U-space Implementation Handbook

U-ELCOME

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Co-funded by the European Union

D4.1 U-space implementation Handbook

Deliverable ID:	**D4.1**
Project Acronym:	**U-ELCOME**
Grant:	**101079171**
Call:	**CEF-T-2021-SIMOBGEN**
Topic:	**CEF-T-2021-SIMOBGEN-SESAR-DSDU-WORKS**
Consortium Coordinator:	**EUROCONTROL**
Edition date:	**04 November 2025**
Edition:	**01.01**
Status:	**Final**
Classification:	**[PU]**

Abstract

To ensure the successful implementation of U-space, collaboration among all stakeholders is paramount. With this goal in mind, we present this handbook as an essential resource. This handbook contains lessons learnt, recommendations and conclusions about the process of implementing initial U-space services to help future implementers based on the findings of the contributors. This document is not intended to be a maxim nor to replace any regulatory document but rather be a support considering all the valuable experience gathered from the contributors inside and outside the U-ELCOME project.

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TopView	31/07/2025
DLR	31/07/2025
PILDO	31/07/2025
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DSNA	31/07/2025
ANRA	31/07/2025
ITG	31/07/2025
UPV	31/07/2025
ENAV	31/07/2025
D-FLIGHT	31/07/2025
PANSA	31/07/2025
PILDO	31/07/2025
IDS-AIRNAV	31/07/2025
PT. FUERTEVENTURA	31/07/2025
INECO	31/07/2025
TopView	31/07/2025
NIMBUS	31/07/2025
NAIS	31/07/2025
EUROSC-ITALIA	31/07/2025
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TELESPAZIO	31/07/2025
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TELESPAZIO SPA	31/07/2025
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EUROUSC ITALIA	31/07/2025
NAIS	31/07/2025
TOPVOEW SRL	31/07/2025
TECHNO SKY	31/07/2025
IDS AIRNAV	31/07/2025
DRONUS SPA	31/07/2025
NIMBUS SRL	31/07/2025
SEA	31/07/2025
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DSNA	31/07/2025
ANRA	31/07/2025
PANSA	31/07/2025
CPR S INVEST	31/07/2025
AEROCAMARAS	31/07/2025

Rejected by[2]

Company Name	Date

Document History

Edition	Date	Status	Company Author	Justification
00.01	30/04/2024	Draft	EUROCONTROL	Initial Draft
00.02	03/05/2024	Draft	EUROCONTROL	Draft after review
00.03	18/10/2024	Draft	EUROCONTROL	Second draft after review
01.00	31/07/2025	Final	EUROCONTROL	Final document
01.01	04/11/2025	Final (Revised)	EUROCONTROL	Final document after revision

[2] Representatives of beneficiaries involved in the project

Copyright Statement

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This document is part of a project that has received funding from the Connecting Europe Facility programme under grant agreement No 101079171 under CINEA.

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This document is a guide for U-space implementation and has been synthesized from experience reports and insights gathered during the U-ELCOME project. The U-ELCOME project gratefully acknowledges the contributions of the BURDI and ÉALÚ-AER projects as well as many other contributions. The content herein reflects the experiences of contributors and while it can never be regarded as definitive, inputs have been many and the authors know of no more comprehensive work.

It is important to mention that in no case is this document intended to be a maxim nor is it intended to replace any regulatory document but rather be a support considering all the valuable experience gathered from the contributors. Similarly, this implementation guidance is not a formal description of any SESAR Solution, but a combination of inputs from different SESAR solutions aiming to implement U-space throughout Europe.

1 Introduction

In recent years, Europe has made significant progress in the development of U-space. This progress has been driven by the applicability of the U-space regulatory framework (Commission Implementing Regulations (EU) 2021/664 [1], (EU) 2021/665 [2] and (EU) 2021/666 [3] in 2023, the valuable outcomes of multiple projects and the initial steps taken by stakeholders towards U-space implementation in accordance with the Acceptable Means of Compliance and Guidance Material to Regulation (EU) 2021/664 [4]. However, many challenges remain to bridge the gap between regulation and research, and practical deployment, which will only be possible with the close collaboration of all the involved stakeholder.

The U-ELCOME project, one of three European Digital Sky Demonstrators (DSDs) running from 2022 to 2025, alongside BURDI and ÉALÚ-AER, stands out as a major contributor to this effort. With 51 partners across France, Italy, and Spain, U-ELCOME brings together diverse expertise and stakeholders, positioning itself as a key driver for harmonisation and foundational deployment of U-space across Europe.

The Belgium-Netherlands U-space Reference Design Implementation (BURDI) project aims to implement a U-space airspace concept able to manage various, dense and complex UAS operations in controlled, uncontrolled and UAM environment. The project also focuses on ensuring that the implemented solutions are economically sustainable and socially accepted for the benefit of society.

In Ireland, ÉALÚ-AER aims to integrate and showcase advanced U-space and eVTOL technologies. The project demonstrates the feasibility and efficiency of eVTOL transport services and fosters the development of autonomous software and U-space systems for innovative air mobility. It integrates a comprehensive U-space technology platform, including communication, control, and radar systems, and executes multiple use cases to validate U-space operations and future services like detect and avoid.

One of the main objectives of these three Digital Sky Demonstrators is to act as a reference for the operational deployment of U-space across Europe. U-ELCOME specifically contributes to this goal by providing guidelines that allow future implementers to build on the experience gained throughout the projects. This handbook supports this goal by collecting and sharing collective experience and insights to guide U-space deployment. By publishing this document, U-ELCOME aims to lay the groundwork for enhanced information sharing and the successful, coordinated deployment of U-space in Europe.

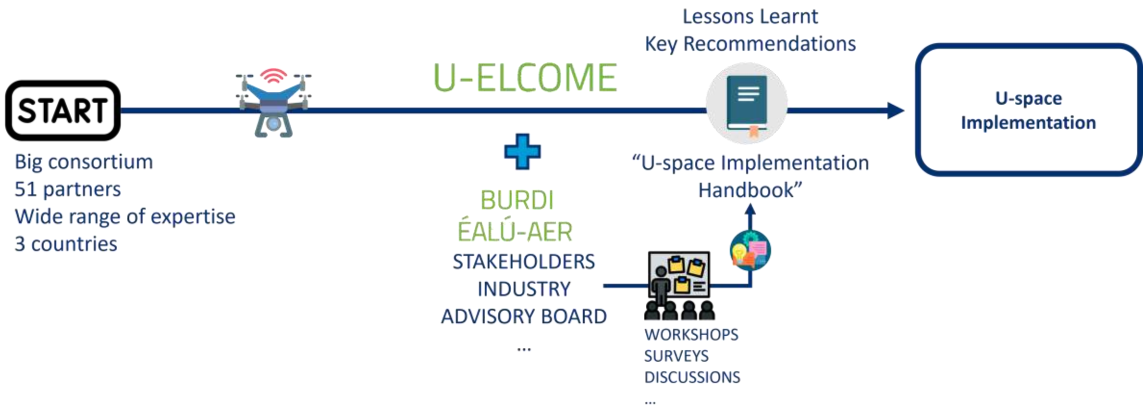

Figure 1. U-space implementation handbook in context

1.1 What is U-space?

The concept U-space refers to a set of services relying on a high level of digitalisation and automation of functions and specific procedures designed to support safe, efficient and secure access to airspace for large numbers of drones. As such, U-space is an enabling framework designed to facilitate any kind of routine mission, in all classes of airspace and all types of environments, even the most congested, while addressing an appropriate interface with manned aviation and air traffic control.

1.1.1 The history of U-space

The term U-space was coined in 2017 by then European Union commissioner of transport Violetta Bulc. The reason for U has never been given but suggests both UAS and "You" as in "Your space" with the implication that the new aviation paradigm would have a lower barrier to entry. U-space grew out of a series of political conferences, technical publications, research projects, consultation papers from EASA and EU regulations. A comprehensive, though not exhaustive, list is presented below:

- 2015: Riga declaration on remotely piloted aircraft (drones) "Framing the future of aviation" [5].
- 2015: EASA Notice of Proposed Amendment (NPA) 2015-10 "Introduction of a regulatory framework for the operation of drones " [6].
- 2016: SESAR Drones Outlook Study [7].
- 2016: Warsaw declaration for unmanned aerial vehicles, adopted at the end of "Drones as a source of jobs and growth" conference [8].
- 2017: SESAR launches 10 research projects on UAS traffic management including the CORUS project to write a concept of operations for European UAS Traffic Management
- 2017: Helsinki declaration on drones. First use of "U-space" [9].
- 2017: U-space Blueprint [10] proposes 4 U-levels
- 2017: EASA NPA 2017-5 " Introduction of a regulatory framework for the operation of drones" under Rule Making Task (RMT) 0230 [11].
- 2018: Regulation 2018/1139 of common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91 [12].
- 2018: EASA Opinion 01-2018 "Introduction of a regulatory framework for the operation of unmanned aircraft systems in the 'open' and 'specific' categories" [13].
- 2018: SESAR "Roadmap for the safe integration of drones into all classes of airspace" [14] names the services in the first three U-levels.
- 2018: SESAR launches 9 demonstrations of U-space technology including DOMUS (Spain) and DIODE (Italy).
- 2019: EU regulations "Commission implementing regulation (EU) 2019/947 of 24 May 2019 on the rules and procedures for the operation of unmanned aircraft" [15] and "Commission delegated regulation (EU) 2019/945 of 12 March 2019 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems" [16].
- 2019: U-space concept of operations (ConOps) third edition published by CORUS project (SESAR) [17].

- 2020: EASA Opinion 01-2020 "High-level regulatory framework for the U-space" under RMT 0230 [18]
- 2021: EU publishes regulations 2021-664, 665 and 666 with date of effect 26 January 2023.
    - "Commission implementing regulation (EU) 2021/664 of 22 April 2021 on a regulatory framework for the U-space" [1]
    - "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" [2]
    - "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 " [3]
- 2022: EASA publish "Acceptable Means of Compliance and Guidance Material to EU Regulations 2021/664, 2021/665 and 2021/666 " [19]
- 2023: U-space regulatory package becomes applicable on 26 January, and some EU Member States start to perform Airspace Risk Assessment (ARA) processes to designate U-space airspaces.
- 2023: U-space ConOps and architecture (edition 4) [20]
- 2024: EASA announces the development of a Notice of Proposed Amendment (NPA) related to RMT[3] 0748 from Q2 2024.
- 2026 onwards: Updates of AMC and GM to Regulations (EU) 2021/664, 2021/665 and 2021/666 are expected

The applicability of the EU regulatory framework for U-space on January 26th, 2023, marked a turning point for U-space after years of research and demonstrations. Seven services are described in the regulation:

- Common information
- Network identification
- Geo-awareness
- UAS flight authorisation
- Traffic information
- Weather information
- Conformance monitoring

These services are further explained in the Acceptable Means of Compliance and Guidance Material (AMC/GM) for EU IR 2021/664.

[3] Rulemaking Task (RMT) 0748 is assigned for the regular update of the U-space regulatory framework, Commission Implementing Regulation (EU) 2021/664 (U-space), Commission Implementing Regulation (EU) 2021/665 (Part-ATS), Commission Implementing Regulation (EU) 2021/666 (Rules of the air), and related AMC/GM.

1.1.2 U-space services

The U-space Blueprint stated that "U-space is a set of services". The services were divided into four levels. These four levels of services represent the different levels of automation and connectivity.

- **U1**: U-space foundation services covering registration, identification and geofencing (as part of Geo-awareness).
- **U2**: U-space initial services for drone operations management, including flight planning, flight approval, tracking, and interfacing with conventional air traffic control.
- **U3**: U-space advanced services supporting more complex operations in dense areas such as assistance for conflict detection and automated detect and avoid functionalities.
- **U4**: U-space full services, offering very high levels of automation, connectivity and digitalisation for both the drone and the U-space system.

The "Roadmap for the safe integration of drones into all classes of airspace" document named the services and complemented these with the expected capabilities of the aircraft. The U-space ConOps was built starting with the services of the Roadmap document. The CORUS project iteratively produced ConOps Editions 1, 2 and 3. Edition 4 was produced by the CORUS-XUAM project and published in 2023. Due to the depth of study required to produce the ConOps, it contains a modified list of services relative to the Roadmap. The ConOps puts the services into the context of different airspaces where they will be used.

Following the publication of the U-space Concept of Operations (ConOps) v2, the European Union introduced a regulatory framework composed of Implementing Regulations (EU) 2021/664, 2021/665, and 2021/666, which came into force to govern operations within U-space airspace. These regulations provide the legal basis for integrating unmanned aircraft (UAS) into the European airspace in a safe manner.

One of the key elements introduced by this framework is a set of four mandatory U-space services. In addition to these, the regulation also describes two optional supplementary services, which may be implemented depending on the operational context and national requirements. In the following table, these services are presented:

U-space service	Mandatory/Optional	Article
Network Identification Service	Mandatory	Article 8 of Commission Implementing Regulation (EU) 2021/664
Geo-awareness Service	Mandatory	Article 9 of Commission Implementing Regulation (EU) 2021/664
UAS flight Authorisation Service	Mandatory	Article 10 of Commission Implementing Regulation (EU) 2021/664

Traffic Information Service	Mandatory	Article 11 of Commission Implementing Regulation (EU) 2021/664
Weather Information Service	Optional	Article 12 of Commission Implementing Regulation (EU) 2021/664
Conformance Monitoring Service	Optional	Article 13 of Commission Implementing Regulation (EU) 2021/664

Table 1. U-space services described in Regulation (EU) 2021/664

These services, together with the functionalities described in Regulation (EU) 2019/947 that are essential for the safe operation of UAS, cover many of the functionalities initially defined in U-space phases U1 and U2.

