RTTA process. The RTTA process is repeated iteratively each γ units of time.

In each RTTA iteration, these parameters are expressed relative to the central time, t_c, for such iteration, as described in the diagram below:

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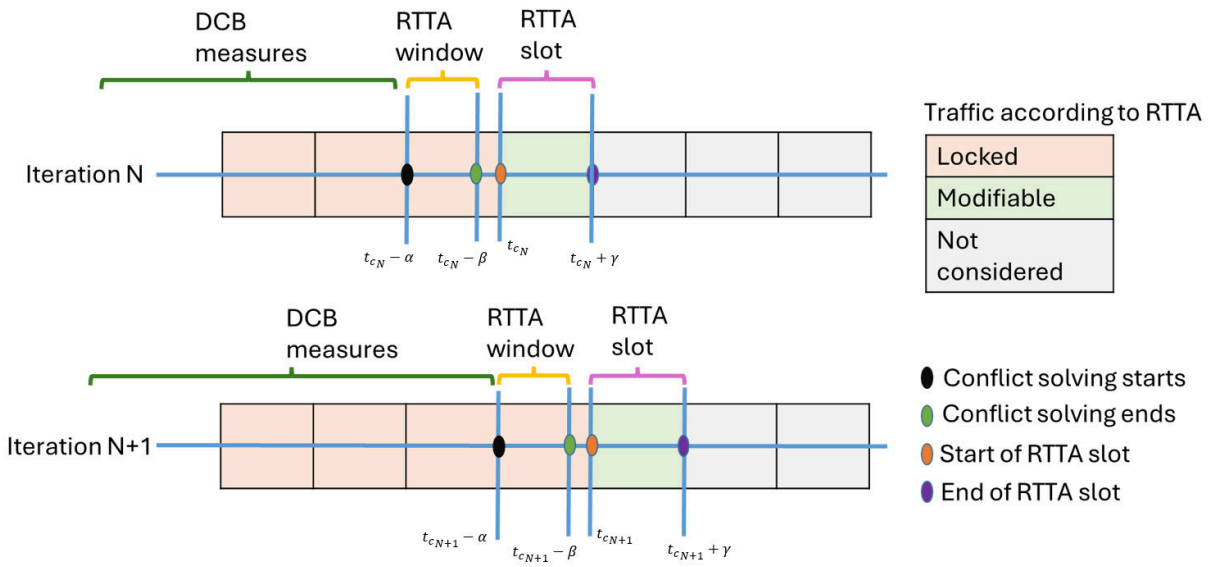


Figure 22. The 3-parameter RTTA timeline

The RTTA process works as follows.

1. From the moment a U-plan request is accepted, the U-plan starts to be subject to potential DCB measures. It is expected that, in general, U-plan requests will be submitted sufficiently in advance, whenever possible. During this process, as USSPs become aware of the demand (either known or predicted), DCB measures can be used to constrain U-plans whenever the demand exceeds the available capacity.
    a. DCB measures do not aim at solving strategic conflicts. These measures aim at moving flights off hotspots and/or applying constraints to the flights to reduce their footprint and make more capacity available.
    b. It is expected that there will be a limit for the maximum time a U-plan can be submitted prior to its expected activation time. It is expected that this maximum time will range between several hours and a few days.
    c. There is little value in implementing DCB actions long before the activation time, due to the high uncertainty. The RTTA model allows USSPs to wait until the traffic demand picture consolidates before implementing DCB actions.
2. When RTTA is reached, the RTTA window starts, and no more DCB measures can be implemented for any of the flights for which the EEAT is within the RTTA slot. During the RTTA window, the traffic synchronisation process begins, aiming at resolving strategic conflicts and ensuring the residual risk of tactical conflict is acceptable. In this process, all flights for which the EEAT happens before the end of the RTTA slot are considered, but only the ones for which the EEAT is within the RTTA slot may be modified (i.e. earlier flights that have already passed the process in previous RTTA iterations are considered to determine potential conflicts but left untouched).
    a. Once the RTTA window starts, the known pool of U-plans for which the EEAT is within the RTTA slot is temporarily frozen.
    b. During the RTTA window, the traffic synchronisation is in process. The RTTA model is architecture-agnostic, and supports both centralised and federated approaches:
        i. In a centralised approach, a single entity looks for a solution to strategic conflicts and will communicate the results (i.e. U-plan updates) to all USSPs before the RTTA window ends.

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- In a distributed process, multiple USSPs collaborate to find a solution. The best[17] solution proposed by USSPs is agreed upon and implemented by all USSPs.
    c. This process ensures that all U-plans pass through the TS function. In addition, it is expected that, in most cases, U-plans can be submitted before RTTA and thus also be considered for DCB purposes.
    d. If a U-plan is submitted late (i.e. after the start of the RTTA window corresponding to the RTTA slot in which the EEAT is defined), the plan cannot be considered in the current TS process and will have to wait until the closure of the RTTA window. Then, two things may happen:
        i. If the U-plan is free of conflict with others (after the U-plans update), it may be accepted to operate as requested.
        ii. If the U-plan is in conflict with other previously existing plans, it will need to be modified to solve the conflicts, without having any priority over the existing plans. If the USSP cannot provide a solution for the requested slot that resolves the conflicts, the U-plan will be delayed and take part in the next RTTA iteration.

3. When RTTF is reached, the solution for strategic conflicts is communicated to all relevant stakeholders and the U-plans are frozen. USSPs shall share this information with operators, who in turn will introduce the new U-plans in their flight management system (FMS) or equivalent.
4. Once the clock reaches t_c, marking the start of the RTTA slot, all operations for which the EEAT lies within the slot are known and deconflicted, and may start requesting their respective activations, according to the activation window provided to each operation.

This process is repeated in a continuous loop, in which consecutive iterations overlap at different phases. For example, while iteration N enters step 4, iteration N+1 may be close to starting step 2. This does not represent any problem as long as two consecutive RTTA iterations do not overlap in the same phase, to prevent synchronisation issues. For example, the RTTA window and the RTTA slot of two consecutive RTTA iterations must not overlap.

To ensure there is no overlap between consecutive RTTA iterations, the following process describes the construction of an RTTA model:

1. Select the width of the RTTA slot, γ. This width is expected to be expressed in minutes and to be a submultiple of 60 (i.e. 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60). In each hour, there will be $\frac{60}{\gamma}$ RTTA slots in each area subject to RTTA (e.g. a U-space airspace).
2. Identify the RTTA schedule. This means which times of the day are the central time t_c of each RTTA iteration. For example, considering $\gamma = 5\,min$, a possible approach would be $t_c = [0{:}\,00, 0{:}\,05, 0{:}\,10, 0{:}\,15, \dots]$.
3. Define the RTTF, β, according to the expected system capacity in communicating and implementing the strategic conflict resolution changes proposed to U-plans. β is expected to be substantially smaller than γ. However, there is a minimum value that can be achieved, due to system performance. Hence, β should be as small as reasonably practicable, providing enough time for the solution to be implemented. The minimum acceptable value for β is heavily influenced by the level of automation used by airspace users for the purposes of U-plan updates.

[17] Common rules are necessary to determine what 'best' means. See C.6 for further details.

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4. Define the RTTA, α. In all cases, $\alpha - \beta$ must be strictly inferior to γ, to prevent overlaps between consecutive iterations. In addition, $\alpha - \beta$ describes the width of the RTTA window, meaning it bounds the time allocated for the purposes of finding a solution to the traffic synchronisation problem. The smaller α, the more the system can benefit from dynamic uncertainty management, but the less time is available for action. Therefore, α should also be as small as reasonably practicable, but large enough according to the traffic demand and complexity, along with the expected computational capability.

The computational cost for solving the traffic synchronisation problem depends on the degrees of freedom of such problem. This means that, for a given traffic demand, the minimum acceptable value of $\alpha - \beta$ also depends on γ. The larger the RTTA slot, the more aircraft for which a solution must be found, increasing the computational cost (usually in a non-linear manner). There are conflicting criteria regarding whether the value of γ should be larger or smaller:

- On the one hand, using larger RTTA slots means that a longer conflict horizon is considered, thus potentially finding a better overall solution that better optimises system-wide parameters. However, the cost of finding the solution increases exponentially with the number of involved aircraft. The refresh rate is reduced, limiting the potential gains due to dynamic uncertainty management.
- On the other hand, smaller RTTA slots allow more frequent RTTA iterations. This refreshes the process more often, meaning the TS solution can be formulated considering updated uncertainty values for those operations that recently started. This is particularly relevant considering the collapse of uncertainty upon the start of flights. Smaller RTTA slots also allow U-plans to be sent shortly before EEAT, thus also including last-minute operations in the TS loop without discrimination.

By resolving conflicts in batches, the 3-parameter RTTA model mitigates the biases from other prioritisation schemes such as FCFS. Instead of focusing on a single flight each time, the model allows for the identification of a coordinated solution that distributes the impact among the affected users, leading to a fairer implementation. This way, the model also prevents systematic disadvantages for operators who cannot file far in advance, as long as they can at least file the U-plan before RTTA (which, anyway, should be only a few minutes). For these purposes, the user preferences described in the U-plan according to Section 5.4.5.2 can be used to identify solutions tailored to each operator.

Another relevant aspect of the RTTA timeline is the provision of feedback to airspace users. As highlighted above, the model clearly identifies at which stage different actions can be implemented, and when these must be communicated to airspace users. In addition, additional feedback may be provided to airspace users at any moment, indicating how likely potential changes to the U-plan are.

C.6 An algorithm for collaborative strategic deconfliction

The goal of this section is to further delve into the details of the RTTA model, proposing an algorithm to perform collaborative strategic conflict resolution in a synchronous manner, as described in the 3-parameter RTTA model. This algorithm also considers fairness aspects to ensure the impact of SCR is evenly distributed and respects user preferences.

The primary input for the algorithm is the pool of U-plans, including:

- The planned 4D trajectories.
- The uncertainties related to the flight. These can be expressed as 4D volumes in a volume-centric approach.
- Airspace user preferences, including constraints.
- Whether the plan is considered to be frozen (i.e. does not accept any changes), or whether the plan is flexible (i.e. can be modified to resolve strategic conflicts). At least one flight in the pool must be

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flexible. High-priority critical flights (e.g. emergency, police) can be flagged as frozen to grant them priority over other airspace users.

Other relevant inputs are:

- Safety-relevant metrics, such as the separation minima, the remain well clear distance, or, when applicable, the deviation thresholds.
- Priority and fairness metrics.
- Airspace structure, including restricted/segregated areas.

The output of the algorithm must be an updated set of U-plans with modified 4D trajectories whenever necessary to resolve a strategic conflict.

The process followed for this purpose is:

1) Identify the flights that can be modified (i.e. flexible ones)

2) Detect potential strategic conflicts between the flights identified in 1) and any other known flight in the U-plan pool.

3) Upon the detection of conflicts, determine the necessary changes that resolve the conflicts while minimising the impact to airspace users, considering airspace limitations, user preferences, and safety, priority, and fairness metrics.

It is the process described in 3) that deserves the most attention. To achieve this, two criteria must be met:

a) **The strategic conflicts are resolved.** What this exactly means depends on how strategic conflicts are defined. In a volume-centric approach, a strategic conflict is the overlap of 4D volumes belonging to different U-plans. Hence, to solve the conflicts, the 4D volumes must be modified so that they no longer overlap[18]. In a trajectory-centric model, a strategic conflict can be triggered by the probability that a pair of flights end up causing a tactical conflict (e.g. a loss of well clear spacing or separation), if no further action is taken. The resolution in this case implies reducing such probability below a predefined threshold. In addition, the resolution of the conflicts must respect the applicable airspace limitations (e.g. consider restricted areas).

b) **The cost to resolve the conflicts is minimised.** This cost should be understood as the impact on airspace users of the proposed changes to the U-plan. As acknowledged before, the necessary changes to the U-plans will create inefficiencies by forcing operators to conduct flights different to what they initially desire. Therefore, the impact does not only depend on the magnitude of the changes to the U-plans, but also on the cost for airspace users to implement such changes, which can be related to delays, longer flight duration, fuel/energy expenditure, operator workload, etc. These costs should be expressed as user preferences, in a manner that describes which (and how much) changes are acceptable for them.

[18] Note that this can be achieved by modifying the underlying 4D trajectory that forms the skeleton upon which the 4D volumes are created, when available.

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To support criterion b), the following process is suggested to describe the cost function for airspace users. First, the intrinsic cost factor for each flight can be described as a function of the cumulative changes introduced to the U-plan, δ_j, and the acceptability of each individual change, κ_j:

$$Cost_factor_flight = 1 + \sum_j \delta_j \cdot \kappa_j$$

It is trivial to see that, for a flight for which no changes are proposed, the cost function is 1 (the original value), while any change will result in larger values. The proposed changes could be applied to the U-plan as a whole (e.g. a delay of X minutes), or to specific parts of it (e.g. changes to one/multiple 4D volumes, or to any waypoint that is part of the 4D trajectory). In addition, unacceptable changes (e.g. hard constraints) can be expressed by arbitrarily large values[19] of κ_j.

Given that multiple flexible flights can be considered by the algorithm, the total combined cost of i flights is simply the addition of all individual costs:

$$Cost_all_flights = \sum_i \left(1 + \sum_j \delta_j \cdot \kappa_j\right)$$

To include fairness considerations in the model, an exponential fairness factor, φ_i, can be introduced. This factor shall have a minimum value of 1 (for which it has no effect). The larger the fairness factor, the more the model emphasises an equal distribution of impacts among airspace users, hence potentially achieving a 'fairer' solution.

$$Cost_all_flights = \sum_i \left(\left(1 + \sum_j \delta_j \cdot \kappa_j\right)^{\varphi_i}\right)$$

The goal of the fairness factor is to promote a more even distribution of efforts, compared to 'all-in' approaches such as FCFS, which consistently penalises the airspace users that cannot request their U-plans sufficiently in advance. In addition, the fairness factor also allows the implementation of additional considerations, such as the 'virtue points' discussed in Section 5.4.3.4. An airspace user that consistently shows appropriate behaviour, such as flying according to the plan, submitting the U-plan requests well before RTTA (hence supporting the DCB function), and accepting DCB recommendations (i.e. those resulting from yellow hotspots as described in Section 5.4.3.3), may have their fairness factor increased compared to the average value, which results in modifications to their flights being 'more expensive'. In the opposite case, operators who consistently 'misbehave' may see their fairness factor reduced.

However, it is noted that the addition of the fairness factor implies including non-linearities into the model, which complicates its resolution from a mathematical standpoint. Further development should be conducted to determine whether it is worth, in a practical implementation, to use the proposed fairness factor.

An implementation based on the described algorithm can support the 3-parameter RTTA distributed model. In this RTTA model, all USSPs, having the same traffic picture (U-plan pool), must start the process when at RTTA, and then find 'the best' solution they can achieve, communicating it to others before RTTF. Among all the proposed solutions, the objectively best one would be the solution that complies with criterion a) (i.e. risk below acceptable threshold) and minimises the cost from criterion b) (i.e. minimises impact on airspace

[19] Theoretically, a hard constraint is mathematically defined by an infinite κ_j, but practical implementations may consider arbitrarily large values instead.

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users). The identification of the best solution may be performed by collective agreement (upon a shared set of rules and conditions) or managed via an arbitration mechanism. Alternatively, this model can also be used in the centralised RTTA approach, by having a unique entity perform the strategic conflict resolution considering criteria a) and b), and then communicating the solution to USSPs, who in turn, communicate with airspace users.

C.7 Future work

The purpose of this section is to highlight a series of developments necessary to further mature the RTTA concept.

- The current version of the model is focused on a single instance of U-space airspace. How does the RTTA model work in the case of multiple contiguous U-space airspaces?
    - Can the RTTA model be applied to an airspace region that is larger than a U-space airspace? (e.g. at national level, at EU level)
    - Must adjacent RTTA regions use the same model parameters to ensure that the process is synchronised?
    - Should entry/exit points to/from RTTA regions (e.g. the boundaries of a U-space airspace, national airspace boundaries) be treated as hard constraints?
- A computational model capable of solving the algorithm described in the previous section needs to be developed. The use of models supported or enabled by artificial intelligence has certain potential for this topic and should be explored.
- Incremental validation of the model is necessary to support further development. Work to develop practical implementations of the model (including quantification of the RTTA parameters and the cost function components) and comparisons between different approaches (e.g. current approach with FCFS, 1-parameter RTTA, 3-parameter RTTA, others), and in different contexts (e.g. trajectory-centric vs volume-centric, centralised vs distributed implementations) is encouraged.
    - The results should be checked with the practical users of the model (i.e. USSPs, airspace users), to validate its usability and acceptability.

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11 Annexes

Double-click on the icons below to open them


Annex_A_Simulations.docx


Annex_B_Public_Acceptance_PF.docx


Annex_C_Public_Acceptance_Surveys.pdf

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Annex A. Simulation results

A.1. Document Introduction

This Annex builds upon the work presented in the Exploratory Research Plan (ERP) [1] and the Exploratory Research Results (ERR) [2] deliverables. The ERP defined the simulation methodology, operational scenarios, and experimental framework, whereas the ERR presented and analyzed the simulation results obtained from their application. Building on this previous work, this Annex provides a more detailed characterization and analysis of the simulation results, complementing and extending the information reported in the ERR.

The Annex has been designed as a self-contained document, providing the methodological and contextual information required to understand the analyses and results presented herein without the need to consult the previous deliverables. Nevertheless, readers are encouraged to refer to the ERP for a more comprehensive description of the objectives of the simulation campaign, the methodological framework, and the rationale underlying the design of the simulated scenarios. Similarly, the ERR provides additional context on the previously analyzed results, including the assessment of a complementary, higher-density operational scenario based on a 1 km × 1 km U-space volume.

The appendix is structured into five main parts:

- Section A.2 introduces the conceptual framework used to asses U-space performance, focusing on the interdependence between safety, capacity, and efficiency. It establishes the main performance dimensions and explains why U-space capacity must be understood as a system-level outcome rather than as a purely geometric airspace limit.
- Section A.3 reviews the state of the art in quantitative U-space assessment, covering analytical collision-risk models, single-flight risk-assessment approaches, and system-level fast-time simulation. Their respective capabilities and limitations are discussed, motivating the use of Monte Carlo fast-time simulation for evaluating emergent system behaviour.
- Section A.4 describes the DronAs Fast-Time Simulation (FTS) framework and the parameter groups used to configure the simulated U-space environment. These include the operational context, traffic demand, flight-operation representation, deviation thresholds, authorization policy, long-term deviations, airspace restrictions, and authorization-service failures.
- Section A.5 presents the simulation methodology and statistical analysis framework. It defines the nominal and non-nominal simulation scenarios, describes the common simulation execution pipeline, specifies the capacity, efficiency, and safety indicators, and introduces the statistical procedures used to quantify uncertainty and compare safety performance across scenarios.
- Section A.6 and A.7 presents and discusses the simulation results obtained for the different operational configurations and scenarios. The analysis examines how traffic density, mission representation, deviation thresholds, strategic deconfliction, and non-nominal conditions affect capacity, efficiency, and safety, and integrates the findings to identify the main system-level trade-offs and operational limitations.

A.2. Introduction: Safety, Capacity and efficiency

In conventional Air Traffic Management (ATM), sector capacity refers to the number of flights that can be safely managed by air traffic control within a given area and time period without

infringing safety margins or causing controller overload. Similarly, in U-space, airspace capacity can be understood as the amount of unmanned traffic that can be safely and efficiently accommodated within a defined airspace [3][4]. However, unlike a purely geometric property of the airspace, U-space capacity should be regarded as a system-level outcome, determined by the required safety margins, the characteristics of the traffic demand, the performance of the conflict-management barriers and supporting U-space services, and the operational constraints imposed on UAS operators.

Although automated U-space services remove the human air traffic controller as the primary capacity constraint, their ability to manage increasing traffic demand remains limited by their performance under different traffic densities and under both nominal and non-nominal conditions. Consequently, U-space capacity should not be interpreted solely as the maximum number of operations that can be accommodated below a given target level of safety. It should also account for the extent to which the system can preserve the original flight intents submitted by UAS operators after the application of mitigation measures.

In this context, flight efficiency can be interpreted as the degree to which the operations ultimately authorised and conducted preserve the flight intents originally requested by UAS operators. Measures required to maintain safe traffic conditions, such as departure delays, trajectory modifications, rerouting, mission rejection or cancellation, and other operational restrictions, introduce an efficiency cost. Therefore, traffic demand should not only be considered accommodated when the corresponding operations satisfy the applicable safety requirements, but also when the modifications imposed on the original flight intents remain within an acceptable level. Excessive operational restrictions may indicate that, although the traffic can still technically be managed safely, the practical capacity of the U-space airspace has been exceeded from an efficiency perspective.

Safety, capacity, and efficiency are therefore structurally interdependent. Measures intended to improve one dimension may directly affect the other two (see Figure 1). For example, more conservative operational volumes, resulting from larger deviation thresholds, may increase separation margins and therefore contribute to safety, while simultaneously reducing the number of missions that can be accommodated. Similarly, a suboptimal strategic deconfliction strategy, such as a First-Come First-Served approach, may require larger modifications to operators' original flight intents to accommodate a given traffic demand. Conversely, relaxing operational constraints may increase the apparent capacity of the airspace and reduce the modifications imposed on individual missions, but may also increase the number and complexity of traffic interactions and ultimately reduce safety margins.

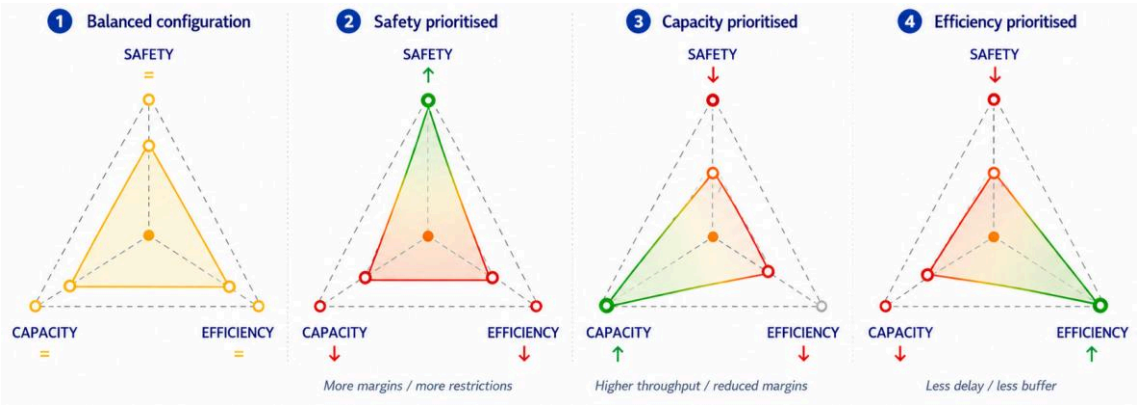


Figure 1. Schematic representation of capacity-safety-efficiency trade-off

Figure 1 provides a conceptual representation of this interdependence. The distance of each vertex from the center represents the relative performance level achieved in the corresponding dimension, while the color scale reinforces this interpretation: green denotes a high level, yellow an intermediate level, and red a reduced level. The equal-area triangles provide a qualitative representation of a constrained system in which improvements in one dimension generally require adjustments in the others. The balanced configuration represents a compromise in which safety, capacity, and efficiency achieve comparable intermediate levels. By contrast, prioritizing one dimension displaces its corresponding vertex towards a higher performance level while the remaining vertices move towards the center, illustrating the potential performance losses introduced in the other dimensions.

The strong coupling among these three dimensions makes isolated analytical evaluations insufficient for characterizing U-space airspace performance. Their interaction emerges dynamically from traffic demand, airspace structure, operational constraints, conflict-management processes, U-space service performance, and the behavior of individual aircraft. Simulation-based approaches are therefore particularly suitable for evaluating how modifications to one element propagate through the overall system and affect safety, capacity, and efficiency simultaneously.

In this context, the development of U-space system simulators becomes an important element for supporting both risk assessment and the design of U-space airspace volumes. Such tools enable the implications of alternative operational and regulatory requirements to be evaluated before deployment, including the target level of safety, the traffic levels that can be accommodated, the acceptable degree of modification imposed on UAS operators, and the performance requirements assigned to supporting U-space services and on-board systems, such as Detect and Avoid capabilities. By reproducing the interactions among traffic demand, airspace structure, conflict-management layers, U-space services, and on-board mitigation functions, simulation provides the evidence required to determine whether a given U-space region can safely and efficiently accommodate the intended operations. Consequently, it can support evidence-based decisions concerning airspace design, operational limitations, service-performance requirements, on-board system requirements, and access conditions for UAS operations within specific U-space regions.

A.3. Simulation approaches: State of the Art

A.3.1 Introduction to U-space simulators

The quantitative assessment of U-space systems is constrained by the limited availability of large-scale operational data. Although the regulatory framework is already being established, U-space services, operational procedures and technical standards are being developed and validated in parallel with their implementation. Consequently, it is required a mature environment from which sufficient evidence can be collected to assess safety, capacity and efficiency performance under the range of traffic conditions expected in future deployments.
This limitation is particularly relevant because U-space constitutes a system of systems in which aircraft, operators, U-space service providers, communication and navigation infrastructures, airspace constraints and regulatory requirements interact. Dependencies between these components may produce emergent behaviors that cannot be identified by assessing each service or subsystem independently. End-to-end quantitative assessment is therefore required both to verify the performance requirements assigned to individual services and to determine whether their combined operation can achieve the desired system-level safety, capacity and efficiency targets [5].

Fast-time simulation (FTS) provides a cost-effective and risk-free environment in which alternative traffic structures, service configurations, performance requirements and non-nominal conditions can be evaluated before large-scale operational data become available. FTS can also support the transition from demonstrations to operational deployment by examining how a U-space system may behave at scale and by identifying the conditions under which additional services, separation provisions or contingency measures become necessary.
However, exhaustive exploration of every possible traffic configuration, disturbance, sensor error and system failure is computationally expensive. This difficulty is amplified by the rarity of safety-critical events such as NMACs and MACs. As an alternative quantitative U-space assessment must therefore combine methods with different levels of abstraction and scopes of analysis. The following subsections examine three complementary approaches: analytical models, which provide transparent aggregate relationships and baseline estimates; individual-flight assessment methods, which evaluate the risk associated with a specific trajectory or mission; and system-level fast-time simulation combined with Monte Carlo analysis, which captures the emergent effects produced by concurrent operations, service interactions, uncertainty and non-nominal events.

A.3.2 Analytical models

Within ATM safety assessment, encounter and collision-risk models constitute one of the main families of analytical approaches used to quantify hazardous interactions between aircraft
Analytical encounter models describe traffic through a reduced set of macroscopic parameters. The original Reich model and its subsequent extensions have provided the analytical basis for deriving route spacing from collision-risk criteria, as described in the European PBN Route Spacing Handbook [6] and separation minima values [7]. Within the U-space domain, Gas model, derived from the kinetic theory of gases that expresses the encounter rate as a function of traffic density, relative speed, and cross-sectional area, has been applied for deriving collision-risk targets and separation minima for UAS operations [8]. ASTM F3548-21 Appendix X4 [9] builds on the same Poisson encounter structure to construct a layered risk framework distinguishing between participating and non-participating aircraft and between nominal and off-nominal operational states.

These models provide rapid order-of-magnitude risk estimates and transparent analytical traceability. However, they are structurally constrained by the assumptions underlying their mathematical derivations: traffic density is treated as spatially homogeneous; trajectories are approximated as straight lines at constant speed; and encounters are assumed statistically independent. As a consequence, analytical models cannot represent the influence of airspace structure — free-routing environments, corridor networks, or hub-and-spoke layouts — on encounter patterns; the variation in UAS platform performance across heterogeneous fleets; the effectiveness of specific U-space service configurations in reducing conflict rates or imposing efficiency costs; or the risk contribution of non-nominal events such as GPS failures, wind-induced deviations, or dynamic airspace restrictions. Furthermore, no analytical method currently exists for determining U-space capacity, nor for estimating efficiency indicators such as authorization delays or acceptance ratios.

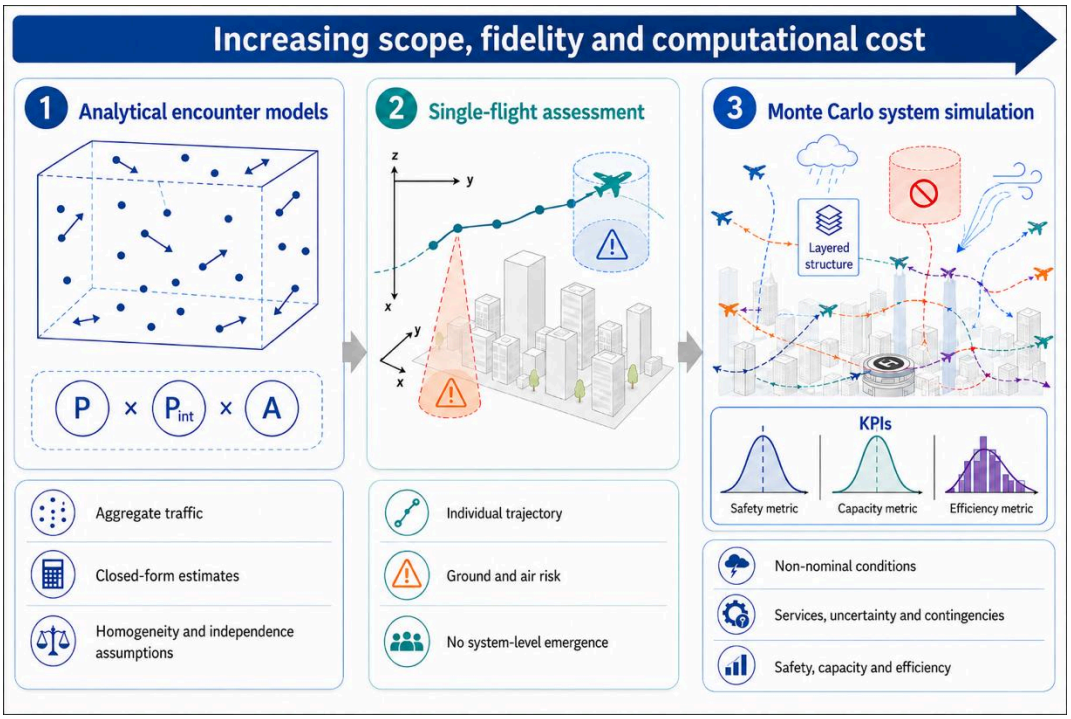


Figure 2. Schematic representation of analytical, single-fligth and U-space system simulations

A.3.3 Single flight assessment methods

An alternative class of quantitative methods evaluates the risk associated with individual flight plans rather than with the aggregate behavior of a managed traffic system. Su et al. [10] propose a comprehensive flight plan risk assessment and optimization framework for urban air mobility (UAM) that decomposes risk into ground and air components using the formulation $R = P_{crash} \cdot P_{impact} \cdot P_{fatality}$. The air risk component models potential collisions with manned aircraft and other UAM participants encountering emergencies.

Such methods account for the geographical risk distribution along a trajectory and can support route optimization or flight-authorization decisions. They therefore provide greater spatial specificity than aggregate density-based models. However, their unit of analysis remains the individual mission. The corresponding risk values do not necessarily reproduce the endogenous interactions that arise when many flight plans compete for the same airspace and U-space services

A.3.4 System-level fast-time simulation and Monte Carlo Analysis

Unlike single-flight assessment methods, which primarily evaluate the risk associated with an individual trajectory, system-level simulation broadens the unit of analysis to concurrent operations, capturing the collective and emergent behavior arising from interactions among aircraft, operators, U-space services, and infrastructure. End-to-end simulation complements this system-wide perspective by connecting the processes and services involved throughout the operational lifecycle, from mission submission and strategic deconfliction to flight execution, conformance monitoring, and contingency management. A simulator provides the computational implementation of this representation, reproducing how the system evolves under a given set of operational conditions and configuration parameters. When these processes are executed faster than real time, the resulting fast-time simulation environment enables multiple operational scenarios and alternative U-space configurations to be evaluated

within a practical computational time. In the State of the Art numerous works have explored the use of Monte Carlos simulations to characterize collision risk at tactical level [11], impact of strategic deconfliction[12][13] or manned-unmanned traffic interaction[14].
End-to-end UTM studies have used this approach to connect vehicle dynamics, operator demand, operational-volume generation, strategic deconfliction and conformance monitoring. The resulting simulations can evaluate relationships between requirements—such as operational-volume dimensions or conformance rate—and system-level [5].
Formally, for a simulator S, the outcome of the m-th simulation run can be expressed as

$$Y^{(m)} = S\left(X^{(m)}; \theta\right),$$

where $X^{(m)}$) represents one realization of the stochastic inputs—including demand, origins and destinations, departure times, vehicle performance or navigation errors—whereas θ defines the U-space configuration, including the operational-volume representation, deconfliction policy, service performance, and contingency procedures.
Fast-time simulation is particularly relevant to U-space because large-scale operational data remain scarce. It provides a cost-effective and risk-free means of evaluating alternative configurations and safety requirements before deployment. Nevertheless, its results remain conditional on the conceptual model, input distributions, and behavioral assumptions implemented.
The computational acceleration provided by fast-time simulation becomes especially valuable when the simulator is embedded within a Monte Carlo experimental framework. While fast-time simulation enables each operational scenario to be executed faster than real time, Monte Carlo analysis repeatedly samples uncertain inputs and propagates them through the simulator. Thus, for m=1,…,M, independent or appropriately designed input realizations X(m) are generated, and the corresponding system-level outputs Y(m) are collected. The empirical distribution of the simulated outputs can be used to estimate the main KPIs variables of the simulated operational context as expected capacity, efficiency limitations and the probabilities of safety-critical outcomes such as LoS, NMAC, and MAC events. This is the fundamental advantage of system-level simulation: safety, capacity and efficiency are obtained as interdependent and emergent properties rather than as independent calculations.
However, crude Monte Carlo simulation becomes computationally inefficient when extremely rare events are characterized (like MACs), as the number of runs required to achieve a given relative precision increases approximately in inverse proportion to the event probability. This motivates the development of simulation strategies that extract more information from each run or allocate computational effort preferentially to the conditions that contribute most to MAC risk. The objective is to obtain estimates with the required statistical precision using substantially fewer simulation runs than crude random sampling.

A.4. Simulator Description

DronAs FTS describes the full operational system through eight independent parameter groups, collectively representing the entities, services, and failure modes that constitute a real U-space environment. This distinction is what enables the framework to address the system-level characteristics that analytical models cannot capture. A simulation study in the proposed simulation framework is fully characterized by a set of independent parameter groups. Each group defines a distinct dimension of the experimental space and together they determine how traffic is generated, represented, perturbed, and managed within the simulated U-space environment (see Figure 3). A simulation study is configured through the following parameter sets, which collectively define the simulation runs according to the experimentation objectives:

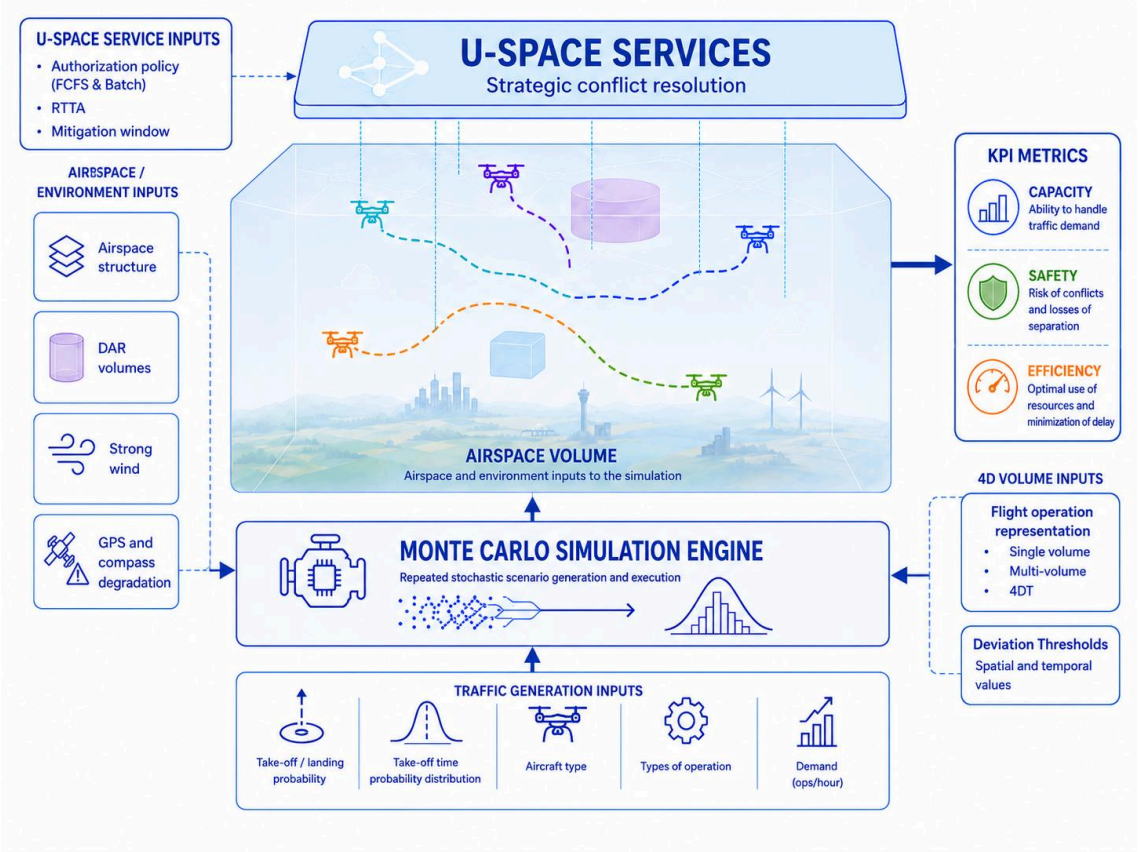


Figure 3. Schematic representation of DronAs simulator

A.4.1 Operational context parameters

This block defines the airspace structure and the operational environment used to generate the traffic, including the types of operations to be analyzed (e.g., delivery, UAM, scanning, mixed scenarios), operator characteristics, and drone characteristics (including the performance model and the TSE). Each generated operation is represented as a 4D trajectory constructed using the corresponding drone performance model.

Three different airspace structures have been included as default scenarios:

- Free routing scenarios: flights departure and landing point are randomly fixed inside the airspace volume, following a straight flight at a random altitude to link them.
- Corridor based scenarios: a predefined set of departure and landing points with a set of fixed corridors network that connect them. The corridor structure is based on CORUS-XUAM, Casteldefells VLD.
- Logistic hubs: a fixed number of origin points feed the demand at any random destination point of the scenario.

Departure time is randomly fixed.

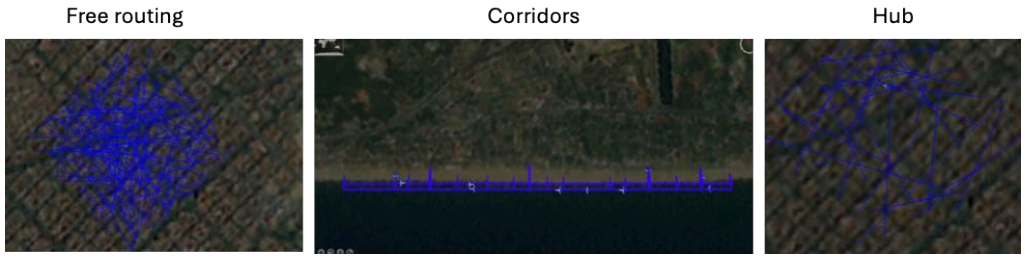


Figure 4. Top view representation of the simulator airspace structures.

Regarding the drone models included in the simulation engine, a set of representative drone types has been incorporated to capture different operational and performance characteristics. The available aircraft are: VTOL_medium_Multirotor, VTOL_Heavy_Lift, Hybrid_Long_Range, Fix_wing_Surveillance, Fixwing_large_platform. In the simulations presented the VTOL medium multirotor and the VTOL heavy lift were used. They present the next features:

- **VTOL medium multirotor**

Parameter	Min	Max	Unit / Notes
Cruise speed	15.0	25.0	m/s
Take-off speed	3.0	6.0	m/s
Landing speed	3.0	6.0	m/s
Maximum vertical speed - climb	-	5.0	m/s
Maximum vertical speed - descent	-	6.0	m/s
MTOW	15.0	30.0	kg
Wingspan	0.8	1.8	m
Maximum altitude	-	150	m
Maximum range	-	20000	m
Maximum flight time	-	60	min
Maximum wind	-	12	m/s

Table 1. VTOL medium multirotor performance parameters

Parameter	Direction / Component	Value	Unit / Notes
Horizontal uncertainty	Along-track	2.91	m
Horizontal uncertainty	Cross-track	2.91	m
Vertical uncertainty	Above	3.19	m
Vertical uncertainty	Below	3.19	m
Time uncertainty	After	9.48	s

Table 2. VTOL medium multirotor uncertainty parameters.

- **VTOL heavy lift**

Parameter	Min	Max	Unit / Notes
Cruise speed	12.0	22.0	m/s
Take-off speed	4.0	8.0	m/s
Landing speed	4.0	8.0	m/s
Maximum vertical speed - climb	-	4.0	m/s
Maximum vertical speed - descent	-	6.5	m/s
MTOW	30.0	100.0	kg
Wingspan	2.0	6.0	m
VTOL	true	true	Boolean
Maximum altitude	-	200	m
Maximum range	-	15000	m
Maximum flight time	-	45	min
Maximum wind	-	15	m/s

Table 3. VTOL heavy lift performance parameters.