1.1.3 U-space airspace

U-space airspace means a UAS geographical zone designated by Member States where UAS operations are only allowed to take place with the support of U-space services. 'UAS geographical zone', as stated in EU Regulation 947/2019, means 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. Member States have complete and exclusive sovereignty over the airspace above their territory and, therefore, have full authority over the designation of the U-space airspace.

1.2 What is the U-space implementation handbook?

A handbook is defined as a book that contains instructions or advice on how to do something, or the most important and useful information about a subject. In this line, the "U-space implementation handbook" compiles experience gained within and outside the U-ELCOME project to help stakeholders implement U-space services and operate them safely within U-space airspace. This document provides a clear theoretical and regulatory foundation, along with practical knowledge from the U-ELCOME project, other DSDs, and real-life experiences.

It contains lessons learnt and recommendations to support the U-space implementation process as well as appendices with detailed information on specific topics and a practical table showing the different solutions on key topics implemented by participants.

The handbook provides the knowledge needed to better understand and address the challenges of U-space implementation, combining theoretical principles with practical examples.

1.3 What is the scope of this handbook?

The scope of this handbook is the deployment of U-space services as defined in the Regulation (EU) 2021/664, along with essential complementary services U1 and U2 services within a designated U-space airspace. It also addresses the use of data exchange services to support the safe and efficient operation of UAS within U-space airspace, where both drones and electronically conspicuous manned aircraft may be present.

Due to the advanced level of system deployment at the beginning of the project, and considering that this development was therefore beyond its scope, this handbook does not address detailed technical aspects of system engineering. Instead, it focuses on providing practical guidance relevant to the deployment and operation of U-space services, while also incorporating some insights on system integration.

Before continuing, it is important to define the terms Lesson learnt and recommendation as they are essential terms in this document.

Lesson learnt: "Experience drawn from past activities that should be actively taken into account in future actions and behaviours."

Recommendation: "Advice about what is the best thing to have or do". Recommendations are suggestions that, while valuable, do not yet have the level of maturity, consensus, or supporting evidence required to be considered best practices. They often serve as guidance for improvement or input for future development.

Lessons Learnt and recommendations are categorised in eight categories: Standardisation, Regulation, Authorities and Responsibilities, ARA (Airspace Risk Assessment), Systems, Services and CNS.

1.4 Intended audience

The intention of this handbook is to be a guide for all the stakeholders involved in the U-space implementation, which might include:

- Competent Authority (NSA, CAA)
- ANSP
- CISP
- USSPs
- USS or CIS solutions providers
- UAS operators
- UAS/GCS developers/manufacturers
- Local authorities (townhalls, city councils, police, etc.)
- UAS training organisations
- Research organisations

1.5 How has this handbook been built?

This handbook has evolved during the progress of the project. The process of building this document consists of different mechanisms:

- Periodical meetings with clusters to monitor the progress of the validation and gather lessons learnt.

- Periodical meetings with the other DSDs, BURDI and ÉALÚ-AER, to maintain a unified approach and promote the harmonisation in the deployment of U-space.

- Workshops conducted by U-ELCOME to facilitate discussions on project learnings and gather insights and feedback from external stakeholders.

- Meetings with the Advisory Board.
- Any additional contributions aligned with the handbook's scope.

1.6 How to navigate this handbook?

This document has been developed in such a way that the readers can easily follow it and find the information that is useful to themselves. Hereunder, the sections and the content of each of them are presented:

Section 1, this section, contains the introduction and the basic concepts to understand the U-space ecosystems and the handbook structure. This includes a description of what is U-space, what are U-space services and what is a U-space airspace.

Section 2 is an overview of the U-space framework including regulation and standards, roles and responsibilities and a high-level overview of the level of U-space implementation nowadays.

Section 3 encompasses the main piece of this document. It contains an indicative timeline of the deployment of U-space in the European Union under the Regulation (EU) 2021/664, 2021/665 and 2021/666. In addition, generic information about the implementation of U-space is included together with references to the lessons learnt and recommendations included in **Section 4.** This section is intended to be a detailed but non-exhaustive guide about the U-space implementation process. For more detailed and precise information, it is necessary to consult the regulations and documents referred to throughout the section.

Note: Each section includes links to the relevant table, if the entire table is applicable, as well as to the corresponding Lessons Learnt and Recommendations in Section 4.

Section 4 contains the lessons learnt and recommendations gathered during the project inside and outside the project.

Section 5 contains a summary as key recommendations for U-space implementation based on the content and inputs of the document.

Section 6 contains conclusions and open questions for further development.

Finally, **Section 7** and **Section 8** include references and acronyms.

The **Appendices** provide more detailed and technical information on the topics covered in the document such as architecture, transition to U-space operations, coordination mechanism as part of the ARA, among others.

The **Annexes** contain relevant information on subjects explored in other SESAR projects.

2 U-space framework

This section offers a comprehensive overview of the current U-space landscape. The current state of deployment of these U-space services varies from country to country, as the adoption of U-space is an evolving process. These services are expected to be implemented in phases according to the level of maturity of the technology and regulation. In the following sections, this document provides an overview of the rules and regulations that concern them. In addition, the last sub-section will delve into the different roles and responsibilities of the stakeholders involved in this development.

2.1 Regulation and Standards

This section outlines the key regulations, standards, and supporting documents that govern the UAS operations and, mainly, the deployment of U-space. The following table presents the main references guiding implementation in Digital Sky Demonstrator (DSD) projects in Europe.

Document type	Title	Description
Regulation	Commission Implementing Regulation (EU) 2017/373 of 1 March 2017 [22]	Common requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight, repealing Regulation (EC) No 482/2008, Implementing Regulations (EU) No 1034/2011, (EU) No 1035/2011 and (EU) 2016/1377 and amending Regulation (EU) No 677/2011
Regulation	Commission Implementing Regulation (EU) 2019/947 of 24 May 2019 [15]	Rules and procedures for the operation of unmanned aircraft
Regulation	Commission Implementing Regulation (EU) 2019/945 of 24 May 2019 [16]	Unmanned aircraft systems and on third-country operators of unmanned aircraft systems
Regulation	Commission Implementing Regulation (EU) 2021/664 of 22 April 2021 [1]	Regulatory framework for the U-space
Regulation	Commission Implementing Regulation (EU) 2021/665 of 22 April 2021 [2]	Amend 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
Regulation	Commission Implementing Regulation (EU) 2021/666 of 22 April 2021 [3]	Amend Regulation (EU) No 923/2012 as regards requirements for manned aviation operating in U-space airspace
AMC/GM	Acceptable Means of Compliance and Guidance	Non-binding detailed explanations and practical guidance supporting the implementation of Regulation

	Material to Regulation (EU) 2021/664 on a regulatory framework for the U-space [4]	(EU) 2021/664, facilitating compliance and consistent application of U-space requirements across the EU
AMC/GM	Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Regulation (EU) 2019/947[19]	Non-binding detailed guidance and acceptable methods to comply with Regulation (EU) 2019/947, supporting safe and consistent UAS operations
EUROCAE standard	ED-269 "Minimum Operational Performance Standard for UAS Geo-Fencing"	Minimum Operational Performance Standards for the Geofencing function of Unmanned Aircraft Systems.
EUROCAE standard	EUROCAE ED-269A Change 1 “Minimum Operational Performance Standard for UAS Geofencing”.	Minimum Operational Performance Standards for the Geofencing function of Unmanned Aircraft Systems
EUROCAE standard	ED-318 “Technical specification for geographical zones and U-space data provision and exchange” [24]	Technical specification for geographical zones and U-space data provision and exchange
ASTM standard	ASTM F3411-22a Standard Specification for Remote ID and Tracking [23]	This specification covers the performance requirements for remote identification (Remote ID) of unmanned aircraft systems (UAS)
ASTM standard	ASTM F3548 Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability [25]	This specification is intended to be used by USS developers, CAAs, and others to assess USS conformance with this UTM specification

Table 2. Regulation and Standards

For more information about Regulation and Standards, see Table 7. STAND Lessons Learnt and Recommendations and Table 8. REG Lessons Learnt and Recommendations in Section 4 Lessons Learnt and Recommendations

2.2 Roles and responsibilities

This section aims to introduce the different roles of those involved in U-space. Section 7.3 of the U-space ConOps and architecture (edition 4), published by the CORUS-XUAM project, is taken as a reference, and is complemented with relevant regulatory sources. This document is focused on the scope of Regulations (EU) 2021/664, 2021/665, and 2021/666 and therefore does not cover any autonomous or crewed vehicles outside the UAS categories defined in these regulations.

To present these roles and responsibilities in a visual way, the following table is proposed.

Role	Responsibility
UAS operator	The legal entity performing one or more UAS operations who/which is accountable for them.
U-space Service Provider (USSP)	Provides the U-space services required in the U-space airspace as listed in the U-space regulation. Must be certified in accordance with the U-space regulation 2021/664
Providers of Common Information	Entities/organisations that provide part of the common information. It is not necessarily a provider of common information services.
Common Information Service Provider (CISP)	A Provider of Common Information Services or Common Information Service Provider (CISP) is a provider of common information services defined by regulation 2021/664 Article 5, considering the designation of one or several U-space airspace(s).
Single Common Information Service Provider (s-CISP)	Member States may decide to designate a dedicated entity to provide CIS on an exclusive basis in one or several designated U-space airspaces. It is, then, a certified organisation that ensures the interface and exchange between the 'providers of common information' and the USSPs. There is one 'single CIS provider' per U-space airspace.
Air Traffic Service Provider (ATSP)	Provider of air traffic services to airspace users. It can be ATS Aerodrome or ATS Approach service provider.
UAS manufacturer	Interested in aircraft and equipment certification processes. The UAS manufacturer or representative may have a role in U-space registration, for example as the provider of UAS characteristics and serial numbers.
CNS Service Providers (CNS)	Provider of Communication, Navigation or Surveillance services.
Aeronautical Information Service Provider (AISP)	Provider of a service established within the defined area of coverage responsible for the provision of aeronautical information/data necessary for the safety, regularity and efficiency of air navigation. It has the task of producing the Aeronautical Information Publication, a collection of data describing the geography and procedures of for flying in a given country.
(Airfield/Airport) Aerodrome operator (civil, Military)	The aerodrome operator is distinct from the ANSP and has business concerns and legal responsibilities which make them interested in/concerned by UAS flight and U-space procedures.
Vertiport operator	Provide services at a vertiport. Service provision might vary between vertiport for private use and public use. It encompasses passenger and Cargo transport. This one operates the facility in a safe and efficient manner including the scheduling of arrivals and departures as well as supplying U-space with information about the aerodrome's status and capacity to accommodate incoming aircraft.

Competent Authority	Generic term to encompass national or local civil aviation authority, or some entity delegated by them. Actions: Registration, safety performance oversight and monitoring, authorised air situation viewer, airspace access authorisation, workflow representative, capacity authority.
Authority for safety and security (police, fire brigade, search and rescue orgs)	Authorities involved in preparation and supervision of the operations of law enforcement such as police, security, military, homeland security that are responsible for law enforcement methods.
Emergency Responders	Organisations involved in preparation and execution of emergency operations such as fire brigade, emergency, first aid, Search and Rescue (SAR).
Local and specific authorities	City / region / prefecture / county / canton / state - support the definition of operating procedures and rules.
U-space Coordinator	(Defined in the Guidance Material to EU IR 2021/664) The U-space coordinator coordinates the Local and Specific Authorities.
Airspace User (other than UAS/UAM)	Include scheduled airlines, charter companies, cargo and air freight service providers, the business and leisure aviation sectors and all forms of non-military air travel, from hot air balloons through police helicopters to general aviation pilots. (Pilot, Authorised viewer of air situation)
General Public	Representing those who may hear, see or otherwise be concerned by a UAS (Citizen, Authorised viewer of air situation)

Table 3. Roles and responsibilities in U-space

2.3 Level of implementation

Significant progress has been made in recent years regarding U-space in terms of the readiness of the required technology and the regulatory frameworks. After the EU U-space Regulation becoming applicable in January 2023, European countries have started or accelerated the process for the deployment of U-space. These initiatives are focused on different key areas such as the designation of U-space airspaces, the certification of both single Common Information Service Providers (CISPs) and U-space Service Providers (USSPs) or the definition or update of a national strategy towards U-space, among others.

USSP and single CISP certification processes are critical to establishing a secure ecosystem, ensuring that safety, security and operational standards are met. This progress is currently driven by collaborative efforts of national aviation authorities and companies together with EASA, who are working on the first certifications. At the date of publication of this document, an initial batch of USSPs and CISPs has been already certified by the competent authorities. In parallel to these efforts, collaborative work is underway to lay the groundwork for a more efficient and standardised certification process that will benefit future developers.

At national level, many countries have also developed or are in the process of refining their U-space strategies, aligning them with the objectives and results of the European projects carried out in recent years. These strategies involve coordinated efforts between national aviation authorities, air navigation service providers (ANSPs) and industry stakeholders to create frameworks that support the safe integration of the drones in the airspace.

As the U-ELCOME project draws to a close, although the pace of implementation varies across countries in the EU, the overall trajectory shows a strong effort to harmonise drone operations in the airspace, ensuring scalability and safety as the technology evolves. Reports regarding the level of implementation are published by EASA, Eurocontrol [21] and other international organisations every so often. The information depicted in this document represents the current reality and we invite the reader to check these reports in order to have an updated picture of de implementation.

3 U-space Implementation process

The U-space implementation involves a set of procedures and frameworks established to safely integrate drones into the airspace using U-space airspace and digital services. Currently, with the regulation in force, U-space is in its early stages of deployment. The European Digital Sky Demonstrators (DSDs), among which are U-ELCOME, BURDI and ÉALÚ-AER, together with other European initiatives aim to bridge the gap between industrial research and industrialisation, and to accelerate market uptake. There are many phases and parts involved in the U-space implementation process. Throughout this section, the most important ones will be introduced as well as the lessons learnt, and recommendations linked to each of these phases of implementation.

Figure 2. U-space implementation process

As stated above, this section is intended to be a detailed but non-exhaustive guide about the U-space implementation process, combining regulatory and theoretical frameworks with practical insights gained by the contributors during the implementation journey. For more detailed and precise information, readers are encouraged to refer to the official regulations and documents referred throughout the section.

3.1 Competent authorities and coordination mechanism

Throughout the U-space implementation journey, various competent authorities will be assigned specific functions. As outlined in the Article 18 of the Commission Implementing Regulation 2021/664, the designated competent authorities will oversee crucial activities for the implementation of U-space such as determining traffic data requirements, coordinating U-space airspace designations and restrictions, and ensuring safety performance monitoring. These competent authorities should ensure the allocation of clear roles and responsibilities for the implementation of the coordination mechanism so that the interests of all U-space actors are well represented and managed in a non-discriminatory manner. More information could be found in **Appendix E Coordination mechanism.**

The coordination mechanism established by the competent authority should be managed by the nominated national U-space coordinator and should address the planning, execution and review phase.

- Planning phase: during this phase, Member States set all the mechanisms necessary for the designation of U-space airspaces, such as:
    - The procedure for the U-space airspaces designation, including governance, and procedures for identifying U-space airspaces needs and request the establishment of a U-space airspace.

- The accountabilities and responsibilities for the U-space airspace management once it is operational.
- Establishment of a multi-stakeholder collaborative set-up referred to as "U-space observatory", and the U-space Coordinator. Please note that both may be established at a local, regional or national level to deal with the multilevel governance required.
- Establishment of indicators/KPIs or metrics (covering aviation performance, safety metrics, and sustainable urban mobility).

- Execution phase: this phase consists of the day-to-day management of the designated U-space airspaces and should enable any modification of such U-space airspace due to any ground/urban life incident affecting such U-space airspace. Such changes of the U-space airspace design may be temporary or dynamic, therefore several different stakeholders may be necessary to be involved, either directly or indirectly in the coordination mechanisms during this phase.
- Review phase: this phase is aimed to gather all lessons learnt from U-space stakeholders' feedback, in order to improve U-space deployment. To this end, during this phase the U-space coordinator should present the monitoring of the KPIs defined during the planning phase, including evidence from and experience from the execution phase to assess the suitability of U-space airspace design, as well as its coordination mechanisms, suitability to fit all U-space ecosystem stakeholders' needs. It is recommended that, as part of the coordination mechanism, the frequency to carry out such assessment of the U-space airspace, as well as the means to report any incident or need related to U-space are clearly defined.

At this level of implementation, it might happen that the local governments of the Member States do not have enough awareness about U-space yet, making it more difficult the decision to start the procedure to designate a U-space airspace. In this case, the national U-space coordinator should take the initiative and propose a specific location to designate a U-space airspace while at the same time stablish mechanisms to show the benefits of U-space enhancing its visibility for others that might be interested.

On the other hand, during the planning phase, it should be considered that the location of the U-space airspace can have a significant impact on safety and operational capacity. Factors such as proximity to controlled areas (e.g., CTR) or areas with high air traffic density must be carefully evaluated, as they influence the complexity of integration and the ARA, as will be discussed in detail in section 3.2.2.

More details about the responsibilities of the authorities could be found in the Regulation (EU) 2021/664.

For more information about the experience regarding competent authorities, see RECO.AUT 4 RECO.AUT 5 in Section 4 Lessons Learnt and Recommendations

3.2 Designation of U-space airspace

U-space airspace means a UAS geographical zone designated by Member States where UAS operations are only allowed to take place with the support of U-space services. 'UAS geographical zone', as stated in Regulation (EU) 2019/947, means 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. Member States have complete and exclusive sovereignty over the airspace above their territory and, therefore, have full authority over the designation of the U-space airspace.

The decision to designate a U-space airspace could respond to different reasons such as safety, security, privacy or environment. This demand or need serves as a trigger to initiate the designation process, which generally follows one of two approaches:

- Top-down: the Member State (any authority) is the one with the initiative, and they trigger the ARA to designate U-space airspaces where/when they consider.

- Bottom-up: the initiative is on the stakeholders (e.g. UAS operators, service providers) to provide a case to the relevant authority and trigger the ARA. We have seen different approaches about the details the case needs to provide (e.g. some states were considering that the case should even cover part of the ARA process, such as the scope and/or the reference scenario)

Consequently, the decision of going through this process should be preceded and based on a preliminary study.

The planning phase starts after the trigger to create a U-space airspace. This phase starts either due to a submitted U-space designation request (submitted, for example, by USSPs or UAS operators), or due to the need to develop a U-space designation recommendation. The engagement of the coordination mechanism should include as a first task the nomination, or confirmation, of U-space coordinators at national, regional and local level, as applicable.

3.2.1 Preliminary study

The designation of a U-space airspace should be based on an existing or expected demand or need whose nature could be safety, security, privacy or environment reasons. Below, some examples of these reasons mentioned in the AMC/GMs of (EU) 664 are presented:

- Safety

  Safety is a priority in any matter of Aviation. Having the need to share a common volume with manned aviation, improve the visibility by e-conspicuity, decreasing the ground risk overpopulated areas or reducing the mid-air collision risk are some of the examples depicted in the AMC/GM to declare a U-space airspace in an area. It can also leverage the workload of ATCo when the U-space is designated inside a controlled airspace as it will enhance the visibility of the UAS operations that might be already being carried out near the airport.

- Economy

  Economy is other of the principal drivers to designate a U-space airspace. It is expected that U-space will enable large-scale commercial operations, ensure a fair and efficient integration with manned aircraft, enable more complex and denser operations, support the development of the sector and providing services to the public, among others.

- Security

U-space airspace could be declared to restrict UAS flight to identified users and in the case of uncontrolled airspace, force electronic conspicuity, thus balancing the benefits of flight with the need for security and enabling the prevention of unauthorized flights over critical infrastructures.

- Privacy

  To support the enforcement of particular conditions for certain or all UAS operations for privacy reasons. Flying over some specific areas could be restricted to some users or to some slots (as it is the case for restricted areas for manned aviation).

- Environment

  In some areas, it will be necessary to define environmental requirements for UAS operations in terms of noise, CO2 emissions or acceptable level of disturbance.

Once the need is clearly identified, an airspace risk assessment shall be performed to provide assurance that the U-space airspace will be acceptably safe. Although this preliminary study should be the trigger to start an airspace risk assessment, at this stage of the implementation gathering enough data to argue that U-space is needed might be a challenge for the interested parties.

However, the economic and safety implications for manned traffic are not the same as in a situation where the U-space is located near a CTR or far from a CTR. This can be seen in detail in the following section 3.2.2.

For more information about the experience regarding the Preliminary study, check LL.ARA 1.

3.2.2 Airspace Risk Assessment

An airspace risk assessment is a combination of qualitative and quantitative analysis ensuring that safety and performance criteria are defined, and that assumptions and enablers are consistent with the current airspace design and procedures. Following the criteria described in the Regulation (EU) 2021/664 and the AMC/GM of (EU) 664, EUROCONTROL has developed Methods and Guidance to perform an Airspace Risk Assessment [32] that is a material produced to support the states to conduct the airspace risk assessment needed to designate a U-space airspace. It is the basis for the definition of UAS capabilities and performance requirements, U-space service performance requirements, and the operational conditions, airspace constraints and other measures necessary for mitigating the risks related to the planned U-space airspace to an acceptable level. Nevertheless, Member States may still decide to use their own method to perform an Airspace Risk Assessment.

The guidance proposed by EUROCONTROL covers the essential processes that support the designation of new U-space airspaces. This proposal includes that the planning methodology used in this process is constructed with a clear set of objectives and a realistic view of airspace operations. The process then consists of a preparation phase, reference scenario phase and assessment phase.

The goal of this section is not to provide detailed guidance on how to perform an ARA but rather to present an overview of the methodology and its main phases as a fundamental step in the U-space implementation process. Likewise, at the end of the section, the linked lessons learnt and recommendations are presented.

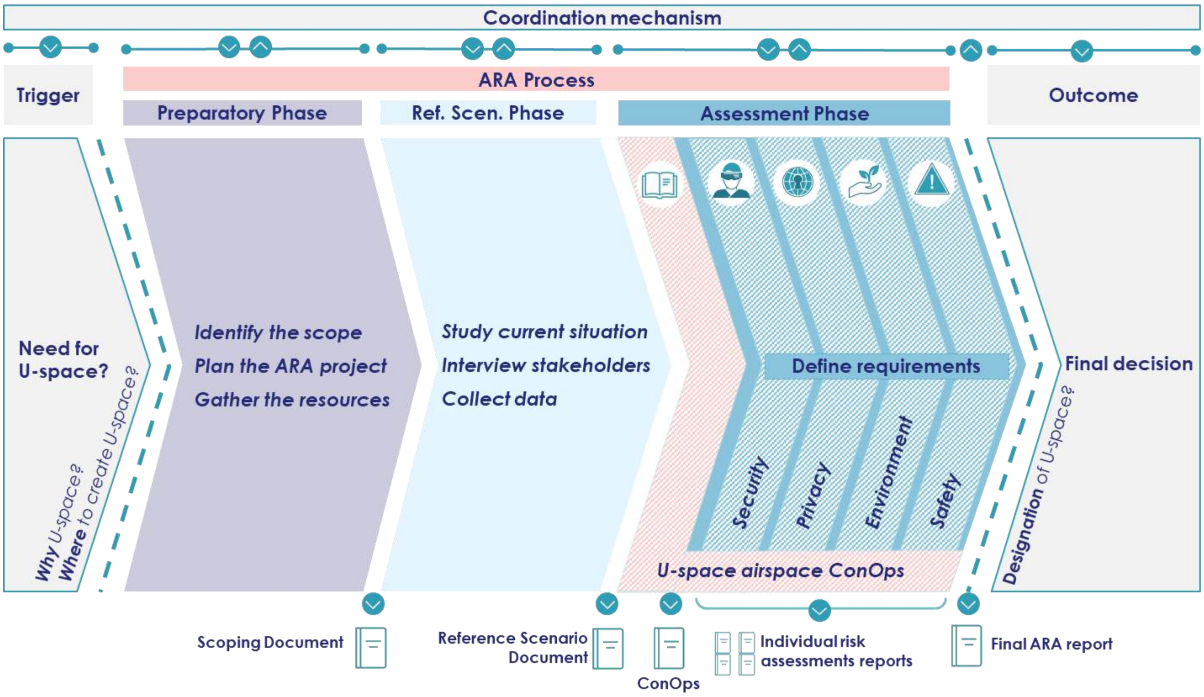

Figure 3. Airspace Risk Assessment Process in context [32]

The preparation phase starts with the creation of an assessment team. This team is divided into two separate teams, i.e., the Core Team in charge of carrying out the assessment and the Support Team that will play an auxiliary role collecting data and information. The core team should be composed of safety experts, national authorities that might be affected by the designation of U-space and a local representative of the location proposed.

Once the preparation phase is completed, reference scenario phase starts. This phase intends to provide a complete description of the relevant location when the assessment is performed. The aim with this phase is to depict the situation before implementing U-space. How the operations are managed, the source of risks to be considered, the stakeholders affected by the change or the applicable regulation are some of the topics addresses in the phase.

The last phase, the assessment phase, is a crucial component of the ARA, comprising five fundamental parts, recommended to be executed in three parts, that may be addressed in parallel: the development of the U-space airspace ConOps, the assessment of risks associated with security, privacy, and environment and the safety risk assessment. Each of these components are essential to the ARA process for the designation of U-space.

The U-space airspace ConOps[4] provides the description of the change associated with the ARA, generally the designation of U-space airspace. The ConOps should consider the findings of the Reference Scenario, as well as any other input to the ARA project, such as national plans/strategies for U-space implementation, and even the outcomes of previously conducted ARAs, if any.

[4] It should not be confused with U-space ConOps [20].

What follows is the security, privacy and environmental assessment. The assessment of security, privacy, and environmental risks should be executed employing methodologies that are tailored to each of these domains, as determined by the assessment team. These methodologies should encompass three common elements: the identification of hazards, the analysis of risks, and the mitigation of these risks to and acceptable level. In addition, the assessments should also include validation and verification activities, as well as the identification of monitoring criteria.

Lastly, and as the most important part of the assessment, the safety assessment, is performed considering the outputs of the previous steps. This assessment will set up the performance requirements for U-space services and UAS, as well as airspace limitations and operational constraints. For the assessment of safety-related aspects within the ARA, the principles of existing methods for safety assessment and assurance of changes to functional are considered using the principles from (EU) 2017/373 [22]. The safety assessment procedure for the ARA should cover the bare minimum requirements outlined in AMC1 to Article 3(1) of Regulation (EU) 2021/664 for the safety component, including hazard identification, risk analysis, risk evaluation and risk mitigation.

In the context of ARA, the safety assessment includes an additional element compared to the principles from Regulation (EU) 2017/373, specified in GM6.f to Article 3(1) of Regulation (EU) 2021/664: the introduction of the airspace safety specification at the operational level. This safety specification outlines what must occur within the airspace at the operational level to satisfy the specified safety criteria.

EUROCONTROL developed the Expanded Safety Reference Material (E-SRM) [22], which is a comprehensive method for conducting safety assessments and safety support assessments in ATM/ANS and UAS/U-space operations. The use of the E-SRM safety assessment process for evaluating safety-related aspects within the Airspace Risk Assessment (ARA) is highly advisable. The E-SRM safety assessment process fully aligns with GM6.f to Article 3(1), by including the definition of the airspace safety specification at operational level.

The assessment finishes with a final report. The intention of this report is to provide as much information as necessary to enable decision makers to understand the requirements for implementing U-space in the assessed airspace. The recommended structure for the final report goes as follows:

- Part 0: Generalities (describe introduction and outcomes)
- Part A: Scoping document
- Part B: Reference scenario document
- Part C: U-space airspace ConOps
- Part D: Reports of the security, privacy, environmental and safety assessments

More information could be found in [30].