Parameter	Direction / Component	Value	Unit / Notes
Horizontal uncertainty	Along-track	4.01	m
Horizontal uncertainty	Cross-track	4.01	m
Vertical uncertainty	Above	4.53	m
Vertical uncertainty	Below	4.53	m
Time uncertainty	After	13.2	s
Time uncertainty	Before	0.0	s

Table 4. VTOL heavy lift uncertainty parameters.

The simulator also provides the capability to define specific airspace volumes in which system performance is degraded. This enables the assessment of non-nominal scenarios where UAS trajectories are affected by unforeseen events. The main events that can be included in section A.4.6 that describes the long-term deviations. The performance characteristics of the UAS determine the Flight Technical Error (FTE). Together with the Navigation System Error (NSE) and the Path Definition Error (PDE, which is assumed to be negligible in this study), the FTE defines the Total System Error (TSE) associated with the intended flight trajectory, as described in EUROCAE ED-301. Accordingly, TSE margins shall be incorporated around the intended flight trajectory to ensure that the UAS remains within the defined flight geography for at least 95% of the flight time. In the presented simulation framework, the 4D trajectory of each flight intent is automatically generated considering the aircraft performance.

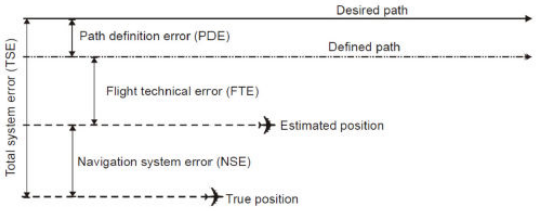


Figure 5. Schematic representation of the components contributing to the Flight Technical Error (EUROCAE ED-301)

Regarding operation types, each operator or UAS can be assigned a specific operation type, which determines how its 4D volumes are generated. All the missions generated in this report are delivery oriented.

A.4.2 Demand parameters

It enables multiple demand impact assessment, in combination with the operational context. The demand values are specified as the number of operations per hour submitted to the strategic deconfliction service.

A.4.3 Flight operation representation

Enable the assessment of different trajectory-representation models. Supported modes include:

- Single volume: specifying the airspace volume that contains the mission, without providing any additional details, and booking this volume for the entire time interval in which it is expected to be flying.
- Multi-volume/Polyline format: as specified in Commission implementing regulation 2021/664[15], flight trajectory as a series of one or more 4D volumes expressed in height (base, ceiling), longitudinal and lateral limits, and duration (entry and exit times). Each dimension includes the uncertainty of the flight, considering the UAS operational performance, and the assumptions on the operator proficiency and weather conditions. The discretization of this polyline volume can vary considerably, changing the level of mission description (see Figure 6). In this study, missions are represented using a multi-volume description, in which separate volumes are generated for the complete ascent, descent, and en-route phases.

- 4D trajectory format: a set of 4D points providing the latitude, longitude, altitude, and time of all the waypoints making up the trajectory. Associated to each of these points there is an uncertainty value (fixed by the TSE and Deviation Thresholds) that models its temporal and position uncertainty.

A.4.4 Deviation threshold parameters (DT)

This parameter enables multiple DT impact assessment by defining the spatiotemporal envelop added to the operation as declared by the operator (in accordance with the Operational Context and Flight Operation Representation parameters). Deviation thresholds define the acceptable deviation from a planned intent defined by a UAS operator (the 4D trajectory defined in the UAS flight authorization request). The 4D volume generated is the input of the strategic conflict resolution services, fixing the volume required for each specific mission.

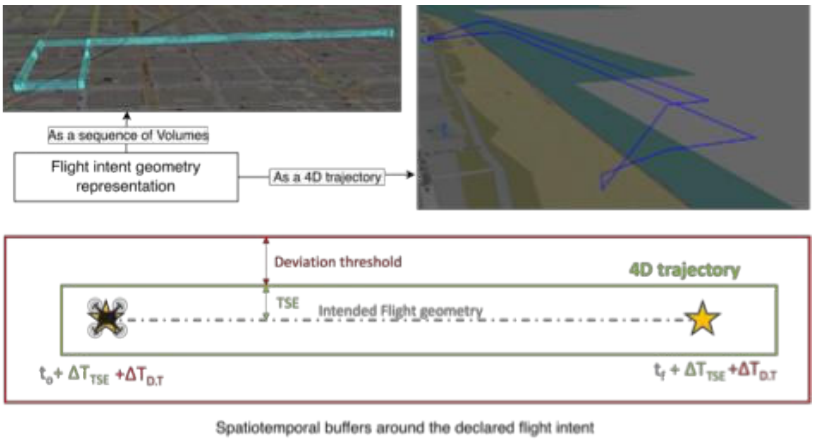


Figure 6. Flight intent representation and 2D illustration of the uncertainty volumes

A.4.5 Authorization policy

The simulator enables multiple strategic conflict resolution planning policy impact assessment. In this study, a time-based separation strategy is adopted, which consists of adjusting the takeoff times of conflicting missions inside a given time interval.

The strategic conflict resolution service applies a set of optimization algorithms to coordinate takeoff time windows and resolve conflicts among concurrent missions. When several missions share the same priority level, (a commonly adopted policy is First Come, First Served (FCFS). Under this approach, mission approvals are granted in the order they are received. While simple and transparent, FCFS suffers from inherent limitations typical of stochastic planning methods: decisions are made sequentially without global optimization, meaning that the order of arrival significantly impacts the ability to efficiently allocate airspace.

In this simulation study a FCFS approach will be used with a parametrized mitigation time window. The mitigation time window describes the size of the interval that will be used to search for possible solutions to the conflict. If no solution is found within the specified interval, the flight authorization is rejected.

A.4.6 Long term deviation

The modeling of long-term deviations enables the impact assessment of events causing long-term deviations from the planned trajectory. In the definition of the operational context parameters (section A.4.1), volumes can be defined within the simulated airspace to represent areas where different effects affecting aircraft performance may occur. These effects are applied to all missions that cross or operate within the corresponding volume. In this way, the following

events can be modelled with different severity levels. Table 5 presents the configurable non-nominal events considered in the simulator. Each event is described by a set of parameters that determine how the corresponding degradation is applied to the missions crossing the affected volume.

Event	Parameters
Wind	Heading Horizontal speed Vertical speed
GPS	Probability Severity (Parameter 0-100)
Compass	Probability Severity (Parameter 0-100)

Table 5. Non-nominal event parameters.

A more detailed description of the methodology used to generate the long-term deviation trajectories is provided in ERR Appendix E Aircraft modelling [2].

Airspace restrictions

The airspace restriction module enables the impact assessment of the contingency measures (RTL, immediate landing, ...) triggered by airspace restrictions such as Dynamic Airspace Reservation (DAR), emergency zone declaration or other restricted-airspace activations. Upon activation of a DAR, all accepted but not-yet-started missions whose planned trajectories are expected to enter the affected airspace during the DAR activation period are automatically withdrawn. Missions already in execution at the time of activation must initiate a contingency maneuver, which in this case consists of a Return to Landing point (RTL).

A.4.7 Authorization service failure

Enable the assessment of cases in which random failures of the authorization service result in non-deconflicted traffic. A probability parameter defines the proportion of flights, i.e., demand, that will not be deconflicted by the strategic service.

A.5. Simulation methodology

The CORUS five Exploratory Research Plan [1] sets three core requirements for simulation: (i) produce quantitative estimates of all three KPAs — safety, capacity, and efficiency — across both nominal and non-nominal operational conditions; (ii) enable comparative assessment of U-space service effectiveness by contrasting mitigated and unmitigated scenarios; and (iii) characterise the capacity and efficiency boundaries of the system as a function of traffic demand. DronAs FTS meets these requirements through a structured set of six simulation scenarios, summarised below and grounded in the ASTM F3548-21 risk decomposition.

A central challenge in the quantitative evaluation of U-space safety is that the risk of collision does not arise from a single, undifferentiated operational condition but from a combination of factors — traffic density, service effectiveness, and the probability and severity of service failures — that must be assessed both individually and in combination. To provide this structured decomposition, DronAs FTS organises its simulation campaign around six scenarios, each activating a specific combination of pipeline elements — strategic deconfliction, long-term deviation events, and airspace restriction handling — to isolate or combine the risk contributors. This design allows the safety, capacity, and efficiency KPIs to be attributed to specific causal mechanisms rather than observed as aggregate outcomes of an undifferentiated operational environment:

- Scenario S0 — Unmitigated baseline. No strategic deconfliction service is active. All submitted U-plans are authorised regardless of conflicts between their 4D volumes. S0 produces the reference random encounter rate equivalent to the P(MAC|¬SD) term in

ASTM F3548-21 Appendix X4, against which all mitigated scenarios are benchmarked. The encounter rate is expected to scale linearly with traffic density, consistent with the Gas Model prediction ($\lambda \propto \rho$).

- Scenario S1 — Nominal conditions with strategic deconfliction. The flight authorisation service is active and operates correctly. All submitted U-plans are assessed for 4D volume conflicts; conflicting requests are resolved according to the configured authorisation policy. All authorised operations conform to their U-plans throughout the flight. S1 establishes the nominal performance baseline and characterises the efficiency cost of strategic deconfliction (acceptance ratio, mean delay) under ideal service operation.
- Scenario S2 — Long-term trajectory deviations. Builds on S1 by introducing sustained non-nominal deviations in which airborne UAS depart from their authorised 4D volumes due to environmental perturbations (modelled as wind effects in a defined spatial region) or navigation system failures (modelled as GPS degradation events). These deviations represent the residual safety risk that remains when strategic deconfliction succeeds pre-flight but operations subsequently deviate from the authorised intent.
- Scenario S3 — Strategic deconfliction failures. Builds on S1 by introducing a configurable probability that the flight authorisation service grants approval to an operation whose 4D volume overlaps with an already-authorised flight, simulating a deconfliction failure mode. This scenario isolates the risk contribution of service-level failures in the strategic layer, independently of tactical deviations.
- Scenario S4 — In-flight replanning failures. Builds on S1 by activating dynamic airspace restrictions (Dynamic Airspace Reservations and high-priority operations) that require in-flight replanning by affected operations. The scenario models the risk arising when contingency trajectories are not executed successfully, or when the replanning service fails to resolve conflicts introduced by the restriction.
- Scenario S5 — Compound non-nominal conditions. Activates all non-nominal elements simultaneously: long-term deviations (S2), strategic deconfliction failures (S3), and in-flight replanning failures (S4). S5 represents the realistic operational environment in which multiple failure modes coexist and potentially interact, providing the most conservative estimate of residual collision risk under realistic U-space conditions.

This scenario structure directly operationalizes the ASTM F3548-21 finding that non-nominal conditions dominate residual risk at high conformance levels: S0 quantifies the unmitigated baseline; S1 isolates the benefit of strategic deconfliction; and S2–S5 progressively account for the failure modes that determine residual risk once strategic deconfliction is in place Figure 7 illustrates the Monte Carlo simulation pipeline.

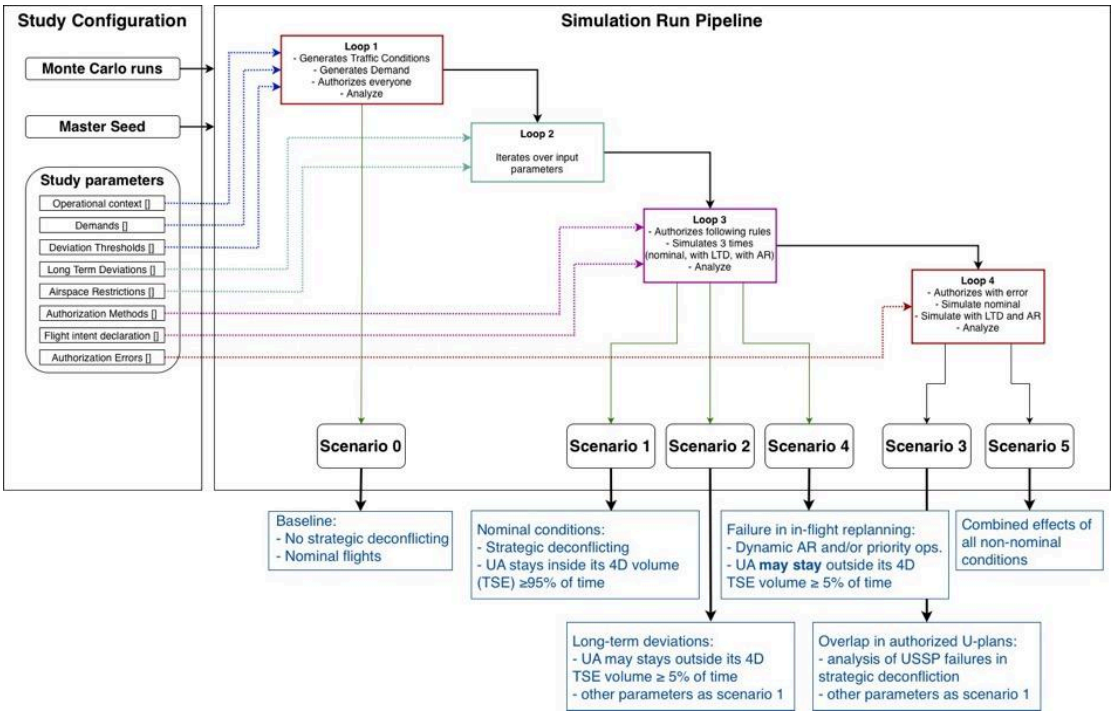


Figure 7. DronAS FTS Monte Carlo simulation pipeline: from study configuration to scenario generation

When analyzing Figure 7, it is important to highlight that the traffic is generated in Loop 1 and subsequently used as a common input for all simulated scenarios. This design choice has an important impact on the interpretation and comparison of the results obtained for each scenario. By using the same traffic realization across scenarios, the variability associated with traffic generation is controlled, allowing differences in the simulation outputs to be attributed more directly to the specific conditions or mechanisms introduced in each scenario. Otherwise, if a different traffic realization were generated for each scenario, an additional source of variability would be introduced, making it more difficult to determine whether observed changes in safety performance, for example under a long-term deviation, are caused by the scenario itself or simply by differences in the underlying traffic configuration, such as a traffic realization that is inherently more prone to conflicts.

A.5.1 Simulation execution

Each simulation replication executes a sequential pipeline of four stages. The combination of parameter group settings determines which elements of each stage are active, thereby realizing a specific scenario. Table 1 maps each scenario to its pipeline configuration (see also Figure 7 for a visual reference of the pipeline).

Stage 1 — Traffic demand generation. Active in all scenarios. The demand generator constructs a set of U-plans [15] by sampling origin–destination pairs from the configured airspace structure (operational context group) and generating 4D trajectories using the platform performance model. Each trajectory incorporates the Total System Error (TSE) [9] defined by the drone performance model. Then the USSP adds the deviation threshold that wraps each trajectory in its protected 4D volume (deviation threshold group), producing the full set of volumes considered by the authorization service (see Figure 6).

Stage 2 — Strategic mission management. This stage differs fundamentally across scenarios. In S0, the authorization service is inactive: all U-plans are approved without conflict checking, producing the maximum possible traffic load and the unmitigated encounter rate. In S1–S5, the authorization service evaluates each request against previously authorized 4D volumes using

the configured policy (authorization policy group). In S3 and S5, the authorization error probability (authorization service failures group) additionally causes a configurable fraction of conflicting requests to be approved without detection, injecting strategic deconfliction failures into the authorized traffic set.

Stage 3 — Tactical simulation. This stage generates the flown trajectories for all authorized operations and again differs across scenarios. In S0 and S1, all operations fly nominal trajectories: the flown path remains within the authorized 4D volume throughout, with short-term positional deviations governed by the TSE declared in the U-plan. In S2 and S5, the long-term deviation event module (long-term deviation events group) activates for selected operations in the affected spatial region and time window, causing the flown trajectory to depart from the authorized volume in a sustained manner consistent with the modelled perturbation (wind or GNSS failure). In S4 and S5, the airspace restriction module (airspace restrictions group) activates dynamic airspace reconfigurations and restrictions; operations whose trajectories intersect the restricted volume are required to execute contingency paths, and replanning failures are injected according to the configured failure rate.

Stage 4 — Analysis. Active and identical in all scenarios. The analysis module processes all flown trajectory pairs to detect and record safety events (LoSD, LoWC, NMAC, MAC) . Efficiency metrics are derived from the authorization records produced in Stage 2. Capacity metrics are derived from the count and simultaneity of authorized operations and their durations. All metrics are accumulated per replication for statistical aggregation across the full Monte Carlo run.

Scenario	Name	Stage 2: Auth. service	Stage 3: LTD events	Stage 3: Airspace restrictions	Primary KPA target
S0	Unmitigated baseline	Inactive (✗)	Inactive (✗)	Inactive (✗)	Safety (baseline)
S1	Nominal + deconfl.	FCFS ✓	Inactive (✗)	Inactive (✗)	Safety, capacity, efficiency
S2	Long-term deviations	FCFS ✓	Active (✓)	Inactive (✗)	Safety (residual)
S3	Deconfl. failures	FCFS + errors (△)	Inactive (✗)	Inactive (✗)	Safety (service failure)
S4	Replanning failures	FCFS ✓	Inactive (✗)	Active + contingency (△)	Safety, efficiency
S5	All non-nominal	FCFS + errors (△)	Active (✓)	Active + contingency (△)	Safety (compound)

Table 6.Mapping of simulation scenarios to pipeline stage configurations. ✓= active/nominal; △ = active with errors; ✗ = inactive; LTD = long-term deviations; AR = airspace restrictions.

A.5.2 Output KPI statistics

Three sets of performance metrics have been defined to characterize the generated traffic in terms of capacity, safety, and efficiency. Together, they provide a consistent baseline for evaluating how changes in the operational context and simulation inputs affect each performance dimension, while also capturing the interdependencies and trade-offs that arise between them.

- **Capacity indicators**

Capacity assessment is grounded in a taxonomy that distinguishes four related but distinct concepts. Demand denotes the rate of operations submitted to the U-space system, expressed in operations per hour [ops/h], and is the primary explanatory variable. Traffic load denotes the subset of demand actually authorized after the mitigation strategy is applied. It is measured in two dimensions: rate [ops/h], expressing the mean and maximum number of authorized operations per hour; and simultaneity [concurrent ops], expressing the mean and maximum number of operations active at the same instant. Airspace

occupancy denotes the fraction of available four-dimensional airspace volume consumed by admitted operations [dimensionless, 0–1], while demand occupancy provides the requested airspace volume to be occupied by all the submitted missions (accepted or not). Capacity denotes the operational boundary of the system — not a fixed value but the demand level beyond which traffic load saturates and the authorization service increasingly constrains the admitted flow. Identifying this transition empirically across the demand parameter space constitutes the central observable for U-space airspace capacity assessment

- **Safety Indicators**
  Safety metrics are used to evaluate the safety performance of the system. The following metrics will be analysed as outputs of the different simulation scenarios.

  •**Frequency of mid-air collisions (MACs):** a MAC is defined as a physical contact between two in-flight aircraft.
  •**Frequency of near mid-air collisions (NMACs):** an NMAC is defined as a situation in which two aircraft are closer than the specified horizontal and vertical NMAC distances. For pairs of small UAS, the NMAC distance of 50ft horizontally and 15ft vertically will be used. For the rest of pairs, the traditional NMAC distance of 500ft horizontally and 100ft vertically. For these purposes, it will be assumed that all aircraft except passenger carrying VCAs and manned aircraft are small UAS.
  •**Frequency of losses of well clear (LoWCs):** in the STH framework, a loss of well clear is produced when the horizontal and vertical distances between two UAS is smaller than the deviation thresholds of any of these two operations. A different spatial criterion will be used for UAS-manned pairs, which is yet to be determined.
  •**Frequency of losses of strategic deconfliction (LoSDs):** in the STH framework, a loss of strategic deconfliction arises when the vertical and horizontal distances between two UAS is smaller than the sum of the respective deviation thresholds, as defined for each UAS pair and scenario.

  Each of these safety events is characterized in two dimensions. The count dimension records the number of events of each type detected during a simulation run, expressed as a non-negative integer (events per run). The duration dimension records the total time each event type persists, expressed in seconds. From counts and durations across pairs of UAS trajectories, the framework derives the three conditional probability ratios P(LoWC|LoSD), P(NMAC|LoWC), and P(MAC|NMAC), all dimensionless, which characterise the geometric and kinematic structure of encounters independently of traffic density.

- **Efficiency indicators**

Three derived metrics capture the impact of the strategic deconfliction service on submitted operations.

- The acceptance ratio is the fraction of submitted U-plans authorized either without modification or with temporal shifts [dimensionless, 0–1].
- The mean authorization delay is the average time shift imposed on authorized U-plans [seconds].

- The dynamic changes ratio is the fraction of U-plans affected by a dynamic airspace reconfiguration or restriction during the simulation run [dimensionless, 0–1].
- These metrics are defined across three authorization outcome dimensions: authorized (requests admitted), regulated (non-airborne flights affected by a dynamic airspace restriction), and regulated while in flight (airborne flights diverted by a restriction).

A.5.3 Output KPI statistics

Statistics plays a central role not only in defining the stochastic inputs of a simulation model, but also in interpreting its outputs. A Monte Carlo experiment produces a finite sample from the population of all possible outcomes that could be generated under the same experimental configuration. Consequently, the value obtained from a finite number of replications is subject to sampling uncertainty and cannot be interpreted independently of its variability.
A statistically simulation study must therefore address two related questions: how precisely the selected output measures have been estimated, and how many independent replications or how much simulated exposure is required to achieve a predefined level of precision. The answer depends on the mathematical nature of the output variable. In the present study, two distinct procedures are used: conventional estimation of mean-valued performance indicators and Poisson-based estimation of rare safety-event rates [16][17].

Efficiency and capacity mean-valued performance outputs

Most capacity and efficiency indicators are continuous or sufficiently smooth numerical responses. Examples include the number of authorized operations, the number of simultaneous operations, flight length (Figure 12) or the delay imposed by the strategic conflict-resolution process. For a fixed experimental configuration, each independent simulation replication produces one realization of the response:

$$Y_1, Y_2, \dots, Y_n$$

Where n is the number of independent Monte Carlo replications. The expected system response, $\mu = E[Y]$, is estimated using the sample mean:

$$\bar{Y} = \frac{1}{n}\sum_{r=1}^{n} Y_r$$

Each additional replication contributes a new independent observation of the system response. The variability among replications is characterized through the sample variance:

$$S^2 = \frac{1}{n-1}\sum_{r=1}^{n}(Y_r - \bar{Y})^2$$

Let σ^2 denote the unknown variance of the simulation output across the population of possible replications. This variance is estimated from the n independent simulation replications using the sample variance S^2.

$$\mathrm{Var}(\bar{Y}) = \frac{\sigma^2}{n}$$

Provided that the replications are independent and identically distributed and that the output has finite variance, the Central Limit Theorem implies that the sampling distribution of $\bar{Y}$ becomes approximately normal as n increses:

$$\bar{Y} \approx N\left(\mu, \frac{\sigma^2}{n}\right)$$

To prove this statement, Figure 8 presents the empirical distribution of simultaneous mission for a given scenario. Bars show the empirical fraction of active traffic time with exactly k simultaneous missions, and the black curve represents the fitted normal approximation. The lower panel shows residuals between observed and fitted frequencies; MAE and RMSE quantify the goodness of fit. The low residual errors, with MAE = 0.0125 and RMSE = 0.0200, show that the fitted Gaussian distribution reproduces the empirical frequencies with small deviations. This supports the use of a Gaussian model as an accurate approximation for the simultaneous-missions distribution under this configuration.

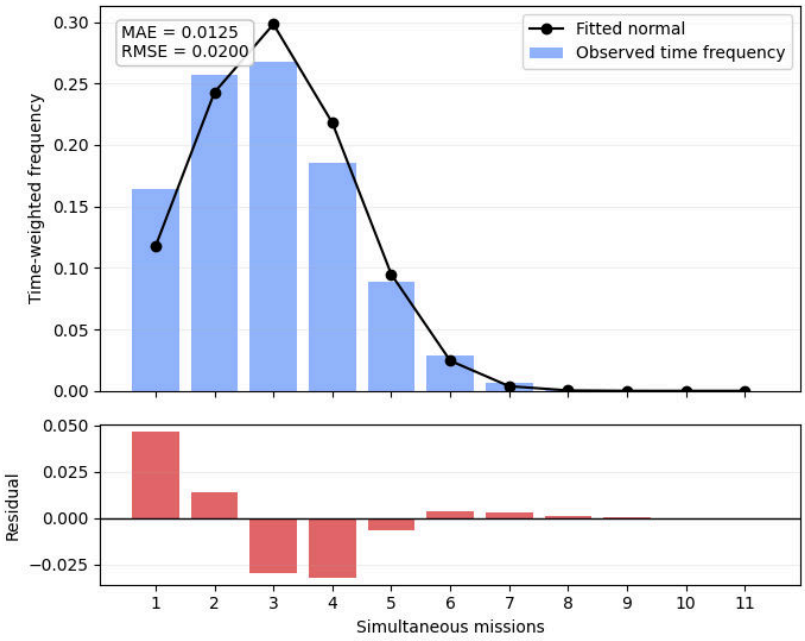


Figure 8 Time-weighted frequency distribution of simultaneous missions

Once the mean value of the performance output has been estimated, its statistical uncertainty is characterized through a confidence interval. Since the true variance of the simulation output is unknown, a two-sided confidence interval for the expected response is defined using the Student's t-distribution [16]:

$$\bar{Y} \pm t_{1-\frac{\alpha}{2},n-1}\frac{S}{\sqrt{n}}$$

Where $t_{1-\frac{\alpha}{2},n-1}$ is the t-Student critical value for a confident Interval 1-α. The term $S/\sqrt{n}$ represents the estimated standard error of the mean. Consequently, the confident Interval quantifies the range of values that is statistically compatible with the unknown expected

response., while its width provides a direct indication of the precision achieved by the Monte Carlo experiment.

Rare safety-event outputs

A different treatment is required for mid-air collision events. Due to the successive safety layers implemented in the U-space system, MAC occurrence is expected to be rare. In this case, the response of interest is not the mean number of MACs per simulation replication, but the MAC occurrence rate per unit of exposure.

For a particular experimental configuration, let define K as the total number of observed MAC events and T as the total accumulated flight exposure (in this study T is expressed in flight hours). Under a homogeneous Poisson model:

$$K \sim Poisson\ (\lambda T)$$

In a Poisson distribution the mean and variance values are given by the next expression:

$$E[K] = \lambda T$$
$$Var(K) = \lambda T$$

The Poisson formulation is appropriate when events are sufficiently independent, the occurrence rate remains approximately constant within the analyzed configuration, and the expected number of events increases proportionally with accumulated exposure. The analysis must be performed separately for each experimental configuration. Simulations with different traffic densities, flight-operation representations, deviation thresholds, failure probabilities or non-nominal scenarios must not be combined into a single rate estimate. Instead, the rate should be understood as a function of the experimental factors $\lambda = \lambda(density, representation, dev.thresholds)$.

To validate this approach Figure 9 shows the empirical distribution of MAC counts per run in a scenario without strategic deconflicting. The blue bars represent the observed number of simulations runs with each MAC count, while the black line represents the expected number of runs under the fitted Poisson model. Since MAC events are rare, most runs have zero MAC events. The inset zooms into the positive MAC counts, showing the observed and expected frequencies for runs with 1 and 2 MAC events. The goodness-of-fit box compares the observed and expected number of runs in two groups: runs with zero MAC events and runs with one or more MAC events. In the simulations, 937 runs had zero MAC events, and 15 runs had at least one MAC event. The fitted Poisson model predicts 937.12 zero-MAC runs and 14.88 positive-MAC runs, which is almost identical to the observed values. The chi-square statistic is very small ($\chi^2 = 0.000944$) and the p-value is high ($p = 0.975$), indicating that there is no statistical evidence against the Poisson assumption. Therefore, the observed MAC counts for this demand level are highly consistent with the fitted Poisson distribution.

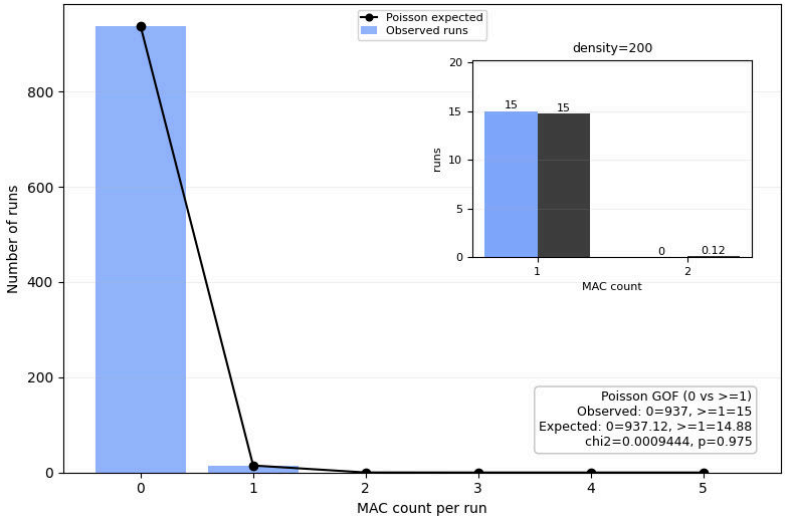


Figure 9. Simulated MAC count per run in unmitigated scenario.

In this context, when a given number of simulations are run

$$\lambda = \frac{K}{T} = \frac{MACs\ events\ observed}{Exposure\ time}$$

That is the variable that we are characterizing in our simulation study:

$$Var(\lambda) = Var\left(\frac{K}{T}\right) = \frac{Var(K)}{T^2} = \frac{Var(\lambda T)}{T^2} = \frac{\lambda}{T}$$

and, for K>0, its standard error is:

$$SE(\hat{\lambda}) = \frac{\sqrt{K}}{T}$$

which shows that the uncertainty in the estimated event rate decreases as the accumulated exposure increases.

This approximation becomes unreliable when very few events are observed. When no MAC events are observed, n=0 and the estimated rate is $\hat{\lambda} = 0$. This result must not be interpreted as evidence that the true rate is zero. The probability of observing no events under a rate λ is:

$$P(K = 0|\lambda) = e^{-\lambda T}$$

A one-sided 95% upper confidence bound is obtained by solving:

$$e^{-\lambda T} = 0.05$$

Which gives:

$$\lambda_U \approx \frac{3}{T}$$

Thus, if no MACs are observed during 10^6 accumulated flight hours, the estimated rate is zero but the one-sided 95% upper confidence bound is: $\lambda_U = 2.996 \cdot 10^{-6}$ MAC/flight hour. The correct interpretation is therefore that no MACs were observed during the available exposure and that, under the Poisson assumptions, the underlying rate is below approximately 3.0×10^{-6} MAC per flight hour with 95% confidence.

When one or more events are observed, an exact two-sided Poisson confidence interval can be calculated using chi-squared quantiles [18] [19]. For a one side 95% upper confident count:

$$\lambda_U = \frac{\chi^2_{2(n+1),0.95}}{2T}$$

being n the number of MAC events detected in a T time exposure. Note that the estimated rate (λ) characterizes the observed safety performance, whereas the upper confidence interval (λ_U) characterizes the statistical precision of that estimate. The upper confident interval quantifies the range of underlying MAC rates that remain statistically compatible with the number of events observed over the accumulated simulated exposure (see Figure 10).

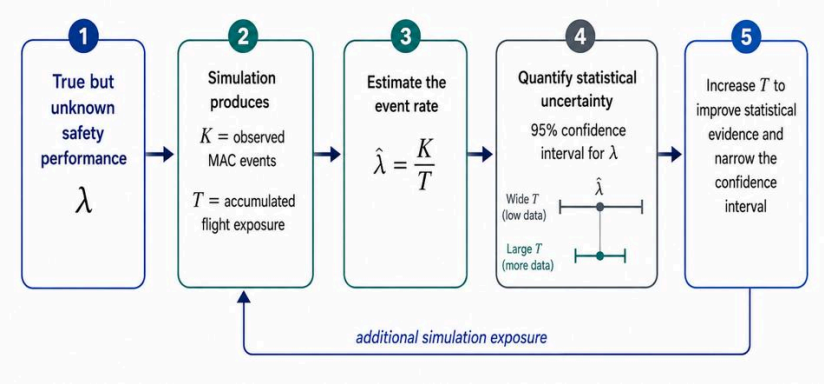


Figure 10. Conceptual workflow for characterizing the underlying MAC occurrence rate, λ, from observed events and accumulated flight exposure, including its estimation and associated confidence interval. Conceptual workflow for characterizing the underlying MAC occurrence rate, λ, from observed events and accumulated flight exposure, including its estimation and associated confidence interval.

The upper 95% confidence limit for the MAC rate (λ_U) represents the maximum underlying rate of Mid-Air Collision (MAC) events per flight hour that is statistically compatible with the observed simulation results at the 95% confidence level. It provides a conservative estimate of the true MAC occurrence rate by accounting for the statistical uncertainty associated with the finite number of observed events and accumulated flight hours. It should therefore be interpreted as an upper statistical bound on the underlying MAC rate, rather than as the expected or observed MAC frequency.

To highlight this idea Table 7 presents the results of two different simulation with similar measure MAC per flight hour but with different total flight

Scenario	K (simulation runs)	(T) [Total flight h]	Measured MAC per flight hour $\hat{\lambda}$	Upper 95% CI (λ_U)
A	1	$1 \cdot 10^6$	$1 \cdot 10^{-6}$	$4{,}74 \cdot 10^{-6}$
B	100	$1 \cdot 10^8$	$1 \cdot 10^{-6}$	$1{,}18 \cdot 10^{-6}$

Table 7. Measured MAC per flight hour and 95% confident Interval with different total flight exposure.

Although both experiments result in the same estimated MAC rate of $1 \cdot 10^{-6}$MAC per flight hour, the statistical evidence supporting this estimate is substantially different. Observing a single MAC over 1.10^6 flight hours results in a one-sided 95% upper confidence bound of $4{,}74 \cdot 10^{-6}$MAC per flight hour. In contrast, observing 100 MACs over 1.10^8 flight hours reduces the upper bound to $1{,}18 \cdot 10^{-6}$ MAC per flight hour. Therefore, identical point estimates do not imply the same level of statistical confidence: as the number of observed events and accumulated exposure increase, the underlying event rate can be characterized with substantially greater precision.

A.5.4 Scenarios safety comparison

The safety performance of the different simulation scenarios is assessed from two complementary perspectives. First, each scenario could be evaluated independently against an external safety requirement, expressed as a Target Level of Safety (TLS). Second, the relative safety performance of alternative scenarios is compared against a reference scenario (as scenario0 and scenario1) to quantify the effect of the mitigation measures or operational conditions under analysis.
These two comparisons address different questions and therefore require different statistical quantities.

A.5.4.1 Upper confident bound

The upper confidence bound of the event rate is used for comparison against the TLS. The safety criterion is then defined as:

$$\lambda_U \leq \lambda_{TLS}$$

A.5.4.2 Relative safety scenarios comparison

Regarding the relative comparison between scenarios, the relative effect of a scenario modification (scenario s, λ_s) is characterized using the observed MAC rates. Taking an scenario as reference condition (usually Scenario0, λ_{ref}), the rate ratio is defined as:

$$RR = \frac{\lambda_{ref}}{\lambda_s}$$

When RR=1 no observed change in MAC rate is observed, RR<1 the scenario s presents a lower observed MAC rate than the reference scenario, RR>1, scenario s presents a higher observed MAC rate than the reference scenario.

A.5.4.3. Relative safety scenarios comparison (with one scenario without safety events)

When MAC events are observed in the reference scenario, but no MAC events are observed in a mitigated scenario, the direct comparison of the estimated MAC rates becomes problematic. In this context ($\lambda_s = 0$) and these results cannot be interpreted as evidence of an infinite safety improvement, since observing zero events over a finite flight exposure does not imply that the underlying MAC rate is exactly zero. A classical approach for comparing two Poisson rates is therefore based on the conditional distribution of the observed event counts [20] [21].
The total number of observed MAC events across the two scenarios is defined as:

$$N = K_0 + K_1$$

Conditional on the total number of observed events, the number of MAC events occurring in Scenario 0 follows a binomial or Bernoulli distribution:

$$K_0 | (K_0 + K_1 = N) \sim Binomial\ (N, p)$$

where

$$p = \frac{\lambda_o T_0}{\lambda_o T_0 + \lambda_1 T_1}$$

The parameter p therefore represents the probability that an event from the combined set of MAC events is associated with scenario0, while explicitly accounting for the different accumulate flight exposures in the two scenarios.
The quantity of interest for the safety comparison is the MAC rate ratio RR, where RR>1 indicate that the MAC rate in scenario 0 is greater than in scenario 2.

The conditional probability p can be related directly to the safety rate ratio. Knowing p, the complementary probability can be defines as:

$$1 - p = \frac{\lambda_1 T_1}{\lambda_o T_0 + \lambda_1 T_1}$$

Therefore:

$$\frac{p}{1-p} = \frac{\lambda_0 T_0}{\lambda_1 T_1}$$

and consequently:

$$\widehat{RR} = \frac{\lambda_0}{\lambda_1} = \frac{p}{1-p}\frac{T_1}{T_0}$$

This relationship allows an exact confidence bound obtained for the binomial parameter p to be transformed directly into a confidence bound for the MAC rate ratio. For a one-sided confidence level of (1 − α), let p_L denote the lower confidence bound for p. For a on-sided exact binomial 95 lower confident interval:

$$p_L = (1-p)^{1/N} = (0.05)^{1/N}$$

$$\widehat{RR}_{L,95} = \frac{p_L}{1-P_L}\frac{T_1}{T_0}$$

This quantity provides a finite and statistically interpretable lower bound on the relative MAC rate. Therefore, rather than reporting an infinite rate ratio when no MAC events are observed in Scenario 1, A value $RR_{_L,95} > 1$ indicates that the available simulation evidence supports the conclusion that the MAC rate in Scenario 0 is greater than that in Scenario 1 at the specified confidence level.

A.6. Results

A.6.1 Simulation study design

A simulation study is defined by selecting a specific instance of each parameter group to represent a target operational context. The eight parameter groups together characterize the who (platforms and operators), the how many (demand), the how (trajectory representation, thresholds, authorization policy), and the what can go wrong (non-nominal events) of the simulated U-space environment. Different combinations of group instances produce studies that represent different stages of U-space evolution.

This simulation study considers a U-space volume with a horizontal extent of 3km×3km and a vertical extent of 150 ft. The departure and destination locations of each mission are randomly generated within this volume, and their take-off times are randomly assigned over a one-hour demand-generation period. Free-routing operations are considered; therefore, the nominal trajectory of each mission directly connects its departure and destination locations without being constrained by a predefined route network.

Four nominal demand levels are considered: 25, 50, 100, and 200 operations per hour. In this context, demand refers to the number of flight authorization requests submitted to the strategic conflict resolution service during the one-hour period.

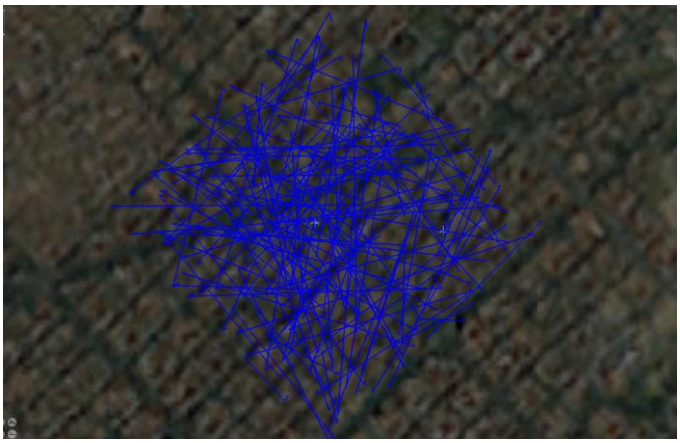


Figure 11. Top view image of a high density free routing scenario.

Table 8 summarizes the main features used in the simulation study.

Parameter	Values considered
U-space volume	3km x 3km x 500 ft
Demand level	25, 50, 100 and 200 operations/hour
Demand generation period	1 hour
Route structure	Free routing
Flight operation representation	Multi-volume and 4D trajectory
Deviation thresholds	Conservative
	Spatial dev. Threshold= 150m (h)/20m (v) Temporal dev. Threshold= 60s
	Reduced
	Spatial dev. Threshold= 50m (h)/15m (v) Temporal dev. Threshold= 30s
	No deviation allowance
	Spatial dev. Threshold= 0m (h)/0m (v) Temporal dev. Threshold= 0s

Table 8. Operational context features

A.6.2 Scenario 0: Unmitigated traffic

Missions' characterization

The analysis of the generated traffic begins by examining the characteristics of the individual missions. Each trajectory comprises two legs representing a logistics delivery operation: an outbound leg from the departure location to the delivery point, followed by a return leg to the original departure location. The distribution of mission lengths for a traffic set is showed in Figure 12. As it can be observed the mean mission length is 3451 m. The mean mission duration is approximately 4 min 30 s.