For more information about the experience regarding ARA process, see Table 10. ARA Lessons Learnt and Recommendations and LL.AUT 1 in Section 4 Lessons Learnt and Recommendations

3.2.3 Final decision

The decision to designate U-space based on the results of an ARA must be completed by a validation process, which would nevertheless be a different type of process in each state, and thus outside the scope of an ARA. This validation should be carried out by an independent team from the authority that will review all the deliverables of the ARA and decide whether the U-space airspace designation is accepted, denied or needed to be amended.

3.2.4 Transition to U-space airspace operations

The implementation of U-space outlined in this document is not straightforward. Once the U-space airspace is designated, transitioning from operations without U-space to U-space operations requires collaboration among companies, organisations, and authorities. This process can occur either alongside the designation of U-space or afterward. In any case, since this process is not detailed in the regulation, it is not included in Section 3. However, the experiences gathered by different implementers are presented in **Appendix C Transition to U-space operations** of this Handbook.

3.2.5 Re-assessment process

To ensure that the required levels of safety and the operability of U-space remain optimal, it is important to follow a re-assessment process. This process is essential for continually assessing and addressing evolving risks and challenges within the U-space operations. By regularly evaluating potential hazards, collaborating with stakeholders, embracing technological advancements, and adhering to new regulatory guidelines, the U-space ecosystem can evolve maintaining the expected levels of performance.

This re-assessment should cover both operational practices and training programmes, ensuring that all actors to changes in traffic density, technology, and procedures. As U-space airspaces begin to be designated, traffic is expected to grow and therefore, new risks can appear. In addition, changes in the surrounding environment, such as the installation of new antennas, the construction of a critical infrastructure, or increased ground risk, may directly affect the requirements for safe operations in the airspace.

Any U-space should have a maximum time set between re-assessments established in the ARA The indicative time could be 6 months/1 year/2 years, with the possibility of a re-assesment before this time if there is a serious modification of the environment of the U-space or some of the KPI established by the Local Coordinator based on the reports of the U-space actors. Ad-hoc re-assessments are also considered based on important changes impacting the overall risk for the airspace plus periodic re-assessment to be written in the ARA ("expiration date of the ARA") considering the context of the Airspace and the environment.

For more information about the experience regarding Re-assessment process, see the Recommendation RECO.ARA 9 in Section 4 Lessons Learnt and Recommendations

3.3 Required CNS infrastructures

The CNS infrastructure necessary to enable safe operations in U-space encompasses both ground-based infrastructure and on-board technology. In the case of on-board systems, the operator is responsible for their installation and proper functioning. The responsibility for the installation and supervision of ground-based infrastructure is divided between U-space service providers, Member States and external companies providing support services for U-space services.

The required CNS infrastructure will depend on the characteristic of the airspace and operations performed on it, as well as the mix of traffic. In this section, the main CNS (Communication, Navigation, Surveillance) infrastructures and technologies used in the UTM/U-space environment to support UAS operations are described.

For more information about the experience regarding Communications, Navigation and Surveillance, see Table 14. CNS Lessons Learnt and Recommendations

3.3.1.1 Communications

Communication infrastructure is a set of systems, devices, networks, and technologies that enable the transmission of information between people, machines, or organisations in the UAS/U-space context. This is an essential element for the functioning of a digital ecosystem such as the U-space one.

The main components of a communication infrastructure are telecommunication networks (e.g. fixed: such as telephone lines, fiber optic cables or mobile networks: such as cellular networks), the hardware equipment necessary for exchanges (e.g. routers, switches, servers, repeaters and personal devices such as smartphones, computers, tablets), data transmission systems (e.g. satellites, radio antennas, Wi-Fi systems, Bluetooth, and electromagnetic waves).

The connectivity service and the related infrastructure, therefore, is typically to be considered external to the UAS and U-space solution and to be characterized as a support service. As the risk of operations increases and the density and complexity of unmanned traffic, further coverage assessment and monitoring services of the operation of the communication infrastructure will increase the awareness of operators with respect to the status of this important enabler, being able to contribute to the mitigation of risk on operations (e.g. communication-link loss).

For more information about the experience regarding Communications, see the Lessons Learnt LL.SER 2 and the Recommendations RECO.SYS 3, RECO.SER 4, RECO.SER 5, RECO.CNS 3, RECO.CNS 4, RECO.CNS 6, RECO.CNS 7 in the Section 4 Lessons Learnt and Recommendations

3.3.1.2 Navigation

The main components of the infrastructure are the Global Navigation Satellite Systems (GNSS). Such systems include core constellations as GPS (USA), Galileo (Europe), GLONASS (Russia) and BeiDou (China) and Satellite Based Augmentation (SBAS, in Europe provided by EGNOS) are worth mentioning, which provide, among other services, precise information on position, speed and time. Other important elements of the system are GNSS antennas and receivers, which allow the devices to receive satellite signals to determine position.

The navigation of a UAS can also be enabled by on-board instruments such as inertial systems (INS), electronic maps, or dead reckoning, especially when GNSS coverage for whatever reason is not available.

For the navigation in UAS operations, especially for the precision of some phases of the flight such as landing, navigation systems based on signage (e.g. use of markers and QR codes), ultrasound or infrared technology are also used, together with differential corrections to GNSS, mainly RTK (Real Time Kinematics) or PPP (Precise Point Positioning). In the UAS/U-space context, the navigation infrastructure is therefore an important enabling factor to:

- support the navigation of the UAS, as a fundamental element of the drone's guidance, navigation and control system for the specific needs of the operation;
- enable the tracking of operations in a U-space context, as a fundamental element for DRI (Direct Remote Identification) and NRI (Network Remote Identification) for the localization component of operations. This will be described more in detail in Section 3.4.5.1 where required equipment for aircraft and systems is described.

The navigation accuracy depends on two elements: the Navigation System Error (NSE), which depends on the navigation sources and receiver, and the Flight Technical Error (FTE), which depends on the features of the UAS (size, fixed-wing/multirotor, autopilot, etc.); previous work provide reference values of NSE and FTE for different UAS models and operations [49][50]. It must be noted that the NSE worsens in urban canyons due to the poorer satellite geometry and multipath effects.

The Airspace Risk Assessment should evaluate the acceptable separation of UAS trajectories with regard to other UAS and obstacles, considering the expected navigation accuracy in the areas considered for the flights and the types of UAS, to ensure the safety of the U-space operations.

As is the case for communication, it is necessary to assess the coverage of navigation services, and the performance levels of the solutions selected for your operation in the area of interest (e.g. field assessment of Operation UAS and in the U-space context the Airspace Risk Assessment).

The most common problems that a satellite system can encounter, affecting the reliability and accuracy of the system, are attributable to:

- Signal problems (e.g. due to physical, multi-path obstacles - Signal reflected from surfaces such as buildings, water or rocks can cause errors in the calculation of the position and signal weakness)

- Positioning errors (e.g. poor satellite distribution, atmospheric errors, receiver clock error)

- Interference (e.g. radio interference, jamming and spoofing).

For more information about the experience regarding Navigation, see the Lessons Learnt LL.CNS 1, LL.CNS 2 in Section 4 Lessons Learnt and Recommendations

3.3.1.3 Surveillance

An aviation surveillance infrastructure is a set of systems, sensors, networks, and operations centres used to monitor air traffic in a specific airspace. This infrastructure is essential to ensure the safety and efficiency of air transport. The main components of an aviation surveillance infrastructure are typically characterized by a combination of on-board elements and ground infrastructure.

In VLL airspace, traffic is characterized by UAS and conventional aviation (e.g. helicopters, ultralights, gliders, military). The surveillance in ATM is generally carried out by means of Radar. However, radar is not well suited to VLL: the curvature of the earth limits range, radar infrastructure and transponders are relatively high cost. New surveillance solutions have been identified that are cheaper and suitable for VLL and the kinds of aircraft expected in U-space airspace; in general, U-space surveillance will be based on dependent (i.e. position reported by the aircraft) solutions.

One of the founding principles of U-space is to facilitate the coordinated management of manned and unmanned traffic. In a U-space context, in fact, manned aviation must be cooperative, i.e. it must make itself visible to drones. The term electronic conspicuity (e-conspicuity) refers to the ability of an aircraft to be visible to other airspace users through electronic surveillance systems, such as ADS-B/ADSL antennas. This improves safety by reducing the risk of collisions. The different means of being electronically conspicuous are defined in the Section 3.4.6.1, where requirements for manned aircraft to access U-space are defined. Regarding traffic information on manned aviation receiving ATC services, air traffic service providers are the ones who must provide, on a non-discriminatory basis, the relevant traffic data on manned aircraft necessary for the provision of common information services.

For drones, on the other hand, the regulation introduces the concept of Remote ID (RID) and NRI (Network Remote Identification), which obliges drones to transmit their position (calculated by its navigation system), ID and other data in real time for tracking by authorities and to enable U-space services where applicable. This will be described more in detail in Section 3.4.5.1 where required equipment for aircraft and systems is defined.

The required surveillance capabilities in a U-space airspace will depend on the density of UAS operations, manned aircraft in the vicinity, etc. The Airspace Risk Assessment should analyse if dependent surveillance provided by NRI and, eventually e-conspicuity for manned aircraft, would suffice to ensure adequate separation among UAS and other UAS and manned aircraft or, in which cases independent and even non-collaborative surveillance systems could be demanded. Previous work has discussed about surveillance deployments in different types of U-space environments [51][52].

For more information about the experience regarding Surveillance, see the Lessons Learnt LL.STAND 11 in Section 4 Lessons Learnt and Recommendations

3.4 Access to U-space airspace

Once U-space airspace is designated, various stakeholders assume specific roles and responsibilities. However, to operate effectively within this environment, they must meet certain essential requirements, ranging from certification and equipment standards to the sharing of relevant information. This section sets out those key requirements and obligations encompassing not only the responsibilities of actors such as service providers and operators, but also critical supporting elements like Common Information Services and training, which are essential to ensure safe, coordinated, and reliable operations in U-space.

3.4.1 Common Information Service

The Common information service (CIS) is a service consisting in the provision of common information, that is the dissemination of static and dynamic data to enable the provision of U-space services for the management of traffic of unmanned aircraft as per Regulation (EU) 2021/664.

Common information is a collection of data that originates mainly from three different sources:

1. the Members States (or sources selected or provided by them), responsible for the design of the U-space airspace, including its dimensions, performance requirements, and static or dynamic restrictions.
2. the ATS providers responsible for the transmission of manned traffic information as laid down in point ATS.OR.127 of Regulation (EU) 2017/373 amended by Regulation (EU) 2021/665, and the ATS units when applying the dynamic reconfiguration of the U-space airspace.
3. the USSPs, through the terms and conditions as regards access to their services.

Regulation (EU) 2021/665 and Article 5 of Regulation (EU) 2021/664 reflect the data that shall be made available as part of the common information services:

- Horizontal and vertical limits of U-space airspace.
- The requirements defined in the report derived from the ARA of that U-space as it is referred in the Article 3.4 of the Regulation (EU) 2021/664, in terms of UAS capabilities and performance requirements (e.g. internet connection, GNSS, RTK, maximum horizontal and vertical speed…), mandatory U-space services (e.g. conformance monitoring and the 4 mandatory services according IR 2021/664), and applicable operational conditions (e.g. possibility of night operations, weather and visibility conditions, possible restrictions relating to manned aviation…) and airspace limitations (airspace activation schedule, static and dynamic geo-zones…). Such data will be determined by the Member State and published by the competent authority or other entity designated by the Member State.
- The list of certified U-space service providers offering U-space services in U-space airspace, indicating their identification and contact details, U-space services provided and limitations of the certification of each of them, if applicable. This data shall be provided by the competent authority.
- Any adjacent U-space airspace(s) published by the competent authority.
- UAS geographic zones relevant to U-space airspace and published by Member States in accordance with Regulation (EU) 2019/947.
- Static and dynamic airspace restrictions defined by the competent authorities and permanently or temporarily limiting the volume of airspace within U-space airspace where UAS operations can take place.
- The terms and conditions of U-space services provided by USSPs operating in each U-space airspace.
- The relevant traffic information regarding manned aircraft that is necessary for a U-space airspace established in the controlled airspace where the air traffic service provider is designated to provide its services.
- The data resulting from the dynamic airspace reconfigurations.

The air traffic services providers shall establish the coordination procedures and communication facilities between appropriate air traffic service units, U-space service providers and, where applicable, single common information service providers permitting provision of manned aviation data in controlled airspace.

According with Regulation (EU) 2021/664 Article 5.5, access to common information services shall be granted to relevant authorities, air traffic service providers, U-space service providers and UAS operators on a non-discriminatory basis.

There are two possible approaches for the provision of Common Information Services (CIS) within U-space airspace:

Designation of a Single CIS Provider

Member States may choose to designate a single CISP, a dedicated entity to provide CIS exclusively within a given U-space airspace. This single common information service provider (single CIS provider) would be responsible for making relevant information available to all operational stakeholders. This approach and the requirements to be met by this entity are defined in the next section.

CIS Provision without a Single CISP Provider

Alternatively, in the absence of a designated single CIS provider, common information is exchanged directly between operational stakeholders through a distributed communication architecture. In this model, each data provider communicates directly with other U-space service providers (USSPs) to share information. A clear allocation of responsibility for common information elements among Member States, ATS providers, and USSPs ensures that data users can access the necessary information efficiently. No additional certification is required in this case, as the provision of information remains covered under the existing certificates and regulatory frameworks defined in Regulation (EU) 2021/664 and Regulation (EU) 2021/665.

3.4.2 Single CISP

In the case that a single CIS provider is designated by the competent authority, it is subject to certification by the relevant competent authority. The certification scheme aims to preserve public interest, most notably in terms of safety. The certificate confirms that the single CIS provider meets the requirements of Regulation (EU) 2021/664. The certificate specifies the rights and obligations of the single CIS provider, with regard to safety. A single CISP may be designated as the exclusive provider in a given Member State. In such a case, this CISP will exclusively provide common information services across all U-space airspaces throughout the national territory.

3.4.2.1 CISP Certification

The requirements to be met by the entity designated as the single CISP in a member state, and therefore required to be certified as a CISP, are set out in Article 15 of Regulation (EU) 2021/664 and its respective AMC and GM within the regulatory framework for U-space. If a single CISP is not designated in accordance with Article 5.5 of Regulation (EU) 2021/664, no certificate is needed for the provision of services by multiple providers.

The application process for CISP certification is described in Article 14 of Regulation (EU) 2021/664. The application must be made to the NSA of the Member State where the applicant's principal place of business is located, unless it is a single CISP established or with a principal place of business in a third country. In that case, the application is to be made to EASA, and always after verifying that the requirements defined in the previous paragraph are met.

Once the request has been made, and after subsequent review and assessment by the relevant Member State NSA, a Common Information Service Provider certificate will be issued in accordance with Annex VII of Implementing Regulation (EU) 2021/664.

For more information about the experience regarding sCISP certification, see the Recommendations RECO.CER 1, RECO.CER 2 in the Section 4 Lessons Learnt and Recommendations

3.4.3 USSP

The provision of U-space services is subject to certification by the relevant competent authority. The certification scheme aims to preserve public interest, most notably in terms of safety. The certificate confirms that the USSP meets the requirements of Regulation (EU) 2021/664 as regards the provision of specific U-space services in the U-space airspace, commensurate with the risk associated with the U-space services they provide. The certificate specifies the rights and obligations of the USSP, with particular regard to safety.

As stated at the beginning of this document, due to the advanced level of deployment of the USSP systems at the beginning of the project and considering therefore that their development was beyond the scope of this project, this section doesn't delve into technical details of system design or development. Nevertheless, some lessons learnt and recommendations were included based on the system development experience and integration of the contributors.

For more information about system development experience, see Table 12. SYS Lessons Learnt and Recommendations in Section 4 Lessons Learnt and Recommendations

3.4.3.1 USSP Certification

The requirements to be met by entities wishing to be certified as USSP are set out in Article 15 of the Regulation (EU) 2021/664 and their respective AMC and GM in the regulatory framework for U-space.

The application process for USSP certification is described in Article 14 of Regulation (EU) 2021/664. The application should be made to the NSA of the Member State where the applicant's principal place of business is located or by the competent authority referred to in the GM1 Article 14 "application for a certificate" from AMC/GM to Regulation (EU) 2021/664, and always after verifying that the requirements defined in the previous paragraph are met.

Once the request has been made, and after subsequent review and assessment by the relevant Member State NSA, a U-space Service Provider certificate will be issued in accordance with Annex VI of Implementing Regulation (EU) 2021/664.

For more information about the experience regarding USSP certification, see the Lessons Learnt LL.STAND 5, LL.CERT 1, LL.CERT 2, LL.CERT 3 and the Recommendations RECO.CER 1, RECO.CER 2, RECO.CER 3, RECO.CER 4, RECO.CER 5 in the Section 4 Lessons Learnt and Recommendations

3.4.3.2 U-space services provision

According to Article 3 of Regulation (EU) 2021/664, the services that must be mandatorily provided by all USSPs operating in U-space are the following:

- Network Identification Service (Art. 8 of Regulation (EU) 2021/664).
- Geo-awareness Service (Art. 9 of Regulation (EU) 2021/664)
- UAS Flight Authorisation Service (Art. 10 of Regulation (EU) 2021/664)

- Traffic Information Service (Art. 11 of Regulation (EU) 2021/664).

For controlled airspace, according to Article 1 of Regulation (EU) 2021/665, USSPs will be notified by ATC units in cases where Dynamic Airspace Reconfiguration occurs, so it is necessary to establish the corresponding procedures to include such operations within the U-space environment in a safe manner.

Additionally, depending on the operational requirements derived from the Airspace Risk Assessment (ARA), member states may require additional services from USSPs in a given U-space airspace, such additional services are:

- Weather Information Service (art. 12 of Regulation (EU) 2021/664).
- Conformance Monitoring Service (art. 13 of Regulation (EU) 2021/664).

For a USSP to be able to operate in a U-space airspace, it is indispensable that it can provide all the services defined as mandatory for the U-space airspace, and in compliance with the determined U-space services performance requirements.

A USSP may subcontract the provision of some or all U-space services to other entities if they remain under its management control. There can also be associations between USSPs or equivalent mechanisms, if there is a single certified entity responsible for providing the required bundle of U-space services to UAS operators. When required, the USSP should ensure that the competent authority is given access to any subcontracted organisation and data relevant to support the USSP certification.

The subcontracting of additional services by USSPs may be done through an entity certified for the provision of such services, or through a transfer of the operating requirements to that subcontracted entity.

In accordance with Article 7.5 of Regulation (EU) 2021/664, it is essential that USSPs have minimum technical requirements for the exchange of information and data with other USSPs, in order to have a common, interoperable and open communication protocol.

In addition, although it is related to the USSP requirements to access U-space, a “U-space Compliance Report for USSPs” should be made. This document will reflect the special requirements that USSPs must meet to operate in the newly established U-space. These requirements may go beyond the USSP's own certification requirements, which is why they are included in a separate document. This is shown in more detail in **Appendix C Transition to U-space operations**, C.2.2**.**

For more information about the experience regarding U-space Service Provision, see Table 13. SER Lessons Learnt and Recommendations in Section 4 Lessons Learnt and Recommendations

3.4.3.3 Recruitment of clients

Depending on the number of requests and the need for the establishment of a U-space, a series of U-space volumes will be defined on which airspace risk assessments will be performed, resulting in minimum operating requirements for each airspace.

The U-space common information will be published in an open and non-discriminatory manner, and all the USSPs that are certified and meet the U-space requirements shall be able to offer their services. In order to be accessible to the largest number of customers, USSPs should perform an analysis of existing U-space volumes and determine which ones they will want to operate in, taking into account whether they have the certificate to provide the necessary services or whether they need to extend their certificate or outsource additional services.

At the same time, it is recommended that USSPs have the means to train UAS operators on the use of their USSP platform or the associated APIs, thus making themselves more accessible to their customers. It is also relevant to carry out actions to promote and make the platform visible, since it is in a competitive market. In this respect, USSPs are expected to offer additional services beyond those required by regulation that can enhance the operator's experience in any part of the operation, such as additional information to facilitate mission preparation or facilities to manage the crew or fleet, and that differentiate them from other competitors.

3.4.4 Operator

3.4.4.1 General requirements

Every operator today and independently of U-space must comply with several previous requirements based on the Regulation (EU) 2019/947, which may be obtained, in most cases, through an operational declaration or an operational authorisation depending on the category and risk of the operation. However, this is a process that must be carried out previously and it is not the purpose of this document to describe it. For more information, you can visit the corresponding CAA website or Regulation (EU) 2019/947.

To access U-space airspace, the UAS operator must be registered. Regulation (EU) 2019/947 Article 14 obliges Member States to create and maintain a UAS operator registry and to share this information with other EU Member States via the EU repository established by the same Regulation. Article 14 also specifies the information that must be included in the registry.

The registry should form part of a multi-national network which is coordinated to ensure registration numbers are unique. Registry entries can be then read, updated and deleted if needed. With a search functions, USSPs can acquire registration data to perform data consistency rules.

In addition to that, UAS operators should ensure subscription to USSP services. The access to U-space by UAS Operators will be done through a service contract with a USSP. However, it is important to note that certain categories of UAS, specifically those that are either privately built or belong to the C0 class (weighing less than 250 grams without cameras or sensors capable of detecting personal data), are excluded from Regulation (EU) 2021/664. Consequently, these drones are not obliged to subscribe to USSP services. Nonetheless, their access to U-space airspace may still be subject to national restrictions or operational limitations established by the Member States to ensure safe integration with other airspace users.

For more information about the experience in the General Requirements for an operator, see the Lesson Learnt LL.AUT 3 in the Section 4 Lessons Learnt and Recommendations

3.4.4.2 Required knowledge

Paragraphs 1, 2 and 3 of Article 6 of Regulation (EU) 2021/664 set out the obligations that UAS operators must comply with in order to carry out U-space operations. These obligations are:

- UAS operators shall ensure that both the UAS they use and the operations they conduct in U-space comply with the requirements defined in the report derived from the ARA regarding U-space services, operational requirements and conditions and applicable airspace limits.

- UAS operators must comply with the requirements of Regulation (EU) 2019/947 including, where applicable, holding an operational authorisation or a certificate issued by the competent authority of the Member State of registration.

- UAS Operators shall comply with the operational limitations established by a Member State in any UAS geographical area.

In addition, UAS Operators must comply with defined procedures with their USSP for U-space operations, as defined in Art 6 (4), (5), (6) and (7) of Regulation (EU) 2021/664. These procedures are related to:

- The application for UAS flight authorisation (Article 10 and Annex IV of Regulation (EU) 2021/664).

- Activation of the UAS flight authorisation.

- Possible changes to the UAS permission to fly during any phase of flight.

- Request for a new UAS flight authorisation if initial conditions cannot be met.

Finally, UAS Operators must define and implement contingency measures and procedures, which they will make available to their USSP.

Although it is not an explicit knowledge requirement in the regulation, it is recommended that UAS Operators familiarize themselves with the emergency management plan defined by their USSP, in order to know the procedure to follow in case of an emergency during UAS operation.

3.4.4.3 Safety Assessment

In addition to complying with the safety requirements defined in the report derived from the ARA, in cases of UAS operations in Specific Category that do not fall under any of the standard scenarios (STS) defined in Appendix I of Regulation (EU) 2019/947, it is necessary for UAS Operators to submit to the Competent Authority an operational risk assessment in accordance with Article 11 of the said Regulation.

Such risk assessment shall be based on the SORA methodology and shall be submitted together with the application for operational authorisation as defined in Article 5 of Regulation (EU) 2019/947.

The rules to follow to properly perform an operational risk assessment can be found in Article 11 of Regulation (EU) 2019/947; however, the following is a summary of the contents that such operational risk assessment should contain:

- A description of the characteristics of the UAS operation.
- A description of the operational safety objectives to be achieved.
- An assessment of the risks of the operation on the ground.
- An assessment of the risks in the air.
- A description of possible risk mitigation measures.

To ensure the effectiveness of the operational risk assessment, the robustness of the proposed mitigation measures will be evaluated to determine whether they are proportionate to the safety objectives and risks of the planned operation to ensure that all phases of the operation are safe.

UAS operators should take into account that their Concept of Operation (ConOps) will be affected when they fly inside a U-space airspace. In U-space, everything relies on the fact that all UAS will be cooperative during the strategic phase (flight planning) and the tactical phase (flight execution) and manned aircraft will be either cooperative (e-conspicuity) or managed by ATC (DAR) during the tactical phase. Each U-space service will affect the safety of the flight in a different way and if the minimum performance of the service is not met or it is lost during the flight it would create a safety risk that should be considered.

There are some Operational Safety Objectives (OSOs) that are prone to be affected by U-space. More information can be found in **Appendix D. U-space impact on Specific Operational Risk Assessment.**

3.4.4.3.1 Operational authorisation timeline.

When applying for an operational authorisation it should be noted that the delay might vary significantly depending on the UAS operator situation and the Member State national regulation. In addition, there are three types of operational authorisation that will influence the delay to obtain the approval. A brief description of each type of authorisation is given hereafter:

- Precise authorisation. This authorisation is given for a specific location. This is usually the quickest way to obtain the operational approval.
- Generic authorisation subject to evidence. In this type of authorisation, the characteristics of the location are defined with generic requirements, but before starting the flights the UAS operator must inform how these characteristics have been evaluated and must be approved by the National Authority.
- Generic authorisation. The characteristics of the location are also defined with general requirements, but the UAS operator do not need to demonstrate it to the National Authority. This type of authorisation is a level below the Light UAS operator certificate (LUC), and the most difficult to obtain because the UAS operator must also demonstrate that it has a proper system to evaluate the conditions of the location chosen for their flights. This problem might be partially solved through “EASA IAM HUB e-SORA” functionality.

The process for obtaining an operational authorisation could be defined, at high level, in three different phases, being one of them optional:

- First is the preparation phase. In this one, it is up to the UAS operator to determine the ConOps of the operation, the UAS that will be used, what type of authorisation is going to request and prepare all the documentation needed. The documentation includes the operator manual, the specific operation risk assessment (SORA) of their ConOps, evidence for the ground risk mitigations and the air risk mitigations and how the OSOs and the containment requirements are met, including if needed evidence of compliance with different MoCs and Standards. Time needed for completing this phase might depend on the resources available by the UAS operator but on average, three months are usually enough.
- Second is the revision phase. In this one, the National Authority review all the information sent by the UAS operator for the requested operation. The time needed to complete this phase is different as it depends on the national regulation of each Member State. For example, in Spain, AESA has a deadline of six months to notice the UAS operator if the operational authorisation is rejected, approved or if there are clarifications/amendments needed in the documentation.

- Third is the amendment phase. This is an optional process that must be done if the National Authority requires clarification or additional documentation from the UAS operator. This process can be triggered as many times as deemed necessary by the National Authority which makes it harder to forecast how long will it take. Once this phase is over the National Authority will either reject or issue an operational authorisation.

The UAS operator must request a new operational authorisation when at least one of the following events occur:

- The conditions of the location have been modified. For example, by the designation of a U-space airspace.
- The UAS used by the operator has been replaced a different model.
- The ConOps of the operational authorisation has been modified. For example, a UAS operator that was authorised to fly in BVLOS up to 5 km now wants to fly up to 15 km.
- The delay for obtaining another operational authorisation will depend on the severity of the changes proposed. For example, a precise authorisation whose location has been changed to another with similar characteristics will not take long to approve because the National Authority only need to check if the conditions of the new location are compliant with the previous authorisation.