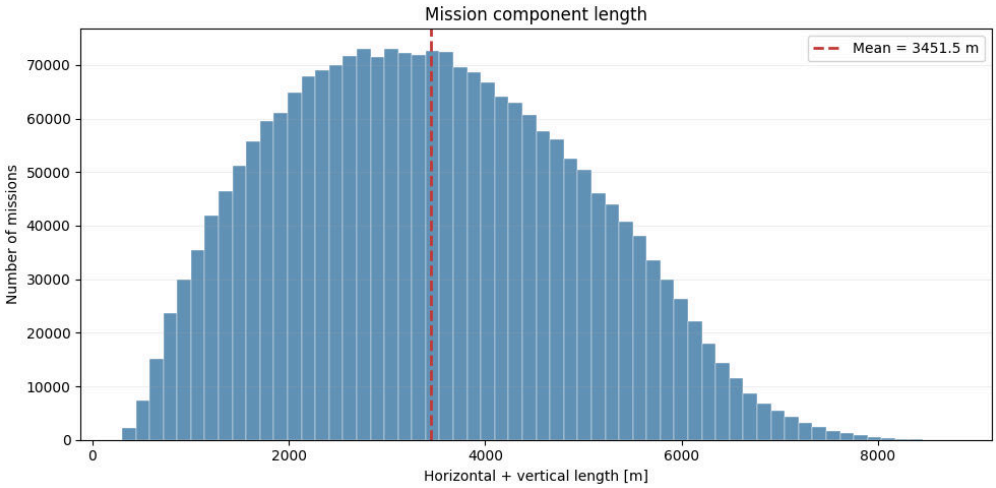


Figure 12. Traffic set mission length distribution characterization

Additionally, as it was presented in Table 8, different deviation-threshold configurations and flight operation representations are considered. Although these parameters do not modify the nominal mission trajectory, they affect the size and structure of the 4D operational volume reserved by each mission. To illustrate this effect, Table 9 presents the mean volume occupation of the for each combination of deviation threshold and flight operation representation. The 4D operational volume column presents mean fraction of the scenario space-time volume occupied by a typical authorized mission, including the TSE and deviation-threshold (DT) envelope.

Volume discretization	Dev. Threshold values	4D operational volume/U-space volume (%)
Multi-volume	Conservative	0,17
	Reduced	0,038
	No Dev. Threshold	4.10^{-4}
4D trajectory	Conservative	0,02
	Reduced	0,002
	No Dev. Threshold	2.10^{-6}

Table 9. Mission operational volumes capacity requirements

The results show that the multi-volume representation consistently requires more airspace-time resources than the 4D trajectory representation, as it was expected. For the conservative deviation-threshold configuration, the reserved volume is approximately seven times larger. This ratio increases to approximately 16 under the reduced configuration and to more than 200 when no additional deviation threshold is applied. Therefore, the relative capacity penalty associated with the multi-volume representation becomes increasingly significant as the deviation thresholds are reduced.

This behavior can be explained by the coarser spatial and temporal discretization of the multi-volume representation. Each volume must contain an entire flight phase, including the ascent, en-route, or descent segment, thereby reserving portions of the airspace that are not occupied by the nominal trajectory. By contrast, the 4D trajectory representation follows the mission path more precisely and consequently requires a substantially smaller reservation. Under conservative deviation thresholds, the large uncertainty envelope partially masks the effect of the representation method. As the thresholds decrease, the discretization of the trajectory becomes the dominant factor determining the reserved volume.

Demand characterization

Having characterized the individual missions, the analysis now shifts to the aggregate characteristics of the generated demand. As a first metric, the number of simultaneous missions provides an initial indication of the traffic load imposed on the U-space system (see Figure 13)

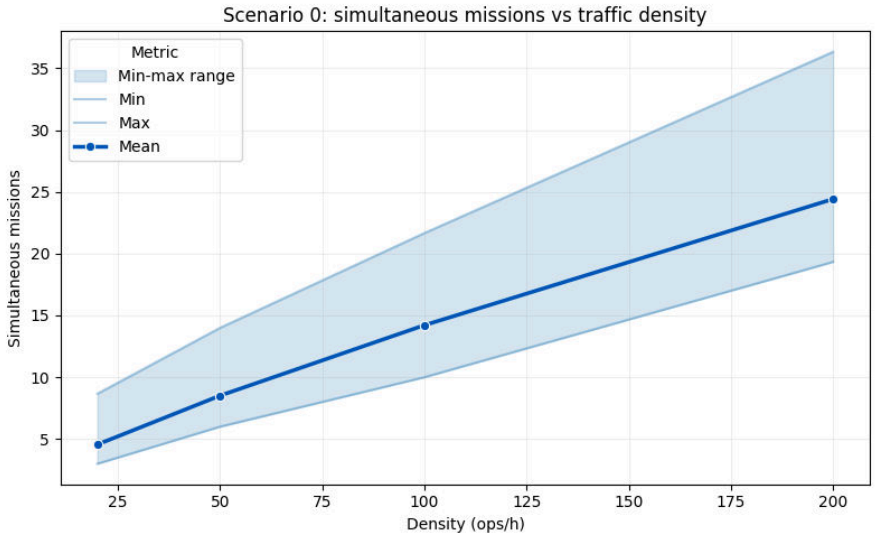


Figure 13. Number of simultaneous missions as a function of traffic density demand

As can be observed, the mean number of simultaneous missions increases from approximately 5 at a demand level of 25 operations per hour to approximately 25 when the demand reaches 200 operations per hour.

However, this metric alone does not fully characterize the demand, as missions may differ substantially in duration and in the amount of space-time resources they occupy. Therefore, the demand characterization also considers the aggregated duration of all the individual missions (Table 10) and their total occupied 4D volume .Together, these metrics describe three complementary dimensions of the demand: the level of temporal concurrency, the time during which missions remain active, and the amount of space-time capacity reserved by their operational volumes.

Density ops/h	Total flight hour (h)
25	1,51
50	3,78
100	7,57
200	15,10

Table 10. Agregated total fligth duration of the generated traffic at different traffic density

While Table 9 characterizes the mean 4D occupancy footprint of an authorized 4D envelope for each combination of volume discretization and deviation threshold, Figure 14 extends this analysis to the system level by aggregating the occupied volume across the different traffic-density levels. The results show that, in Scenario 0, the total occupancy associated with the authorized envelopes is primarily driven by the deviation-threshold magnitude and increases approximately linearly with traffic density. The use of a 4D trajectory-based discretization substantially reduces the occupied volume compared with the multi-volume representation, with the difference becoming particularly significant when conservative deviation thresholds are applied.

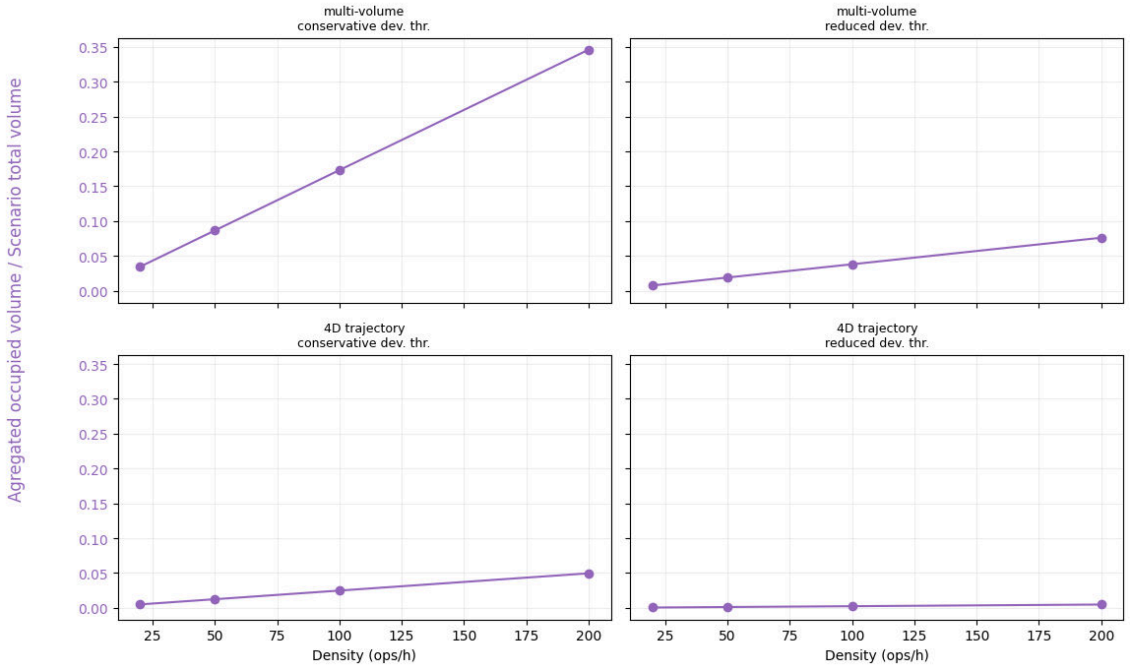


Figure 14. Aggregated occupied traffic volume for different discretization and dev. threshold values

Safety characterization

Scenario 0 represents the unmitigated baseline used to quantify the safety performance of the traffic demand in the absence of strategic conflict prevention. The strategic deconfliction service is not active and all submitted U-plans are authorized and executed at their requested departure times, regardless of potential overlaps between their 4D operational volumes. Consequently, no authorization delays, temporal displacement, or mission cancellations are introduced, and the entire offered demand becomes effective traffic load. Safety events therefore result from random spatiotemporal encounters between simultaneously operating aircraft. Scenario 0 provides the reference unmitigated encounter rate, conceptually corresponding to P(MAC|¬SD), against which the safety benefit of the mitigated scenarios can be assessed. Since no strategic conflict detection or resolution is performed, the flight-operation representation and deviation-threshold configuration do not affect the authorization process or the expected safety outcome.

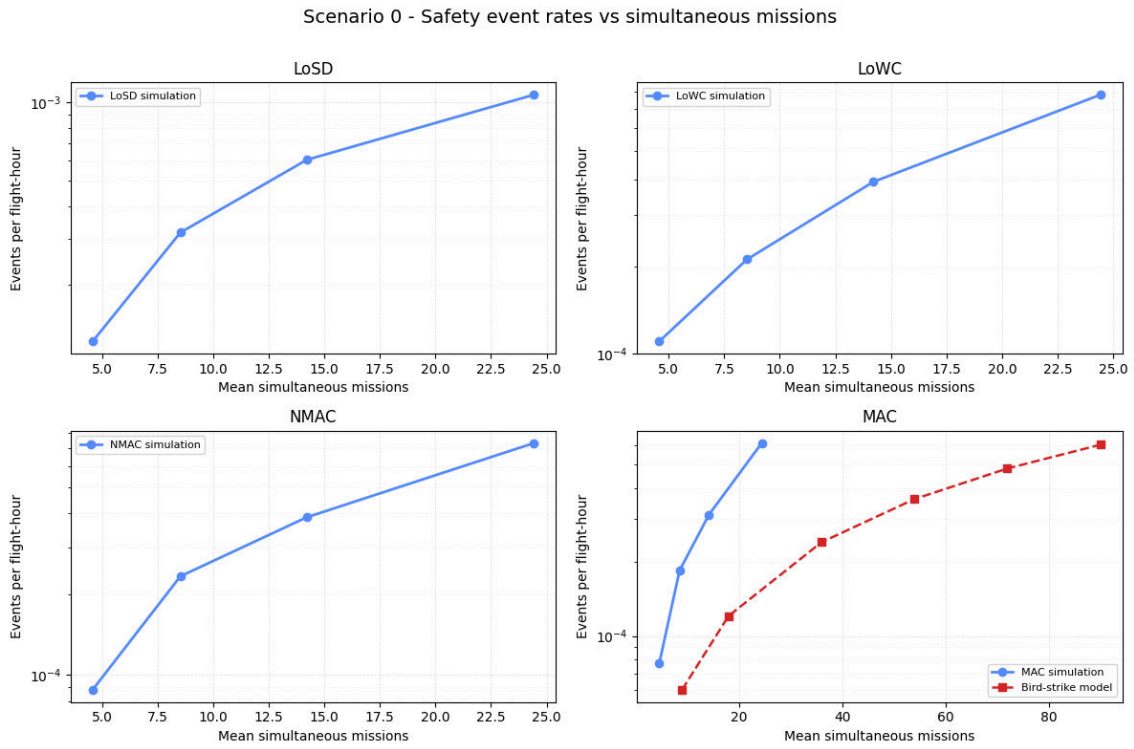


Figure 15 Comparison of safety event per flight hour using the Bird strike model (in MAC safety events) and the simulation framework.

Figure 15 shows the safety-event rates obtained in Scenario 0 as a function of the mean number of simultaneous missions (λ). A monotonic increase is observed for all event categories, indicating that a higher traffic load produces a greater frequency of hazardous encounters. Since the rates are normalized by total flight hours, this trend cannot be attributed exclusively to the increase in aggregate exposure. Instead, it indicates that the safety risk per flight hour also increases as more aircraft coexist within the airspace. The expected severity hierarchy is also preserved, with LoSD and LoWC events occurring more frequently than NMAC and MAC events. To compare the obtained result with a probabilistic/analytical approach the bird-strike-model is used [9] . Appendix X4 breaks down P("MAC") (probability of midair collision per flight hour) into conditional components based on whether aircraft participate in strategic deconfliction and whether they remain nominal or go off-nominal. It is calculated as:

$$P(\text{MAC}) = P(\text{MAC}|\text{SD}) \cdot P(\text{SD}) + P(\text{MAC}|\overline{\text{SD}}) \cdot P(\overline{\text{SD}})$$

where:

$P(\text{SD})$ is the probability both aircraft participate in strategic deconfliction.

$P(\overline{\text{SD}})$ probability at least one does not participate.

If one or both aircraft do not participate, MAC probability modeled similar to bird-strike scenarios:

$$(\text{MAC}|\overline{\text{SD}}) \approx \text{random encounters Poisson model}$$

that uses:

- Traffic density δ (aircraft per area) and height band
- UAS Cross-sectional area A
- Relative speed V
- Flight duration T

In our particular case:

- δ: 5-25 aircraft per square kilometer in a 150 m heightband

A= $\pi \cdot d^2$ m² where d is the diameter of the UA. We suppose that the diameter is equal to 1m
V: 11.2 m/s
T: 1 hour (for per-hour probability).

Step 1. Calculate the 3D density r as:

$$\rho = \frac{1 \text{ aircraft}}{9.10^6 m^2 \times 150m} \approx 7.40 \times 10^{-10} \text{ aircraft}/m^3$$

Step 2. Calculate the Swept volume per hour S (cross-section area x speed x time):

$$S = 3.14m^2 \times 11.2\, m/s \times 3600s \approx 126.60 \times 10^3 m^3$$

Step 3. Calculate the expected number of collisions per hour under random encounter assumption:

$$\lambda = \rho \times S = (7.40 \times 10^{-10} \text{ aircraft}/m^3) \times (126.60 \times 10^3 m^3) \approx 9.37 \times 10^{-5}$$

Step 4. Convert to probability

$P(\text{MAC}|\overline{\text{SD}}) = 1 - e^{-\lambda} \approx 9.37 \times 10^{-5}$ per flight hour

To calculate how this probability evolves with different simultaneous missions the number of flights in r is swept (number of missions per km2).

As indicated in section A.5.3, having the estimated rate (λ measured) based on the simulation results and the total exposure time T the upper confident interval of the MAC events can be found, λ_U (see Table 11). The results show that the MAC probability increases with traffic density, providing a baseline safety threshold for operations without mitigation measures. The next section assesses the impact of strategic deconfliction services not only on safety, but also on system capacity and operational efficiency.

Demand (ops/h)	Total flight hour (h)	Total NMAC	λ (MAC per flight hour measured)	λ_U (MAC per flight hour 95 confident interval)
20	90.792	7	$7{,}70 \cdot 10^{-5}$	$1{,}44 \cdot 10^{-4}$
50	227.007	42	$1{,}85 \cdot 10^{-4}$	$2{,}39 \cdot 10^{-4}$
100	454.174	142	$3{,}12 \cdot 10^{-4}$	$3{,}52 \cdot 10^{-4}$
200	908.065	556	$6{,}12 \cdot 10^{-4}$	$6{,}56 \cdot 10^{-4}$

Table 11. MAC per flight hour 95 confident interval

A.6.3 Scenario 1: Strategic deconflicted with short term deviations

Capacity and efficiency

The previous section characterized the airspace demand generated under each parameter configuration. This demand constitutes the input to the strategic deconfliction service, which applies risk-mitigation measures to ensure that the resulting traffic satisfies the defined safety target. These measures may delay, modify, or reject missions, thereby reducing or redistributing the number of operations simultaneously present in the airspace. Safety is therefore achieved at an efficiency cost, both at the system level, through a potentially less intensive use of the available airspace, and at the mission level, through the temporal or spatial modifications required to obtain conflict-free trajectories.

In this context, airspace demand refers to the operations intending to use the U-space airspace, whereas traffic load represents the operations actually allowed to operate after the applicable risk-mitigation constraints have been imposed. Both can be expressed in terms of operations per hour, simultaneous operations, or airspace occupancy.

Figure 16 illustrates how the strategic deconfliction service transforms the initial airspace demand into the traffic load that can be safely accommodated. The total length of each bar represents the submitted demand, which is decomposed into conflict-free missions, missions accepted after applying trajectory modifications, and missions for which no feasible conflict resolution can be found. Consequently, the sum of the conflict-free and modified missions represents the resulting traffic load, whereas the unresolved missions correspond to demand that cannot be accommodated under the considered configuration (cancelled mission). It is important to highlight that the performance of the strategic conflict resolution service, together with the range and effectiveness of the mitigation measures available, strongly influences the proportion of missions that can be accepted and those that must ultimately be cancelled. In this specific study a mitigation window of 15min has been used to shift mission's take-off time ensuring a conflict free flight.

The characterization of trajectory-based operations with no deviation threshold provides an estimate of the intrinsic conflict rate of the generated traffic. When no deviation threshold is applied, a conflict is identified only when the Total System Error (TSE) volumes associated with two missions overlap. Under this configuration, even at the highest demand level, approximately 92% of the missions remain conflict-free, while the remaining 8% require strategic conflict mitigation. However, as the volumes used by the strategic deconfliction service are enlarged by introducing deviation thresholds, the proportion of detected conflict-free missions decreases dramatically. The multi-volume representation reserves larger portions of the airspace-time domain and consequently generates more conservative conflict detections. For the trajectory-based representation, it falls from approximately 92% with no deviation threshold to 14% and 6% for the two considered threshold configurations, respectively. At the same time, the 4D volume reserved by each mission as dev. threshold are defined increases, which reduces the available solution space for strategic deconfliction and therefore limits the service's ability to resolve all detected conflicts. Consequently, mission cancellations start to occur, as can be observed in the results presented in Figure 18.

At low demand levels, demand and traffic load largely coincide, since most missions can operate without modification. As density increases, however, the proportion of initially conflict-free missions decreases, and the system becomes increasingly dependent on trajectory time modifications to maintain the required level of safety. Under the most constraining configurations, a growing proportion of missions cannot be resolved, widening the gap between demand and traffic load. This trend is clearly illustrated in Figure 17 through a comparison of the number of simultaneous missions obtained with and without the application of mitigation measures.

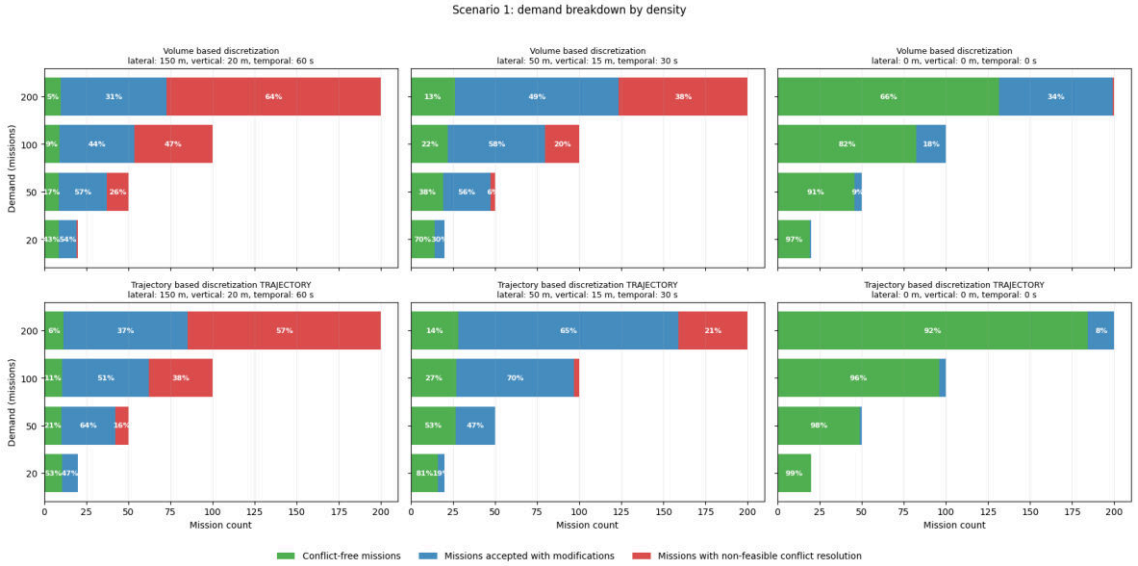


Figure 16. Characterization of demand conflicts under different flight-intent representations and deviation-threshold configurations

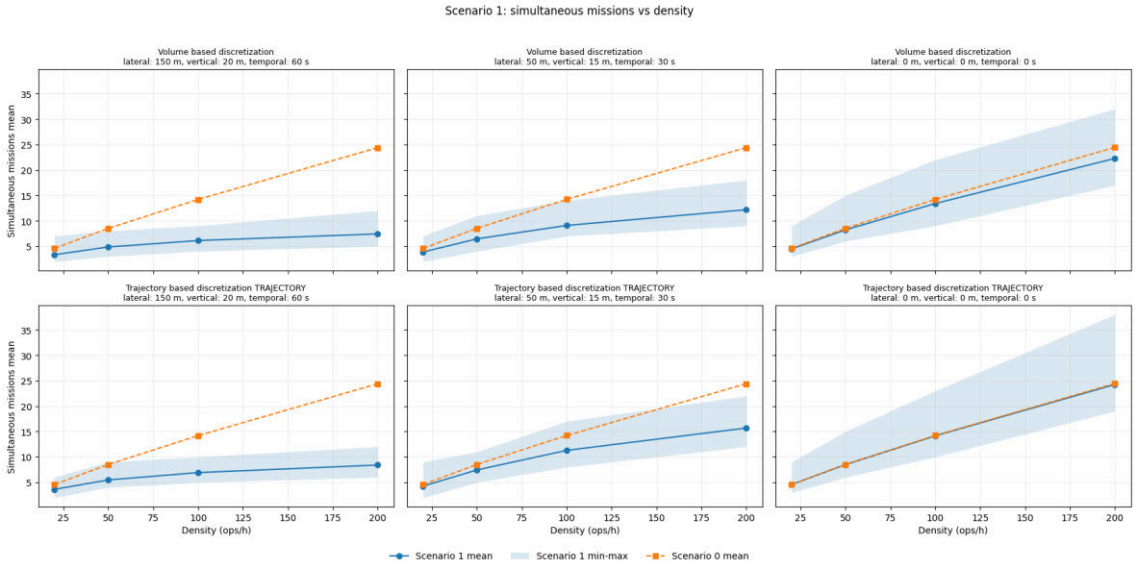


Figure 17. Number of simultaneous missions, under different flight-intent representations and deviation-threshold configurations, with (Scenario 1) and without (Scenario 0) strategic conflict resolution services

Figure 17 presents the mean number of simultaneous missions obtained under different demand levels, flight-operation representations, and spatial and temporal deviation thresholds. The orange curve represents the traffic generated without strategic deconfliction, whereas the blue curve corresponds to the traffic load resulting from the application of the strategic deconfliction service.

As it was already highlighted, when the additional deviation thresholds are set to zero and the protection margins are therefore determined primarily by the Total System Error, the mitigated and unmitigated curves remain close over the entire demand range. Under these conditions, strategic deconfliction imposes only a limited restriction on the resulting traffic load. However, the difference between the two curves progressively increases as the spatial and temporal deviation thresholds become more conservative. This divergence is particularly evident at high demand levels, where the larger operational volumes generated around each mission produce more detected conflicts and reduce the number of missions that can be simultaneously accommodated.

A further relevant observation is the change in the slope of the mitigated curves. While the unmitigated traffic load continues to increase proportionally with demand, the mitigated curves exhibit a progressively flatter response for non-zero deviation thresholds. This behaviour indicates that the strategic deconfliction process becomes increasingly binding and that additional demand does not translate into an equivalent increase in simultaneous operations. Instead, a growing proportion of missions must be delayed, rescheduled, or cancelled to maintain the required separation margins. The results therefore suggest the emergence of an effective traffic-load saturation region, whose level depends on both the deviation thresholds and the selected flight-operation representation. This is translated into a reduction of the acceptance ratio that shows the percentage of demand missions that are accepted (see Figure 18).

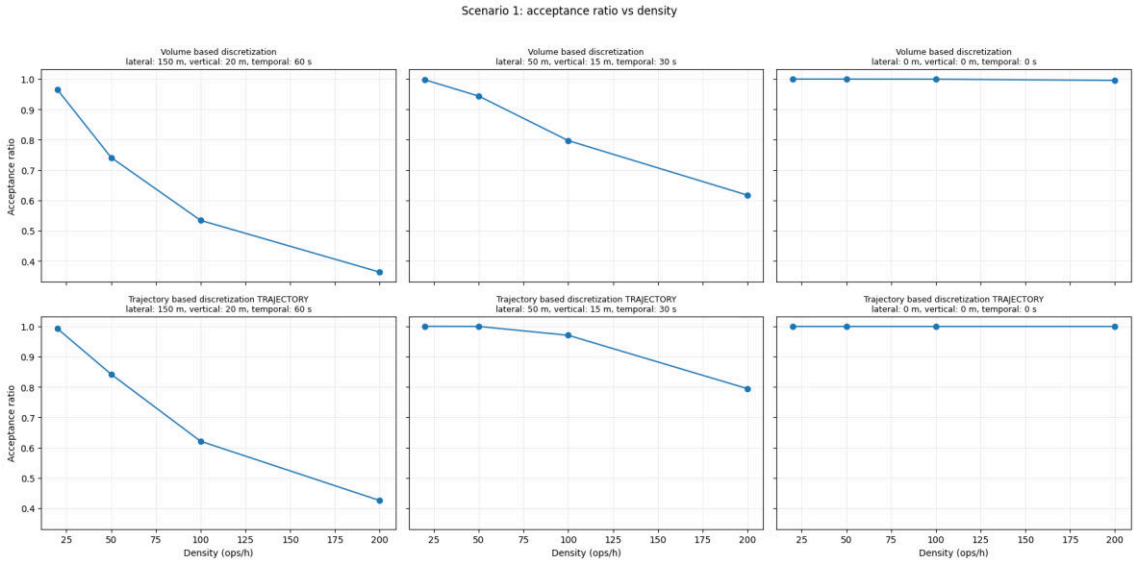


Figure 18. Acceptance ratio values as density increases for volume and 4D trajectory representation with conservative, moderate and non deviation thresholds.

This impact of strategic deconflicting service can be also observed while studying the aggregated number of hours flown in each run under each parametrization. Figure 19 compares the total flight hours obtained in the baseline scenario with those resulting from the different combinations of flight-operation representation and deviation threshold.

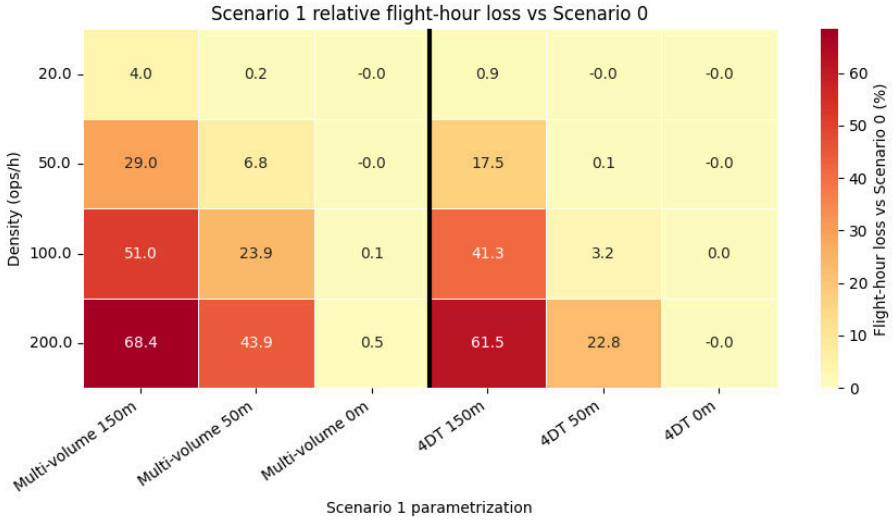


Figure 19. Heatmap comparing relative flight-hour loss under different discretization and dev. threhold values (between scenario 0, no strategic deconflicting, and scenario 1 with strategic mitigations)

To facilitate comparison across demand levels, the results can be normalized by the total flight hours obtained in Scenario 0. The normalized values show that, when the additional deviation thresholds are set to zero, both representations retain approximately 100% of the baseline flight hours across the complete demand range. In contrast, non-zero deviation thresholds produce an increasingly pronounced reduction as demand increases. At 200 ops/h, the 150 m configuration retains only 31.6% of the baseline flight hours with the multi-volume representation and 38.5% with the 4D-trajectory representation. For the 50 m threshold, the corresponding values increase to 56.1% and 77.2%, respectively. These results indicate that the deviation threshold is the primary factor determining the reduction in accommodated traffic,

while the trajectory-based representation partially mitigates this effect by providing a more precise description of the space-time occupancy of each mission.
The influence of discretization is nevertheless configuration-dependent. Its effect is negligible when the deviation thresholds are zero, but becomes substantial at intermediate thresholds and high demand. This behavior reveals an interaction between demand, deviation threshold, and flight-operation representation. Consequently, their effects should not be interpreted independently or ranked using the raw aggregated values alone.

To ensure that the demand levels remains below the Target level of safety, the strategic conflict resolution service modifies or cancel de demand missions to transform it to a traffic load that satisfies the safety requirements. Figure 20 shows the mean delay applied to authorized operations as a function of the requested demand for the different flight-operation representations and deviation-threshold configurations. This delay represents the efficiency cost introduced by the strategic deconfliction service, as mission departure times must be shifted to identify conflict-free execution intervals.

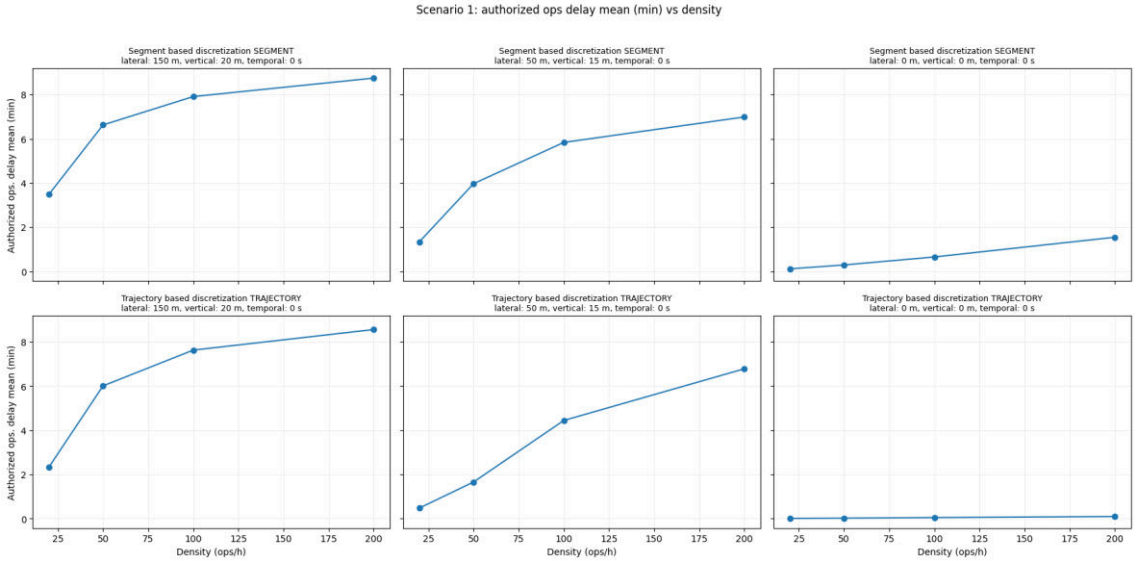


Figure 20. Strategic deconfliction service mean delay applied for each of the discretization and dev. Threshold values.

For all configurations with non-zero deviation thresholds, the mean delay increases with traffic demand. Larger spatial and temporal margins enlarge the protected 4D volume associated with each mission, increasing the number of detected conflicts and reducing the availability of feasible departure slots. Consequently, the most conservative threshold configuration produces the highest delays, reaching approximately 9 min at the highest demand level. Under the FCFS policy, increasing delay is also closely linked to a higher probability of mission cancellation: once a mission is delayed and authorized, its shifted trajectory becomes an additional constraint that must be considered when mitigating subsequent missions. As these constraints accumulate sequentially, the solution space available to future missions progressively shrinks, increasing the likelihood that no feasible departure time can be found within the mitigation window. Therefore, the observed flattening of the mean delay at high demand should be interpreted together with the mission-acceptance rate, since additional traffic may increasingly result in cancellations rather than further increases in the delay of authorized missions. This relationship is expected to be weaker under RTTA or batch-processing policies, where several missions can be jointly optimized rather than mitigated sequentially, potentially decoupling, at least partially, the increase in delay from the increase in mission cancellations (decoupling capacity and efficiency).
The trajectory-based representation generally results in equal or lower delays than the segment-based representation because its more precise space-time description reduces unnecessary

overlaps between mission reservations. This effect is particularly evident when no additional deviation threshold is applied, for which the trajectory representation produces virtually no delay, while the segment-based approach still introduces a small residual delay due to its more conservative discretization. At the most conservative thresholds, however, the differences between both representations become smaller, indicating that the size of the deviation margins progressively dominates the conflict-detection process

Safety characterization

Figure 21 presents the empirical characterization of the mission deviations with respect to the flight intent, which is subsequently used to define the TSE values considered in the safety analysis. This process emulates the procedure that operators would perform to characterize the aircraft Flight Technical Error (FTE), together with the Navigation System Error (NSE) and other relevant system contributions, in order to determine the applicable TSE margins

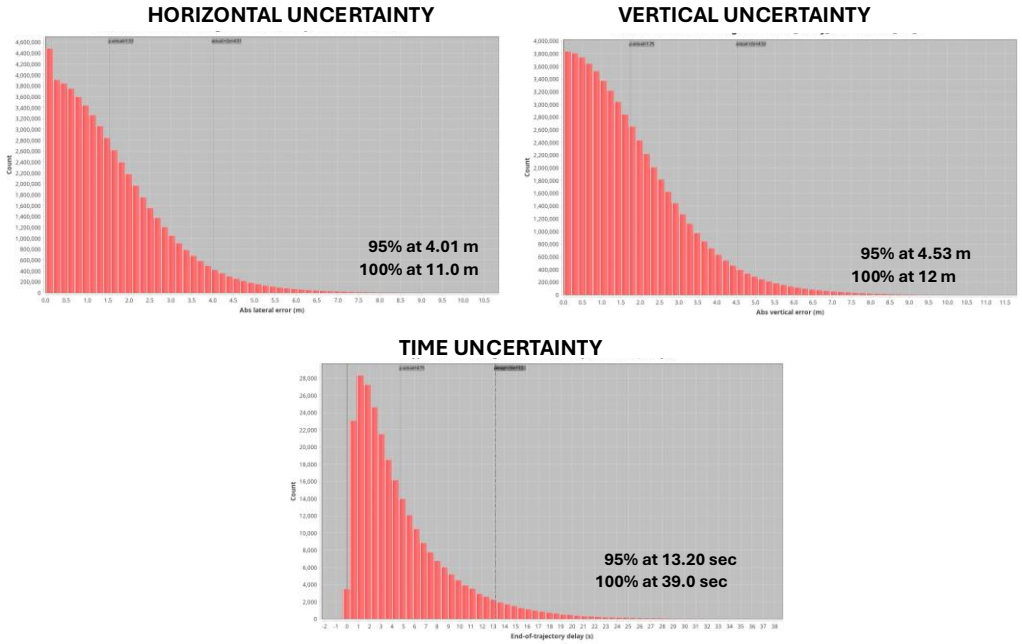


Figure 21. Empirical characterization of the Total System Error components observed in VTOL heavy lift flown missions.

The upper panels show the horizontal and vertical spatial uncertainties, while the lower panels represent the temporal uncertainty. The results indicate that 95% of the horizontal and vertical errors remain below 4.01 m and 4.53 m, so these values will fix the TSE defined volume. Additionally, the temporal buffer will be fixed by the addition of the 95% time delay while executing the mission is 13,20 s.

The mission is expected to remain within the defined flight geography for 95% of the flight time. However, when deviations outside this volume occur, the maximum observed deviations can also be derived from Figure 21. As shown in the figure, the maximum horizontal deviation is 11 m, while the maximum vertical deviation is 12 m. The maximum temporal deviation during flight is 39 seconds. The occurrence of safety events caused by these deviations depends on the deviation-threshold values used to define the acceptable deviation from the planned intent. These thresholds are added to the spatiotemporal TSE boundaries to establish the effective containment margins considered in the safety assessment.

Once the deviation of the aircraft has been analyzed it will be presented the safety events observed with the different dev. threshold defined. The analysis of the results will be divided in the two blocks: conservative dev. Threshold and scenario without dev. threshold values

- **Conservative dev. thresholds**

In this analysis, two different protection volumes have been defined around the operational intent (dev. threshold and TSE). Their absolute values are shown in Table 12. The results indicate that the effective spatial margins, obtained by adding the deviation thresholds to the TSE boundaries, are substantially larger than the maximum deviations observed in the empirical TSE characterization. In particular, the maximum horizontal and vertical deviations are 11 m and 12 m, respectively, whereas the effective horizontal and vertical margins range from 54 m to 159 m and from 15.5 m to 24.5 m, depending on the study case.

Hor. Dev.T.+ TSE	Ver. Dev.T. + TSE	Temp. Dev.T+ TSE	Maximum Hor. Dev.	Maximum Ver. Dev.	Maximum time dev.
154m	24,5 m	73 s	11m	12 m	39 s
54m	19,5m	43 s	11m	12m	39 s

Table 12. Effective deviation margins obtained by adding the deviation thresholds to the TSE boundaries, and maximum observed deviations derived from the empirical TSE characterization.

Regarding safety events, no LoWC, NMAC or MAC events were detected in the designed scenarios, regardless of the deviation thresholds considered or the mission representation used, either 4DT-based or volume-based. This result can be explained by the fact that the deviation-threshold buffers added to the Total System Error values are highly conservative (see Table 12). By contrast, LoSD events were observed under the smaller deviation-threshold configuration (50 m) when the trajectory-based mission representation was used (see Figure 22). These events can be explained by the maximum horizontal and vertical deviations that an aircraft may experience relative to its planned trajectory. It is important to note that they occurred only under high-traffic-density conditions and would not necessarily require a reduction in system capacity. Instead, they could be treated as warning-level events, prompting the aircraft operator to monitor the operation or apply tactical corrective actions before the situation escalates.

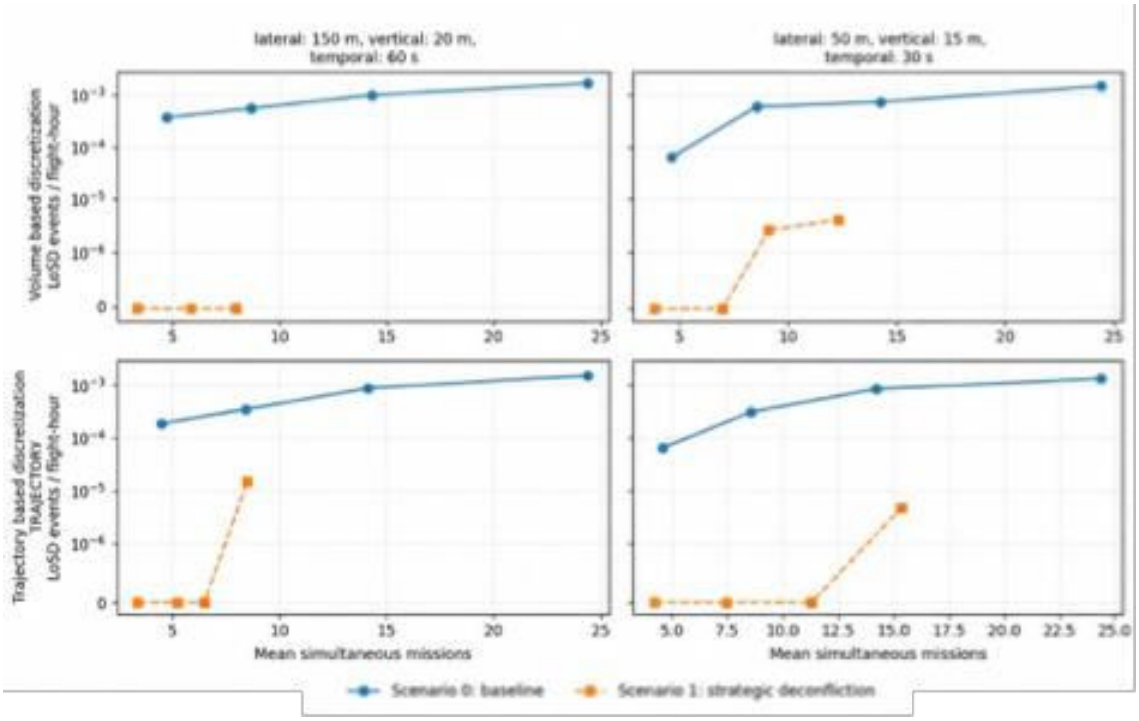


Figure 22. LoSD events under different flight-intent representations and deviation-threshold configurations

As it was described in section A.5.3, MAC event per frequency hour is defined by the number of simulated hours. Table 13 and Table 14 reports the total flight time, the 95% confident interval MACs per flight hour and the lower 95 confident interval safety rate ratio with scenario 0 defined in section A.5.4, as no MAC are found in the scenario 1.