3.4.5 Aircraft and systems

3.4.5.1 UAS Required equipment

UAS used to fly in U-space must meet a series of minimum requirements that allow them to fly safely with the rest of the airspace users. These requirements include proper connectivity of the aircraft and associated systems to enable the exchange of essential data. The table below outlines the key types of data exchanged between the UAS and relevant platforms:

Exchange	Application	Typical solutions
UA-GCS	Command and control, reception of telemetry and Payload communications	Radio links, mobile networks, satellite links, or a mix.
UAS-USSP	The UA transmits its Network ID information to the USSP by different means.	**Hook-on device** equipped with a battery and GNSS receiver transmits its Network ID via the mobile network. **Custom integration with the Ground Control Station** (GCS) allows the USSP to provide the U-space services directly to the operator through the USSP APIs. **UAS with integrated Network ID capability** enabling direct connectivity to the USSP via built-in mobile network modules.

Remote Pilot-USSP	Receive U-space services	UI in the USSP application or APIs.

Table 4. UAS Communication links and typical solutions

For these exchanges to be successful, a reliable data connection between the USSP and the remote pilot must be ensured throughout the flight. In practice, this requires that the UAS can transmit its Network ID to the USSP and that the remote pilot can access and consume U-space services. The following sections describe these two key functionalities in more detail.

- **Network ID**

  As described in Regulation (EU) 2021/664 Article 8, the UAS must be equipped with the means to transmit Network remote identification (N-RID), that includes the UAS operator registration number, the unique serial number of the unmanned aircraft or, if the unmanned aircraft is privately built, the unique serial number of the add-on and the telemetry of the drone.

  To achieve that, it is necessary to have an embedded solution or means to transmit telemetry data from the UAS to the USSP. This can be achieved by different means. Below, two common solutions are described. The first consists of integration in the GCS (Ground Control Station) that communicates network ID to the USSP. The second is a hook-on device, sometimes called a tracker. Other solutions, including hybrids, are also possible.

  - Solution 1: Telemetry data is transmitted from UAS GCS to USSP

    The USSP platform should enable the direct integration of telemetry from Ground Control Stations (or GCS) through an API. In this case the drone uses on-board components and sensors to collect a set of telemetry data. Although it depends on each GCS, it usually includes both position data (lat, long, height WGS84) and kinetic data (speed, heading, etc.) along with other data needed for flight management (battery, engine status, etc.). This telemetry data is transmitted via the C2 (Command & Control) link, normally via a radio frequency signal, to the Ground Control Station (GCS), where it is used by the remote pilot for flight management.

    Through the USSP API, communication is established with the GCS in order to extract the subset of data to be forwarded to the telemetry data capture system of the USSP U-space platform.

  - Solution 2: Telemetry data is transmitted from a Network remote identification system (tracker device) to USSP:

    In case the drone or GCS does not support direct integration through the offered set of APIs, or the operator prefers another connection model, the possibility to integrate an external position reporting device (drone tracker) could also be offered.

    This device, which operates largely independently of the drone's onboard systems, determines the drone’s 4D position and transmits the data via mobile networks. The information can be sent either directly to the USSP platform or to a service managed by the tracker provider. In the latter case, the USSP must integrate with that external service to retrieve the Network ID.

- **Pilot display of U-space information**

  The remote pilot needs to be aware of the information provided by U-space services during flight. If the services cannot be presented on the GCS, then an additional screen may be needed to visualize U-space services.

  In the early stages of U-space deployment, this additional screen will be necessary since manufacturers are not currently including in their GCS an interface with the USSPs that allows the visualization of U-space services, although in the future the possible development of systems that allow dispensing with this additional screen is contemplated.

  An internet connection is required to receive data related to U-space services, which are provided to the UAS pilot by the USSP. Additionally, the UAS must comply with the performance requirements of the U-space volume in which it operates, as well as any applicable UAS Zones within that volume.

For more information about the experience regarding UAS Required Equipment, see the Lessons Learnt LL.STAND 1, LL.STAND 3, LL/RECO ID, LL.SYS 2, LL.SYS 3, LL.SYS 4, LL.SYS 5, LL.SYS 6, LL.SYS 7, LL.SYS 8 and the Recommendations RECO.SYS 2, RECO.SYS 3, RECO.SYS 4, RECO.SYS 6, RECO.SYS 7, RECO.SYS 8, RECO.SYS 9, RECO.SER 13 in Section 4 Lessons Learnt and Recommendations

3.4.6 Manned aircraft

U-space interaction with manned aircraft is approached differently depending on whether the manned aircraft is provided with an air traffic control service or not.

- Manned aircraft provided with ATC service: the Air Traffic Control Service Provider is responsible for coordinating the entry of manned aircraft into U-space. Regulation (EU) 2021/665 states the requirement to apply a Dynamic Airspace Reconfiguration (DAR) when a manned aircraft enters in a U-space airspace. DAR consists of a temporary modification of a defined U-space airspace. Whether partially or entirely, it is performed by the Air Traffic Control Service Provider to accommodate short-term changes in manned traffic demand.

- Manned aircraft not provided with ATC service: where no ATC service is provided by the ANSP (Air Navigation Service Provider), manned aircraft must be made electronically visible to the USSP through an electronic conspicuity system. The electronic conspicuity requirement is further described in Regulation (EU) 2021/666.

Therefore, manned aircraft operating in airspace designated by the competent authority as a U-space airspace and not provided with an air traffic control service by the ANSP, shall continuously make themselves electronically conspicuous to the U-space service providers. The subsequent subchapters will provide more details on:

- The approved means for transmitting such information.

- The coordination actions expected to happen in such scenario.

3.4.6.1 Information to be transmitted by manned aircraft in U-space and means to transmit it

As explained in detail at EASA's "Easy Access Rules for Standardised European Rules of the Air (SERA)" [34], manned aircraft who operates in U-space airspace should transmit information through one or more of the following means to continuously make themselves electronically conspicuous to U-space service providers.

1. A certified ADS-B OUT system compliant with ICAO Annex 10 Volume IV [36] Chapter 5 (Mode-S Extended Squitter).

2. A certified ADS-B OUT system compliant with ICAO Annex 10 Volume III [35] Chapter 12 (Universal Access Transceiver) 12 months after its implementation and deployment for that purpose in all Member States.

3. A system that transmits the information specified in Appendix 1 to AMC1 SERA.6005(c) (titled "Requirements for communications, SSR transponder and electronic conspicuity in U- space airspace AMC") using a short-range device (SRD) 860 frequency band, and the information is transmitted in compliance with the format as documented in technical specification ADS-L 4 SRD-860.

4. A system that transmits the information specified in Appendix 1 to AMC1 SERA.6005(c) using a standardised mobile telecommunication network services coordinated for aerial use in the relevant decisions of the Electronic Communication Committee (ECC) of the European Conference of Postal and Telecommunications Administrations (CEPT), and the information is transmitted in compliance with the format as documented in technical specification ADS-L 4 MOBILE.

The systems used for transmission in accordance with points (3) and (4) should:

- Bear an appropriate CE marking.
- Be either installed on the aircraft with the installation approved by the competent authority or carried on board the aircraft as non-installed equipment.
- The information should be transmitted in a machine-readable format accessible to USSPs without any restrictions.

For more information about the experience in the transmission of information by manned aviation, see LL.REG 3. in Section 4 Lessons Learnt and Recommendations .

3.4.6.2 Expected coordination actions

According to the current European regulatory framework, specifically Regulation (EU) 2019/947 and the associated AMC/GMs, there are no specific procedural actions required for manned aircraft prior to entering U-space airspace in uncontrolled airspace. The primary obligation is for the aircraft to be electronically conspicuous upon entry.

However, this minimal requirement may give rise to safety-critical situations, particularly during the initial implementation phases of U-space services. To address these concerns, the development of Airspace Risk Assessment (ARA) may include the definition of strategic and pre-tactical procedures aimed at ensuring the safe integration and operation of manned aircraft within U-space airspace.

This chapter summarizes the possible coordination actions expected in a scenario where a manned aircraft enters an uncontrolled U-space airspace:

3.4.6.2.1 Strategic and pre-tactical phase:

- Manned aircraft notifies by means of radio or phone before entering the airspace.
- The relevant information is to UAS operators through Geo-awareness Service, which informs them about operational conditions, airspace constraints and potential temporary airspace restrictions within the U-space.
- USSPs providing services in the relevant U-space will ensure that the operators are informed the designated part of airspace (i.e. corridor) are unavailable through Flight Authorisation Service.

3.4.6.2.2 Tactical phase

- Manned aircraft makes itself electronically conspicuous to the USSPs.
- USSPs will make the information available to all UAS operators in the same U-space through the Traffic Information Service.
- Additional information will be also accessible to UAS operators through Geo-awareness Service.

It can be noted that, currently, it is not intended to provide manned aircraft with U-space services when operating within a U-space airspace. Potential benefits and implications of this option are part of ongoing research.

3.4.7 Training

3.4.7.1 UAS operators

As established per AMC1/GM1 of Article 6(1)(c) and AMC5 Article 7(2) of AMC/GM to Regulation (EU) 2021/664, USSPs should provide the UAS operator with instructions to carry out their operations in a U-space airspace. These instructions should include:

- Conditions and restrictions of the U-space airspace
- Guidance on how to configure and use USSP services.
- If the services are provided through the USSP API, a user guide with the technical instructions and requirements to the UAS operators.
- Recommendations ensuring the security of the exchange.
- the normal, contingency, and emergency procedures related to U-space services, to be applied by UAS operators.

Although there is no mention on how these instructions should be provided, it would be desirable to include as many options as possible, for example a user’s manual, FAQs, video recordings, training courses or technical support from the USSP.

3.4.7.2 State and military authorities

State and military authorities are part in the decision-making process of the coordination mechanism (as per Article 18(f) of Regulation (EU) 2021/664) for the designation of U-space to cover the safety and security aspects in a U-space airspace. While their operations are out of the scope of the U-space regulation, coordination and training is necessary to ensure the safety of the operations.

Operators that perform these operations will be affected by the designation of U-space airspace. These UAS operators may be subject to certain national requirements but are excluded from the scope of Regulation (EU) 2021/664. This includes activities conducted by military, customs, police, search and rescue, firefighting, border control, coastal surveillance, or similar entities, under the control and responsibility of a Member State, and carried out in the general interest by or on behalf of a body vested with public authority. These operators may make use of U-space rules for their operations but may, in some cases, require special accommodations due to the nature of their flights. Some of the privileges listed above may be used to allow non-EASA operators to receive priority in flight authorisations or to conceal their ID and position from nearby users.

Given the context of these operations, usually emergencies, following the normal procedure of U-space will not always be possible. Defining procedures to act in these situations is necessary as well as coordination and training. UAS operators should also be included because their operations will probably be cancelled or delayed by these operations.

3.4.7.3 Local authorities

Local authorities play a key role in the designation of a U-space airspace as they will be in charge of supporting the deployment of U-space. For this reason, they need to understand what their responsibilities inside U-space are and how to stablish proper coordination mechanisms to ensure an effective response when needed.

3.4.7.4 Manned aircraft

Manned aircraft will be directly affected by U-space, especially those flying at low levels and in non-controlled airspace where traditional Air Traffic Services may be absent or limited. Training should include understanding U-space concept and mainly e-conspicuity, which is essential for the safe coexistence of manned and unmanned. While U-space expects experienced drone pilots and advanced systems, drones still pose unique risks due to their small size and high manoeuvrability.

3.4.7.5 ATSP

Air Traffic Service Providers should work closely with the relevant authorities to train their staff on safely interacting with U-space operations. Air Traffic Controllers will have an important role, especially in managing Dynamic Airspace Reconfiguration and handling emergencies involving drones. Training should focus on understanding new tools and procedures, maintaining situational awareness, and coordinating effectively with other U-space actors to keep the airspace safe.

For more information about the experience regarding Training, see the Recommendation RECO.REG 4 in the Section 4 Lessons Learnt and Recommendations

3.5 Operations in U-space airspace

This section provides a comprehensive description of the operational process of operating in U-space airspace using digital services, as well as the coordination procedures not only with ATM but also with other relevant authorities, which may not be directly related to U-space or aviation but play a crucial role in ensuring safe operations. The U-space architecture is also described with some examples of implementations carried out in the U-ELCOME and BURDI projects in the Appendices.

3.5.1 Architecture

This section describes different types of architecture and the exchange of information between different actors. The concepts of centralised and decentralised architectures are based on the definitions outlined in the EU Regulation.

3.5.1.1 Centralised model

Centralised model refers to a U-space architecture with a single CIS provider which collects common information elements (data) from providers of common information and makes them available to all operational stakeholders (e.g. USSPs).

As defined in Table 3. Roles and responsibilities in U-space and previously in this document, single CIS provider refers to a certified organisation that ensures the interface and exchange between the providers of common information and the USSPs.

Member States may designate a single common information service provider to supply the common information services on an exclusive basis in all or some of the U-space airspaces under their responsibility. This is the solution adopted by Italy and Spain and more details can be found in **Appendix B Architecture.**

3.5.1.2 Decentralised model

Decentralised architecture refers to a U-space architecture without a single CIS provider where each provider of common information makes common information elements (data) directly available to the other operational stakeholders. A clear allocation of common information elements between Member States, ATS providers and USSPs would allow data users to find target data quickly and efficiently.