Demand	Simultaneous Missions	Deviation threshold	Total flight time (h)	$\lambda_U \approx \frac{3}{T}$ (MACs per flight hour 95% confident interval)	$\widehat{RR}_{L,95} = \frac{\lambda_o}{\lambda_1}$
20	3,3	150m (h), 30m (v) 60 s.	14.525	$2{,}05 \cdot 10^{-4}$	0,29
50	4,8		26.879	$1{,}11 \cdot 10^{-4}$	1,60
100	6,1		37.062	$8{,}06 \cdot 10^{-5}$	3,82
200	7,4		47.868	$6{,}24 \cdot 10^{-5}$	9,75
20	3,8	50m (h), 30m (v) 60 s.	15.104	$1{,}98 \cdot 10^{-4}$	0,31
50	6,4		35.279	$8{,}49 \cdot 10^{-5}$	2,10
100	9,0		57.585	$5{,}19 \cdot 10^{-5}$	5,94
200	12,1		84.869	$3{,}52 \cdot 10^{-5}$	17,29

Table 13. MAC events per flight hour for multi-volume mission description

Demand	Simultaneous Missions	Deviation threshold	Total flight time (h)	$\lambda_U \approx \frac{3}{T}$ (MACs per flight hour 95% confident interval)	$\widehat{RR}_{L,95} = \frac{\lambda_o}{\lambda_1}$
20	3,6	150m (h), 30m (v) 60 s.	14.996	$1{,}99 \cdot 10^{-4}$	0,30
50	5,4		31.229	$9{,}57 \cdot 10^{-5}$	1,86
100	6,9		44.464	$6{,}72 \cdot 10^{-5}$	4,59

200	8,4		58.254	$5{,}13 \cdot 10^{-5}$	11,87
20	4,2	50m (h), 30m (v) 60 s.	15.137	$1{,}97 \cdot 10^{-4}$	0,31
50	7,4		37.810	$7{,}90 \cdot 10^{-5}$	2,25
100	11,2		73.237	$4{,}08 \cdot 10^{-5}$	7,56
200	15,6		116.858	$2{,}55 \cdot 10^{-5}$	23,82

Table 14. MAC events per flight hour for 4D trajectory mission description

The results show that the statistical evidence of safety improvement increases markedly with traffic demand. At 20 operations per hour, the 95% lower confidence bound of the MAC safety rate ratio remains below unity for all configurations, with values around 0.29–0.30. Therefore, although no MAC events were observed in the strategically deconflicted scenarios, the limited number of MAC events observed in Scenario 0 at this demand level is insufficient to demonstrate, at the 95% confidence level, that the mitigated MAC rate is lower with the strategic deconfliction service. From 50 operations per hour onwards, however, the lower confidence bound exceeds one for every configuration, providing statistical evidence that strategic deconfliction reduces the MAC rate relative to Scenario 0. This evidence strengthens rapidly with increasing demand, reaching lower bounds between 9.75 and 23.82 at 200 operations per hour.

The deviation-threshold configuration also has a clear influence on the strength of the demonstrated safety improvement. For a given mission representation and traffic demand, the reduced horizontal deviation threshold generally results in a higher $\widehat{RR}_{L,95}$. This effect is not caused by the observation of fewer MAC events, since all mitigated configurations produced zero MACs, but rather by the greater flight exposure accumulated without observing a collision. The increased number of authorized and simultaneous missions results in a larger total flight time, reducing the Poisson upper confidence bound on the mitigated MAC rate and increasing the minimum safety improvement that can be statistically supported.

A similar effect is observed when comparing the multi-volume and 4D trajectory mission representations. The 4D trajectory representation consistently supports a larger accumulated flight exposure and, consequently, produces higher lower confidence bounds for the MAC rate ratio, particularly at medium and high traffic demand. For example, at 200 operations per hour with the reduced deviation threshold, the minimum safety improvement increases from 17.29 for the multi-volume representation to 23.82 for the 4D trajectory representation. This result should not be interpreted as evidence that the trajectory representation is intrinsically safer per se; rather, it indicates that the more precise representation supports a greater traffic load and accumulated flight exposure while maintaining zero observed MAC events, thereby providing stronger statistical evidence of safety improvement relative to the unmitigated baseline.

The results indicate that the deviation threshold is the dominant parameter in safety improvement, while the more precise 4D trajectory representation provides a complementary improvement whose effect becomes more pronounced when combined with a reduced deviation threshold.

- **Mitigates scenario with non-deviation threshold**

Under this scenario configuration, the 4D operational volume is constructed using only the Total System Error (TSE), with no additional protection margin associated with the deviation threshold. As shown in Table 12, the maximum horizontal and vertical deviations may exceed

the resulting TSE-based containment volume. Consequently, NMAC and MAC events may occur when aircraft deviate beyond the protected volume. However, their occurrence also depends on the traffic load, since higher levels of simultaneous traffic increase the likelihood that such deviations lead to hazardous interactions with other missions.

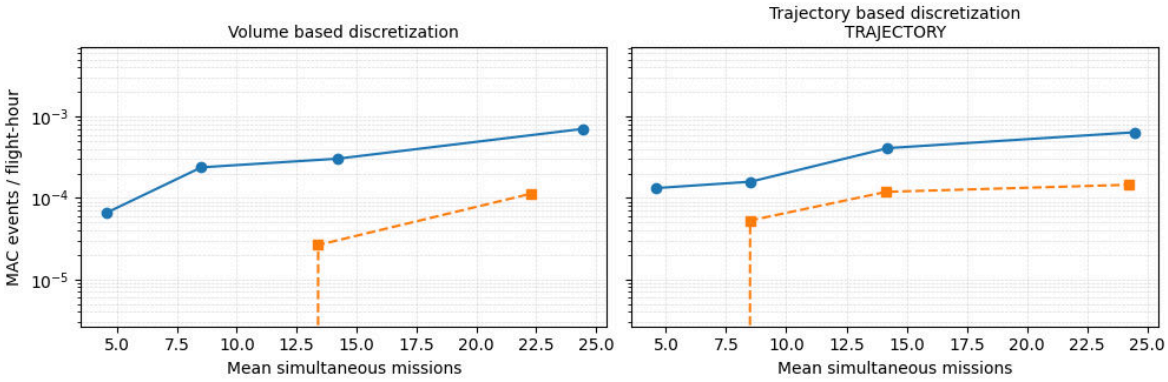


Figure 23. MAC events per flight hour without deviation threshold volume

Figure 23 presents the MAC event rates obtained under nominal operating conditions. The observed events are associated with the small fraction of deviations that exceed the TSE-based containment volume. Although such deviations are expected to occur in only approximately 5% of cases, their impact is not negligible, since an excursion beyond the protected volume may lead to a MAC when another mission is simultaneously present in a conflicting position. The comparison between flight-operation representations shows that the volume-based approach delays the appearance of MAC events to higher traffic densities. This is because it reserves a larger airspace volume over time, reducing the probability that other missions are authorized nearby. Conversely, the more compact trajectory-based representation supports higher capacity but increases the likelihood that an out-of-volume deviation results in a hazardous interaction. Table 15 compares de MAC event compares the MAC events per flight hour with scenario 0, as it was done for those configurations with deviation thresholds.

Demand	Simultaneous Missions	Mission Description	λ (MAC per flight hour)	λ_U (MACs per flight hour 95% confident interval)	$\frac{\lambda_{Sce0}}{\lambda_{Sce1}}$
20	4,4	Multivolume	0	$1{,}97{\cdot}10^{-4}$	-
50	8,2		0	$7{,}90{\cdot}10^{-5}$	-
100	13,4		$2{,}60{\cdot}10^{-5}$	$9{,}55{\cdot}10^{-5}$	12,0
200	22,2		$1{,}13{\cdot}10^{-4}$	$1{,}89{\cdot}10^{-4}$	5,4
20	4,5	4D trajectory	0	$1{,}97{\cdot}10^{-4}$	-
50	8,4		$5{,}30{\cdot}10^{-5}$	$1{,}90{\cdot}10^{-4}$	3,49
100	14,1		$1{,}19{\cdot}10^{-4}$	$2{,}27{\cdot}10^{-4}$	2,62
200	24,2		$1{,}45{\cdot}10^{-4}$	$8{,}29{\cdot}10^{-4}$	4,22

Table 15. MAC events per flight hour for 4D and mulit-volume trajectories without dev. thresholds.

When comparing the safety improvement achieved using only the 4D volumes based on the Total System Error (TSE) with that obtained by introducing additional deviation thresholds, it can be observed that, at low traffic densities, both configurations provide similar safety performance. This suggests that, under low traffic-load conditions, strategic deconfliction based exclusively on the TSE could be sufficient to maintain the required safety level.

However, as traffic density increases, the relative safety benefit provided by the deviation thresholds becomes more significant. In other words, **the safety performance of the TSE-only configuration progressively deteriorates with increasing traffic load, whereas the additional deviation margins provide greater protection as the number of simultaneous missions increases**

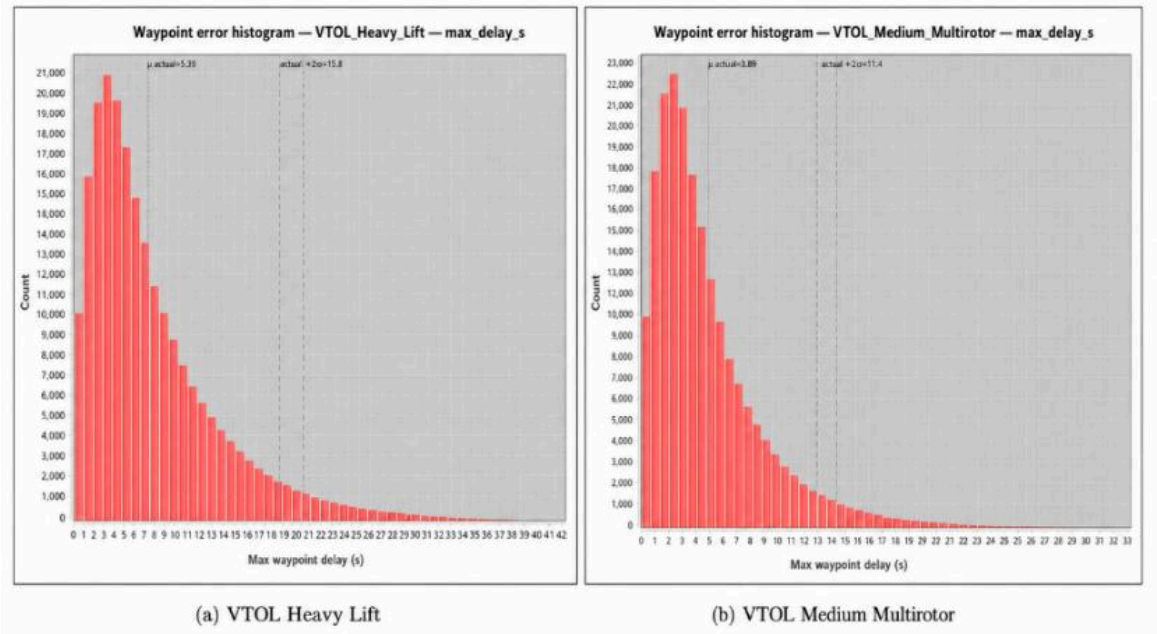
A.6.4 Scenario 2: Strategic deconflicted with long term deviations

In these scenarios, a set of environmental and navigation-degradation events are introduced to reduce the aircraft's ability to follow its planned flight intent. In the simulated scenario, the entire airspace volume is affected by a northerly wind of 15 m/s. In addition, the U-space volume is divided into two sub-volumes (east and west), each covering half of the original airspace volume, where GPS and compass degradation effects are applied. The specific characteristics of each degraded sub-volume are detailed in the Table 16

Event	Volume	Parameters
Wind	Full volume	Heading= 0 Horizontal speed = 15m/s, Vertical speed = 0 m/s
GPS	East & West	Probability=100%, Severity East=100%, Severity West= 75%
Compass	West	Probability=100%, Severity = 100%

Table 16. Configuration of environmental and navigation-degradation events in the simulated scenario.

The deviation of the executed flight from the indented flight trajectory was characterized under this environmental and navigation degradation event. The results are showed in Figure 24, Figure 25, Figure 26 and Figure 27 for both medium multirotor and heavy lift multirotor and Table 17 summarizes the deviation values.



(a) VTOL Heavy Lift (b) VTOL Medium Multirotor

Figure 24. Maximum accumulated delay distributions for the VTOL Heavy Lift and VTOL Medium Multirotor models under wind-window perturbations.

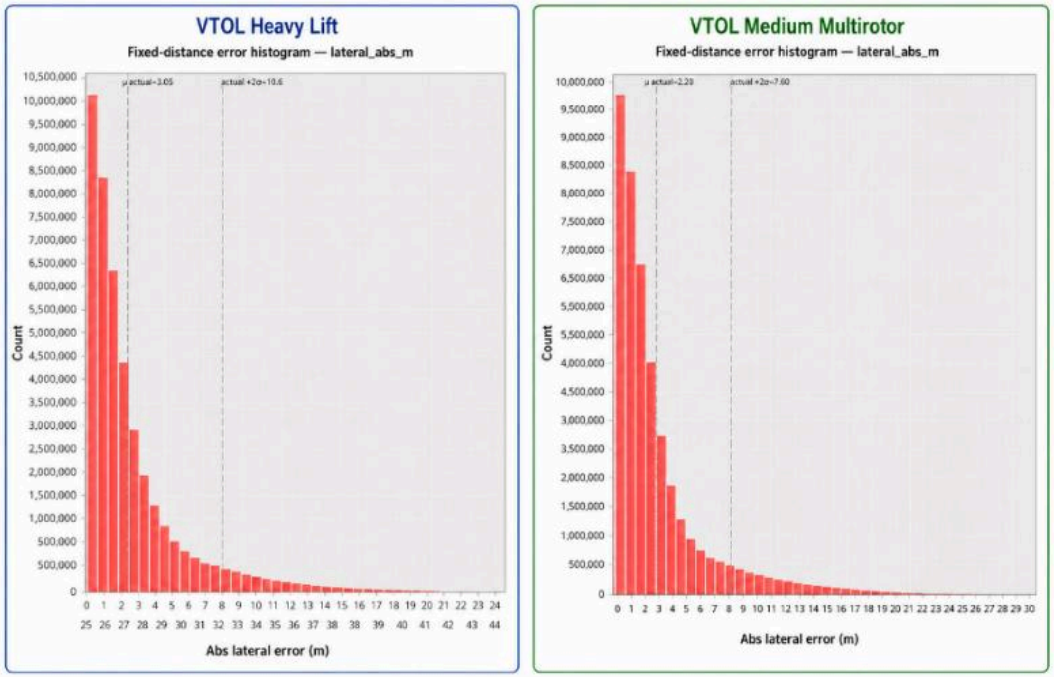


Figure 25. Lateral deviation under sensor-degradation windows. Absolute lateral error comparison for the VTOL Heavy Lift and VTOL Medium Multirotor configurations.

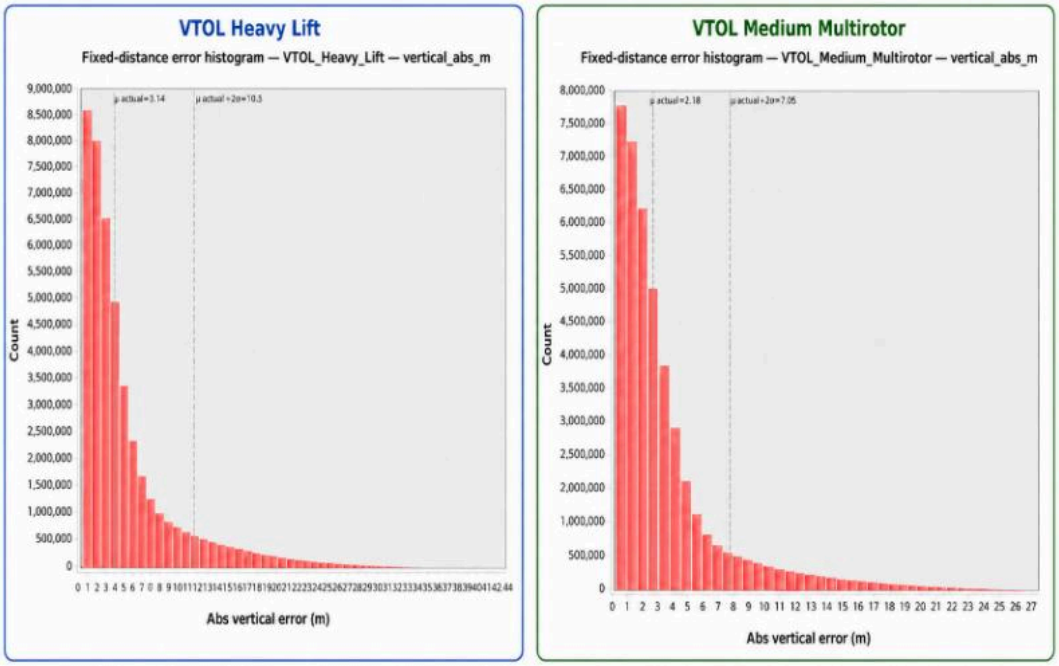


Figure 26.Vertical deviation under sensor-degradation windows. Absolute vertical error comparison for the VTOL Heavy Lift and VTOL Medium Multirotor configurations.

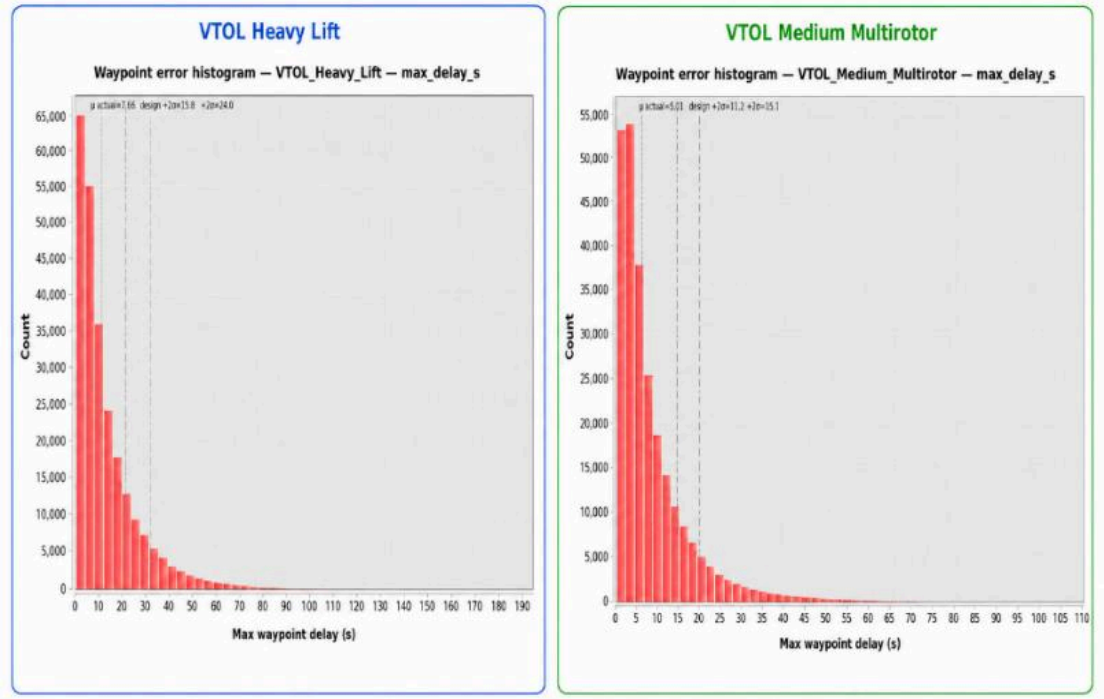


Figure 27. Temporal deviation under sensor-degradation windows. Maximum accumulated waypoint delay comparison for the VTOL Heavy Lift and VTOL Medium Multirotor configurations.

Model	Wind temporal delay (s)	Sensors horizontal dev. (m)	Sensors vertical dev.	Sensors temporal dev. (s)
VTOL heavy	μ= 5,3 2σ=12,8 max =42	μ= 3,0 2σ= 10,0 max =44	μ= 3,1 2σ= 10,5 max =44	μ= 7,6 2σ= 15,8 max =190
VTOL medium	μ= 3,8 2σ=11, 4 max=33	μ= 2,20 2σ= 7,60 max =30	μ= 2,1 2σ= 7,0 max =27	μ= 5,0 2σ= 11,2 max =110

Table 17. Spatial and temporal characterization of Heavy and Medium rotor deviation under wind and sensor degradation.

As shown in Table 17 , the 2σ spatiotemporal confidence intervals, corresponding to a 95% containment level, remain within the conservative deviation thresholds for both the wind- and sensor-degradation conditions. However, the maximum sensor-induced temporal deviation substantially exceeds the temporal limits established for the two threshold configurations, namely 60 s and 30 s, respectively. Therefore, when deviations fall outside the 95% containment interval, the potential for LoSD, LoWC, NMAC, or MAC events increases. Whether such deviations ultimately lead to a safety event depends strongly on the traffic conditions, particularly the number of simultaneous missions and the resulting likelihood of interaction with other aircraft. Figure 28 presents the evolution of MACs event with traffic demand for each dev. threshold values and mission representation.

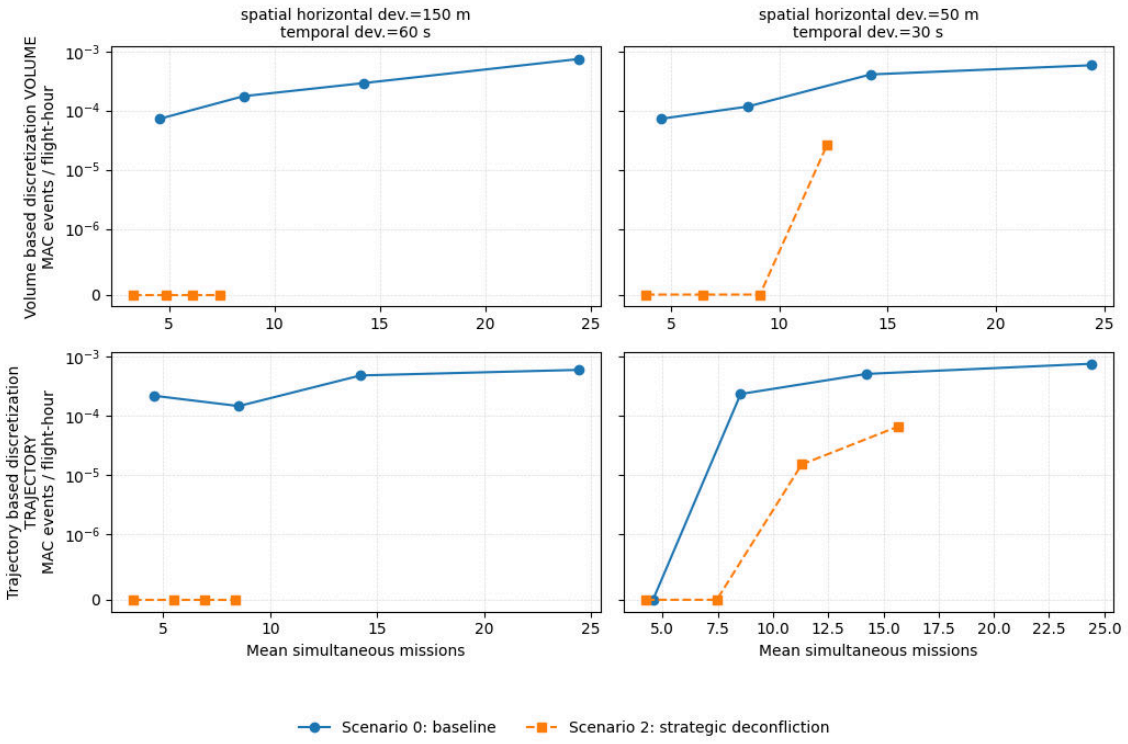


Figure 28. NMAC per flight hour under different flight-intent representations and deviation-threshold configurations

As shown in Figure 28, no MAC events were observed in the strategically deconflicted degraded scenario under the conservative deviation-threshold configuration, with a horizontal threshold of 150 m and a temporal threshold of 60 s. This result holds for both the volume-based and the 4D-trajectory representations. So the safety improvement in this context is the same as in scenario 1, when short deviation was included.

By contrast, when the reduced deviation-threshold configuration is applied, with thresholds of 50 m and 30 s, residual MAC events become observable once the traffic load reaches approximately 8–10 simultaneous missions. This effect is particularly evident for the 4D-trajectory representation, which accommodates higher levels of concurrent traffic and therefore exposes the system to a larger number of potentially hazardous interactions. Table 18 column $\lambda_{Sce0}/\lambda_{Sce2}$ shows that the MAC rate per flight hour is lower than in Scenario 0, as in all the scenarios with MAC events the ratio is bigger than 0. A higher difference is obtained in the multivolume configuration (safer scenarios) as the number of concurrent operations is lower.

Demand	Mission Description	Total number of MAC Scenario2	Total number of MAC Scenario0	λ_U (MACs per flight hour 95% confident interval)	$\frac{\lambda_{Sce0}}{\lambda_{Sce2}}$
20	Multivolume	0	2	$2{,}17 \cdot 10^{-4}$	-
50		0	11	$9{,}27 \cdot 10^{-5}$	-
100		0	31	$5{,}68 \cdot 10^{-5}$	-

200		2	107	$9{,}77 \cdot 10^{-5}$	9,92
20	4D trajectory	0	2	$2{,}17 \cdot 10^{-4}$	-
50		0	11	$8{,}69 \cdot 10^{-5}$	-
100		1	31	$8{,}61 \cdot 10^{-5}$	8,49
200		8	107	$1{,}44 \cdot 10^{-4}$	6,71

Table 18. NMAC per flight hour in moderated deviation thresholds (50m horizontal and 30 seconds) comparison with scenario0.

These results reinforce the interpretation that, under degraded operational conditions, residual safety performance is not determined exclusively by whether the realized deviations exceed the margins provided by the deviation thresholds. It also depends strongly on the resulting traffic load, particularly the number of simultaneously active missions. When degraded deviations extend beyond the protected envelope during the residual fraction of trajectories not covered by the 95% containment target, the probability that such deviations lead to a MAC increases with the number of concurrent operations and, consequently, with the number of potential aircraft interactions.

However, MACs should not be considered in isolation. They represent the most severe outcome of a progressive degradation in aircraft separation. LoSD, LoWC, and NMAC therefore characterize increasingly severe stages of the same encounter process, although only a small proportion of precursor events escalate to the next severity level. Figure 29 and Table 19 presents the evolution of safety events with traffic load.

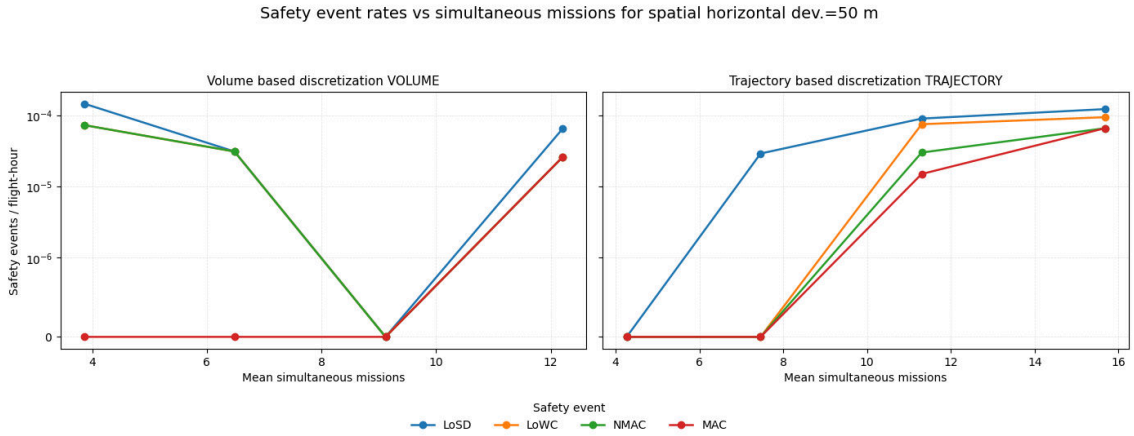


Figure 29. Safety events evolution under different traffic loads (volume and trajectory mission representation)

Simultaneous missions	LoSD	LoWC	NMAC
11,3 (trajectory)	16,6	20	50
12,20 (volume)	40	100	100
15,6 (trajectory)	54	70	100

Table 19. % of safety events that evolves to MAC events (trajectory representation)

Figure 29 shows that, at the lower traffic loads admitted by the volume-based representation, separation-loss events do not necessarily escalate into collisions. LoSD, LoWC, and NMAC events may occur without producing a MAC, indicating that the earlier stages of the encounter can remain contained. Table 19 quantifies how this relationship changes as traffic load increases: a larger proportion of precursor events is associated with MAC occurrence at

higher numbers of simultaneous missions. For the trajectory-based representation, for example, the MAC-to-LoSD ratio increases from 16.6% at 11.3 simultaneous missions to 54% at 15.6 missions, while the corresponding MAC-to-LoWC ratio increases from 20% to 70%. This suggests that increasing traffic concurrency not only raises the frequency of safety events but also increases the likelihood that a separation-loss event progresses towards its most severe outcome.

The progressive evolution from LoSD to LoWC, NMAC, and ultimately MAC can be interpreted from a tactical conflict-management perspective, with each safety indicator representing an increasingly critical alert level and requiring a correspondingly more urgent response. A LoSD may trigger an early advisory requesting the operator to recover conformance with the authorized U-plan, whereas a LoWC would indicate the need for tactical conflict resolution or in-flight replanning. If the encounter progresses to an NMAC, an immediate avoidance or contingency maneuver may be required. The temporal characteristics of the observed events reinforce this escalation framework. At a demand level of 200 missions per hour, the mean event duration decreases from 5.39 s for LoSD to 4.26 s for LoWC and 2.30 s for both NMAC and MAC. This progressive temporal compression suggests that the available intervention window becomes increasingly limited as aircraft separation deteriorates. LoSD therefore provides the earliest and longest opportunity to issue an advisory and restore conformance, while LoWC requires a more immediate tactical response. By the time the encounter reaches the NMAC level, the remaining time may be insufficient for operator-in-the-loop intervention, making automated avoidance or predefined contingency maneuvers increasingly necessary.

A.6.5 Scenario 3: Failure in strategic deconflicting

Scenario 3 models a partial failure of the strategic deconfliction process through a predefined failure probability. This probability defines the proportion of demand missions that are authorized directly, without being processed by the strategic deconfliction service.
For this analysis, the failure probability is set to 1%, and 0,5%. The resulting performance metrics are presented in Figure 30.

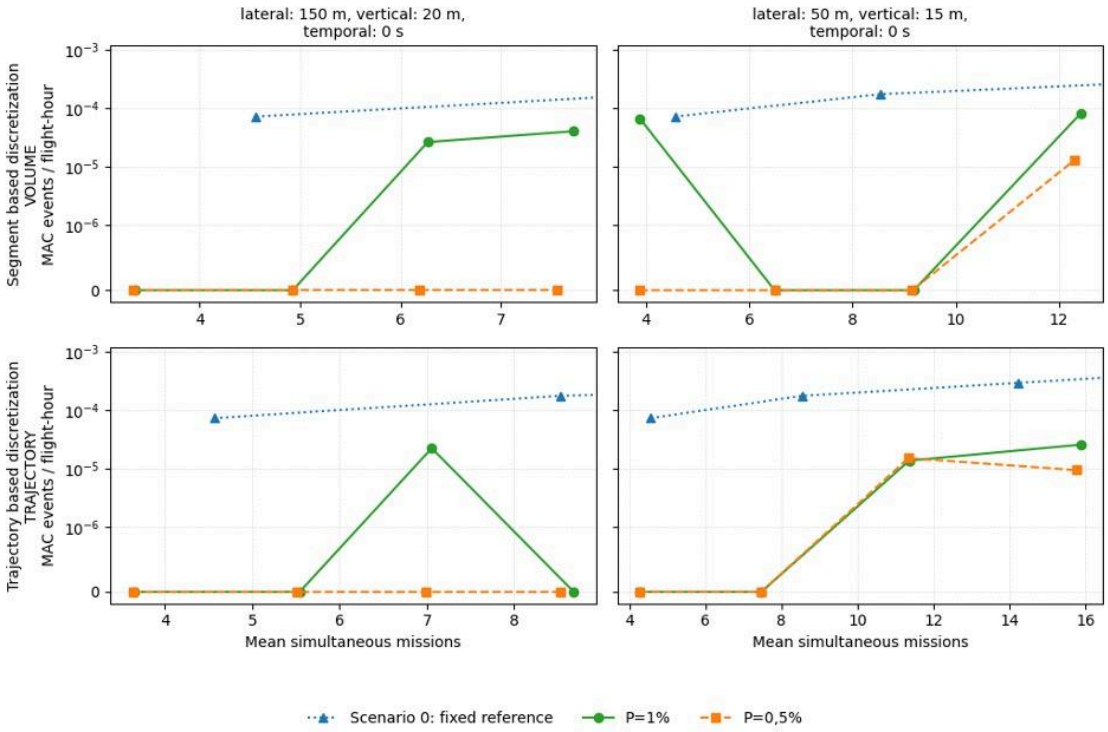


Figure 30. Safety events characterization in a partial failure (1% and 0,5%) of the strategic deconfliction process.

Figure 30 compares the unmitigated baseline (Scenario 0) with two cases in which the strategic deconfliction process fails with probabilities of 1% and 0.5%. Across all deviation-threshold configurations and flight-operation representations, the resulting safety-event rates remain below those observed in the non-deconflicted baseline. With a failure probability of 0.5%, MAC events are observed only at the highest traffic loads with the reduced deviation threshold of 50m. When the failure probability increases to 1%, MACs occur over a broader range of traffic loads, including lower and intermediate concurrency levels in some configurations. However, analyzing the reduced deviation threshold MAC per flight hour values subgraph, it can be seen the the λ values are quite similar in both failure probabilities**.** It is also important to highlight that increasing the probability of strategic-deconfliction failure makes MAC occurrence less dependent on reaching the highest traffic densities.

A.6.6 Scenario 4: Failure in flight replanning (Scenario 4)

In this scenario, several Dynamic Airspace Reconfiguration (DAR) volumes of different dimensions, as specified in Table 20, are activated for a period of 10 minutes. The dimensions of each DAR volume are defined relative to the total U-space airspace volume, which covers an area of 3 km × 3 km and extends vertically to an altitude of 150 m.

Following DAR activation, approved missions that have not yet commenced are regulated and subsequently cancelled. Missions already in progress at the time of activation execute one of two contingency procedures: Return to Launch (RTL), in which the aircraft follows a direct trajectory back to its launch point while maintaining its current altitude; or immediate vertical landing, in which the aircraft descends vertically from its position at the time of DAR activation to the ground.

These contingency manoeuvres are executed without prior deconfliction. Consequently, the resulting trajectories may interact with those of other ongoing missions, potentially leading to safety events during the execution of the contingency procedure.

DAR name	DAR dimensions
DAR-L (Large)	¾ U-space volume
DAR-M (Medium)	½ U-space volume
DAR-S (Short)	¼ U-space volume

Table 20. DAR dimensions

Figure 31 presents the percentage of regulated missions before flight execution, where Figure 32 shows the number of missions regulated in flight, reported in term of both mean and maximum values.

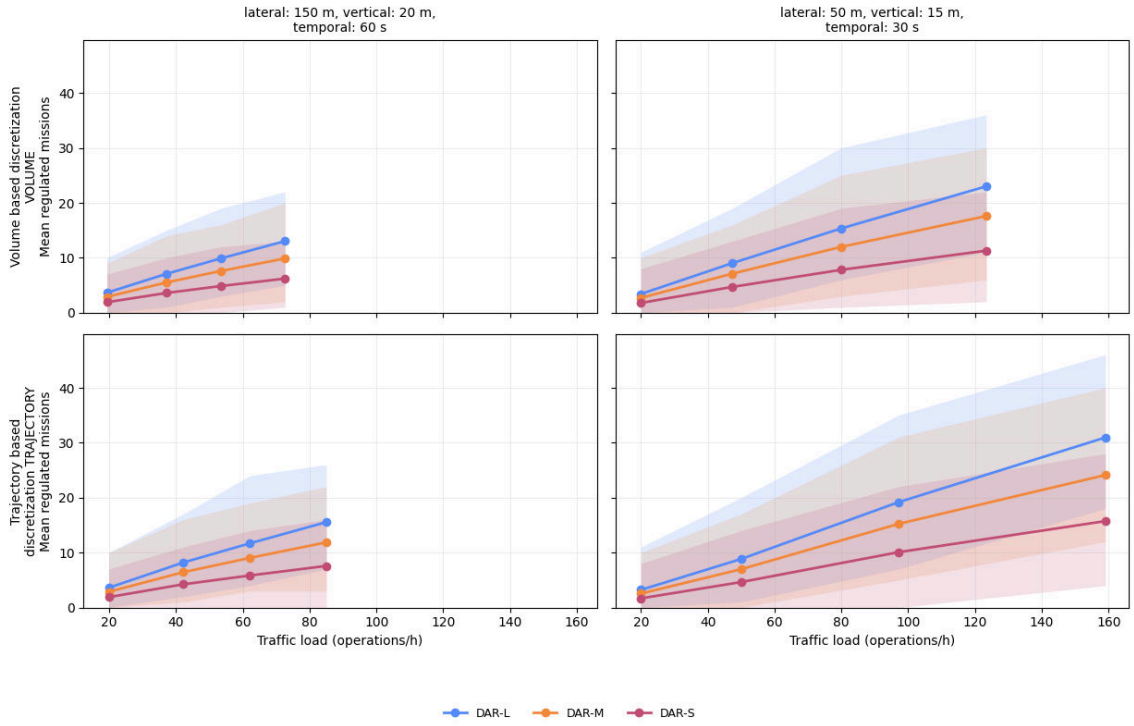


Figure 31. Number of regulated missions before flight in the different mission discretization and dev. threshold values parametrization.

Figure 31 shows the number of missions regulated, and therefore cancelled before departure, due to their interaction with an activated DAR volume. The x-axis represents the traffic load obtained for each scenario parameterization. Operational contexts with reduced deviation thresholds reach higher traffic-load values because they impose fewer spatial and temporal constraints on mission authorization. The y-axis indicates the number of regulated missions. As expected, the number of regulated missions increases with both the spatial extent of the DAR volume and the traffic load. Larger DAR volumes affect a greater proportion of the operational airspace and are therefore more likely to intersect approved missions. Similarly, higher traffic loads increase the number of missions potentially affected by the airspace restriction. This regulation mechanism prevents affected missions that have not yet commenced from entering the airspace during the DAR activation period. Consequently, the traffic density surrounding aircraft already in operation is reduced, decreasing the likelihood that unplanned contingency maneuvers, such as Return to Launch (RTL), will result in safety events.

Figure 32 shows the number of missions subject to in-flight regulation in each operational context, defined by the deviation-threshold configuration and mission-representation method, as the traffic load increases. For most operational configurations, the mean number of in-flight regulated missions remains approximately constant despite the increase in traffic load. This

value is close to one mission under the most conservative deviation-threshold configuration and when missions are represented using volumes. Similarly, variations in DAR size do not substantially affect the mean number of missions subject to in-flight regulation in these operational contexts. A different pattern can be observed for the operational context combining reduced deviation thresholds with a 4D-trajectory mission representation. Although the traffic load still does not produce a clear direct increase in the mean number of in-flight regulated missions, the size of the activated DAR volume has a more noticeable influence, due to a higher number of simultaneous missions. Depending on the DAR dimensions, the mean value increases from approximately one to three missions. Moreover, individual simulation runs may reach a maximum of eight missions simultaneously subject to in-flight regulation.

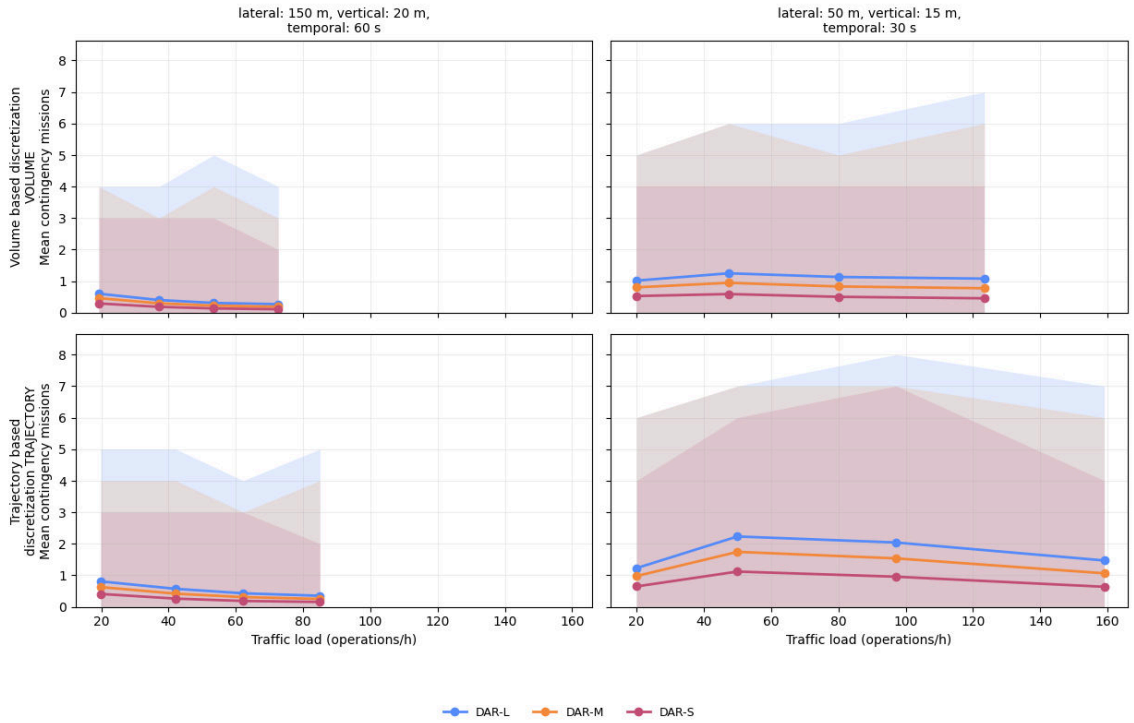


Figure 32. Number of regulated in-flight missions in the different mission discretization and dev. threshold values parametrization.

These in-flight regulated missions may become a potential source of safety events when executing contingency maneuvers such as immediate vertical landing or Return to Launch (RTL). Figure 33 present the results of its characterization.

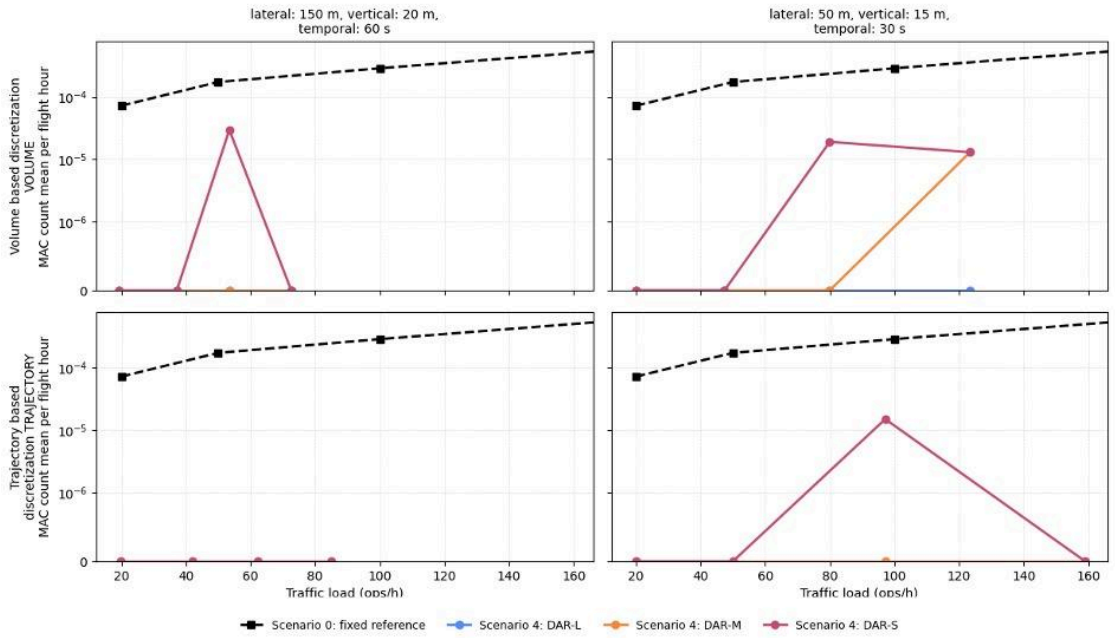


Figure 33. MACs events characterization due to in-flight regulation for different DARs volumes.

The main finding is that the smallest DAR volume generates the highest number of safety events across all operational configurations. This result can be explained by its limited spatial extent: because it affects fewer missions before departure, fewer operations are cancelled prior to execution. Consequently, the reduction in concurrent traffic is less pronounced, and missions subject to in-flight regulation continue to coexist with a larger number of active operations while performing their contingency manoeuvres. Regarding the influence of traffic load, no safety events are observed below 30 operations per hour, regardless of the operational context. This may be attributed to the relatively small number of missions in execution at the time of DAR activation. Once this threshold is exceeded, safety events begin to appear across the different deviation-threshold configurations and mission-representation methods, indicating that traffic density becomes the dominant factor governing the likelihood of hazardous interactions. It should also be noted that starting from an already deconflicted traffic scenario reduces the safety-event rate compared with Scenario 0, in which no strategic deconfliction is applied. Nevertheless, the activation of a DAR and the subsequent execution of non-deconflicted contingency manoeuvres increase the risk relative to the fully deconflicted scenario, in which no safety events were observed.

A.7. Discussion

Based on the results obtained across the different simulation scenarios, this section provides an integrated discussion of the main findings from an operational perspective, using traffic density and mission representation as the main dimensions of analysis.

Low density operations with volume based description and conservative deviation threshold (short term time horizon)

This scenario corresponds to that operational context with a demand of 20 missions/hour, multi-volume representation and a conservative deviation threshold of 150m (horizontally), 30m

(vertical) and a temporal buffer of 60 seconds. As it has been showed in the results section (section A.6):

- **Capacity and efficiency**: Despite the relatively low proportion of actual conflicts in the generated traffic, with only 3% of missions involved in a real conflict, the use of conservative deviation thresholds results in 54% of missions requiring mitigation (Figure 16). Nevertheless, the strategic deconfliction service can accommodate almost all submitted traffic, achieving an acceptance ratio of 97% (Figure 18). This high level of traffic accommodation comes at the expense of a mean take-off time adjustment of approximately 4 minutes (Figure 20).
- **Safety in nominal conditions:** The simulation results are consistent with a safety benefit from strategic deconfliction, since no MAC events were observed in the deconflicted scenario. However, the 95% lower confidence bound of the MAC rate ratio is 0.29, below the reference value of one. Therefore, the available simulation exposure is insufficient to demonstrate, at the 95% confidence level, that strategic deconfliction reduces the MAC rate under this traffic condition. It was proven that using protection volumes based exclusively on TSE no MAC events were detected at this traffic load.
- **Safety in non-nominal conditions:** The combination of a low baseline conflict probability at this traffic density and the conservative protection margins provided by the deviation thresholds prevented the simulated non-nominal conditions from propagating into MAC events, including long-term deviations, strategic deconfliction failures, and DAR-induced replanning.

Medium density operations with conservative deviation thresholds (medium term time horizon)

This scenario corresponds to that operational context with a demand of 50 missions/hour, multi-volume and 4D trajectory representation and a conservative deviation threshold of 150m (horizontally), 30m (vertical) and a temporal buffer of 60 seconds.

- **Capacity and efficiency:** In this context, the proportion of real conflicts in the unmitigated traffic increases to 10%. However, the addition of the deviation-threshold protection volume prevents 26% of the submitted missions from being accepted when the multi-volume representation is used. This rejection rate is reduced by approximately 10 percentage points when a trajectory-based representation is adopted. The resulting traffic load is approximately five simultaneous operations within the U-space volume. Achieving this traffic load requires a mean take-off delay of about six minutes in both configurations.
- **Safety in nominal conditions:** For both configurations, the 95% lower confidence bound of the MAC rate ratio remains above one ($\widehat{RR}_{L,95} = 1{,}60$ and $\widehat{RR}_{L,95} = 1{,}86$), providing statistical evidence that strategic deconfliction reduces the MAC rate relative to the unmitigated scenario. The corresponding bounds imply that the mitigated MAC rate is at least approximately 37.5% and 46.2% lower, respectively, than in Scenario 0
- **Safety in non-nominal conditions:** Thanks to the large protection buffers and the moderate number of simultaneous missions, long-term deviations do not propagate into MAC events. Regarding failures of the strategic deconfliction service, no MAC events are detected for failure probabilities below 1%. However, once this limit is reached MAC events are begin to occur even under low traffic load and conservative volume mission definition. In the third scenario, when replanning is triggered by DAR activation, safety events do occur when a small DAR volume is defined. In this case,

fewer missions are regulated before departure, and the execution of the replanned trajectories therefore takes place under a higher level of traffic simultaneity, increasing the likelihood of safety events.

The results obtained under this operational context indicate that, even at moderate traffic loads and with conservative deviation thresholds, improvements in the replanning of contingency events, particularly for missions affected in flight by an activated DAR volume, are required. Additionally, these results highlight the need to define a minimum performance threshold for the strategic deconfliction service to ensure and acceptable level of safety.

High density operations, trajectory based operations with reduced deviation thresholds (long term time horizon)

This scenario corresponds to that operational context with a demand of 100 missions/hour, 4D trajectory representation and reduced deviation threshold of 50m (horizontally), 20m (vertical) and a temporal buffer of 30 seconds.

- **Capacity and efficiency:** In this context, due to the smaller protection volume associated with the reduced deviation thresholds, only 3% of the submitted missions are cancelled. However, approximately 70% of the missions still require a temporal adjustment, with a mean delay of about 4 minutes. Under this configuration, the mean number of simultaneous missions increases to approximately 11 aircraft.
- **Safety in nominal conditions:** The larger accumulated flight exposure, together with the absence of observed safety events, results in a 95% lower confidence bound for the MAC rate ratio of $\widehat{RR}_{L,95} = 7{,}56$. This provides strong statistical evidence of the safety benefit achieved under nominal strategic deconfliction, indicating that the MAC rate in the unmitigated scenario is at least 7.56 times higher than that of the strategically deconflicted traffic at the 95% confidence level. Despite the absence of MAC events, the use of reduced deviation thresholds is expected to increase the occurrence of tactical alerts associated with Loss of Strategic Deconfliction (LoSD) events.
- **Safety in non-nominal conditions:**
  Under this configuration, all the characterized unforeseen events result in safety events. Table 21 compares their impact on safety using Scenario 0 as the reference case. Among the evaluated configurations, Scenario 3, representing a failure of the strategic deconfliction service, exhibits the lowest safety performance.
  It is important to emphasize that these results are strongly influenced by the parametrization of each unforeseen event, including the characteristics of the long-term deviations, the probability of failure of the strategic conflict-resolution service, and the size of the DAR volume, as demonstrated in the previous analyses. Therefore, although traffic density remains a primary driver of safety performance, these scenario-specific parameters must also be explicitly considered when interpreting and comparing the resulting safety levels.

$\frac{\lambda_{Sce0}}{\lambda_{Sce2}}$	$\frac{\lambda_{Sce0}}{\lambda_{Sce3}}$	$\frac{\lambda_{Sce0}}{\lambda_{Sce4}}$
8,49	7,28	20,93

Table 21. MAC per flight hour comparison in the non nominal scenarios at high density traffic.

The results indicate that the parameters governing U-space performance cannot be ranked independently of the operational regime. Under nominal strategic-deconfliction conditions, deviation thresholds constitute the primary capacity-limiting parameter, while the effect of

flight-intent representation becomes increasingly important as protection margins are reduced and traffic demand increases. From a safety perspective, effective traffic concurrency is the main driver of hazardous interactions, but its influence is strongly modulated by the protection margin and the integrity of the strategic-conflict-management layer. Conservative deviation thresholds prevent the appearance of MAC events under the nominal and long-term-deviation conditions evaluated, whereas reduced or absent margins make safety progressively dependent on traffic concurrency and trajectory representation. Under degraded service conditions, the probability of strategic-deconfliction failure can become the dominant safety factor, partially masking the influence of geometric parameters. Similarly, during dynamic airspace reconfiguration, the safety impact is governed not simply by the size of the restricted volume but by the traffic that remains active while non-deconflicted contingency trajectories are executed. Consequently, the dominant safety and capacity factors vary across operating regimes, demonstrating that U-space performance is fundamentally determined by interactions among traffic demand, operational-volume definition, trajectory representation and conflict-management service performance.

A.8. References

[1] CORUS five Consortium. D2.2 — Exploratory Research Plan. Edition 02.00. SESAR 3 Joint Undertaking, Grant Agreement No. 101166763. December 2025.
[2] CORUS five Consortium. D3.1 — Exploratory Research Results. Edition 02.00. SESAR 3 Joint Undertaking, Grant Agreement No. 101166763. December 2025.
[3] CORUS five D2.2 – Exploratory Research Plan (ERP), CORUS five consortium, Edition 02.00, 15th of December 2025.
[4] SESAR Joint Undertaking. U-space Concept of Operations, Edition 4.0. Brussels: SESAR JU, July 2023.
[5] Egorov, M., Evans, A., Campbell, S., Zanlongo, S., & Young, T. (2021, September). Evaluation of utm strategic deconfliction through end-to-end simulation. In Proceedings of the Fourteenth USA/Europe Air Traffic Management Research and Development Seminar (ATM2021), Virtual Event (pp. 20-23).
[6] European PBN Route spacing Handbook No 3. Eurocontrol 2020.
[7] International Civil Aviation Organization. Doc 9689 — Manual on Airspace Planning Methodology for the Determination of Separation Minima. First Edition. Montreal: ICAO, 1998.
[8] Vila Carbó, J.A., Iocchi, L. BUBBLES Project Deliverable D4.1: Collision Risk Models. SESAR JU, Grant Agreement No. 893206, Edition 01.01.00. February 2021
[9] ASTM International. ASTM F3548-21: Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability. West Conshohocken, PA: ASTM International, 2021.
[10] Su, Y., Xu, Y., Inalhan, G. “A comprehensive flight plan risk assessment and optimization method considering air and ground risk of UAM.” In: 2022 IEEE/AIAA 41st Digital Avionics Systems Conference (DASC), Portsmouth, VA, 2022, pp. 1–9. DOI: 10.1109/DASC55683.2022.9925844
[11] Zhi Hao Z. Quek, Wei Dai, and Kin Huat Low. “Analysis of Safety Performance of Tracking Services Based on Simulation of Unmitigated UAS Conflicts”. In: AIAA SCITECH 2023 Forum. AIAA SCITECH 2023 Forum. National Harbor, MD & Online: American Institute of Aeronautics and Astronautics, Jan. 23, 2023. DOI: 10.2514/6.2023- 0607.
[12] Antony D. Evans et al. “Safety Assessment of UTM Strategic Deconfliction”. en. In: AIAA SCITECH 2023 Forum. National Harbor, MD & Online: American Institute of Aeronautics and Astronautics, Jan. 2023. DOI: 10.2514/6.2023-0965.
[13] Antony Evans et al. “Simulating Safety and Efficiency Impacts of Airspace Constraints in U-

Space Airspace". In: 2023 IEEE/AIAA 42nd Digital Avionics Systems Conference (DASC). Barcelona, Spain: IEEE, Oct. 2023, pp. 1–10. DOI: 10.1109/DASC58513.2023.10311226.
[14]Karolin Schweiger et al. "Assessing Safety for U-space airspace: A simulation study of UAS impact on low-altitude helicopeter operations in Zurich", SESAR Innovation days ,Rome (Italy), November 2024
[15]Commission Implementing Regulation (EU) 2021/664 of 22 April 2021 on a regulatory framework for the U-space. Official Journal of the European Union, L 139I, pp. 161–183, 2021
[16]Simulation Modelling and Analysis, Fifth Edition, Averill M.Law McGrawHill Education
[17]Simulation Fourth Edition, Sheldon M. Ross Elsevier
[18]Garwood, F. (1936). Fiducial limits for the Poisson distribution. Biometrika, 28(3/4), 437-442.
[19] Porter, F. C. (2025). Confidence intervals for the Poisson distribution. arXiv preprint arXiv:2509.02852.
[20]Krishnamoorthy, K., & Thomson, J. (2004). A more powerful test for comparing two Poisson means. Journal of statistical planning and inference, 119(1), 23-35.
[21]Price, R. M., & Bonett, D. G. (2000). Estimating the ratio of two Poisson rates. Computational Statistics & Data Analysis, 34(3), 345-356.

Public Acceptance Indicators

Introduction

A Performance Framework (PF) is a structured system or blueprint used to define, measure, manage, and improve success against specific goals. It helps in translating vision and mission strategy into measurable results. The key elements of a performance framework are: Objectives, defined as high level goals; Key Performance Indicators (KPI), used to measure progress towards objectives using quantitative metrics; Targets, given by the exact numbers or milestones in relation to the KPIs; and Action Plans, resulting from a continual review loops where objectives, KPI and targets are assessed and updated.

The International Civil Aviation Organization (ICAO) uses a specialized Performance-Based Approach (PBA) detailed in ICAO Doc 9883 and is framed in the ICAO Global Air Navigation Plan (Doc 9750). ICAO PF maps directly to the general core components of a performance framework, once adapted for the complex world of aviation. It adds a top layer to organize the context, named Key Performance Areas (KPA), for up to 11 specific domains, such as Safety, Capacity, Environment, Cost-effectiveness, and Predictability. The objectives layer is named as Performance Objectives and is established within specific KPAs. Key Performance Indicators (KPIs) are obtained through well-defined metrics to track progress against objectives. Targets are usually defined with a baseline reference year. Action Plans are part of the Performance Management Process, a continuous cycle, typically following a Plan-Do-Check-Act model.

Designed specifically for European airspace, the SESAR Performance Framework (SESAR PF) is built directly on the principles of the ICAO PBA, and shares the same fundamental layers: KPA, KPI, targets, and review cycles. The SESAR PF primary goal is to validate that new technologies/concepts in development by R&D projects funded by the SESAR programme meet the targets set in the European strategy given in the ATM Master Plan. The SESAR PF uses ICAO's KPAs but heavily prioritizes Safety, Environment, Capacity, and Cost-Efficiency as main pillars. SESAR PF requires research projects to measure and project the performance impact of their solution to prove it justifies public and private investment. For this, SESAR PF enforces standardized formulas used across all European airspace. U-space and Innovative Air Mobility (IAM) are key objectives for the European ATM Master Plan.

The PEARL project [PEARL], named after Performance Estimation, Assessment, Reporting and simuLation, serves as the central performance management body for the SESAR 3 Joint Undertaking. Its primary role is to measure and verify whether new ATM technologies and operational concepts proposed by individual research projects align with the performance ambitions set out in the European ATM Master Plan and deliver quantifiable improvements toward the Digital European Sky vision. PEARL maintains and updates the SESAR PF, standardizing and refining the list of KPI and adapting it to cover emerging domain areas, including U-space. PEARL also evaluates individual research projects outcomes by objectively calculating the real-world benefits across all KPA. The consolidated performance reports inform decision-making, policy development, and future investment priorities for the European Commission and aviation stakeholders.

The European Commission in its document EU Drone Strategy 2.0 provided the strategic vision of the European Union for integrating drones into the economy by 2030. In it, societal acceptance is a core pillar of the strategy. Unlike traditional high-altitude air traffic, where aircraft operate thousands of feet above the ground, the U-space will occupy the Very Low Level (VLL) airspace. Because operations

may take place directly above homes, parks, and urban centers, technical feasibility alone is considered insufficient, and public acceptance is added as a standalone objective of the strategy.

In this document, we focus on the objective of achieving the public acceptance of U-space and IAM and, specifically, propose the list of indicators to assess the evolution of those aspects that most concern the citizens according to existing public surveys. The list of indicators is just one element of the review loop that, in the hands of the governance board, shall push towards the achievement of the target objective.

Performance framework for U-space

In parallel with the writing of this ANNEX, the PEARL project has released a new version of the SESAR Performance Framework [PEARL]. It integrates, for the first time, the U-space as an intrinsic part of the Single European Sky Performance Framework (SES FP). Chapter 5 lists an update of the ATM indicators, and Chapter 6 provides a full new review of the former Companion Document of SESAR PJ-19 indicators for U-space [PJ19].

Two new key performance areas (KPA) are defined in the ATM PF: the Passenger Experience KPA (PAXEX) and Civil-Military Cooperation (CMC). The PAXEX shows an interesting trend to include external stakeholders (the passengers) in the assessment of the ATM system performance. In addition, a new U-space focus area has been created in all KPA of the ATM PF. The objective of the U-space focus area is to measure the impact of the creation of U-space in the ATM.

The proposed new U-space PF has more indicators than before. Figure A1 summarizes the difference of the former U-space PF from the PJ19 and the current version from PEARL. We have organized the areas in a hexagon-shaped grid surrounded by four main stakeholders: national safety agencies, air navigation service providers (ANSP), drone operators (UASO) and finally citizens. The location of each area in the grid is trying to approach each area to its interested stakeholder. Notice that citizens, as the major representative of the public acceptance, is basically related to the Environment area. This area has a Noise focus area that goes far beyond noise. Visual impact, privacy concerns and wildlife are also part of the 11 noise indicators defined in it.

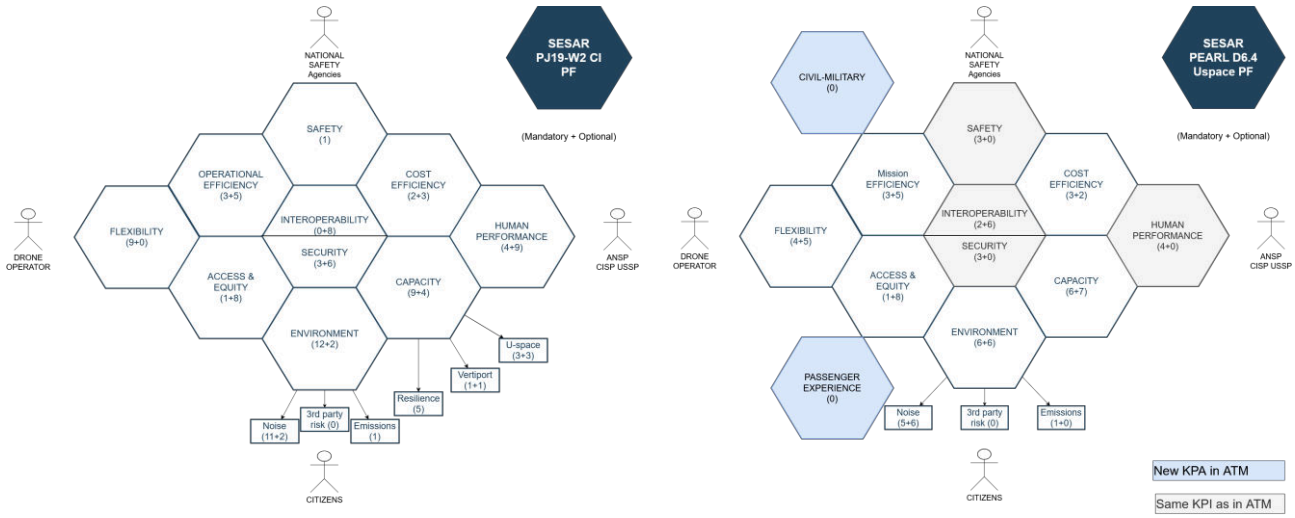


Figure A1. Evolution of the U-space performance framework for SESAR

In figure A1, the number of indicators of each area is shown in parenthesis under the area name. The first number provides the number of mandatory indicators and the second has the number of optional

indicators of the area. Observe that PEARL has better homogenized the number of indicators across the different areas, aiming at a more coherent PF, with some indicators that were considered mandatory before that are now optional. Observe also that four areas share the same indicators across ATM and U-space in the PEARL PF: Safety, Security, Interoperability and Human Performance. Despite the creation of 2 new KPA in the new ATM PF, no indicators have been established for U-space PF in any of them.

The PEARL project proposes different granularity levels for different maturity levels: The more mature the solution, the more realistic in-depth analysis is expected. Some indicators have a comment indicating that it is mandatory only when it is possible to calculate. Some indicators have subindicators which can be used only under certain circumstances to substitute the first level indicators (see for instance SEC2, which has a SEC2.1 available from TRL4 onward). In this document only the first level indicators are considered.

Recent research projects on public acceptance of U-space: ImAFUSA and MUSE

A holistic approach is taken by the **ImAFUSA** project [ImAFUSA]. ImAFUSA proposes that the areas (and their indicators) can be divided into internal and external. As shown in Figure A2, internal indicators and areas are those that measure the internal functioning of the traffic management system, while external indicators are those that measure the impact of the air traffic to third parties, which in general, are the citizens not involved in the flights, and the environment.



a) Internal vs. external indicators b) External impact categories

Figure A2. Areas and subareas by type (ImAFUSA [ImAFUSA])

In addition to the new taxonomy for the internal areas, the main contribution of ImAFUSA is in the deep analysis of external indicators. As seen in Figure A2-b, the external areas proposed contain the Environment area, similar to PEARL KPA but with more indicators. Figure A2-b also shows how ImAFUSA extends the number of areas with Perceived Safety, Perceived Security, Spatial and the huge area on Socio-economics. The final list of indicators contains 32 items: 19 indicators in the Environmental area (13 for noise, 4 for visual pollution, 2 for emissions), 4 indicators in the Socio-economic area, 2 in the Spatial area, 4 in the Perceived Safety area and 3 in the Perceived Security

area. While the 29 former indicators have defined quantification methods, the last ones are treated as qualitative concerns for strategic policy-making.

The indicators proposed by the ImAFUSA project are derived through a data-driven approach that combines subjective data, gathered from citizens via questionnaires and immersive experiences, and objective data, quantified through physical measurements, mathematical modeling, and simulations. The proposed indicators in the perceived safety/security areas are mainly subjective indicators, collected through structured surveys, focus groups, and sentiment analysis involving humans in some of the UAS flight trials or virtual reality experiences. These experiments allow ImAFUSA to capture the psycho-acoustic effects of UAS not captured in any other PF. Examples of these indicators that measure human perception, sentiments, and behavioral reactions are:

- Social Acceptability and Acceptance of IAM: Derived from a 9-item survey for acceptability (prior to exposure) and a 10-item survey for acceptance (after exposure) using a 5-point Likert scale.
- Percentage of Highly Annoyed Persons: Quantifies noise annoyance based on feedback from humans involved in field studies and soundwalks.
- Probability of Unsafe Perception: Calculated from survey responses provided by participants in controlled VR simulations.

Moreover, ImAFUSA proposes some methods to relate objective inputs and indicators to predict subjective outcomes. For example, the Visual Pollution Predictive Analytic Tool uses objective data (drone density and path type) to predict subjective Social Acceptance values based on AI models trained with captured data. Similarly, the IAM Noise Assessment tool relates the set of energy-based noise objective metrics (like Sound Pressure Level (dBA) or Sound Frequency Spectrum) with the psycho-acoustic perception-based metrics (like Loudness and Sharpness) through mathematical formulas or trained annoyance models able to simulate the biological and psychological processes of the human ear and brain.

In contrast, the **MUSE** project proposes a fully objective performance framework. It mainly addresses the Environment KPA of the PEARL U-space PF as this is the one that most directly affects citizens. In addition, MUSE proposes a new Economic Aspect area, with two indicators to measure the economic impact of IAM on citizens, that do not have a counterpart in the PEARL PF. Finally, a set of indicators is defined also for the Access&Equity area. In the MUSE Access&Equity area, although it has the same name as a SESAR PF area, the indicators are completely different. Basic difference is the target set of actors to whom equity is being measured: While MUSE tries to measure the distribution of the negative externalities across citizens living in an urban area, the SESAR PF assesses the fair distribution of air space access across UASO. In terms of ImAFUSA taxonomy, the MUSE Access&Equity area is external while the PEARL Access&Equity area is internal.

Figure A3 shows the scheme of MUSE PF areas and indicators and their intersections with the KPAs of the PEARL U-space PF.

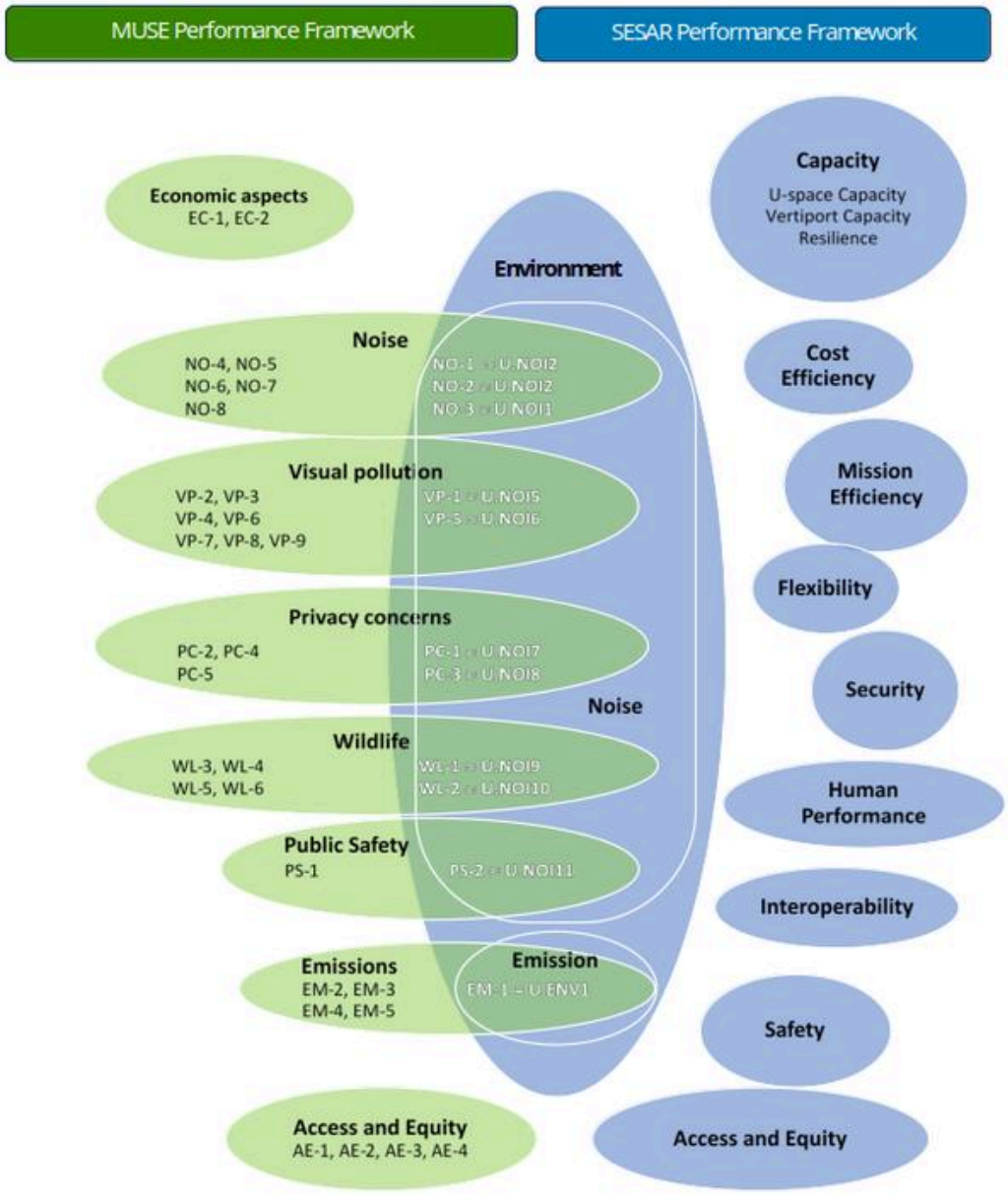


Figure A3. SES PF KPAs with relation with societal acceptance (by MUSE [MUSE])

Observe that the Noise focus area of the Environment KPA of PEARL PF has been refined in MUSE and divided into new areas, more in accordance with the semantics of the indicators: visual pollution, privacy, wildlife, and public safety.

The final PF proposed in MUSE consists of 41 indicators distributed across 8 areas. In addition, seven cross-cutting areas have been defined to further assess the indicators' values across demographics and geographics. From those, 25 from the areas of Noise, Visual Pollution, Privacy and Access&Equity, have been tested and validated through simulations.

Following the example of PEARL, some indicators have a dual definition, trajectory based or area based, trying to assess the impacts per operation or the cumulative impact of many trajectories over an area. For instance:

- NO-1: Area-based people's exposure to noise (LAeq): Number of people exposed to an equivalent noise level higher than a certain threshold in dBA for a fixed period of time within an area.
- PC-2: Trajectory-based people exposed to hovering drones: Total number of people visually exposed to a hovering drone at a distance less than a certain threshold for a single drone operation.

All indicators in MUSE have, as the main unit, the number of persons, demonstrating that the final target is calculating the IAM externalities on citizens.

All indicators are objective, meaning that they can be calculated from traffic data or sensor inputs. The measured values are related to humans' perception and annoyance through the introduction of thresholds. For instance, the two examples above, NO-1 and PC-2, both require a 'certain threshold'. Those thresholds do not have a defined value yet and probably need to start with an educated guess and be adjusted over time with the feedback from citizens obtained in surveys.

In summary, both SESAR research projects, ImAFUSA and MUSE, have proposed indicators to measure public acceptance, which have a clear intersection with the Environment KPA of the current SESAR PF. Both have also proposed a new area for the (socio)-economic aspects. Human perception (on safety and security) indicators are mainly proposed by ImAFUSA, while MUSE proposes the Public safety area, more related to liability than on human perception. Liability is present in the SESAR PF, in the Safety KPA, specifically in its Third party risk focus area, but PEARL did not propose any indicator on this focus area for U-space.

The Spatial area proposed in ImAFUSA takes into consideration locality; this is, the impact in a community area. For instance, how a house can increase or decrease value because of the flights happening close to it, or how local mobility is affected. These concepts are similarly considered with the MUSE cross-cutting areas and also by the PEARL and MUSE area based indicators.

Comparison of the indicators proposed by the three projects

The following tables show the indicators proposed by the 3 projects related to public acceptance. Indicators are listed in the same row when they address similar concepts. In some (few) cases there is an exact match of indicators in more than one project, but most indicators, although addressing similar concepts, have different perspectives or implementations. Some other indicators are proposed only by one of the three projects, while some are shared by two or all three projects.

The full table is long and is attached as an Appendix to this Annex in spreadsheet format. Next follow most relevant parts as subtables gathering the indicators for the areas that the Advisory Board has considered most priority: noise, privacy, security and economic aspects (see Figure 16 on Chapter 7 of the ConOps). The last area has been renamed after ImAFUSA as socio-economic. Next sections go through each of these areas and present per each indicator the different definitions by PEARL, MUSE and ImAFUSA in a tabular form. Some indicators from one project may relate with none, one or more indicators in the other project. When the relation exists, they are grouped in the same row. Empty cells indicate that no similar indicator is available for the given project. A general comparison text follows each table.

Noise indicators

The area of noise is the most extensive one. In this comparison, we have divided them into those that are directly related to physical measures of acoustic signals (in Table A1.a) and those related to the assessment of the annoyance of noise (in Table A1.b). The indicators in the area of noise that are in fact related to other environmental concerns are presented in the following sections.

Table A1.a - Comparison of Noise indicators

PEARL	MUSE	ImAFUSA
U.NOI1 - Trajectory-based exposure The number of people exposed within the noise contours of a single drone operation	**NOI-3** The amount of people exposed to a sound exposure level (SEL_A) higher than a certain threshold in dBA, for a single drone operation, for a time period fixed by the drone trajectory, within an area.	**Sound exposure level (SEL)** A single event metric that considers both the noise level and duration of the event, relative to a standardized duration of 1 s. It represents the constant sound energy which has the same energy in one second as the acoustic event of duration T. For an aircraft noise event such as a flyover, T is considered the time within the 10 dB below LAmax.
		Effective perceived noise level (EPNL) EPNL is primarily used in the noise certification of civil aircraft and represents the cumulative auditory impact of a single aircraft pass-by. It reflects how humans perceive aircraft flyover noise by incorporating adjustments for tonal content and duration.
U.NOI2 - Area-based exposure The number of people exposed to noise within an area during a period of time	**NOI-1** The amount of people exposed to an equivalent noise level (L_Aeq) higher than a certain threshold in dBA, for a fixed period of time, within an area.	**Equivalent sound pressure level (Leq)** Cumulative measure (at a single receiver point in an area) of a continuous sound pressure level that represents the average energy of sound experienced over a specific time.
	NOI-2 The amount of people exposed to an equivalent noise level (L_DEN) higher than a certain threshold in dBA, over a whole day (24 hours), within an area.	**Sound pressure level (SPL)** Acoustic pressure energy over a period of time T (at a single receiver point in an area)

PEARL	MUSE	ImAFUSA
	NOI-4 The number of events exceeding a certain noise level in dBA multiplied by the number of people exposed, over a fixed period of time, within an area.	
	NOI-5 The duration of noise levels exceeding a certain threshold in dBA multiplied by the number of people exposed, over a fixed period of time, within an area.	
	NOI-6 Difference between the noise generated by the overflying drones (L5) and local background noise level (L90) multiplied by the number of people exposed, over a fixed period of time, within an area.	
	NOI-7 The number of people multiplied by the Intermittence Ratio (IR), over a fixed period of time, within an area. The IR is defined as the ratio between the events' energy and the total energy (including background noise and drones)	**Fluctuation strength** This metric evaluates the sensation produced by periodic changes in time-variant envelope or frequency modulations of the sound (slow modulations, typically < 20 Hz).
	NOI-8 The amount of people exposed to maximum noise level (L_Amax) higher than a certain threshold in dBA, for a time period fixed, within an area.	**Maximum sound level (Lmax)** Maximum A-weighted sound level recorded during an event
		1/n Octave Band Frequency distribution One/n octave band analysis measures sound pressure levels within narrower frequency bands. This provides a more detailed and precise representation of a sound frequency content.

PEARL	MUSE	ImAFUSA
		Power spectral density Acoustic power distribution over frequency components. The signal would be presented as frequency-bands contribution from this point (e.g.1/3 oct bands).

We can observe the clear dichotomy between area versus (single) trajectory indicators, highlighted in underline font text in the table in all three projects. While for aircraft certification, individual footprint (trajectory based) indicators are more relevant. From the perspective of a U-space governance board, area indicators are preferred as the ones of high interest. Thus, CORUS five proposal is to select area based indicators for the U-space performance framework.

In research, area indicators can be built by combining individual trajectories. In a real U-space airspace, a network of environmental sensors on ground could be the way forward to obtain the actual indicators' values. Smart-cities initiatives have already deployed selected sensors in many cities, connected to sensor-networks. They are mostly measuring air quality, many already able to capture the ambient noise and it is easy to complement the rest with acoustic sensors. Their connectivity into a network allows for accounting and correlating the interactions between noise and traffic.

Other differences of the noise indicators above are the range of frequencies to capture (i.e. using dB or dBA, which use all frequencies or only human perceived), the decision about using thresholds to capture only extraordinary events or using averages, and the units of the indicators.

The use of thresholds is proposed in MUSE and in PEARL, but only ImAFUSA is able to provide some values for those thresholds, supported by their experiments. When analyzing the next table, we will go back to them.

For the selection of the units of the noise indicators, PEARL and MUSE mainly opt for using the number of people. The way to count people in MUSE is novel, thanks to a dynamic population mapping tool based on cellphone data and validated through satellite images. Thus, MUSE provides the number of people in the streets affected by the noise footprint at the exact time of the flights, while the others use static population density data, which basically accounts for the people inside their houses at non business periods. ImAFUSA proposes signal-based and psychoacoustic sound quality metrics. The signal-based indicators are measured with physical units characterizing it (frequencies, sound pressure, loudness, etc.), very convenient for noise experts. Units of psychoacoustic sound quality-metrics are Phon, Tonality, Sone, etc. Those units are linear, such that they directly scale with human sensation. Thus, a sound rated i.e. 2 sones or 2 acums feels twice as loud or twice as sharp as one rated at 1.

The importance of the area of flight and the time of the flight is also the aim of some indicators. It is not the same to fly at night as during the day, on the weekends or during weekdays, or over a busy and noisy area than in a suburban quiet neighborhood. Another feature that affects people is the number of repetitions of annoying events.

All these aspects are considered by the following acoustic indicators, with the aim of capturing human perception and impact. In the case of PEARL the indicators account for people reporting annoyance. ImAFUSA uses literature review to propose annoyance models and further proposes its own models.

MUSE does not propose any indicators based on subjective studies or individual responses and assumes the existence of a sound pressure threshold as the barrier for annoyance.

Table A1.b - Comparison of Noise annoyance indicators

<table>
<tr><th>PEARL</th><th>MUSE</th><th>ImAFUSA</th></tr>
<tr><td>U.NOI3 - <u>Trajectory</u> based annoyance

The number of people who reported being annoyed
by drone noise operations

(not mandatory)</td><td></td><td rowspan="2">Psychoacoustic Annoyance models at <u>single receiver</u> position.

These models combine the assessed psychoacoustic sound quality metrics Loudness, Tonality, Sharpness, Fluctuation strength, Roughness and Impulsivity.
PA models have been intended to be "universally" applied for steady-state sounds. Although initially modelled from mechanical sounds, new PA models have been optimised for specific noise sources.
• Widman’s (Zwicker) and DI’s models were optimised for mechanical sounds [Lotinga].
• More’s model [More] has been developed for aircraft noise.
• Torija’s model has been modified for open contrarotating propeller noise [Torija].
• Boucher’s model has been optimised for Urban Air mobility noise [Boucher].
• Georgiou has been optimised for aircraft noise including civil jet aircraft, helicopters and propellered aircraft [Georgiou].</td></tr>
<tr><td>U.NOI4 - <u>Area</u>-based annoyance

The number of people who reported being annoyed by drone noise operations within an area during a period of time

(not mandatory)</td><td></td></tr>
</table>

PEARL indicators implicitly propose the existence of a reporting system for U-space airspace. As of today, there is no clear vehiculation process or communication channel on how citizens will report annoyance and to whom. Public reporting is a necessary item to be added to the check list of the U-space deployment process.

The annoyance models, such dose-response curves [Lotinga], are mathematical or data-driven models able to infer the percent of the annoyed people from a given sound exposure level (i.e. LAeq). Finding the thresholds on the noise limits that most people are expected to accept (i.e. 80% of the population can accept noise up to 70 dBA during the day) is a continuous process. Although there will always be sensitive people outside of the limits, the continuous revision of the models is necessary to capture the changes in noise perception of the general population.