3.5.1.3 Comparison between Centralised and Decentralised Architectures

The Centralised and Decentralised models both aim to guarantee reliable access to common information for all operational stakeholders; however, they differ fundamentally in terms of structure, governance, and data management. The following table summarises these aspects:

Aspect	Centralised Architecture	Decentralised Architecture
Definition	A single, certified CIS provider collects all common information from various data sources and distributes it to operational stakeholders.	Each provider of common information shares its own data directly with other stakeholders, without a single central CIS.
Data Flow	All data passes through one CIS hub that aggregates and validates information before dissemination.	Data flows directly between multiple entities (e.g. USSPs, ATS providers, authorities).
Governance and Control	Strong central governance and regulatory oversight; simpler supervision by the competent authority.	Distributed governance requiring coordination and harmonisation between multiple providers.
Interoperability	Easier to ensure interoperability since only one CIS interface is used.	Requires common standards and synchronisation mechanisms to ensure interoperability across multiple nodes.

Scalability	May face limitations as the number of service providers and data exchanges grows, since the central node must handle an exponentially increasing load in terms of processing, storage, and network throughput. Scaling such a system relies on vertical scaling, which can be implemented but requires careful management to prevent bottlenecks and maintain system reliability.	Highly scalable and adaptable to larger, distributed U-space ecosystems, where new nodes or service providers can be added independently without overloading a central component. Data exchanges are distributed across multiple trusted entities
Resilience	Risk of single point of failure if the central CIS experiences downtime.	No single point of failure; higher redundancy and resilience.
Implementation Complexity	Easier to implement and maintain; lower integration complexity for stakeholders.	More complex implementation due to multiple data exchange interfaces.

Table 5. Comparison between centralised and decentralised architectures.

3.5.1.4 Data Exchange Interface

Independently of the model chosen for the architecture, the USSPs should exchange information related to Flight Plans, Network ID and Conformance alerts, among others. For this exchange, different technical solutions are possible.

3.5.1.4.1 Indirect exchange

In the following diagram, a simplified example of a centralised architecture encompassing Common information services and other centralised capabilities and the required exchanges with USSPs is presented.

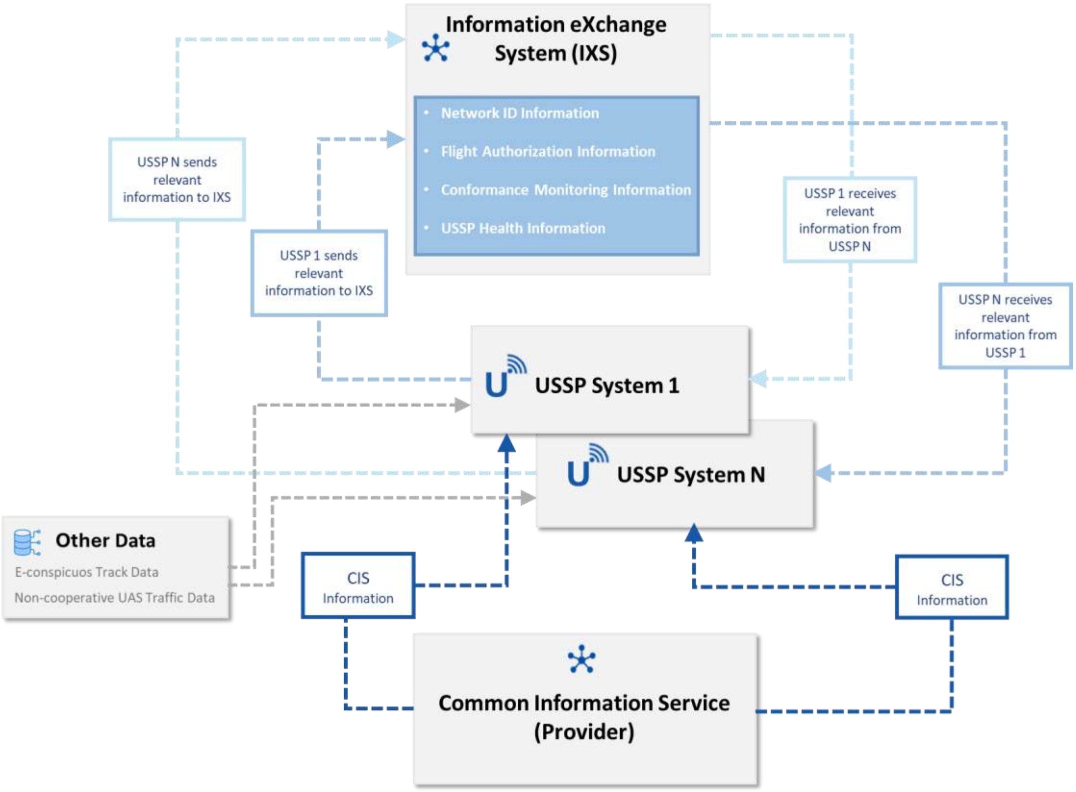

Figure 4. Example of centralised architecture and exchanges.

The diagram in Figure 4 shows a simplified diagram of an architecture model with CISP (or single CISP in case of centralised architecture). In this architecture, various actors such as the CISP (or single CISP), the USSPs and the information exchange mechanisms between USSPs stand out.

The Common Information Service (CIS) is responsible for supplying and maintaining essential data to ensure the safe and efficient operation of air traffic, particularly within U-space environments, regarding Article 5 of Regulation (EU) 2021/664. This service includes the following types of information:

1. AIP and NOTAM Information.
2. Controlled Airspace Manned Traffic Data.
3. CIS Status.

Regarding Article 7.5 of Regulation (EU) 2021/664, USSPs shall exchange any information that is relevant for the safe provision of U-space services amongst themselves.

In the centralised U-space architecture this information is exchanged between U-space Service Providers (USSPs) through a centralised platform. The diagram illustrates the process using two USSPs for simplicity; however, the "N" denotes that the same process applies regardless of the number of USSPs involved.

Regarding the relevant information exchanged within the Information eXchange System (IXS), as established in Regulation (EU) 2021/664, it is specified that this information must include:

- Network ID Information (Article 8) based on the standard ED-339
- Flight Authorisation Information (Article 10)
- Conformance Monitoring Information (Article 13)
- USSP Health Information (Article 7)

The process to perform this exchange is simple: each USSP sends the relevant information to the Information Exchange System (IXS), which is responsible for distributing it to the other USSPs involved in the U-space.

On the other hand, IXS manage Flight Plan information related to the Network-ID and Conformance. In both cases, the information is transmitted asynchronously, which means that the receiving USSP does not need to take any action to obtain it, it will receive it automatically thanks to the protocol used (AMQP 1.0).

In contrast, when it comes to flight plans, it is the interested USSP who must actively check which other plans exist in the area. To do this, it makes a synchronous request (API REST).

Once the strategic deconfliction process is completed, the USSP sends the new flight plan to the Information eXchange System, also through a synchronous request (API REST). If it wishes to finalize or activate that plan, it must make a new request, this time asynchronous with the status change (API REST).

Finally, as shown in the diagram USSP can receive E-conspicuous Track Data and Non-cooperative UAS Traffic Data, through external sources.

3.5.1.4.2 Direct exchange

In the absence of a dedicated exchange module, information is exchanged directly between USSPs, potentially following a discovery phase facilitated by the Discovery and Synchronization Service (DSS), as detailed in the ASTM F3411-22a standard, which is referenced as an Acceptable Means of Compliance in the AMC/GM to Regulation (EU) 2021/664.

It is important to note that, while the Discovery and Synchronization Service (DSS) is part of the ASTM F3411 standard and referenced in European regulation as an acceptable implementation, the Common Information Service (CIS) in the U-space architecture already centralises several key functions that DSS would otherwise provide. In this section, the direct exchange of information among USSPs is presented as described in the ASTM standard since there is a lack of standard for direct exchange of information in Europe.

Following discovery via the DSS (if applicable), USSPs establish direct communication links to exchange operational information, such as UAS flight authorisations and strategic deconfliction messages, in accordance with standards like ASTM F3411 and ASTM 3548. While the DSS enables discovery and coordination, the data exchange itself is conducted directly between USSPs through standardized APIs.

Entity Exchange

The following diagram illustrates how "entities" are exchanged. An *entity* refers to a dataset originating from a USSP. In this model, none of the USSPs are assumed to be known in advance. Instead, they discover each other dynamically through the DSS.

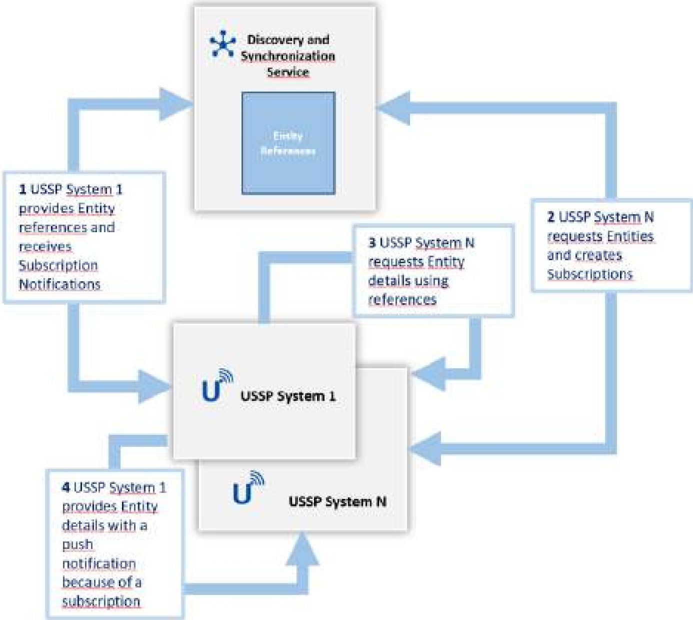

Figure 5. Example of a direct exchange architecture

Entity Exchange Process:

- **Publishing the Entity:**
    - The originating USSP registers metadata about the entity (including its unique identifier and associated geographic area) in the DSS.
    - This makes the entity discoverable to other USSPs that may be interested.
- **Discovering the Entity:**
    - Interested USSPs can obtain references to entities in two ways:
    - Querying for entities in a specific area of interest (a one-time interaction).
    - Subscribing to an area of interest, allowing the DSS to notify them whenever relevant entities are created, updated, or deleted. The DSS maintains knowledge of active subscriptions and informs publishers of who must be notified.
- **Retrieving Entity Details:**
    - Once a USSP obtains a reference to an entity, it can directly request detailed information from the USSP that published it.
- **Notifying Subscribers:**
    - Any USSP that creates, updates, or deletes an entity must proactively notify other USSPs that have an active subscription covering the area affected by that entity.

Direct UAS Flight Authorisations Exchange:

In the context of UAS flight authorisation exchange, the **entity** is referred to as an **Operational Intent**. It represents a reduced subset of a full UAS flight authorisation, containing only the mandatory fields required for strategic conflict deconfliction.

- A USSP shares the **Operational Intent** of a UAS flight with the DSS.
- Another USSP queries the DSS for operational intents intersecting a particular area of interest. The DSS may return:
  - No results (if there are no relevant operations),
  - One or more matching operational intents.
  - The USSP may also subscribe to that area, allowing it to receive future notifications with full intent details.
- With the reference provided by the DSS, the interested USSP can request the full operational intent directly from the USSP managing it.
- If a USSP creates, modifies, or deletes an operational intent, it must notify all subscribed USSPs whose subscriptions intersect the affected volume.

Direct Network ID Exchange:

In the context of Network ID exchange, the **entity** is referred to as an **Identification Service Area (ISA).** This defines the volume where the operations are taking place.

- A USSP managing one or more active flights publishes an **Identification Service Area (ISA)** to the DSS.
- Another USSP queries the DSS for ISAs intersecting a volume of interest. The DSS may return:
  - No ISAs (if there are no active flights),
  - One or more relevant ISAs.
  - The USSP may also subscribe to the area to receive notifications when new ISAs are published.
- Using the ISA reference, the interested USSP can:
  - Request **real-time position updates** for aircraft within that ISA at a frequency it deems appropriate.
  - Access **static flight details**, such as the operator registration number or take-off location, via a separate interface.
- If a USSP creates, modifies, or deletes an ISA, it must notify all USSPs with subscriptions covering that area.

3.5.2 Operational process

The following diagram summarises the interactions described in detail in the subsequent sections regarding the operation of a flight in U-space, covering the phases of flight preparation, flight authorisation, flight execution, and post-flight. The duration of these phases will depend on the type and nature of the operation. For instance, the flight preparation phase may begin several months in advance for scheduled operations, while for last-minute activities, such as deliveries or emergency missions, it may take place only a few minutes before the flight.

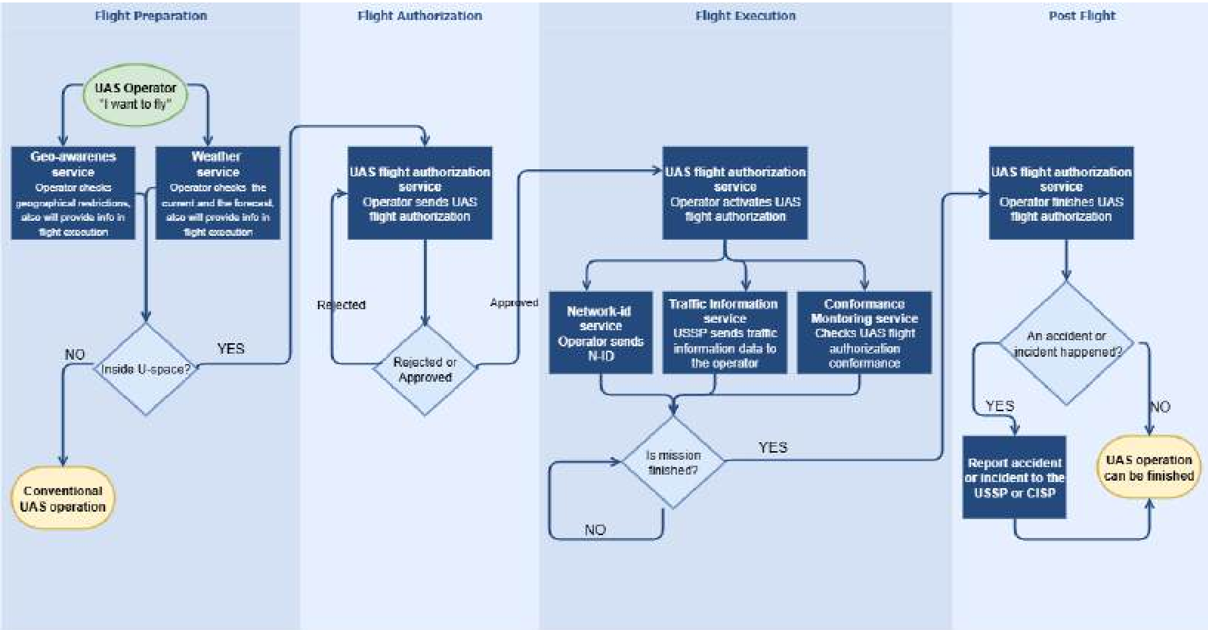

Figure 6. Operational process flow diagram

3.5.2.1 Flight preparation

An operator with the objective to execute UAS operation must perform several activities. Apart from the ones described in Section 3.4.4.1, related to the requirements to access to U-space, the operator should follow a process to fly in U-space.