MUSE made a recommendation to PEARL [MUSE PF] and selected NOI-4 and NOI-6 as the most relevant noise indicators for the SESAR PF (see Table A1.a). NOI-4 takes into account the importance of repetitions while NOI-6 the importance is the background noise. Conclusions of the ImAFUSA field

studies are in the same direction: perception is dominated by background noise interactions and the number of events (or repetitions). Thus, the selection of CORUS five for noise indicators, as shown in Chapter 7 of the ConOps, is the following pair, adapted from the selection proposed by MUSE (NOI-4 and NOI-6):

Selected Noise Indicators

Noisy events: The number of events exceeding a certain noise level in dBA multiplied by area-type/time-of-the-day factor

Delta noise: Difference between the noise generated by the overflying drones (L5) and local background noise level (L90) over time

The main difference with MUSE is that the units proposed are no people impacted. Alternatively, the metrics used to calculate the noise indicators shall be geolocated and time labeled, this is, available for consultation over a map and filtered by time.

The **Noisy events** indicator returns a count of events. It needs a sound pressure threshold and two penalty factors.

- The sound pressure threshold that acts as the boundary of a sound to be classified as noisy or not. For instance, a threshold of 60 dBA indicates that sounds below it are not noise while sounds about or equal 60 dBA will be counted as noisy events.
- The two multiplication factors are the area penalty and the time penalty.
    - Area penalty factor has the form of a list of geographic shapes, each with a penalty value.
    - Time penalty factor is a list of intervals of the day, each with a penalty value.

  The simplest penalty factor criteria are setting both factors to 1 for all the area and time of the day. Another example can be a Time penalty set to 10 for the night period (i.e. 21h to 07h) and 1 during the day. Similarly, the governance board can decide to delimiter the leisure parks of the city with a penalty factor of 2, while setting the rest to 1.

  The values obtained over the years could be used to assess how the evolution of IAM traffic is affecting the area in number of noisy events. Moreover, it can help to take informed measures on the airspace capacity, area restrictions, time limitations, etc.

The **Delta noise** indicator is measured in decibels. It is calculated from the subtraction of two other decibel measures: L5 and L90: L5 returns the highest noise levels generated by punctual drone flyovers, while L90 correctly represents the ambient background noise level. They need to set a time interval to calculate them.

- L*n* is a statistical percentile sound level value that captures the sound pressure value from which the *n*% of the signal is above it. Since noise is a signal that fluctuates over time, statistical functions help to characterize it. L50 in the statistical median, this is, sound is louder than the L50 value for half the time and quieter for the other half. Similarly, L90 is the low 90% percentile and L5 is the high 5% percentile. Figure A4 below shows an example for an interval period of 15 minutes.

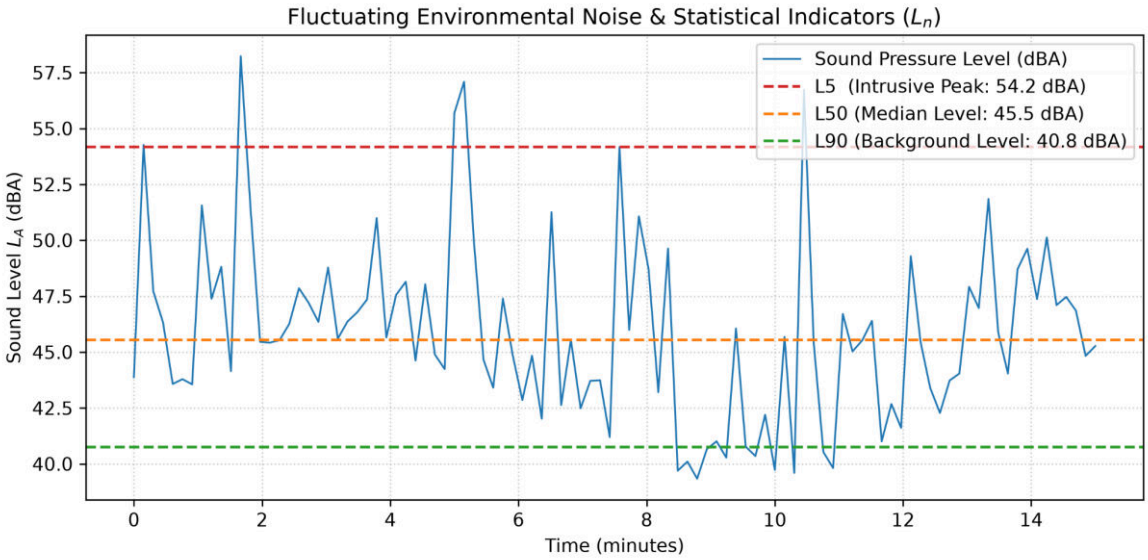


Figure A4. Graphical explanation of the meaning of a statistical percentile sound level

- A practical example for Delta Noise is a drone with an absolute maximum sound pressure of 60 dBA, could result in L5 equal to 58 dBA. If the neighborhood reports an L90 of 45 dBA (a typical suburban neighborhood can be around 40 to 50 dBA), the Delta noise will be equal to 13 dBA (58 - 45). The same drone flying over a noisy environment (i.e. 60 to 70 dBA) will be unnoticed and the indicator will return 0.
- For drones, an adequate time interval could be set between 2 to 10 minutes. A practical example follows to show the impact of the time period on L5 calculation. Imagine that the same drone mentioned above is flying over the area for only 3 minutes. If the time interval is set to 15 minutes and the drone is gone for 12 minutes, the L5 value may drop to something slightly above the ambient noise.

It is the responsibility of the governance board to adapt the indicators' factors/thresholds/periods, with the advice of local members with good knowledge of the area where the U-space airspace is deployed. Only locals know how crowded or sensitive is the area where the repetitions of noise events happen, or what could be the most adequate time period for the statistical percentiles.

Privacy & security (and visual pollution) indicators

A privacy concern refers to an individual's or group's apprehension, worry, or awareness regarding the potential unauthorized access and misuse of their personal data, identity, or private life. In the case of U-space, the potential of unauthorized access is linked with the capability of UAS to capture images at spaces that, without U-space, are kept private, especially when at home. Few indicators have been proposed for this area and they are very dispersed: related with visual annoyance (MUSE), with perceived safety (ImAFUSA), or by counting complaints and drones hovering events (PEARL).

A security concern refers to an individual's, organization's, or system's awareness or fear of potential threats, vulnerabilities, or unauthorized actions that could cause harm, loss, disruption, or destruction to physical, digital, or human assets. Security threads involve an action (attack) which may end up in damage. In the case of U-space, the potential threat is one or more drones intentionally crashing on persons or properties to produce damage. Only PEARL defines some few indicators for the security area, which are the same for ATM and U-space. They are defined for low TRLs and are limited to

checking the existence of secure methodologies while developing a technology for a new operational concept. Find them in Table A2.

Table A2 - PEARL security indicators

SESAR PF Security Area
SEC1 - A security risk assessment has been carried out
SEC2 - Risk Treatment has been carried out
SEC3 - Residual risk after treatment meets security objectives.

These three indicators have origin in NIST, a tool for the computer science field [NIST], and thus they include cybersecurity threads. Since PEARL/SESAR use performance indicators to validate research projects outcomes, from the three types of NIST proposed measures (Implementation, Effectiveness and Impact) only those of type Implementation Measures are selected. With them, SESAR created a methodology for the assessment of security of the ongoing research and deployment project. The methodology is named SecRAM 2.0 [SecRAM]. None of these three indicators is applicable for measuring security in an already deployed U-space airspace.

In CORUS five we have opted to join both areas into one, Privacy&Security. The reason is that both aim to measure the potential threats towards citizens introduced by IAM. There is also a situational link that connects privacy (for instance, a drone potentially observing someone's property) with security (the potential of a following robbery). The only PEARL indicator addressing public security in U-space (see U.NOI11 in Table A3) is an example of this situation. The drone's intention becomes more suspicious when the drone is hovering, not moving. Suspicious drone activity also raises security perception issues. Perceived security includes aspects connected to the protection of infrastructures, technologies and people, such as potential technological threats.

Privacy indicators are calculated from the capability of a drone to watch/record people during its trajectory and the perception of the people on ground about the drone's intentions. This capability is given by the existence of a line-of-sight between drone and persons. If the line-of-sight exists then the situation is symmetric, this is, the drone can see the persons and the persons can see the drone. When those people become concerned by seeing the drone, we enter into the visual pollution area. In the end, the metrics for visual pollution are the same as the metrics for privacy concerns, being the calculations the same. When the subject is on the person, we obtain visual pollution indicators, and when it is on the drone then it is privacy. For instance, MUSE uses visual pollution data and converts them to privacy indicators taking into account annoyance sensitivity values found by DACUS [DACUS]. These sensitivity values are related to land use (residential, industrial, commercial area), considering the percent of annoyed or highly annoyed people as 80, 60 or 30 percent of the people in direct line-of-sight respectively.

In summary, there is a high correlation between visual pollution, privacy indicators and perceived security and thus we integrate them in the same area that we named Privacy&security.

Similar indicators classified across these areas in all three projects are listed in Table A3. Only the subset of the indicators that approach similar concepts on privacy, visual annoyance and/or perceived security for at least two of the projects are given. The full list can be found in the Appendix.

Table A3 - Comparison of Privacy&security indicators

PEARL	MUSE	ImAFUSA
U.NOI5 - Visual trajectory-based exposure The number of people who reported visible drone operations during the day	**VP-1** The amount of people exposed (able to see) to a single drone operation	
U.NOI6 - Visual area-based exposure The number of people who reported visible drone operations within an area during a period of time	**VP-5** The amount of people exposed to UAM traffic, within an area.	**Visual density** Number of drones flying in the vicinity
U.NOI7 - Visual trajectory-based annoyance The number of people who reported being annoyed by visible drone operations	**PC-1 & PC-3** Total amount of people annoyed by (presence of) - a single drone operation, or - UAS within an area during a time period.	
U.NOI8 - Visual area-based annoyance The number of people who reported being annoyed by visible drone operations within an **area** during a period of time	**PC-2-4** Total amount of people visually exposed (able to see and be seen) to hovering drone at a distance less than a certain threshold - for a **single** drone operation, or - within an **area**, during the observed time period.	
U.NOI11 - Privacy based on area exposure Duration of hovering of drone operations for given areas. This addresses “privacy” issues.	**PC-5** Total number of people visually exposed multiplied by the accumulated visual exposure to hovering drones in a given area for a given time.	
	PS-1 Total number of drones hovering at a height below a certain threshold within an **area** during the observed time period.	

PEARL	MUSE	ImAFUSA
	PS-2 Total duration of drones hovering at a height below a certain threshold within an area during the observed time period.	

The behavior of a UAS flying in a neighborhood is considered suspicious when it does not follow a clear straight path. Stationary (hover) flights or repeated flyovers (surveillance) close to people are clear components of the proposals from MUSE and PEARL. In CORUS five, after considering the feedback from the Workshops, we selected the PEARL U.NOI11 indicator and proposed a new one to extend potential suspicious flights.

The density of operations is also present in several indicators of all three projects. Nevertheless, although high density can be annoying, it does not affect the privacy or security so directly, thus they are not selected for the CORUS five PF. Instead, based on PEARL U.NOI7 and U.NOI8 indicators, we proposed a third indicator based on citizens' claims. This is against the MUSE recommendations [MUSE PF], which states that indicators related to the number of people reporting annoyance are currently not applicable as there are no such reports nor relevant annoyance curves that could be used to assess annoyance. As the main justification, we are proposing a 'front desk' to receive claims and we will filter only privacy and/or security reports. Additionally, the MUSE recommendations did not address privacy and security areas on its selection.

The final selection for the proposed area of Privacy&security is:

Selected Privacy & Security Indicators

Surveillance: Number of surveillance missions over residential areas
Hovering: Duration of hovering of drone operations in an area
Reporting: number of (security) reports

The **surveillance** indicator could be easily captured from the declaration by UASO on their flight request. Current ASTM Standard Specification for UAS Traffic Management UAS Service Supplier Interoperability (ASTM F3548) does not provide any field not related to safety. Thus, alternative ways are needed to be able to calculate this indicator: per operator, per type of drone, etc. To complete the calculation, this indicator needs the geographical shapes of the areas considered residential.

The **hovering** needs access to the U-space flight information or flight logs services to calculate the number of seconds the trajectories have been stationary.

The **reporting** indicator needs the deployment and publicity of a web site, open to the public, where any citizen can request information about U-space traffic supported by a legitimate reason. This same web site can host claims from neighbors reporting being annoyed. The web site will need a content administrator (human and/or bot) to be able to answer arriving claims and requests. It can be hosted as part of another web site (i.e. local administration, safety agency, CISP, etc.) participating in the U-space governance board) and sharing resources to reduce costs.

All three indicators need the implicit declaration of a time period (i.e. one day. At the start of the time period the counter is set to zero and the indicator is delivered with the value at the end of the period.

Socio-economic indicators

Transport evaluation methods of socio-economic aspect often focus on the assessment of traffic flow, cost and efficiency. From the public acceptance point of view, we need to adequately consider other aspects, such as how the transport system influences broader welfare. Aspects such as well-being, inclusion, equity, jobs or housing are proposed by ImAFUSA in the Welfare area, which includes socio-economic indicators. MUSE also proposes two indicators in the Access&Equity area, aiming at measuring externalities inequities between population sectors. Also, two are the selected indicators from PEARL with some relation to socio-economic aspects of the U-space. Nevertheless, they are focused on the UASO economies more than on the public economy.

The following table A4 shows the details of these indicators. There is very little relation between all the project proposed indicators, which makes the selection of CORUS five a challenge.

Table A4 - Comparison the socio-economic indicators

PEARL	MUSE	ImAFUSA
		GDP Estimation of the regional economic productivity caused by U-space, using econometric models. It helps assess UAM's potential to stimulate growth and improve financial well-being across urban areas
		Real Estate Cost Impact of U-space on housing affordability, by modeling links between IAM traffic, persons' salaries and population density. Reveals real estate values shift, possible gains/losses, or risks of displacement.
	AE-1 The number of deliveries of goods and equipment to areas with limited or no transport connections during the observed time period.	**Travel time** Estimated travel time to the nearest vertiport based on distance and available ground transport modes. It identifies underserved areas and supports equitable urban planning by highlighting where modal improvements can reduce access gaps.

PEARL	MUSE	ImAFUSA
		Population to Jobs Ratio Assesses spatial balance between residents and employment opportunities. Values far from 1 indicate imbalances, either job deserts or dormitory zones. Proposed for guiding U-space infrastructure placement to improve labor market access and reduce commuting inequalities.
U.ACCESS2 - Time/airspace restricted to operations Percentage of time/airspace segregated for special (emergency or other) flights that could limit access to regular operators.		
U.TRANSP1 - Access to real time flight information Public access to real-time status of flight requests and reasons for denials.		

Only two indicators, MUSE AE-1 and ImAFUSA Travel Time, are found to be somehow connected. Both measure a positive impact on citizens' lives from the introduction of U-space. One indicator counts parcel deliveries while the other accounts for travel time savings. From those two CORUS five has consolidated an indicator.

As a second indicator we have selected from the long ImAFUSA list, the indicator that we believe is easier to calculate. We disregarded the PEARL indicators as they address UASO instead of citizens.

Selected Socio-economic Indicators

Economic growth: percent of GDP (local economic productivity) growth due to U-space and IAM

Time efficiency: time won in operations with UAS compared to those with vehicle using road

The **economic growth** indicator is based on the classical gross domestic product calculations. The only consideration is that it needs to be calculated for the geographical area of the U-space airspace. What area is considered to be affected by the U-space airspace is something that the governance board shall define for each deployment.

The **time efficiency** indicator can be calculated using the actual time of flight available from the Flight information service or from the flight logs. It also needs the estimation of ground trip time. This can be easily calculated using cloud services available today such as Waze, GoogleMaps or their European alternatives: WeGo, OpenRouteService or TomTom. A variant of this indicator could focus only on trips to remote (i.e. an island) or to underserved areas (i.e. a neighborhood without rail stations).

Conclusions

A final list of seven indicators, organised in three areas, is proposed as part of the CORUS five ConOps performance framework. They aim to be easy to implement, cheap to deploy and useful to monitor public acceptance. They should be managed by the governance board, or whoever they designate, as the main actor in the decision making process connected with the review cycle of the U-space performance framework.

Further work is needed first to set informed values to the thresholds implicitly or explicitly mentioned in each indicator. It is also necessary to test their viability when first European U-space airspaces are declared, or while this is not happening yet, in populated areas where UAS are flying at regular bases. A strategy for transparency, inclusiveness and public reporting is also needed. Finally, indicators need to be complemented with periodic surveys to complement the objective information with subjective perceptions and to adjust the performance framework for improvement.

REFERENCES

[A1] [PEARL] PEARL SESAR project. DES Performance Framework. PEARL Deliverable D6.4. Jan 206.2

[A2] [PJ19] PJ19-W2. SESAR Performance Framework - U-space Companion Document. Deliverable D4.7. 30 June 2022.

[A3] [ImAFUSA] ImAFUSA SESAR project. DES HE SESAR solution. ImAFUSA Deliverable D2.2. Dec 2025

[A4] [MUSE] MUSE SESAR project. U-space Environmental and Social Performance Framework. MUSE Deliverable D3.1. March 2024.

[A5] [Lotinga] Lotinga, Michael JB, and Antonio J. Torija. Comment on “A study on calibration methods of noise annoyance data from listening tests”. J. Acoust. Soc. Am. 156, 1877–1886 (2024). The Journal of the Acoustical Society of America 157, no. 5 (2025): 3282-3285

[A6] [More] More, S. R. (2011). Aircraft Noise Characteristics and Metrics.

[A7] [Torija] Torija, A. J., Li, Z., & Chaitanya, P. (2022). Psychoacoustic modelling of rotor noise. *The Journal of the Acoustical Society of America*, *151*(3). https://doi.org/10.1121/10.0009801

[A8] [Boucher] Boucher, M. A., Christian, A. W., Krishnamurthy, S., Tracy, T., Begault, D. R., Shepherd, K., & Rizzi, S. A. (2024). Toward a Psychoacoustic Annoyance Model for Urban Air Mobility Vehicle Noise. http://www.sti.nasa.gov

[A9] [Georgiou] Georgiou, F., Schäffer, B., Heusser, A., & Piren, R. (2024). Prediction of Noise Annoyance of Air vehicle flyovers using psychoacoustic models. ICSV30, Annual Congress of International Institute of Acoustics and Vibration (IIAV), 8-11 July 2024 2, 1–6

[A10] [MUSE PF] MUSE SESAR project. Recommendations for enhancing the SESAR Performance Framework: Insights from the MUSE project. Jan 2025.

[A11] [NIST] NIST’s Performance Measurement Guide for Information Security. Special Publication 800-55 Revision 1. Available at https://nvlpubs.nist.gov/nistpubs/legacy/sp/nistspecialpublication800-55r1.pdf

[A12] [SecRAM] SecRAM 2.0 SESAR Project. Deliverable in Security Reference Material Guidance. Available at https://www.sesarju.eu/sites/default/files/documents/transversal/SESAR%202020%20-%20Security%20Reference%20Material%20Guidance.pdf

[A13] [DACUS] DACUS SESAR project. DACUS Performance Framework. Deliverable D5.3. Nov. 2021.

APPENDIX:

A spreadsheet of key performance indicators is embedded here.

Double click on the icon to open the file.



C5_AnnexKPIs_Appendix.xlsx

AREA	PEARL D6.4	MUSE	ImAFUSA	Definitions	Comments
Environment Noise	U.NOI1 - **Trajectory**-based exposure The number of people exposed within the noise contours of a single drone operation	NOI-3 The amount of people exposed to a sound exposure level (SEL_A) higher than a certain threshold in dBA, for a **single** drone operation, for a time period fixed by the drone trajectory, within an area.	Sound exposure level (SEL) A **single event** metric that considers both the noise level and duration of the event, relative to a standardized duration of 1 s.	SEL represents the constant sound energy which has the same energy in one second as the acoustic event of duration T. SEL_A is the actual noise in 1sec.	Similar indicators, but different: - frequencies (all vs human) - thresholds (yes vs no), and - units (people vs dB)
			Effective perceived noise level (EPNL) EPNL is primarily used in the noise certification of civil aircraft and represents the cumulative auditory impact of a **single** aircraft pass-by. It reflects how humans perceive aircraft flyover noise by incorporating adjustments for tonal content and	Effective perceived noise level (EPNL) - Standardized metric used to evaluate the perceived loudness of an aircraft noise event, accounting for both its intensity and duration.	
	U.NOI2 - **Area**-based exposure The number of people exposed to noise within an	NOI-1 The amount of people exposed to an equivalent noise level (L_Aeq) higher than a certain threshold in dBA, for a fixed period of time, within an **area**.	Equivalent sound pressure level (Leq) Cumulative (**area**) measure of a continuous sound pressure level that represents the average energy of sound experienced over a specific time.	Leq and L_Aeq are the average noise over a period of time, but with all frequencies or only the ones in human perception	Duality of indicators (area vs trajectory) Similar indicators, but different - frequencies (all vs human) - thresholds (yes vs no), and - units (people vs dB)

	area during a period of time	NOI-2 The amount of people exposed to an equivalent noise level (L_DEN) higher than a certain threshold in dBA, over a whole day (24 hours), within an **area**.	Sound pressure level (SPL) Acoustic pressure energy over a period of time T (**area**)	It is given in logarithmic scale, and compared to a reference value pref=2*10^-5 Pa. By changing T, it is possible to calculate environmental indicators such as Lday, Lnigth, Ldn, and so on.	Similar indicators, but different - frequencies (all vs human) - thresholds (yes vs no) - units (people vs dB), and - day/night
		NOI-4 The number of **events** exceeding a certain noise level in dBA multiplied by the number of people exposed, over a fixed period of time,	[A-weighted] - Acoustic pressure time-series		Importance of repetitions.
		NOI-5 The **duration** of noise levels exceeding a certain threshold in dBA multiplied by the number of people exposed, over a fixed period of time, within an **area**.	[Frequency-weighted] - Time-vector representation of pressure fluctuations at a specific point in the air that surrounds a sound source.		Importance of noise length. But different units (secs vs time-vectors)
		NOI-6 Difference between the noise generated by the overflying drones (L5) and local **background** noise level (L90) multiplied by the number of people exposed, over a fixed period of time, within an **area**.			Considers also the fly area environment. Only MUSE
		NOI-7 The number of people multiplied by the Intermittence Ratio (IR), over a fixed period of time, within an **area**.	Fluctuation strength This metric evaluates the sensation produced by periodic changes in time-variant envelope or frequency modulations of the sound (slow modulations, typically < 20 Hz).		Similar concept, but different time scales (secs vs Hertzs)

		NOI-8 The amount of people exposed to maximum noise level (L_Amax) higher than a certain threshold in dBA, for a time period fixed, within an	Maximum sound level (Lmax) Maximum A-weighted sound level recorded during an **event**		Similar concept although one is area and the other trajectory. Also differences in frequency bands and final units.
Environment Noise Anoyance	U.NOI3 - **Trajectory** based annoyance The number of people who reported being annoyed by drone noise operations (not mandatory)		**Pyschoacoustic annoyance** - (by Lotinga) Statistical psychoacoustic annoyance model based on SQMs (N,R,S,F,T) // (by Zwicker) Psychoacoustic experiments involving synthesized narrowband and broadband noise, specifically comparing modulated and unmodulated noise. // (by More) Modified version of Zwicker and Fastl's Psychoacoustic Annoyance model in	**Sound properties**: Loudness - It evaluates the non-linear response of the human perception of sound intensity. Roughness - Subjective judgment of sound as rough. It ocours when the time-variant envelope of the sound exist in a	Good for aircraft dessigners. Useful to set thresholds. Not practical: options: people reporting or by models. Too many alternative models, all very academic, not easy to obtain (sensors quality).

	U.NOI4 - **Area**-based annoyance The number of people who reported being annoyed by drone noise operations within an area during a period of time (not mandatory)		which a tonalness term is included. This addition aims to evaluate the annoyance caused by conventional aircraft noise. // (by Di) Modified version of Zwicker and Fastl's Psychoacoustic Annoyance model by including a different form of the tonality term. This version was specifically developed using noise samples from transformers, enhancing the understanding of how tonality affects sound perception for this kind of equipment // (by Torija) A psychoacoustic model developed using recordings from laboratory experiments involving single and coaxial rotor propellers // (by Boucher) A psychoacoustic model for UAM vehicle noise using sharpness and fluctuations strength terms from the Zwicker's PA model. A tonality term is included with the form proposed by Di et al. (2018), with tonality computed using the Hearing model. The stimuli were based on auralizations of a NASA reference quadrotor vehicle in two flight conditions. // (by Georgiou) An psychoacoustic annoyance model based on synthesised and measured sounds of civil jet aircraft (current and future designs), helicopters, and propeller aircraft	critical band between 20 and 300 Hz. Sharpness - Subjective prominence of high frequency content Tonality - Perception of very narrow band components or pure tones in the signal Impulsiveness - The "impulsiveness" of a sound refers to the degree of impulsive content perceived in the sound. Root mean square - Average acoustic power over a segment of time. It is related with the acoustic energy Power spectral density - Acoustic power distribution over frequency components. The signal would be presented as frequency-bands contribution from this point (e.g.1/3 oct bands). 1/n Octave Band Frequency distribution - One/n octave band	
Environment Noise+visual			Social Acceptance of Audiovisual Pollution - The degree to which citizens tolerate the visual and auditory disturbances caused by IAM operations, considering drone density, distance from drones, duration of exposure to drone operations, and the combined effects of visual and audio input.		Only ImAFUSA
			Visual noise - Level of Service (LOS) based on drone density and noise		

Environment Visual	U.NOI5 - Visual **trajectory**-based exposure The number of people who reported visible drone operations during the day	VP-1 The amount of people exposed (able to see) to a **single** drone operation			binary: in or out of sight Reported to whom?
	U.NOI6 - Visual **area**-based exposure The number of people who reported visible drone operations within an area during a period of time	VP-5 The amount of people exposed to UAM traffic, within an **area**.	Visual density - Number of drones flying in the vicinity		reported vs exposed
		VP-2 The amount of people exposed to a visual pollution concentration higher than a threshold, for a **single** drone operation.			percent of sky occupation
		VP-3 The amount of people exposed to a visual pollution concentration higher than a threshold, for a period longer than T, for a **single** drone operation.			duration
		VP-4 Total visual pollution exposure perceived by the people exposed to a **single** drone operation.			percent of sky occupation
		VP-6 The amount of people exposed to a visual pollution concentration higher than a threshold at least once a day, within an **area**.			
		VP-7 The amount of people exposed to a visual pollution concentration higher than a threshold, for a period longer than T, along the day, within an **area**.			

		VP-8 Total visual pollution concentration perceived by the people exposed to UAM traffic, within an **area**.			
		VP-9 Kilometres travelled above a zone multiplied by the **population** density in that zone.			
Environment Visual Annoyance / Privacy / Perceived Safety	U.NOI7 - Visual **trajectory**-based annoyance The number of people who reported being annoyed by visible drone operations	PC-1-3 Total amount of people annoyed by (presence of) - a **single** drone operatio, or - UAS within an **area** during a time period.			Using surveys responses to set the % of annoyed people over total people
	U.NOI8 - Visual area-based annoyance The number of people who reported being annoyed by visible drone operations within an **area** during a period of time	PC-2-4 Total amount of people visually exposed (able to see and be seen) to hovering drone at a distance less than a certain threshold - for a **single** drone operatio, or - within an **area**, during observed time period.			
	U.NOI11 - Privacy based on **area** exposure Duration of hovering of drone operations for given areas. This addresses “privacy” issues.	PC-5 Total amount of people visually exposed multiplid by the accumulated visual exposure to hovering drones in a given **area** for a given time.			
		PS-1 Total number of drones hovering at a height below a certain threshold within an **area** during the observed time period.			
		PS-2 Total duration of drones hovering at a height below a certain threshold within an **area** during the observed time period.			

Environment Perceived safety			Velocity of the drones - The velocity at which the drones are flying		
			Distance between the drones and the observer - The minimum distance between the flight path of the drone and the observer		
			Distance between the drones and the bystander - The minimum distance between the flight path of the drone and the bystander		
			Nature of path - The drones travelling in one direction in one way path and opposite to each other in two way path		
Environment Wildlife	U.NOI9 - **Trajectory**-based fauna exposure The number of individuals per animal species within the noise contours of the drone operations (not mandatory)	WL-1 Total amount of wildlife exposed within noise and appearance contours.			
	U.NOI10 - **Area**-based fauna exposure The number of individuals per animal species within the noise contours of the drone operations during a period of time	WL-2 Total amount of wildlife exposed within an **area** during the observed time period.			
		WL-3 Total amount of affected wildlife within noise and appearance contours.			from DACUS
		WL-4 Total amount of affected wildlife within an area during the observed time period.			from DACUS

		WL-5 The difference between the total amount of wildlife within noise contours for the two consecutive measurements.			measures intermittences
		WL-6 The difference between the total amount of wildlife within their appearance contours for the two consecutive measurements.			measures intermittences
Environment Perceived safety			Velocity of the drones - The velocity at which the drones are flying		Only ImAFUSA
			Distance between the drones and the observer - The minimum distance between the flight path of the drone and the observer		
			Distance between the drones and the bystander - The minimum distance between the flight path of the drone and the bystander		
			Nature of path - The drones travelling in one direction in one way path and opposite to each other in two way path		
Environment Emissions	U.ENV1 - Average CO_2 emission per flight Amount of fuel burnt multiplied by the CO_2 emission index/kg divided by the number of flights	EM-1 Total amount of CO_2 emitted by a given number of flights (based on the emissions index of the fuel used, e.g., conventional or sustainable fuel) divided by the number of flights	CO_2-equivalent emissions - Amount of climate relevant emissions associated with an amount of electricity, specific to the energy grid used to charge the drone		
		EM-2 The amount of energy consumed by a single drone operation (based on the type of UAM and trajectory).			
		EM-3 The amount of CO_2-eq emitted by a single drone operation.			

		EM-4 The amount of CO2-eq emitted by UAs within an area during the observed time period.	CO2-equivalent emissions - Amount of climate relevant emissions associated with an amount of electricity, specific to the energy grid used to charge the drone		
		EM-5 The amount of CO2-eq emitted less for the observed deliveries with UA introduction (compared to road traffic delivery) within an area during the observed time period.			
Socio-Economic		AE-1 The number of deliveries of goods and equipment to areas with limited or no transport connections during the observed time period.	Travel time - This indicator models estimated travel time to the nearest vertiport based on distance and available ground transport modes. It identifies underserved areas and supports equitable UAM planning by highlighting where modal improvements can reduce access gaps.		
			Population to Jobs Ratio (PJR) - The PJR assesses spatial balance between residents and employment opportunities. Values far from 1 indicate imbalances, either job deserts or dormitory zones, guiding UAM infrastructure placement to improve labor market access and reduce commuting inequalities.		
			GDP - How UAM affects regional economic productivity as potential to stimulate growth and improve financial well-being across urban areas		
			Real Estate Cost - Index that measures the impact of UAM on housing affordability and urban pressure.		
			Social Acceptability of IAM - Holistic citizen’s response towards IAM services prior to the actual exposure or use to IAM operations		afordability + willingnes to pay 2 indicators by IMAFUSA

			Social Acceptance of IAM - Holistic citizen's perception towards IAM services after exposure to IAM operations		
Access & Equity (* only if affect social acceptance)	U.ACCESS2 - Time/airspace restricted to operations Percentage of time/airspace segregated for special (emergency or other) flights that could limit the access to regular operators. In can be calculated per month to allow for particular circumstances on a specific day or week.	*Very different view from MUSE A&E indicators: Suggested indicators by MUSE (AE-3 + AE4) are in fact noise and visual respectively*.			
	U.TRANSP1 - Access to real time flight information Public access to real-time status of flights requests and reasons for denials.				

Public Acceptance Surveys

Introduction

To support the public acceptance of U-space, the CORUS five Concept of Operations (ConOps) proposes monitoring traffic evolution and externalities using objective indicators, complemented by periodic surveys to citizens living or working within U-space airspace. By proposing periodic outputs from technical indicators and public surveys, which complement one another, we create a dual-framework approach for U-space governance. This ensures that the board overseeing U-space airspace, during their decision-making process, can rely on a comprehensive understanding of both, the technology actual performance, and the human perception of that performance. The final global proposal can be found in Chapter 7 of the main ConOps document. Two annexes complement the chapter on public acceptance, Annex B about indicators and this one, Annex C, about the surveys on public acceptance.

To design an effective survey, this Annex C first presents a comprehensive review of public acceptance surveys identified to date. These sources are primarily drawn from academic journals, conference proceedings and technical reports, supplemented by news feeds and social media surveys. This document synthesizes general findings from these publications, and ends with the core contribution of this Annex: a standardized, concise and practical questionnaire designed for immediate use in upcoming U-space deployments.

The analysis of public surveys started in previous CORUS projects (CORUS and CORUS-XUAM). This Annex aims to build on that foundation, acting as a structured follow-up to [1] which was published in 2022 and covered surveys up to 2021. Recent and empirical studies, specifically survey data collected from 2022 onward have been added to them.

Building on earlier work too, the analysis encompasses passenger, cargo, and aerial work vehicles. We examine the underlying acceptance constructs and, where available, we document the response formats used by the authors. The primary constructs found in the surveys literature are a wide range including: perceived safety, privacy, noise, perceived benefits, trust, public influence, automation, etc. Most surveys are complemented with demographic factors. We have expressively excluded safety from the public acceptance since the full body of the ConOps is basically addressing safety. On the public acceptance sections we assume that very high levels of safety are in place and well-known by the public.

Most of the works presented in this Annex are providing results of responses from people who have little to no experience with the UAS services being questioned about. According to ImAFUSA nomenclature [2], those surveys do not measure "acceptance" but rather "acceptability", this is, a judgement about whether a proposed operation is considered acceptable in principle, under hypothetical conditions. Nevertheless, across this review, we will use the term “public acceptance” for coherence with most reviewed publications nomenclature and with the terminology used in the CORUS five ConOps. The text will clearly highlight those studies that actually cover a geographical area where real UAS missions are being flown, and also those experiments done with Virtual and Augmented Reality, where respondents are immersed into a representation of IAM. Virtual and Augmented Reality set-ups try to close the gap between acceptability and acceptance.

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Public Acceptance Survey Papers

First paper on public acceptance of drones was published in 2011 [3]. Since then a large number of empirical studies have been published. It is important to note that survey answers are not necessarily from the same year of publication, but many times from the year before.

Surveys till 2021

A comprehensive review of global surveys conducted between 2015 and 2022 [1] has conducted as part of the SESAR CORUS-XUAM Very Large Demonstrations project [4]. During that period the overall public acceptance of drone operations generally ranged between 50% and 83%, being the highest acceptance given for the large survey published by EASA in 2021 [5]. However, acceptance varies considerably depending on the specific question and on the UAS mission: public safety, emergency response, and search-and-rescue operations receive overwhelming support, whereas passenger transport (air taxis) and private commercial deliveries face higher skepticism.

The study showed that the nature of survey questions evolved over time. While early surveys ($2015 - 2018$) prioritized privacy and criminal misuse, studies on the last part of that period ($2019 - 2021$) focused heavily on flight noise, environmental impacts on urban wildlife, cybersecurity, and physical safety. This, of course, depends on the survey focus and provided questions, but also shows that citizens opinions are subject to change over time, influenced by their experiences and the experiences related by others. Survey findings indicate that higher flight altitudes and strategic vertiport placement mitigate noise concerns, that digital privacy regulation and municipal involvement foster community trust, and that transparent public communication significantly increases acceptance and reduces perceived risks.

Taking the opportunity given by CORUS-XUAM, which created situation where citizens were directly exposure to flight demonstrations, additional responses were collected. We found that the acceptance values were inside the ones measured by previous work, showing that acceptability is a good proxy for acceptance.

The analysis of the state of the art included the evaluation of the factors influencing public and societal acceptance of UAS and the identification of the key barriers for public approval. The study concluded with the proposal of a list of mitigation measures for drone operators to promote the public acceptance of drones and eVTOLs into urban airspace.

The following table provides the list of surveys up to 2022, together with the year of publication and title. The one marked with an asterisk was a website collecting responses, not a report or a paper. The website from 2018 is not available any more, so we have substituted it with the last survey conducted in 2025 that shows the evolution since 2023.

Table 1: List of 14 public acceptance surveys to 2022 assessed in [1]

Ref	Title	Publication year
[3]	Public Perception of Unmanned Aerial Vehicles	2011
[6]	Risk Perception and the Public Acceptance of Drones	2015
[7]	Public Perception of Drone Delivery in the United States	2016
[8]	Droning on About Drones—Acceptance of and Perceived Barriers to Drones in Civil Usage Contexts	2017
[9]	Urban Air Mobility Market Study: Final Report	2018
[10]	New and Emerging Technologies: drones and digital towers *	2018/2025
[11]	An assessment of public perception of Urban Air Mobility	2019
[12]	The acceptance of civil drones in Germany	2020

[5]	Study on the societal acceptance of Urban Air Mobility in Europe	2021
[13]	Public acceptance of drone applications in a highly urbanized environment	2021
[14]	Social acceptability of urban air mobility by aircraft category and autonomous phases	2021
[15]	Up in the air: How do consumers view advanced air mobility	2021
[16]	Aerial Uptake Intereg Europe - Regional Analysis. Comparative Summary of Regional Questionnaire Responses	2022
[17]	Drone Delivery in the United States: American Consumer Attitudes on Home Drone Delivery of Goods and Food	2022

New public surveys

A structured literature search was conducted from main bibliographic databases and internet to identify empirical survey-based studies exploring public acceptance of U-space and the supported civil drone applications. Titles, abstracts, and keywords were combined using U-space/UTM together with drone-related terms (such as advanced air mobility, innovative air mobility, urban air mobility, drones, etc.), complemented with acceptance-related wording (such as public acceptance, social acceptance, societal acceptance, public attitude, etc.). Only records in English published since 2022 were selected. Duplicate records identified were removed. Two meta surveys or other review works were treated apart. The process ended with 45 new documents to add to the previous 14, resulting in a total of 59 surveys.

The following table provides the list of new surveys together with the year of publication and title. The one marked with an asterisk (*) is a website collecting responses, not a report or a paper.

Table 2: List of 45 public acceptance surveys from 2022 to 2026

Ref	**Title**	**Publication year**
[18]	Assessing Social Acceptance of Urban Air Mobility using Virtual Reality	2022
[19]	Analysis and Empirical Study of Factors Influencing Urban Residents' Acceptance of Routine Drone Deliveries	2023
[20]	Attitudes towards Urban Air Mobility for E-Commerce Deliveries: An Exploratory Survey Comparing European Regions	2023
[21]	User Acceptance of Urban Air Mobility for Passenger Transport: A Choice-Based Conjoint Study	2023
[22]	A mixed-method approach to investigate the public acceptance of drones	2023
[23]	Students' Acceptance of Drones Using the Knowledge, Attitudes, and Practice Model	2023
[24]	Acceptance of medical drone technology and its determinant factors among public and healthcare personnel in a Malaysian urban environment: knowledge, attitude, and perception	2023
[25]	Public Acceptance of the Use of Drones in City Logistics: A Citizen-Centric Perspective	2023

[26]	AMU-LED Cranfield Flight Trials for Demonstrating the Advanced Air Mobility Concept	2023
[27]	Urban Air Mobility in the next future: main findings from a technical survey	2023
[28]	Modelling public attitude towards drone delivery in Germany	2023
[29]	Beyond the AISLE: The 2024 State of Grocery, Shopping and Delivery	2024
[30]	The role of technology belief, perceived risk and initial trust in users' acceptance of urban air mobility: An empirical case in China	2024
[31]	Exploring the Factors Influencing Public Acceptance and Intention to Use Automated Drone Delivery Systems: A Trust Theory Approach	2024
[32]	Consumer Acceptance of Drones for Last-Mile Delivery in Jeddah, Saudi Arabia	2024
[33]	Effects of trust and customer perceived value on the acceptance of urban air mobility as public transportation	2024
[34]	Insights of the citizens perception during a 3-days outdoors flight demonstration	2024
[35]	Towards Engineering Fair and Equitable Software Systems for Managing Low-Altitude Airspace Authorizations	2024
[36]	Consumer acceptance of drone-based technology for last mile delivery	2024
[37]	The Future of Travel: A Study on Urban Air Mobility Acceptance	2024
[38]	Modelling public attitude towards air taxis in Germany	2024
[39]	Public acceptance of civilian drones and air taxis in Germany: A comprehensive overview	2025
[40]	"We Need Time..." An Expert Survey on Societal Acceptance of Urban Drones	2025
[41]	Examining the acceptance of drone delivery services among Chinese consumers: A perspective from urban and rural areas	2025
[42]	Public acceptance of autonomous and remotely piloted drones in civil and military domains: Socioeconomic, political, and safety correlates	2025
[43]	Blockchain in Drone Systems: Advancements, Security Implications and Community Acceptance	2025
[44]	Citizen Survey Report Drones, Generative AI, Digital Twins & Emerging Tec	2025
[45]	Green, Safe, and Cost-Effective? An Integrated Structural Analysis of Public Acceptance of Urban Air Mobility	2025
[46]	Exploring the Existence of Moderated Mediation of Attitudes Between Privacy Risk and the Intention to Use Drone Delivery Services	2025
[47]	Innovating the last mile: Consumer acceptance and economic drivers of drone deliveries in urban logistics	2025

[48]	Demographics, technology acceptance, and willingness to pay: a pilot study on urban air mobility adoption in Indonesia	2025
[49]	Public Acceptance of Civil Drones in Light of their Purpose	2025
[50]	Unmanned deliveries: A complexity theory approach to understand consumer acceptance and intention in drone food delivery in Africa	2025
[51]	Assessing the acceptance and aesthetics of unmanned aerial vehicles (drones): An experimental and survey-based comparison between students and older adults	2025
[52]	Innovation of food delivery: Acceptance of drone use among consumers in Peru based on Technology Acceptance Model and Behavioral Reasoning Theory	2025
[53]	Modeling the adoption of urban air mobility based on technology acceptance and risk perception theories: A case study on flying cars	2025
[54]	See it, hear it, feel it: an explorative virtual reality study to identify factors determining public acceptance of drones in different city environments	2025
[55]	Comparative Public Attitudes about Drone Strikes: Survey Experiments in Italy, Poland, and Germany	2025
[56]	Intricate and multifaceted socio-ethical dilemmas facing the development of drone technology: A qualitative exploration	2025
[57]	Understanding consumer preferences for Urban Air Mobility: A choice-based conjoint analysis approach with the case of South Korea	2026
[58]	Facilitating sustainable urban air mobility: Social influence and human oversight	2026
[59]	Public Acceptance of Remotely Piloted Aircraft Operations in Sydney Harbour	2026
[60]	Here we get the burger delivered by drone. Would you like to get food delivered by drone? *	2026
[61]	Analysing real-world demand for U-space services: A data-driven market viability analysis for future U-space business models	2026
[62]	Social-psychological determinants and nonlinear thresholds, behavioral insights into urban air mobility adoption as an airport shuttle	2026

Meta-surveys

Other publications exits that compare and analyse the opinion about U-space and UAS captured by empirical studies. For instance, in 2019, utilizing a comprehensive meta-analysis of archival survey data, Legere [63] investigated the relationship between public acceptance and the intended missions of UAS, evaluating how societal views influence technological integration. The study revealed for the first time that applications like search-and-rescue enjoy the highest levels of public approval, whereas proactive and armed law enforcement tasks face significant scepticism due to privacy and security concerns.

Last year Cicek at al, conducted a new meta-survey [64], a comparative and systematic review, aggregating empirical studies published over a five-year period. The objective was to

compare the primary user acceptance drivers for drone deliveries against side walk delivery robots. Consumer opinions regarding autonomous last-mile delivery technologies and adoption trends were analysed from global survey-based publications. The authors analysed the core psychological and technological drivers, such as performance expectations and perceived risks, that influence whether everyday users are willing to embrace these automated logistics systems. Ultimately, the work aims to guide industry developers and policymakers in formulating strategic deployment plans and regulatory frameworks by highlighting both shared acceptance metrics and technology-specific hurdles.

These two meta-surveys contrast in their opposite focus. While the first one is analysing public acceptance from a third party perspective, the second is more oriented to the consumer role of the citizens and market prospect.

Very recently Huang et al. published a new meta-survey [65] that presents a systematic review and three-level meta-analysis synthesizing 30 empirical surveys on public acceptance of urban air mobility (UAM). The 30 independent sources were obtained from 2021 to 2025, encompassing 18,346 participants. Because individual papers frequently report multiple survey questions and statistical relationships, the authors extracted a total of 253 distinct statistical data points (effect sizes) from which 58 are acceptance mean scores while the rest are correlation coefficients. The meta-survey refers a substantial heterogeneity between studies (86.9%), showing that public sentiment varies considerably depending on specific survey designs, participant samples, and operational contexts. For instance, the acceptance mean scores can measure of public acceptance, general attitude, or willingness to use. To be able to compare the different reported results, the authors rescaled diverse Likert-scale measurements onto a standardized -2 to +2 scale (where 0 represents a neutral attitude). The pooled analysis yielded a mean acceptance score of M = 0.62, with a confidence interval between 0.40 and 0.83. This indicates a small but statistically significant positive baseline of public attitude toward UAM.

In evaluating key acceptance determinants, the meta-analysis revealed that stable individual traits, and more specifically the personal innovativeness and environmental principles, serve as strong positive predictors of early adoption. Among perceptual factors, socio-emotional constructs like public trust and hedonic enjoyment demonstrated strong influence on acceptance, more than traditional functional factors, such as perceived usefulness, ease of use, and safety. Furthermore, social influence emerged as a powerful driver of public support, whereas cultural contexts (collectivist vs. individualistic) and presentation media (static vs. interactive) showed no statistically significant moderating effects on overall acceptance levels.

In this annex we will provide a comprehensive review of 59 surveys conducted from 2011 to 2026. The intention is to to find trends across time and geography, but separating public acceptance from public adoption. The final objective is to get inspiration from the sources to build a simple, yet useful, questionnaire to deliver to the governance board of U-space airspaces to be use as a tool to monitor public acceptance across the years.

Bibliometric Analysis

A structured extraction form supported a consistent coding across studies: title, authors, affiliation, year, publisher, geographical scope and sample size (number of valid responses). Following subsections show the analysis of those dimensions in graphical support.

Titles

Figure 1 shows the cloud of words built from most frequent terms extracted from the dataset of the research paper titles.

It visually represents key terminology on the topic of interest about drones and air mobility. Dominant Words, represented with largest font size, are "Acceptance" and "Public" in deep pur-

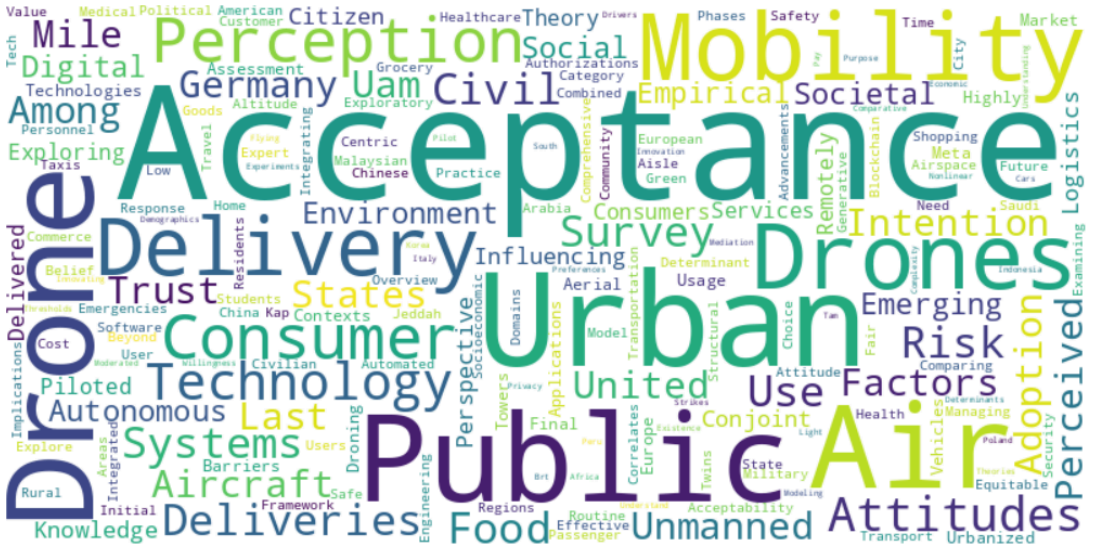


Figure 1: Cloud of words built from the survey publication titles

ple and teal; "Drone", "Drones", "Urban", "Air", "Mobility", and "Delivery" in prominent teal, yellow, and green. Secondary Words, represented with medium font size are "Perception", "Consumer", "Technology", "Attitudes", "Risk", "Trust", "Last", "Mile", "Food", "Societal", "Survey", and "Intention". Other less frequent words, shown with smaller font size include "Germany", "United States", "Civil", "Conjoint", "Autonomous", "Medical", "Logistics", "Piloted", and "Acceptability".

Authors' affiliation

We extracted only the first author's affiliation. The list is long with institutions from almost all the world, except Africa. There is only two authors from an institution of Africa, the Takoradi Technical University in Ghana, but they are not the first author.

Europe remains the central focal point for UAM social acceptance and technical flight testing, supported by EU Horizon and SESAR JU frameworks. Major multi-institution clusters include Germany (DLR, RWTH Aachen, TU Berlin, EASA) and Portugal (CEiiA / Univ. of Porto). Additionally Sweden (RISE), Spain (UPC Barcelona), Italy (University of Bari Aldo Moro) and Finland (VTT) have published empirical studies.

In North America only US institutions have publications. The list includes NASA, FAA, U.S. Postal Service, Purdue University, Embry-Riddle Aeronautical University, Iowa State University, University of Central Florida, and Wing (Alphabet). In Central-South America only Universidad San Ignacio de Loyola (Lima, Perú) has a publication on the topic.

Asia and Oceania have a large set of papers too. In China the following institutions have lead a survey: Tsinghua University of Beijing, Beijing Jiaotong University, Chengdu University of Information Technology in Chengdu, Kunming University of Science and Technology in Kunming and Guangdong University of Technology. Also in the East of Asia South Korea institution are KAIST, Pusan National University, Gachon University and KDI School of Public Policy and Management. In the South East we found the Indonesian Universitas Gadjah Mada (Yogyakarta), the Malaysian Universitiy Kebangsaan and in Singapore the Nanyang Technological University. In Australia the RMIT University (Melbourne) and the University of New South Wales (Sydney).

Growing research activity in Saudi Arabia (KFUPM, Univ. of Jeddah), Israel (Ben-Gurion Univ.), and Oman (MCBS) contribute with additional studies for the Middle East.

Figure 2 shows the locations of the affiliation of all first authors of the empirical studies

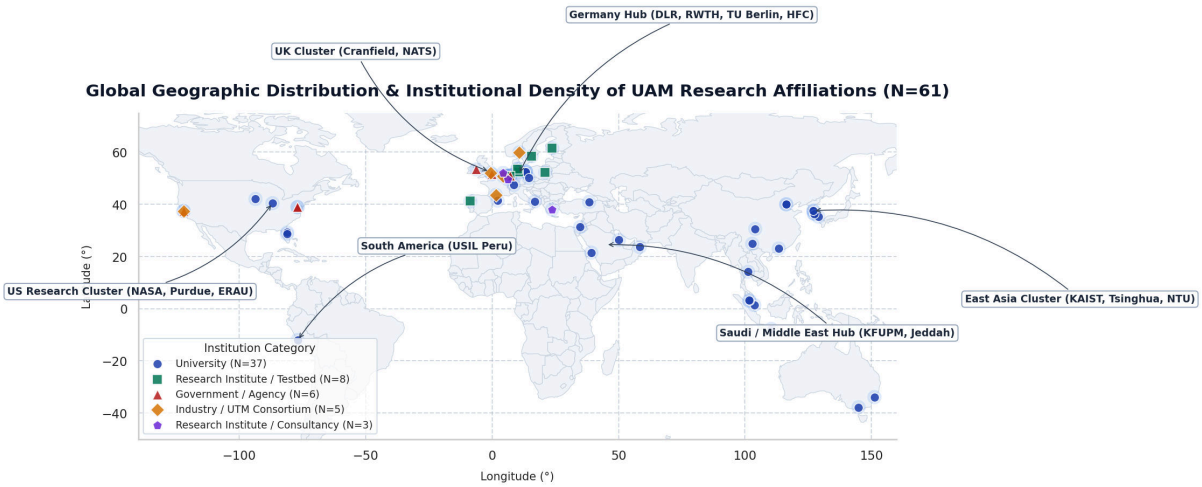


Figure 2: First author affiliation map

bibliography. In global we see that most studies have been produced by universities and research institutes.

Publishing method

The majority of the documents are scientific publications or technical reports from projects, governmental institutions and companies. Two of them are results of online surveys published in the Internet with no further statistical analysis. Reference [10] is a recurrent survey conducted by NATS, the British air navigation service provider, and the other, reference [60] still open to new responses, is organised by Aviant, a UAS operator conducting drone flights in Norway.

Most of the surveys (42) have been published on journals and peer review conferences, both from Social sciences and humanities and Science and engineering collections. They are studies conducted, in general, by the academia.

Then there are 15 sources that have been published as reports, such as for instance EASA survey [5], or the Wing study [29]. Also some academic works, such as Master Thesis, are also published as reports. It is important to note that the larger surveys, as we will see in section , are published as technical reports, so they did no go through a peer review process. The rest (just two) appeared in websites of companies from aviation.

Figure 3 shows graphically the distribution between academic papers, technical reports and webs

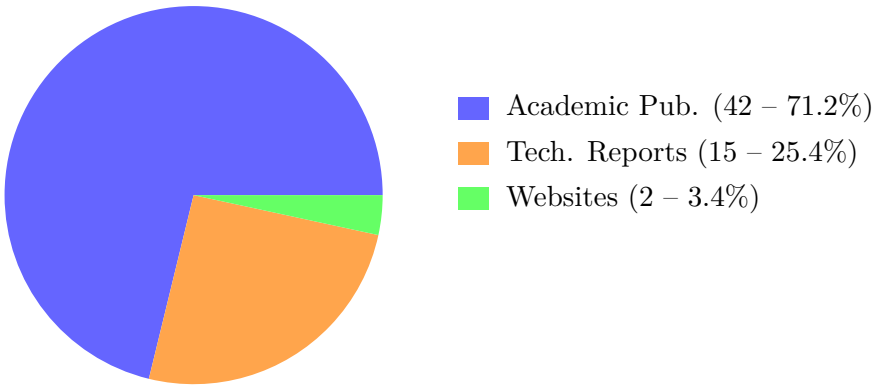


Figure 3: Distribution of sources.

Geographic distribution

The geographical coverage, shown in Figure 4, addresses the geographical scope of the surveyed population. It is a different view of the data from section , where the geographical information was showing the researchers affiliation. For instance, Ghana (Africa) is the target of the [50] survey, but the first author is from University of Central Florida (US). Public acceptance surveys showcases a fairly wide international reach, but the actual distribution of the data is quite uneven. There is a significant research focus in just a few nations, with Germany as the most noticeable.

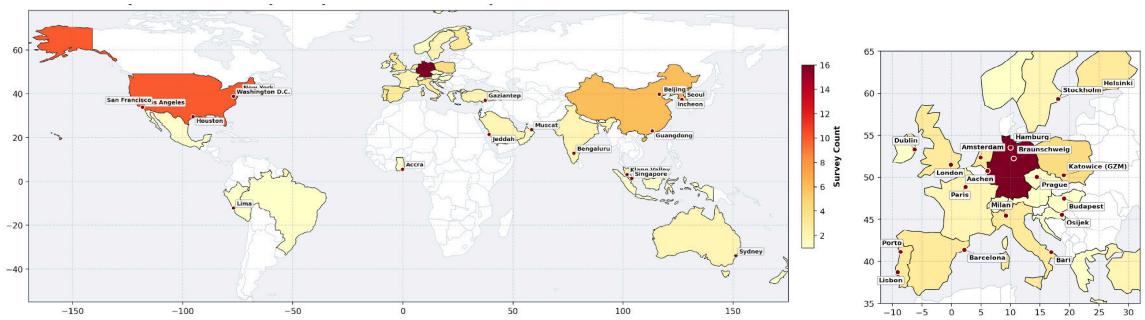


Figure 4: Geographical distribution of the population targets by surveys across the world.

If we break it down regionally, we see that most studies are concentrated in Europe and Asia, while there is a noticeable lack of research in African and Latin American contexts. Interestingly, few empirical survey from Australia is quite surprising considering the number of real-world drone delivery flights already taking place there.

Germany, United States, South Korea, China and Poland represent the most heavily surveyed populations in the UAS empirical literature, reflected by the darkest color shading. Countries with fewer studies (e.g., UK, Spain, Portugal, Italy, Netherlands, Finland, Saudi Arabia, Malaysia, Australia) are shaded in lighter gold/yellow, while unmentioned nations remain empty (white). Table 4 shows the countries where more surveys have been conducted.

Country	papers
Germany	16
U.S.A.	10
South Korea	7
China	6

Table 3: Top surveyed countries

In Europe cities like Braunschweig, Hamburg, Aachen, London, Dublin, Paris, Amsterdam, Prague, Katowice (GZM), Milan, Bari, Barcelona, Porto, Lisbon, Helsinki, and Stockholm are highlighted with red markers as they are explicitly mentioned in one or more the surveys.

Americas, Asia-Pacific and Middle East have as major surveyed metropolitan hubs Seoul, Incheon, Beijing, Guangdong, Jeddah, Muscat, Accra, Gaziantep, Klang Valley, Singapore, Bengaluru, Sydney, Lima, Los Angeles, San Francisco, Houston, New York, and Washington D.C.

Public acceptance of drones is a research topic raising interest all around the world. While former surveys were conducted in United States and European Union, the most recent surveys are from China, South Korea, Malaysia, Turkey, Saudi Arabia, Israel, Indonesia, Ghana and Peru, in addition to 9 from the European Union.

The dataset mainly features surveys from individual countries, still 11 empirical studies extend to capture multi-country comparative studies. The local geographical focus limits how

global are their conclusions about public acceptance, but help to capture opinions that depend heavily on local factors like regulations, urban design, experiences and trust in institutions.

Sample size

The sample size of the surveys ranges from 21 to almost 10 thousands respondents. Figure 5 and Table 4 show the statistical distribution of the samples. In general the number of valid responses is selected, but some of the surveys do not have a validation process and for those the total number of responses is selected.

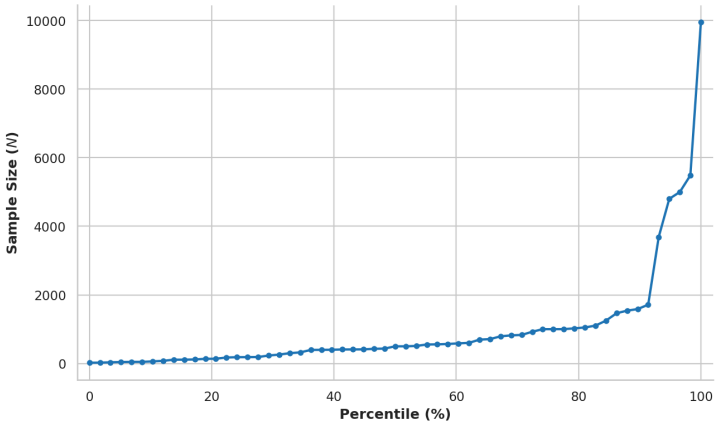


Figure 5: Sample size distribution of the surveys.

Table 4: Percentile Distribution of Survey Sample Sizes ($N = 59$)

Statistic / Percentile	**Notation**	**Sample Size (N)**
Minimum (Ref.[22])	Min	21
10th Percentile	P_{10}	57
25th Percentile (Q1)	P_{25}	184
50th Percentile (Median)	P_{50}	500
Mean	μ	981.3
75th Percentile (Q3)	P_{75}	1,000
90th Percentile	P_{90}	1,612
Maximum (Ref.[60])	Max	9,954

The smallest value (21 respondents) is for a survey conducted under an integrated mixed-method approach that combines interactive team tasks and group discussions with quantitative measures. With less respondents the group dynamics was possible to achieve a deeper insight about societal needs and find the drivers that increase societal acceptance [22]. Other small surveys are those that are conducted on experimental drone operating environments [34] or using virtual or augmented reality[18, 54].

The largest value (9,954 respondents) is for the recent online survey promoted by Aviant [60]. This is a one-question only survey that only ensures that answers are originated from different computers (IP duplication detection).

In between, the larger surveys are the ones that address multi-country studies ([55, 15, 5, 66, 20]), are market prospect conducted by companies at large scale in the country they planned to operate ([29, 11, 7, 67]) or are conducted by governmental organizations ([9, 44]). Exceptionally, some academic works can reach more than 1,000 citizens ([62, 42, 14, 31]). The median of the sample size (500 respondents) shows that most surveys generally smaller.

Vehicle type, use-case classification and evolution over the years

Figure 6 illustrates the number of publications over the year. The plot differentiates also the type of vehicle and the focus of survey questions. The focus of survey questions is represented by colour. The two main topics are: questionnaires that focus on public acceptance, as third-party opinions, which is shown in blue; and questionnaires that focus on market analysis prospect, which are represented in green. The type of vehicle is shown with three icons:

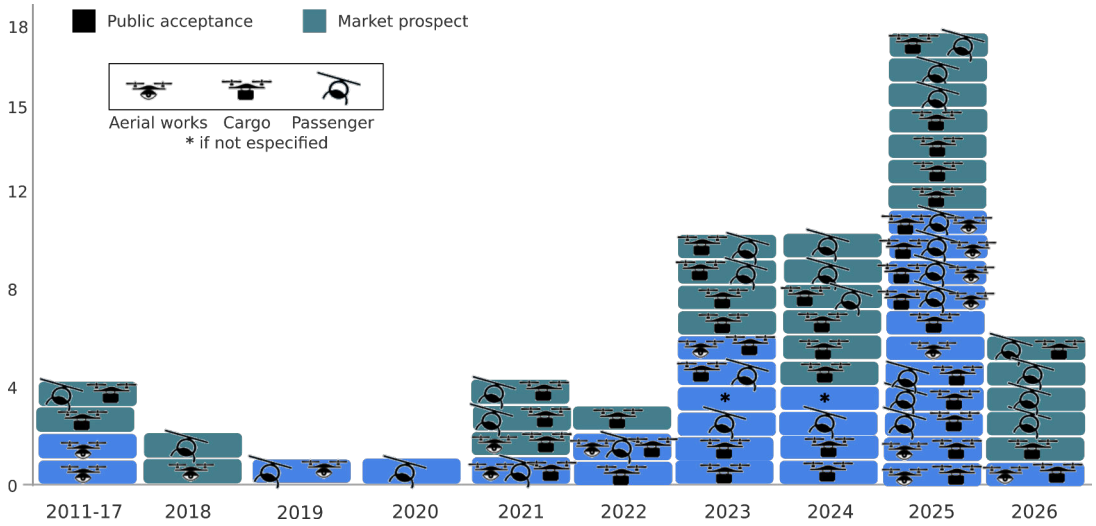


Figure 6: Surveys published across the year, annotated with vehicle type (passenger, cargo, aerial works) and focus of questionnaire (public acceptance or market prospect).

- The small vehicle with a camera: It represents aerial works like photography, environmental monitoring and inspections. It may also include public service or police missions, such as emergency responses and civil protection efforts.
- The medium vehicle with a package: It represents the delivery flights, which can be commercial parcels or medical goods.
- The larger passenger-carrying vehicle: It represent IAM flights, such as taxi-drones, flying cars or ambulances.

Each study (or scenario within a study) was assigned to one of three vehicle categories: *passenger* (e.g., air taxi, passenger services), *cargo* (e.g., delivery or freight applications), and *aerial works* (civil non-transport services such as emergency response, surveillance/monitoring, inspection, and similar operational missions). When a paper reported results for more than one vehicle category, we recorded multiple icons.

Cargo drones are still the most dominant target of surveys. They have similar interest in public acceptance (e.g., privacy fears over residential yards, low-altitude noise annoyance, and airspace safety) and market prospect surveys (e.g., food/parcel delivery purchase intentions, delivery fees, service speed trade-offs).

Passenger carrying aircraft, including airport shuttles, are most dominant for market prospect surveys, with questions such as discrete mode choice, willingness-to-pay fares, ride-hailing substitution, and passenger preference conjoint experiments.

Minor interest is given to aerial works, such as police surveillance, industrial inspection, and emergency search-and-rescue. All survey mentions addressing them focus exclusively on public acceptance. These surveys include questions about governance ethics, and civil liberty concerns.

Looking at the evolution over the years, we observe an important increase in the volume of drone-related public acceptance surveys, peaking with a massive surge of surveys in 2023, 2024

and 2025. As we have seen in section the main reason is the expansion of surveys across the world.

In the early period till 2020, the number of surveys was relatively limited and primarily balanced between public acceptance and market prospect. We observe a major focus on aerial works on the earlier years. This initial landscape reflects the time when drones were mostly considered for specialized inspection tasks, before the broader concepts of Urban Air Mobility (UAM) and Innovative Air Mobility (IAM) began to dominate the global research agenda.

The thematic focus of these surveys shifted notably around $2021 - -2023$. While interest in surveillance missions starts a decreasing curve on the literature, there is a clear and growing emphasis on cargo and especially taxi drones in the most recent years. The interests align with the expected shift from demos to scheduled services to be produced in major global markets.

By 2025, the research volume covers a dense and diverse mix of all vehicle types, including several unspecified categories, marked with an asterisk. The figure indicates that researchers are now simultaneously addressing the challenges of generic UAS nevertheless their usage, some cases focusing on U-space services, levels of automation, or full integration of UAS technology into urban environment.

Questions and construct families

Across the empirical survey literature only 21 surveys out of 59 include, fully or partially, the exact questions used in the questionnaires. For those, questions are generally structured around established theoretical construct families grounded in technology acceptance models, risk perception theory, and trust theory.

The primary construct families include behavioural intention (i.e. "I plan to use UAM services if available" used in [45] and similar texting in [33, 37, 48]), perceived usefulness (i.e. "Using air taxis will reduce my overall commute/travel time" used in [45] and in [30]), perceived ease of use (i.e. "Learning to use the UAM system will be easy for me" from [48]), trust in technology and regulators (i.e. "I trust regulatory authorities to enforce airspace safety", [5, 45]), and perceived risks (i.e. "I think that the drone might malfunction and damage property or injure someone", [50]). Because these constructs adapt standardized psychometric scales, core questionnaire items are virtually found all across international studies. Surveys routinely ask respondents to rate on 5-point or 7-point Likert scales whether drone operations "infringe on personal privacy" [7, 32, 41], whether they fear "vehicle malfunction causing ground injury" [6, 39, 42], or whether medical delivery drones offer "vital societal benefits" [66, 68]. Table 5 shows some examples of most common questions organised by construct family.

Conversely, several studies incorporate highly specialized or rare questionnaire items tailored to unique experimental setups, choice experiments, or operational niches:

- **Virtual Reality (VR)**: In immersive simulator experiments, post-trial items measure subjective physiological and psychological reactions linked directly to live VR exposure, asking participants questions such as "In the scenario, I felt as if I was being watched" or requiring them to trigger real-time controller inputs whenever a drone's flight path caused visual disturbance [18, 54].
- **Acoustic scenarios**: Specialized psychoacoustic studies pair survey choice cards with real auditory playback, evaluating citizen acceptance when "the sound of aircraft resembles a bee buzzing for 5 consecutive seconds" [11].
- **Emergency delivery**: Specific medical delivery questionnaires include items such as asking citizens whether eVTOLs should prioritize transporting human organs versus automated external defibrillators [66, 68].

Table 5: Overview of most common questions organised by construct families.

Construct family	**Example of questions**	**Literature citations**
Behavioral Intention: Willingness to adopt, usage frequency	*"I plan to use air taxis / delivery drone services regularly once they become commercially available."*	[33, 36, 45, 46, 53]
Perceived Usefulness: Time savings, travel efficiency, societal utility	*"Using urban air mobility will significantly reduce my overall travel time compared to ground transport."*	[36, 45, 68, 66]
Ease of Use: Booking method, accessibility, operational simplicity	*"Interacting with mobile booking interfaces / automated vertiports will be easy for me to learn."*	[33, 36, 32]
Trust: Credibility of aviation authorities, operators and safety systems	*"I trust regulatory authorities (e.g., EASA/FAA) to enforce strict airworthiness and airspace safety rules."*	[31, 5, 56, 52]
Perceived Risks: Fear, privacy violation, noise annoyance, and cyber threats	*"I am concerned that drones flying over residential property infringe on personal privacy / cause ground injury."*	[7, 6, 39, 42, 32, 41]
Simulated scenarios: Subjective virtual reality presence, visual disturbance, real-time annoyance	*"During the trial scenario, I felt watched / disturbed whenever a drone passed through my field of view."*	[18, 54]
Acoustic/Psychoacoustics: Sound level perception, buzzing characteristics, background masking	*"Rate your level of discomfort with the sound of an approaching aircraft."*	[11, 34]
Stated Preference: Cost, vertiport distance, access time	*"For an airport shuttle journey, select the single most and least important feature among the options presented."*	[57, 62]
Governance/Policy: Authority readiness, airspace rights, emergency priority	*"Local municipal authorities have sufficient capability to regulate low-altitude urban air traffic."*	[56, 16, 52]

- **Governance**: Governance and expert questionnaires probe unique administrative dimensions, evaluating local municipal capacity to enforce low-altitude air rights, regional policy coordination, and public concerns regarding cybersecurity and vulnerabilities in autonomous vehicles [56, 16, 52].

Response formats

To obtain the public acceptance each paper defined one or more response methods to collected and presented their survey data. Methods include binary choices (Yes/No), Likert scale ordinal categories (typically 5-point, e.g. from not likely to likely, or from very negative to very positive), multi-choice categorical selections (for example, select reasons for fear), linear slider (position you willingness to pay), worst-best scaling or simultaneous multi-selection (for instance, select all situations you consider dangerous). One same survey may propose different response formats for different questions.

Table 6 shows the frequency of each method across the literature.

Table 6: Frequency distribution of the most frequent response formats

Response Format Category	**Frequency**
5-point Likert scale	35
Binary choice	18
Multi-choice categorical selection	17
7-point Likert scale	7
4-point Likert scale	3
Other Likert scale (3/6/10/11-point)	10
Others: 1–10/100 slider, multi-choice categorical checkboxes, best-worst scaling	6
Not specified	2

The diversity of response methods complicates the comparison of results across different empirical studies, but the majority of the surveys convert most of the input methods into a percent. For instance, Wang, Mutzner and Blanchet [40] used 5-point Likert scale, 10-point slider and multi-choice categorical rating formats, but the reported a 69% of acceptance. Question "Drones can improve the efficiency and accuracy of certain tasks ..." was proposed as 5-point Likert scale, with options from "Not at all convincing" to "Absolutely convincing", but responses are then aggregated into a 0.73 representing the percent of responses that have selected the "Largely convincing" or "Absolutely convincing". Other works prefer to report for the same 5-point Likert scale response format the average value over 5. For instance, Lotz et al. [21] report mean score, median and standard deviation obtained from weighting response options from 1 to 5. In this way they obtain that the "Willingness to use air taxis" ranges from 2.36 to 3.23 depending on the choice-based conjoint group created from the preferences of the person. Nevertheless, they also refer to the percent of people, for instance "72 % stated they could imagine using air taxis with a pilot on board", by applying the same split explained above.

Target UAS service

The context of the UAS mission has been shown to have a very high correlation with the level of acceptance [5, 63]. Nevertheless the type of UAS, the aim of its flight can be described as a commercial service, like e-commerce delivery or a private passenger commute, or as a public-benefit application, such as medicines transport or emergency evacuation. For instance [13] proposes the large list of missions shown in Table 7.

Some surveys focus on one type of target service [36, 52, 57], but others propose several scenarios to be able to compare between them [59, 26]. For those paper that compared mission

Table 7: Target UAS services, disaggregated by user [13]

Government	**Commercial**	**Private**
Search and rescue	Monitor atmospheric conditions	
Disaster management	Agricultural monitoring	
Wild life/nature reserve	Infrastructural maintenance/ inspection	
Public infrastructural maintenance	Delivery	
Research	Research	
Fire fighting	Transport people	
Performances	Performances/Entertainment	Entertainment
Communication/broadcasting	Communication/broadcasting	
Military	Internet provision	
Security	Security	
Photography	Photography	Photography
Issuing speed/park tickets		

types, the key factors that either boost or hinder acceptance are reported in addition to the different levels of acceptance, included statistically significant predictors, identified barriers or benefits, and recurring themes found in the results sections.

Data-collection method and population sampling

Researchers gathered data through various survey methods. The bast majority used online web surveys, but others included interactive computer-assisted web interviewing, telephone surveys conducted by humans and assisted by computers, paper questionnaires, face-to-face discussions and, in some cases, a mix of several of these approaches. These variations are important because the method used can influence who decides to participate and how they respond to questions, ultimately affecting the reported levels of acceptance.

The sampling approach is also very diverse. Most studies used strong statistical methods to validate the sample, thus they used a random sampling representing the demographics of the target population. Other methods mentioned in the bibliographic dataset include online panels, social media, in-person on-site intercept at local sites, and event-based recruitment.

Findings about acceptance from surveys

This section provides the most relevant outcomes of the 59 analysed surveys. First we will pick some relevant highlights from the papers. Then subsection will provide a figure of the normalised results about public acceptance and willingness to adopt extracted from the sources.

Studies outcomes and discussion

Mission: The included studies show that acceptance is not solely tied to the type of vehicle but it is heavily influenced by how the mission is framed. In general, missions framed as serving the public good consistently receive higher positive feedback compared to those framed as private conveniences or surveillance. For example, medical transport and emergency operations are frequently highlighted as the most accepted applications with [24] reporting an 83% acceptance rate for medical delivery drones in Malaysia and [23] retrieving a 78% acceptance for search-and-rescue and wildfire monitoring. Conversely, operations driven by private convenience face much more skepticism. A striking example is a survey conducted in Ireland [44], which highlights a massive 84% support for aerial works (emergency, police, medical), while commercial uses drop to just 45%.

Drone delivery across geography: Acceptance values for cargo and parcel delivery fluctuate significantly across different regions, revealing interesting geographical contradictions. In Asian and Middle Eastern contexts, the support is notably high, with a Saudi Arabia study [32] reporting an 87% of intention to use, an Indonesian survey [48] reporting an 83% of willingness to pay for air taxis, and a Chinese study [41] reporting an 80% of acceptance. Drone deliveries in China during pandemic[19] reported a 65% of acceptance, but 35% of the respondents reject the normalization of drone delivery in urban areas after it. Surveys in the United States achieve also good acceptance, for instance 70% of acceptance reported in [46] or 64% support to cargo drones [67]. These high rates are primarily driven by perceived usefulness, the eco-friendliness vehicles, and time savings.

On the other hand, European-based studies report much lower and fragmented support for routine deliveries: the Finland survey [31] shows only a 44% of acceptance, in contrast with the web survey [60], managed from the same country, a 69% of respondents are willing to get food through drone delivery. An European wide study [49] shows a similar acceptance (68%) for drones delivery, while Ireland survey [44] reports an 84% acceptance of public-benefit aerial works like emergency and environmental monitoring.

Socio-Demographics Average acceptance scores can often mask significant differences tied to socio-demographics such as gender, age, work or education level. For instance, paper [41] uncovered a "social norms paradox" when looking at urban versus rural population. In cities, social influence play a big role in boosting acceptance, while in rural areas acceptance hinges solely on practical benefits.

A person's educational background also introduces strong opinion biases. Respondent's field of study significantly influences their trust in automation [30]: Individuals with a scientific background showed less fear to drones. Conversely, those with a humanities background often exhibit a natural scepticism toward autonomous vehicles.

Privacy concerns of young people was the target of [23]. Through interviews, it emerged that their primary privacy concern is not related to government or police surveillance, but to malicious individuals could use drones to take photos of children in private backyards. This highlights a very real public fear that goes beyond abstract data protection.

Accountability, Liability, and Trust: The most relevant fear among the respondents is the feeling of been powerless [44], referred to as the "complaints desk" problem. With a 64% of citizens expressing fear of drones, respondents express their incapacity to identify them and their lack of knowledge about whom to reach for their complaints. This absence of clear accountability amplifies the perceived risks. Literature suggests some innovative technological solutions to solve accountability. For instance, Kumar et al. [43] propose leveraging blockchain technology for UAS operations. Regulatory solution to drone identification is already in place in Europe (EASA Regulation (EU) 2019/947) and in United States (FAA Remote ID rule). "Remote ID" is a mandatory system acting as a digital license plate. The fact that citizens still express high levels of fear regarding drone identification suggests a significant knowledge gap. While the legal framework already exists, the general public remains largely unaware of these tools or does not yet have easy access to the platforms required to read this digital identification.

Gap between expectation and experience: The context of real-world exposure plays a crucial role in changing views. Survey [19] showcases a unique real-world experiment, in which authors spoke with residents in a neighbourhood in China where drones were used to deliver essential goods during the COVID-19 lockdowns. Their findings reveal that when people experience a tangible and necessary benefit, their acceptance increases based on practical utility, helping to overcome their initial doubts.

A significant takeaway from the research is the gap between what people say they may find acceptable (acceptability) and what they actually embrace once exposed to daily operations (acceptance). Most surveys ask individuals to envision drones, but studies grounded in real-life experiences reveal the "awareness paradox." For instance, research in Dublin (Ireland) [44]

indicates that as people become more acquainted with drones, their support can actually wane. Between 2021 and 2025, as citizens began to see real drones in action rather than just imagining them, acceptance plummeted from 82% to 54%, and concerns about noise surged from 14% to 45%.

Survey [23], conducted over secondary school and university students, backs up the notion of the "illusion of education". In this study, the authors assessed students' views before and after discussing the medical and environmental advantages of drones. Surprisingly, there was no significant change in their opinions. This points to the idea that public perceptions are already quite entrenched, and a straightforward theoretical explanation is not enough to sway them when they only receive theoretical information.

Virtual and Augmented Reality: The strategic role of high-fidelity simulation and physical test beds is paramount in mitigating the gap that currently separates acceptance from acceptability. High fidelity simulators can anticipate the future traffic under many different concept of operations, use cases, altitudes, vehicles, etc. Leveraging those simulators with virtual and augmented reality (VAR) brings the public into a future U-space and allows to obtain more realistic survey results. To transition from marketing narratives to deployment, the decision-makers must rely on evidence-based data to build the necessary public license to operate. Works by DLR [18, 54], ImAFUSA [2], AMU-LED [26] and University of Bolonia[69] are examples of such experiments. They allow to mitigating the systemic risk posed by the euros invested in infrastructure relative to potential growth of the drone services. VAR environments are also useful to identifying annoyance thresholds. By using immersive tools researchers can establish empirical limits for public noise perception and visual intrusion[2].

An example is the DLR high-fidelity MoSAIC pedestrian simulator. It allows participants to physically walk through a virtual city while UAS fly overhead at varying altitudes and frequencies. The environment synchronizes localized noise signatures with visual flight paths. Moreover, it is able to track ocular movements and pupillary responses, providing quantitative data on visual annoyance and attention capture. Similarly, Cranfield Advanced Air Mobility Laboratory utilizes a dedicated flight simulator equipped with a six-degree-of-freedom motion platform combined with VR headsets for on-flight tests [26].

These type of tools represent a critical strategic shift in capturing human-centric data prior to physical deployment and allow researchers to observe pedestrian and resident reactions to UAM noise and visual presence in a controlled, repeatable setting. On the contrary, they can not expand to multitudes, so the number of respondents from such works in minority with respect to large scale surveys as already pointed in section .

Findings from an augmented reality experiment [18] that the general attitude towards civilian drones slightly dropped from 76.6 percent of acceptance before the experiment to a 76.0 afer the simulation. Additionally, it shows that flight height has a significant effect on feeling comfortable with drone flying near by. Feeling comfortable responses significantly differ between 10 m (5.80 over 7) and 50 m (6.23). Table 8 shows additional findings about the impact on acceptance of the flight altitude and the environment where mission is taking place [54].

Table 8: Public Acceptance of U-space by Environment and Altitude [54]

Environment Type	**Flight Altitude**	**Impact on Acceptance**
Residential / Parks	Low-level (<50m)	Low acceptance; high sensitivity to privacy and intrusive noise signatures.
Industrial / Urban Hubs	50–150m	Moderate – High acceptance; noise often masked by existing urban machinery.
Scenic / Tourism Zones	150m+	High acceptance; proven by 5–10 minute scenic rides in Guangzhou and Hefei.

Results by Stolz et al. [54] indicate that drones are perceived positively when operations are conducted in industrial areas, with 8 out of 9 respondents feeling comfortable when the drone was flying within an industrial area and 7 in city centre, but only 4 in in a park or 2 in your residential area. The reported main concerns were mostly concentrated in feelings of being watched and disturbed.

Similarly, for an open area of a large city Gomes et al. [**?**] report an average 5.02 (over 7-point Likert scale) acceptance, this is, a positive receptiveness across several scenarios observed by 100 respondents (the maximum number of surveyed population under a VAR simulators). The specific question "Drones should be used to transfer goods to people" received an average of 5.89 over 7.

Results based in VAR confirm many conclusions obtained by online surveys. For instance, that public acceptance is highly contextual. The degree of annoyance is dictated by the environment where the UAS operates and its altitude.

Other findings are that traffic density and vehicle type factors are equally critical. There is a marked difference in public perception between the larger, passenger-carrying prototypes (i.e. the five-seat Archer Midnight or Joby's tilt-rotor designs) and small delivery or private drones. While the latter are often viewed as nuisances, larger UAS are evaluated against the reliability and professionalism of commercial airlines. Building trust requires demonstrating that these larger vehicles can maintain visual and auditory comfort levels across varying urban topographies.

Passenger and automation: Surveys to potential passengers shows moderate and highly safety conditional acceptance. Values generally range from 51% in Germany [21], 72% in South Korea [33], and peaking an 83% in a pilot study in Indonesia [48].

A recurring barrier in this category is scepticism against automation. While the industry is pushing hard on introducing autonomous vehicles to reduce operations cost, surveys [21, 57] explicitly note that having a pilot on board strongly increases user acceptance. Furthermore, survey in Germany [39] reveals a strong contrast between delivery drones, which get an acceptance of 66% and air taxis, which achieve only an acceptance of 46% mainly because most respondents perceive as them as risky.

Environment: The literature reveals a disconnection between economical growth goals and environment. For instance, a survey conducted in Portugal [25] shows that citizens care very little about this extreme speed for fast deliveries. Instead, respondents strongly prefer flexibility in the time of the delivery and observe environmental benefit such as zero emissions. While extra costs are usually seen as a major barrier to drone delivery adoption, Li et al. [45] demonstrate that environmental consciousness acts as stronger moderator, with a high percent of respondents that are willing to pay extra fees for drone deliveries, as long as the service replaces polluting delivery vans.

Positive and negative factors: Figure 4 shows the common factors that emerge across all geographies and mission types, positive factors in the left and negative factors in the right.

On the positive side, acceptance is driven by expectations of increased efficiency (faster service, flexibility) and system-level benefits, particularly lower emissions and reduced traffic. Environmental considerations frequently emerge as a strong positive factor (e.g., papers [19], [41], [25], [47]). Trust in operators, clear regulations, and the legitimacy of public authorities also play significant roles.

On the negative side, privacy consistently emerges as a major barrier, especially for delivery services and situations seen as intrusive (e.g., papers [53], [32], [46], [49]). Alongside privacy, safety and security concerns—such as the fear of crashes, delivery errors, and criminal misuse—are frequently mentioned. Another significant drawback is noise (e.g., papers [19], [20], [30], [47]]). While it might seem that busy urban environments would mask drone sounds, the high-frequency acoustic signature of these vehicles is often perceived as particularly annoying, especially in quiet residential or extra-urban areas where last-mile deliveries typically occur.

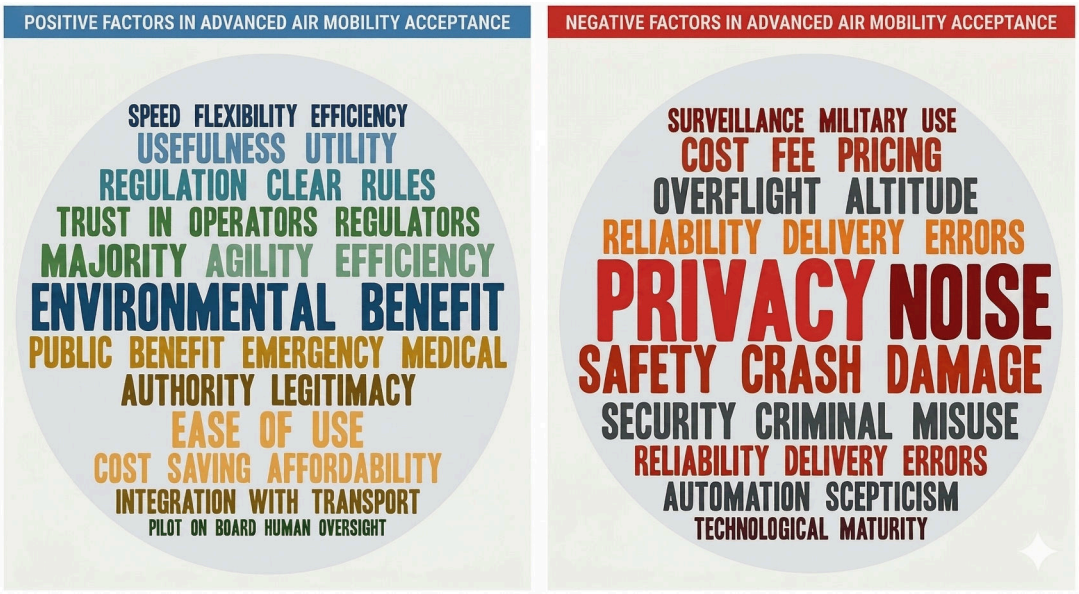


Figure 7: word cloud highlighting positive and negative factors

Finally, economic factors play a crucial role in shaping acceptance, particularly in logistics scenarios. It is not the general willingness to pay that hinders adoption, but rather the demand for extra fees; for instance, paper [25] notes that acceptance drops significantly when an extra premium is required for delivery speed.

Global acceptance

Table 9 shows the acceptance results of the surveys across the years. It shows separately the results given in a Likert-like scale from those given as percent. Also two main construct families about public acceptance and public adoption are also given separately. If a study reports results for only one construct, the other construct is left blank.

Table 9: Summary of Public Acceptance and Adoption Studies

Year	Ref.	Public Acceptance (scale)	Public Adoption (scale)	Public Acceptance (%)	Public Adoption (%)
2011	[3]		1.61 over a 5		
2015	[6]	6.26 over a 11			
2016	[7]				62
2017	[8]	2.70 over a 6			
2018	[9]				55
2019	[11]			44.5	60.2
2020	[12]			53	
2021	[16]			46.52	
	[13]			80.8	62
	[5]			83	71
	[15]				24.5
	[14]		4.22 over a 7		
2022	[18]			76	
	[66]			45 – 80	
	[68]	4.10 over a 5	3.80 over a 5		

	[67]				58
2023	[19]			35	
	[26]			65	
	[20]			66	
	[23]			78	
	[28]			83.4	
	[24]	4.18 over a 5	4.62 over a 5		
	[22]		5 – 7 over a 8		
	[27]				35
	[21]		3.50 over a 5		
	[25]				71
2024	[31]			44	
	[38]			84.6	77.4
	[32]			87	
	[35]			40 – 80	
	[34]	3.54 over a 5			
	[37]	3.71 over a 5	3.68 over a 5		
	[30]	3.74 over a 5	3.90 over a 5		
	[38]	4.98 over a 7	5.34 over a 7		
	[36]		3.24 over a 5		
	[29]				58
2025	[49]			42.30	
	[42]			45.35	
	[54]			58.3	
	[39]			75	42.5
	[43]			77	90.3
	[10]			86	40
	[40]			89	
	[52]			91.9	89.6
	[44]			45 – 84.6	35
	[45]	3.34 over a 5	3.76 over a 5		
	[46]	3.80 over a 5	3.33 over a 5		
	[51]	3.88 over a 5			
	[53]		3.99 over a 5		
	[55]	4.00 over a 7			
	[50]	5.34 over a 7	5.70 over a 7		
	[56]	8.7 – 8.87 over a 10			
	[47]				61
	[48]				82.9
	[41]				75 – 85
2026	[59]			82	
	[61]				60
	[58]				44.54
	[57]				58.5
	[60]				69
	[62]				35

The table shows the complexity of the harmonization of all these results. Many studies using

a Likert scale response format present results as the percent of respondents that have selected any option above the middle point. Still some studies report results only as the average in their scale (e.g., Likert 1–5, 1–7, or 1–11 averages). Regression coefficients, structural equation models and other statistical analysis presented in the surveys are omitted. When a study provides multiple results, the most general overall representative percentage for that category is presented.

In some surveys we needed to make some assumptions to convert their results into a comparable number. For instance, in the RISE Aerial Uptake study [16] the results were given per country in Net Promoter Score (NPS). This is a standardized metric widely used to measure overall sentiment, satisfaction, or public support. Respondents select a value on a 0 to 10 scale and the score balances positive and negative attitudes, where positive are responses 9–10 and negative are responses 0–6. The provided scores where all negative, ranging from-48 to -9 NPS across the 5 countries under analysis (Poland, Croatia, UK, Spain, Netherlands). We harmonise this measure with a weighted average for the percent of respondents that selected option 7 or above.

Additionally, some papers had not an acceptance value. For instance, paper [62] investigates public acceptance and adoption intentions for airport shuttle services based on a stated preference survey of 1,250 respondents in South Korea and identifies demographic characteristics of early adopters (individuals under 40, high income, high education, users of business class travel, without personal car). But the paper does not provide any detail about the share of positive public adoption preferences.

To better interpreting the global acceptance trends, Figure 9 presents a harmonized plot from the different scales. Bars now include percent of acceptance and Likert-like results, all converted to percent and aggregated for all surveys of the year. Whisker lines show the range of values from where the average was calculated.

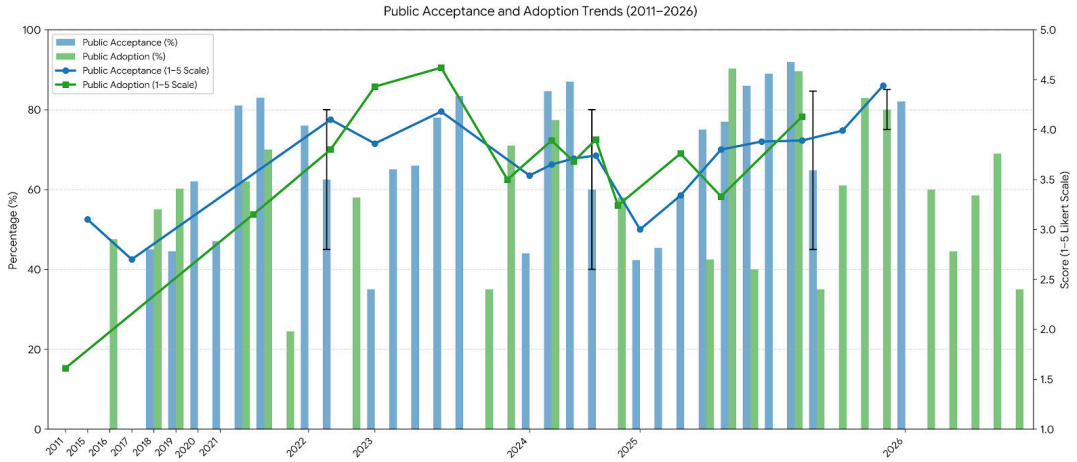


Figure 8: Acceptance mean across the studies and over the years.

We can observe a step rise in public acceptance, from averages below 50% between years 2017 to 2019, to averages close to 70% during the period 2021 to 2025 and ending with a promising 80% on the last year surveys.

However, the averages in public adoption, this is the constructs on the family of willingness to pay, are not so promising. While in the period 2016 to 2019 seems to have a conservative increase, it stops and even reduces in the following period. The highest average was in 2024, but did not reach the 50%.

Most of the variability is due to the focus mission, with high acceptance rates for medical transport and emergency services and lower rates for cargo and passenger transportation.

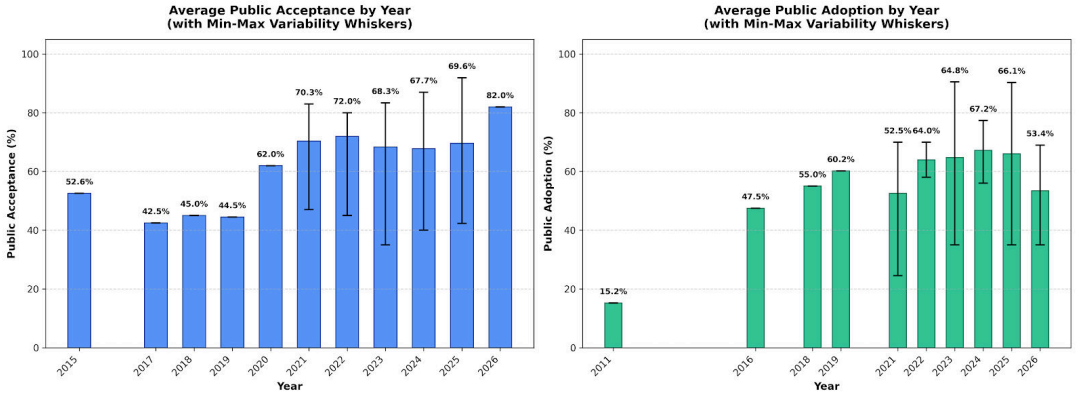


Figure 9: Public acceptance and Public adoption averages across the years.

U-space public acceptance survey

Construct families

In the reviewed literature, the concept of "acceptance" is far from monolithic; it is assessed through a highly diverse mix of constructs and response formats. For every study included, we identified the key acceptance-related outcomes and organised them in the following construct families. Table 10 provides a comprehensive summary of the acceptance construct families identified in this review.

The first constructs of the table identify the societal approval or general feelings about the deployment of U-space and UAS services. They are the most common metrics in surveys that look at public-benefit operations, such as medical deliveries or emergency responses and at general civil drone flights. In these constructs the respondents are acting as 3rd-party citizens, assessing a societal shift rather than consumers purchasing a service.

The family constructs on the bottom of the table reflect this other role of citizens, as potential targets of a service. This is particularly common in consumer-facing market prospects, where persons adoption is key. Examples are passenger carrying UAS and drone deliveries for e-commerce.

Survey design

The U-space citizens survey aims to identify the seven distinct psychological and behavioral constructs families mentioned in section **??**. Each construct is measured using a framework of three questions, such that the first two questions in each construct focus on a specific vehicle type (delivery drones vs. passenger air taxis), while the third question addresses the construct from a general perspective. Final list of questions is given in next section ().

Statements across different vehicle types ensure that the question is measuring exactly what it was intended to measure. The inclusion of a third, generalized question on each survey construct serves as a vital methodological safeguard to ensure statistical robustness and construct integrity and prevent a full construct being declared invalid during post-survey analysis. In psychometric research, a question that appears well-phrased can be invalidated if statistical analysis reveals that respondents misinterpreted it or if their answers do not correlate with the intended psychological dimension. By having a third item that generalizes the vehicle type, we ensure that we can still measure the construct (e.g., "Institutional trust" or "General attitude") even if one of the specific questions regarding delivery drones or air taxis fails. This ensures that the data reflects a respondent's feelings about the technology class as a whole, rather than just their specific reaction to one use case.

Construct family	Definition
Mission support (SUP)	Approval or acceptability for deployment or operations in specific applications or contexts. Indicates approval or acceptability for deployment in specific applications, contexts, or situations (like support for a particular use case or acceptability of operations in a certain area).
General attitude (ATT)	Overall evaluative judgement or sentiment towards the service or technology. Represents an overall evaluative judgment or sentiment (whether favorable or unfavorable) towards the technology or service
Policy support (POL)	Support for regulation, public investment, permissions, or governance decisions related to deployment. Captures preferences regarding governance and collective decisions, such as backing for regulations, permissions, public investment, or implementation rules; PAY looks at economic trade-offs, like willingness to pay, fee thresholds, or acceptance based on price.
Institutional trust (TRU)	Trust regarding the system and responsible actors, including perceived reliability and safety assurance. Covers trust-related outcomes, such as trust in the system, operators, institutions, reliability, or perceived dependability.
Intention to use (USE)	Intention or willingness to use or adopt a service or technology. Reflects the respondent's intention or willingness to use or adopt a service if it were available.
Willingness to pay (PAY)	Economic acceptance expressed as willingness to pay or to accept cost trade-offs. Support the monetary scope that hold the trade-off between the desire and the cost of the desired service.
Automation preference (AUT)	Acceptance differences conditioned on the level of autonomy or control. Highlights acceptance differences that depend on the level of autonomy or control (like piloted, remotely supervised, fully autonomous, or preferred automation levels).

Table 10: Acceptance construct families: first the constructs addressing public acceptance and then the constructs addressing market prospect.

All responses are intended to be captured on a **4-point Likert** scale to avoid neutral responses. Using a Likert scale that lacks a middle "neutral" option forces respondent to indicate a clear positive or negative leaning, preventing "fence-sitting" behaviour.

Questions are formulated using the **first person** (e.g., "Overall, I feel positive about...") because their core objective is to capture the subjective perceptions of the individual respondents. The use of "I" in survey items encourages respondents to share their own internal insights, viewpoints, and experiences rather than providing a detached or general opinion. This is critical because research in this field centers on each participant's personal interpretations and justifications. The psychological and behavioral constructs aim to directly measure respondent's at personal level.

Phrasing simple sentences, in positive, and in a direct manner, facilitates they are easy to imagine and self-explanatory for non-experts. Questions are formulated avoiding negatives. The formulation of survey questions only in positive is a standard research practice aimed at ensuring clarity, reliability, and unbiased data collection. Positive formulation minimizes misinterpretation by avoiding negative formulations, such as "I do not support..." which lead to respondents' confusion. Even questions that seem perfect on paper can be declared invalid if statistical analysis reveals that respondents misinterpreted them. Negative phrasing increases the cognitive load and the risk of double negatives (e.g., a respondent who disagrees with a negative statement actually holds a positive view), which can disrupt the overall integrity of the measured construct. Phrasing questions as direct, positive affirmations (e.g., "I support city policies...") allows respondents to provide more authentic and accurate evaluations of their true feelings.

The questionnaire is structured into two parts to capture the respondent's dual role as citizen and as customer. This dual approach provides a complete view of both the community's license to operate and the actual market demand. We named them as public perception and public adoption.

The first 4 constructs (12 questions) show the survey questions designed after the public perception of all citizens affected by the externalities of the declaration of a U-space. They address the following four constructs: general attitude, institutional trust, mission support and policy support. Using the terminology used by EASA (2021), these construct represent the societal acceptance drivers that determine if the U-space technology and drones as a concept have the community support and the socio-political legitimacy. Policy support and trust apply in general to regulators, which emphasizes the relationship between the technology acceptance and its governance bodies.

General attitude construct holds the most general questions about acceptance. To enhance participant comprehension, we utilize the common terms 'air taxi' and 'drone', relatable and graspable for non-experts. To mitigate the military connotations often linked to 'drone' technology, the global question in this construct explicitly bounds the usage to civilian missions, ensuring that the measured construct remains focused on peaceful applications. Also, by asking about the "UAS technology" in general terms, the survey helps to stabilize the respondent's mental model.

Literature suggests that public acceptance varies significantly based on the specific application (e.g., emergency vs. commercial). The questions the Mission Support construct act as an essential benchmark for social vs. commercial missions, both often yielding higher and more stable acceptance rates to social than to commercial or leisure use.

The following two constructs, Policy Suport and Institutional Trust, present more generic questions than previous constructs about the two types of vehicle, which are not so explicitly mentioned. Trust ensembles organizations such as regulators, UAS operator companies and law enforcement agencies trying to capture the perceptions on how the rules are suitable, the industry behaves accordingly and that the actions against rogue UAS can be neutralize. Policy support includes investment, permissions and support in general.

A person might support the general introduction of drone technology (general attitude) while remaining personally hesitant to fly in an air taxi (intention to use). This group gathers three constructs: intention to use, willingness to pay and, as an optional construct, the automation preferences. While these seems more market oriented constructs, it is important also for the U-space governance board to know the rate of citizens that aim to use the UAS services and their level of enthusiasm. Decisions such as new permissions for operating in the U-space or the update of the geographical borders can be better funded with the responses to the questions of these constructs.

Next questions present the major construct of this group, the intention to use. Two questions explicitly mention the market breaking operations: air taxi and drone delivery. The third question is open to potential new aerial services that U-space may offer, leaving the mind open to respondent's prognosis.

Next 3 questions address the economic dimension of adoption by presenting three items within the willingness to pay construct. Given that UAM services will inevitably be charged to end-users, pricing strategies will fundamentally dictate service affordability across different demographic segments. Rather than soliciting exact numerical values, these items are designed to evaluate the public's readiness to accept a premium fee in exchange for the distinct advantages provided by drone technology, such as increased speed and novel service categories.

The final construct proposes the questions for the construct of automation preference using a simplified language designed to be graspable and relatable for non-experts. To maintain clarity, the items avoid technical jargon on formal automation levels, instead presenting a direct choice between human oversight and full autonomy for the most prominent use cases: air taxis and parcel delivery. Consistent with the 2(+1) framework, a third generalizing item evaluates the broader acceptance towards advancing automation in UAS management. This construct is designated as optional because automation is a transversal trend extending beyond U-space; its inclusion is a strategic decision for the governance board based on their understanding of the local societal context

Survey

The standardised questionnaire for U-space governance, based on the state of the art research, and simplified for an ease and continuous monitoring of citizens opinions is given below.

Conclusions

The provided literature review agrees that all acknowledgeable efforts of regulators in establishing a robust legislation of U-space and of safety agencies in ensuring technical safety of U-space are, alone, insufficient to guarantee their social legitimacy. While industry press for urgent U-space deployment to achieve economic growth, the top-down approaches often overlook the subjective perceptions of the humans exposed to the new landscape. The traditional development, focused only on Technology Readiness Level (TRL), merely answers the technical question will it work, and it does not address another vital question of whether the innovation will address broader, long-term societal concerns. A high technological maturity does not automatically guarantee the necessary public acceptance. Ultimately, the success for the sustainable introduction of UAS into our cities relies on closing the gap between technical progress and societal readiness. It is no longer just about proving they can fly safely, but about demonstrating that they are genuinely beneficial and considerate of local communities.

Acceptance must be actively earned through public listening, community engagement and transparent communication. Ultimately, the public acceptance is highly context-dependent, where the genuine value to the community is particularly recognized for emergency or medical missions. These type of missions serve as the primary driver of adoption. EU projects, such

Construct	Item ID	Survey Question Text
Mission Support	(i)	I am in favour of UAS being utilized for emergency and medical support operations.
Mission Support	(ii)	I am in favour of UAS being utilized for commercial logistics and business operations.
Mission Support	(iii)	I am in favour of integrating UAS as a standard operational tool for public civil missions
General Attitude	(i)	Overall, I feel positive about the introduction of UAS technology in my municipality.
General Attitude	(ii)	I consider air taxis to be a beneficial innovation for society as a whole
General Attitude	(iii)	I consider delivery drones to be a beneficial innovation for society as a whole
Policy Support	(i)	I support local government investment in building dedicated UAS infrastructure (e.g., vertiports)
Policy Support	(ii)	I support city policies that facilitate commercial and emergency UAS to fly over my city
Policy Support	(iii)	I believe public authorities should actively foster and support UAS technological innovation
Institutional Trust	(i)	I trust aviation regulatory authorities to ensure the highest safety standards for UAS flights.
Institutional Trust	(ii)	I am confident that UAS operating companies will respect and safeguard citizen privacy.
Institutional Trust	(iii)	I trust law enforcement agencies to effectively protect society from malicious or rogue UAS
Intention to Use	(i)	I would likely use a passenger air taxi service if offered at a reasonable price
Intention to Use	(ii)	I am willing to select drone delivery options for my routine online retail purchases.
Intention to Use	(iii)	I aim to try innovative aerial services provided by UAS
Willingness to Pay	(i)	I am willing to pay a premium fee to achieve faster delivery times via commercial drones.
Willingness to Pay	(ii)	I am willing to pay extra for rapid urban transit using air taxi passenger services.
Willingness to Pay	(iii)	I am willing to pay additional fees for specialized local aerial services.
Automation preference	(i)	I would likely use a passenger air taxi service if offered at a reasonable price
Automation preference	(ii)	I am willing to select drone delivery options for my routine online retail purchases.
Automation preference	(iii)	I aim to try innovative aerial services provided by UAS

as AiRMOUR, SAFIR-MED, SkyMed, ASSURED UAM, AMU-LED, Uspace4UAM, etc, are clear examples of EU funding used in the correct direction.

This Annex presents a review of surveys, conducted by academy, agencies and industry, to capture the public opinion about U-space and UAS services. Surveys are an important step of the governance framework and provide valuable insights about the maturity level of public in accepting a technology. Build on the questions and constructs found in the reviewed surveys, the Annex ends proposing a short and standardized survey to adopt by U-space governance board to be used in a regular basis on U-space deployments. By adopting a standardized baseline and sharing the exact statements proposed, researchers and governments can generate truly comparable global data. By repeating them periodically, they can also keep historical evolution of public perception and use this assessment on future decisions related with the U-space governance. Ultimately, influencing the SESAR Performance Framework with the adoption of the questions is the final objective of the Annex.

Limitations

This study has its limitations. First, many surveyed papers lack sufficient detail about their scenarios. Most do not provide the complete list of questions used. Second, while selecting questions that show the overall acceptance trend, we oversimplify the nuances that exist across the original survey multiple questions. Lastly, this review focuses solely on quantitative surveys, which means it might overlook the deeper, qualitative insights that focus groups or interviews could provide. Future research should utilize the classification introduced in this study to compare data more effectively, distinguishing between public benefit missions and commercial ones to truly grasp what influences public acceptance.

For all these reasons the results have to be cautiously taken and generalization is too risky. Data are drawn from only a handful of countries, missing insights from regions where drones are already in action, like Australia or various parts of Africa and Latin America. Because of this, it is difficult to determine a single 'global' acceptance rate. Public acceptance is always influenced by local culture, urban design, and specific regulations.

Future research directions

Vertiports and UAS traffic at scale may be a major source of local disruption (noise, privacy, pollution). To minimize negative externalities, the U-space (EU) 2021/664 regulation promotes the inclusiveness principle through its Article 18(f): *Aviation authorities shall coordinate with other authorities and entities, including at local level, for the designation of a U-space airspace, the establishment of airspace restrictions and the determination of the U-space services.* The way this coordination must be achieved requires further work, in particular, on the location of vertiports. Moreover, once a U-space airspace has been deployed, the way the governance boards have to monitor and involve citizens is yet to be defined. The proposed survey needs further work to be tested and validated in one U-space airspace before scaling to others. Moreover, the interpretation of the survey results need to be complemented with the active participation of citizens and their usage in decisions such as the capacity of the airspace, the areas of exclusion and the time schedule allowed for the commercial UAS operations.

Aviation Performance frameworks should be extended to include U-space, so that safety, capacity, efficiency, environmental impact and public acceptance indicators are tracked at system level. Societal Readiness Levels should be used to measure and encourage societal maturity alongside technological readiness, and economic models must be adjusted to integrate U-space and ATM charges into a coherent system without cross-subsidisation.

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References

[1] Ender Çetin, Alicia Cano, Robin Deransy, Sergi Tres, and Cristina Barrado. Implementing mitigations for improving societal acceptance of urban air mobility. *Drones*, 6(2), 2022.

[2] European Commission. ImAFUSA: Impact and capacity assessment framework for u-space societal acceptance. EU Horizon Europe Project Fact Sheet, Grant Agreement ID: 101114776, September 2023. Funded under Horizon Europe (HORIZON-SESAR-2022-DES-ER-01).

[3] Alice Tam. Public perception of unmanned aerial vehicles. Master's thesis, Purdue University, November 2011.

[4] SESAR Joint Undertaking. CORUS-XUAM: Concept of operations for european U-space services – extension for urban air mobility. EU Horizon 2020 Project Fact Sheet, Grant Agreement ID: 101017682, January 2021. Funded under Horizon 2020 / SESAR Joint Undertaking under Grant Agreement No. 101017682.

[5] European Union Aviation Safety Agency (EASA). Study on the societal acceptance of Urban Air Mobility in Europe. Technical report, EASA, May 2021. Prepared by McKinsey & Company.

[6] Reece A Clothier, Dominique A Greer, Duncan G Greer, and Amisha M Mehta. Risk perception and the public acceptance of drones. *Risk analysis*, 35(6):1167–1183, 2015.

[7] J. Soffronoff, P. Piscioneri, and A. Weaver. Public perception of drone delivery in the united states. Technical Report RARC-WP-17-001, U.S. Postal Service Office of Inspector General (RARC), October 2016.

[8] Chantal Lidynia, Ralf Philipsen, and Martina Ziefle. Droning on about drones—acceptance of and perceived barriers to drones in civil usage contexts. In Pamela Savage-Knepshield and Jessie Chen, editors, *Advances in Human Factors in Robots and Unmanned Systems*, volume 499 of *Advances in Intelligent Systems and Computing*, pages 317–329. Springer, Cham, 2017.

[9] Rohit Goyal, Colleen Reiche, Chris Fernando, Jacquie Serrao, Shawn Kimmel, Adam Cohen, and Susan Shaheen. Urban air mobility (UAM) market study: Final report. Technical Report HQ-E-DAA-TN65181 / NASA/CR-20190001472, Booz Allen Hamilton for National Aeronautics and Space Administration (NASA), November 2018.

[10] NATS. Public support for drones in the UK reaches new heights, September 2025.

[11] Pavan Yedavalli and Jessie Mooberry. An assessment of public perception of Urban Air Mobility (UAM). Technical report, Airbus UTM, 2019.

[12] H Eißfeldt, V Vogelpohl, M Stolz, A Papenfuß, M Biella, J Belz, and D Kügler. The acceptance of civil drones in Germany. *CEAS Aeronautical Journal*, 3(11):665–676, 2020.

[13] Lynn Kai Lin Tan, Beng Chong Lim, Guihyun Park, Kin Huat Low, and Victor Chuan Seng Yeo. Public acceptance of drone applications in a highly urbanized environment. *Technology in Society*, 64:101462, 2021.

[14] Sung Woo Park and Yu-Jin Joo. Social acceptability of urban air mobility by aircraft category and autonomous phases. Master's thesis, KDI School of Public Policy and Management, Sejong-si, Republic of Korea, 2021.

[15] Benedikt Kloss and Robin Riedel. Up in the air: How do consumers view advanced air mobility?, 2021.

[16] Rasmus Lundqvist. Aerial uptake Interreg Europe – regional analysis: Comparative summary of regional questionnaire responses. RISE Research Institutes of Sweden, EU Interreg Europe, 2022. pp. 1–109.

[17] Auterion. Drone delivery in the United States: American consumer attitudes on home drone delivery of goods and food. Auterion Survey Report, 2022. Accessed: 2026-09-24.

[18] Maria Stolz and Tim Laudien. Assessing social acceptance of urban air mobility using virtual reality. In *2022 IEEE/AIAA 41st Digital Avionics Systems Conference (DASC)*, pages 1–9. IEEE, 2022.

[19] Zhao Zhang, Chun-Yan Xiao, and Zhi-Guo Zhang. Analysis and empirical study of factors influencing urban residents' acceptance of routine drone deliveries. *Sustainability*, 15(18):13335, 2023.

[20] André Teixeira Silva, Sérgio Pedro Duarte, Sandra Melo, Adriana Witkowska-Konieczny, Michele Giannuzzi, and António Lobo. Attitudes towards urban air mobility for e-commerce deliveries: an exploratory survey comparing european regions. *Aerospace*, 10(6):536, 2023.

[21] Vivian Lotz, Ansgar Kirste, Chantal Lidynia, Eike Stumpf, and Martina Ziefle. User acceptance of urban air mobility (uam) for passenger transport: A choice-based conjoint study. In *International Conference on Human-Computer Interaction*, pages 296–315. Springer, 2023.

[22] Maria Stolz, Anne Papenfuss, Georgia Cesar de Albuquerque Richers, Anna Bahnmüller, Azeem Muhammad Syed, Andreas Gerndt, Martin Fischer, Jan Wegener, Teemu Joonas Lieb, and Marcus Biella. A mixed-method approach to investigate the public acceptance of drones. *CEAS Aeronautical Journal*, 14(4):835–855, 2023.

[23] SNM Yunus and U Techanamurthy. Students' acceptance of drones using the knowledge, attitudes, and practice (kap) model. *Jurnal Kejuruteraan*, 6(2):143–159, 2023.

[24] Muhammad Za'im Sahul Hameed, Rosdiadee Nordin, Aniza Ismail, Muhammad Aidiel Zulkifley, Aina Suraya Helmy Sham, Raja Zahratul Azma Raja Sabudin, Mohamed Afiq Hidayat Zailani, Ismail Mohd Saiboon, and Zaleha Abdullah Mahdy. Acceptance of medical drone technology and its determinant factors among public and healthcare personnel in a malaysian urban environment: knowledge, attitude, and perception. *Frontiers in public health*, 11:1199234, 2023.

[25] Sandra Melo, Flavia Silva, Mohammad Abbasi, Parisa Ahani, and Joaquim Macedo. Public acceptance of the use of drones in city logistics: A citizen-centric perspective. *Sustainability*, 15(3):2621, 2023.

[26] Arinc Tutku Altun, Mehmet Hasanzade, Emre Saldiran, Guney Guner, Mevlut Uzun, Rodolphe Fremond, Yiwen Tang, Prithiviraj Bhundoo, Yu Su, Yan Xu, et al. Amu-led cranfield flight trials for demonstrating the advanced air mobility concept. *Aerospace*, 10(9):775, 2023.

[27] Gabriella Ducaa, Barbara Trinconea, Bartosz Dziugielb, Adam Liberackib, Raffaella Russoa, Vittorio Sangermanoa, and Adriana Witkowska-Konieczny. Urban air mobility in the next future: main findings from a technical survey. *Transportation Research Procedia*, 72:965–972, 2023.

[28] Robin Kellermann, Tobias Biehle, and Hamid Mostofi. Modelling public attitude towards drone delivery in Germany. *European Transport Research Review*, 15(1):38, 2023.

[29] Wing. Beyond the aisle: The 2024 state of grocery shopping and delivery, 2024. `https://static.wing.com/Content/Wing_Sept2024_BeyondTheAisle.pdf`.

[30] Enjian Yao, Dongbo Guo, Shasha Liu, and Junyi Zhang. The role of technology belief, perceived risk and initial trust in users' acceptance of urban air mobility: An empirical case in china. *Multimodal Transportation*, 3(4):100169, 2024.

[31] Virpi Oksman, Minna Kulju, and Vadim Kramar. Exploring the factors influencing public acceptance and intention to use automated drone delivery systems: A trust theory approach. In *2024 AIAA DATC/IEEE 43rd Digital Avionics Systems Conference (DASC)*, pages 1–9. IEEE, 2024.

[32] Ghada Talat Alhothali, Felix T Mavondo, Bader A Alyoubi, and Haneen Algethami. Consumer acceptance of drones for last-mile delivery in jeddah, saudi arabia. *Sustainability*, 16(13):5621, 2024.

[33] Rattawut Vongvit, Kyuho Maeng, and Seul Chan Lee. Effects of trust and customer perceived value on the acceptance of urban air mobility as public transportation. *Travel Behaviour and Society*, 36:100788, 2024.

[34] Cristina Barrado Muxí, Jovana Kuljanin, Esther Salamí San Juan, and Enric Pastor Llorens. Insights of the citizens perception during a 3-days outdoors flight demonstration. In *QuietDrones 2024: Manchester, 8th-11th September 2024*. University of Salford, 2024.

[35] Usman Gohar, Michael C Hunter, Agnieszka Marczak-Czajka, Robyn R Lutz, Myra B Cohen, and Jane Cleland-Huang. Towards engineering fair and equitable software systems for managing low-altitude airspace authorizations. In *Proceedings of the 46th International Conference on Software Engineering: Software Engineering in Society*, pages 177–188, 2024.

[36] S Schmidt and A Saraceni. Consumer acceptance of drone-based technology for last mile delivery, 2023.

[37] Funda Mermertaş and Halil İbrahim Karakan. The future of travel: A study on urban air mobility acceptance. *Suleyman Demirel University Journal of Faculty of Economics & Administrative Sciences*, 29(1):13, 2024.

[38] Hamid Mostofi, Tobias Biehle, Robin Kellermann, and Hans-Liudger Dienel. Modelling public attitude towards air taxis in Germany. *Transportation Research Interdisciplinary Perspectives*, 24:101045, 2024.

[39] Albert End, Carolina Barzantny, Maria Stolz, Paul Grupe, Ruth Schmidt, Anne Papenfuß, and Hinnerk Eißfeldt. Public acceptance of civilian drones and air taxis in germany: A comprehensive overview: A. end et al. *CEAS Aeronautical Journal*, 16(3):745–761, 2025.

[40] Ning Wang, Nico Mutzner, and Karl Blanchet. 'we need time...': An expert survey on societal acceptance of urban drones. *Science and Public Policy*, 52(3):356–374, 2025.

[41] Jingqiong Wu, Ziwei Chen, Zhixian Zhang, and Mingrui Cen. Examining the acceptance of drone delivery services among chinese consumers: A perspective from urban and rural areas. *PLoS One*, 20(9):e0333422, 2025.

[42] Nik Hynek, Beata Gavurova, Matus Kubak, and Michal Senk. Public acceptance of autonomous and remotely piloted drones in civil and military domains: Socioeconomic, political, and safety correlates. *Oeconomia Copernicana*, 16(3):1295–1352, 2025.

[43] Basant Kumar, M Mohammed Mueen Pasha, J Sandeep, P Vijaya, Afaq Ahmed, and Joseph Mani. Blockchain in drone systems: Advancements, security implications and community acceptance. In *AI and IoT: Driving Business Success and sustainability in the Digital Age: Volume 1*, pages 863–872. Springer, 2025.

[44] Doublin city council. Citizen survey report drones, generative ai, digital twins emerging tech, 2025. `https://www.dublincity.ie/sites/default/files/2025-09/your-dublin-your-voice-emerging-technology-survey-results-q3-2025.pdf`.

[45] Xiangyu Li, Anrong Dang, and Maini Chen. Green, safe, and cost-effective? an integrated structural analysis of public acceptance of urban air mobility. *Transport Policy*, page 103795, 2025.

[46] Kyung-A Sun and Joonho Moon. Exploring the existence of moderated mediation of attitudes between privacy risk and the intention to use drone delivery services. *Sustainability*, 17(6):2585, 2025.

[47] Angela Stefania Bergantino, Giulio Fusco, and Mario Intini. Innovating the last mile: Consumer acceptance and economic drivers of drone deliveries in urban logistics. *Research in Transportation Business & Management*, 63:101510, 2025.

[48] Fitri Trapsilawati, Trusti Hapsari, Iqbal Fikri, Muhammad Addinul Haniv, Widya Sari, and Zainal Arifin Harahap. Demographics, technology acceptance, and willingness to pay: a pilot study on urban air mobility adoption in indonesia. *Sustainable Futures*, 9:100777, 2025.

[49] Vaishnavi Upadrasta, Rodney Leitner, Astrid Oehme, and Harald Kolrep. Public acceptance of civil drones in light of their purpose. *Transportation Research Procedia*, 88:201–208, 2025.

[50] Frank Badu-Baiden, Weisheng Chiu, Eudora Hagan, and Victor Anderson Hodibert. Unmanned deliveries: A complexity theory approach to understand consumer acceptance and intention in drone food delivery in africa. *International Journal of Hospitality Management*, 130:104234, 2025.

[51] Svantje T Kähler, Miriam Tomat, Aquiles Luna-Rodriguez, and Thomas Jacobsen. Assessing the acceptance and aesthetics of unmanned aerial vehicles (drones): An experimental and survey-based comparison between students and older adults. *Transportation Research Interdisciplinary Perspectives*, 32:101497, 2025.

[52] Nidia Chahua-Huaqui, Shyla Del-Aguila-Arcentales, Juana Quispe-Presentación, and Ana Ruiz-Cordero. Innovation of food delivery: Acceptance of drone use among consumers in peru based on tam and brt. *Sustainable Futures*, 10:101038, 2025.

[53] Sangen Hu, Zikang Huang, Ke Wang, Haiyuan Lin, and Mingyang Pei. Modeling the adoption of urban air mobility based on technology acceptance and risk perception theories: A case study on flying cars. *Multimodal Transportation*, 4(2):100200, 2025.

[54] Maria Stolz, Michaela Rehm, Anne Papenfuß, Fabian Utesch, Franziska Dunkel, Frank Baumgarten, and Martin Fischer. See it, hear it, feel it: an explorative virtual reality study to identify factors determining public acceptance of drones in different city environments. *CEAS Aeronautical Journal*, 16(1):119–139, 2025.

[55] Diletta Alparone, Jaroslaw Kantorowicz, and Graig R Klein. Comparative public attitudes about drone strikes: Survey experiments in italy, poland, and germany. *Foreign Policy Analysis*, 21(2):oraf003, 2025.

[56] Hisham O Khogali and Samir Mekid. Intricate and multifaceted socio-ethical dilemmas facing the development of drone technology: A qualitative exploration. *AI*, 6(7):155, 2025.

[57] Junmin Lee, Harin Chae, Woojin Bang, Daeho Lee, Myoungjin Oh, Jungwoo Shin, and Keungoui Kim. Understanding consumer preferences for urban air mobility: A choice-based conjoint analysis approach with the case of south korea. *Travel Behaviour and Society*, 43:101236, 2026.

[58] Woojae Kim, Hyeonjun Jin, and Kyuho Maeng. Facilitating sustainable urban air mobility: Social influence and human oversight. *Transportation Research Part D: Transport and Environment*, 157:105411, 2026.

[59] Yan Teo, Tay TR Koo, Rockie U Kei Kuok, Matthew Dunn, and Kadek Sumaja. Public acceptance of remotely piloted aircraft (rpa) operations in sydney harbour. *Drones*, 10(1):19, 2025.

[60] Aviant. Dronelevering av mat testet i Ski, 2026.

[61] Anna Palaiologk, Mahdi Gholami, and Nikoleta Krousouloudi. Pricing the sky: Analysing real-world demand for U-space services: A data-driven market viability analysis for future U-space business models. White paper, Future Needs Management Consulting Ltd., May 2026. BURDI Project, Horizon Europe Grant Agreement No. 101079693.

[62] Kaihan Zhang, Xiang Liu, Qinyu Cui, Xing Gao, Mengqiu Cao, and Inhi Kim. Social-psychological determinants and nonlinear thresholds: behavioral insights into urban air mobility adoption as an airport shuttle. *Transportation Research Part A: Policy and Practice*, 205:104856, 2026.

[63] Miles M. Legere. Meta-analysis of public acceptance of unmanned aircraft systems in the united states. Graduate capstone project, Embry-Riddle Aeronautical University, July 2019.

[64] Didem Cicek, Burak Kantarci, and Sandra Schillo. A comparative review of user acceptance factors for drones and sidewalk robots in autonomous last mile delivery. *Green Energy and Intelligent Transportation*, 4(4):100310, 2025.

[65] Jingyu Huang, Amjad Pervez, Xingda Qu, and Tingru Zhang. Flying into the future: A systematic review and meta-analysis of urban air mobility acceptance and its determinants. *Transportation Research Part A: Policy and Practice*, 213:105–198, 2026.

[66] Lucy Mascarenhas and Patrick van Egmond. Enabling sustainable air mobility in urban contexts via emergency and medical services. Technical report, AiMOUR Project, 2022. Accessed: 2026-09-18.

[67] Auterion. Drone delivery in the united states: American consumer attitudes on home drone delivery of goods and food. Technical report, Auterion, July 2022.

[68] Stav Shapira and Jessica R Cauchard. Integrating drones in response to public health emergencies: A combined framework to explore technology acceptance. *Frontiers in public health*, 10:1019626, 2022.

[69] Millene Gomes Araujo1, Cristina Barrado, Francesca Starita, and Francesca De Crescenzio. Assessing pedestrian perceptions on drone operations in urban environments using virtual reality: the effects of mission transparency on acceptance. *CEAS Aeronautical Journal*, in revision:48, 2026.