During the Flight Preparation phase, the operator must leverage all available services to support the strategic planning process, aiming to gather as much information as possible and ensure the safety of the upcoming operation.

First, the operator must use the mandatory **Geo-awareness** service to identify any potential operational limitations and/or restrictions in their area of interest, where the operation is planned to take place, considering the intended time period for the flight.

The operator will receive detailed information about the existing operational conditions in the U-space airspace where the operation will take place. This includes time windows for requesting authorisation and activation, U-space protection buffers, deviation thresholds that must be applied to flight plans or the minimum distances that must be maintained between UAS and manned aircraft. This information will be crucial for the operator's first flights in U-space. If it is a regular operational area, the operator will already be familiar with its operational conditions. This information will be provided through the

Geo-awareness service by means of the parameters associated with each U-space airspace which is itself a type of UAS geographical zone.

USSP will also provide information about current airspace restrictions, including relevant UAS geographical zones and temporary restrictions. The operator will be informed about areas where UAS operations are prohibited, including dynamic airspace reconfigurations, as well as areas where entry permissions and/or specific technical requirements are necessary to fly. Based on the information related to the area and time of interest and the stakeholder of the UAS operation needs, the operator will be able to define or decide the geography/trajectory of the flight, along with other operational aspects such as the type of operation or the selected model of UAS for the mission. Operator remains responsible to obtain the permit required to fly in certain areas as part of a previous process.

It is expected that many UAS operators will have a tool to develop plans for flights and send those plans for authorisation. This tool may be a service provided by a USSP or provided by third party companies specialised in this type of service and is referred to as the **U-plan Preparation/Optimisation** service. Different versions of this service could be imagined for different business sectors. These tools are expected to be very valuable to UAS operators and a commercial added value for USSPs.

If a **Weather Information** service is offered, the operator must be provided with current weather data and forecasts both before and during the flight to ensure safety and support operational decisions within the relevant U-space. In this context, the operator must ensure that the weather conditions in the area and time of interest meet the parameters related to their mode of operation (VLOS vs BVLOS) and, if possible, any specific restriction associated with the aircraft model being used for the mission. In an unfavourable scenario, the operator may seek an alternative area or a more suitable time to conduct the operation, depending on their needs.

Additionally, UAS operators may use other additional information sources provided by their service provider: geo-temporal profiles, extended weather information, geospatial information about obstacles or infrastructures, population density, and any other input information suitable to prepare the flight.

*For more information about the experience regarding Flight Preparation, see the Lessons Learnt LL.SER 3, RECO.SER 2, RECO.SER 5, **Error! Reference source not found.** in the Section 4 Lessons Learnt and Recommendations*

3.5.2.2 Flight Authorisation

Once the UAS operator has completed flight preparation and gathered the relevant information, they are ready to request authorisation through the **UAS flight authorisation** service, which is mandatory under the European regulation (Regulation (EU) 2021/664 Article 10). UAS operators will typically follow a sequential process by filling out a form that covers the main aspects of the intended operation.

During this process, a critical step will be defining the 4D volume of the operation. Additionally, based on the information collected during flight preparation, this volume should be free of conflicts with areas where flight is prohibited or where weather conditions are not suitable for flying. The operator will also need to provide important information about the type of operation, the UAS to be used and the pilot responsible for the operation.

Once all the flight information has been entered, the operator can request authorisation. USSP will receive the request and perform a series of basic checks for strategic deconfliction.

First, it will verify that the request is complete and correct, ensuring the operator has provided the minimum required information and submitted the request within the allowed time window. It may also check whether the maximum capacity and density of UAS flights in U-space for the specified area and time have not yet been reached (if defined).

USSP will also check that the request is free of intersections with any airspace restrictions. Although the operator should have checked this using the geo-awareness service before submitting the request, new restricted areas may have emerged during the process.

One aspect the operator cannot foresee during flight preparation is the existence of other UAS operations in the same area of interest. USSP will check whether the requested 4D volume with the corresponding deviation thresholds intersects with any previously accepted authorisations.

If a conflict is detected during these checks by the **UAS flight authorization** service, the flight cannot be authorised. USSP will provide the reason for the rejection and may suggest an alternative where the operation could be conducted without issues (change of path, new start time). At this point, the operator can decide whether to update or resubmit the request to resolve the conflict or, if the alternatives are not sufficient, end the process.

On the other hand, if the request is complete and correct, and no geo-temporal overlap is detected, the request will be accepted and the UAS operator will be notified. In this scenario, checks may have identified intersections between the 4D volume and areas requiring entry permissions or specific technical requirements. If the USSP has a tool or service responsible for verifying these requirements, the process may enter an intermediate status while these verifications are conducted. Competent authorities may also access the system at this point to verify the requirements in their role as authorities. However, this is not mandatory nowadays; USSP may accept the request if it clearly notifies the operator of the detected areas and the necessary requirements for flying in them, emphasizing that it is the operator's responsibility to meet these requirements before requesting flight activation. Once accepted, USSP continuously monitors the status of the flight authorisation in relation to potential changes in the situation and the emergence of new conflicts, such as new dynamic geo-zones, dynamic airspace reconfigurations or higher-priority special operations. If any of these occur, the authorisation will be withdrawn and the reason will be provided to the operator, allowing them to decide whether to update the authorisation, request a new one or end the process,these evaluations are managed by the **UAS flight authorisation** service, which is connected to the **Geo-awareness** service to remain updated with the latest information on UAS Geographical Zones

Another possible scenario is that the operator cancels the accepted UAS flight authorisation before activating it and starting the operation.

For more information about the experience regarding Flight Authorisation, see the Lessons Learnt the LL.STAND 7, LL.STAND 9, LL.SYS 11, LL.SER 1 and the Recommendations RECO.REG 14, RECO.REG 15, RECO.SER 1 in Section 4 Lessons Learnt and Recommendations

3.5.2.3 Flight Execution

If all checks are favourable and the UAS flight authorisation request has been accepted, the UAS operator can request activation when ready to start the flight. Before confirming activation, USSP will perform final checks to ensure that the flight plan remains compliant.

USSP will verify that the activation request was made within the correct time window using the **UAS flight authorization** service, that the planned flight remains compatible with any airspace restrictions in the area, and, if applicable, with weather parameters. It will also ensure that the flight is free of intersections with prohibited zones, DARs, or higher-priority flights.

If any of these checks fail, USSP will not accept the activation request, indicating the reason for the rejection and may propose alternatives. On the other hand, if the final checks are successful, USSP will confirm the activation. As the operation is about to begin, the provision of tactical services will be triggered: **Network Identification** service, **Traffic Information** service, and, when applicable, **Conformance Monitoring** service.

The UAS operator will initiate the flight by sharing e-identification (e.g. switching on the hook-on device or through the GCS) via the **Network Identification** service. USSP will receive the flight's location and identification and will share this information with all relevant stakeholders. USSP will gather traffic data from several sources to provide **Traffic Information** service to UAS operators. It will inform them of any manned or unmanned traffic near their position or intended route.

Traffic information data will include traffic information provided in controlled airspace by the responsible ATS provider via the CIS or s-CISP, electronically conspicuous manned traffic in airspace where manned aircraft are not subject to ATC and remote identification of UAS through the **Network Identification** service (including information from other USSPs). Additionally, it could encompass complementary traffic information on uncontrolled manned aircraft and data from other sources, such as unmanned traffic detection systems, if available and integrated (not required by regulation).

With this information, the UAS operator will have complete situational awareness of the traffic both near their position and along their intended route. Additionally, this traffic information will be considered in the final activation checks to ensure that the flight plan does not pose a risk to manned aircraft in an emergency, cooperative but non-conflicting drones, non-cooperative drones (if possible) or electronically conspicuous manned aircraft. Furthermore, while the **Geo-awareness** and the **UAS flight authorisation** services are mainly strategic, they will also be relevant during flight execution. USSP will inform the operator of any new dynamic geo-zone, dynamic airspace reconfigurations or higher-priority special operations that may affect the accepted and active flight plan. UAS operator must always be aware of these issues and act accordingly to conduct a safe UAS operation.

When available, during flight execution, USSP can provide conformance information for both the operator's own flight, issuing alerts for possible deviations from its authorisation, as well as for flights of other UAS operators that may be flying in their vicinity. The same applies to weather information.

*For more information about the experience regarding Flight Execution, see the Lessons Learnt LL.STAND 4, LL.SYS 7, LL.SYS 9, LL.SYS 10, LL.SER 3, LL.SER 4, LL.SER 5, LL.SER 6, LL.CNS 1, LL.CNS 2, **Error! Reference source not found.** and the Recommendations RECO.STAND 2, RECO.STAND 3, RECO.REG 5, RECO.REG 6, RECO.REG 11, RECO.REG 14, RECO.SER 5, RECO.SER 6, **Error! Reference source not found.**, RECO.SER 9, RECO.SER 10, RECO.SER 11, RECO.CNS 1, RECO.CNS 2, RECO.CNS 3, RECO.CNS 4, RECO.CNS 5 in Section 4 Lessons Learnt and Recommendations*

3.5.2.4 Post Flight activities

When the mission for which the UAS flight authorisation was requested is completed or if it has been withdrawn, the UAS operator must land to conclude the flight. Once landed, UAS operator must stop sharing e-identification (e.g. switching off hook-on device or through the GCS) and request a UAS flight authorisation deactivation. The ending of the flight will stop the provision of tactical services. The pilot should perform the normal post flight activities such as updating flight registries and doing the corresponding checks.

In the case of an incident or accident during the flight, it should be investigated and reported to the corresponding authorities. Occurrences, according to Regulation (EU) 2019/664, should also be reported to the competent authority by both CISP and USSPs, who must stablish procedures for it.

3.5.2.4.1 Occurrence Investigation and Reporting

According to Article 5 of Regulation (EU) No 2010/996 [33], paragraphs 1 and 2, all accidents and serious incidents involving aircraft to which Regulation (EU) No 2018/1139 applies shall be investigated. It will be responsibility of the Member state where the accident or the serious incident to carry out the investigation or in case the location cannot be stablished, a safety investigation shall be conducted by the safety investigation authority of the Member State of registration. In addition, paragraph 4 stablishes that all incidents other than those referred in paragraphs 1 and 2, may be investigated if it is expected to draw safety lessons from them.

Finally, paragraph 5 stablishes that an accident or serious incident may not be investigated when it concerns unmanned aircraft for which a certificate or declaration is not required pursuant to Article 56(1) and (5) of Regulation (EU) 2018/1139, i.e. unmanned aircrafts that are used in the Open Category of the IR 2019/947.

The following non exhaustive list from ICAO Annex 13 – Aircraft Accident and Incident Investigation, Attachment C [37] provides examples of what could be considered serious incidents:

- Near collisions requiring an avoidance manoeuvre to avoid collision or an unsafe situation or when and avoidance action would have been appropriate.
- Collisions not classified as accidents.
- Multiple malfunctions of one or more aircraft systems seriously affecting the operation of the aircraft
- System failures (including loss of power or thrust), weather phenomena, operations outside the approved flight envelope or other occurrences which caused or could have caused difficulties controlling the aircraft.

The following entities are or may be part of the investigation process:

- Civil Aviation Safety Investigation Authority (CASIA). According to Article 4 of Regulation (EU) No 2010/996, it is responsible to conduct or supervise safety investigations, either on its own or through other safety investigation authorities. The Member State shall ensure the independence of the authority, give them the means required to carry out its responsibilities independently and shall be able to obtain sufficient resources to do so. The Safety Investigation Authority have unrestricted authority over the conduct of the safety investigations.

- Safety Investigation Authority from other Member States. According to Article 6 of Regulation (EU) No 2010/996, the safety investigation authority from one Member State may request the assistance of safety investigation authorities from other Member States.

- EASA. According to Article 8 of Regulation (EU) No 2010/996 the Safety Investigation Authority shall, provided that the requirement of no conflict of interest is satisfied, invite EASA to appoint a representative to participate.

- National Civil Aviation Authorities. According to Article 8 of Regulation (EU) No 2010/996 the Safety Investigation Authority shall, provided that the requirement of no conflict of interest is satisfied, invite the CAA of the Member State concerned to appoint a representative to participate.

As established per "AMC1 Article 15(1)(d) Conditions for obtaining a certificate" of the Regulation (EU) 2021/664, both CISP and USSPs must stablish procedures for reporting occurrence to the competent authority and to any other organisation necessary. Although this requirement only applies to the CISP and USSP, given the context of U-space expected operation it would be desirable to implement a tool open for the public to report occurrences that may have gone unnoticed by the CISP/USSP, e.g. privacy issues.

For more information about the experience regarding Occurrence Reporting, see the Lessons Learnt LL.REG 6 in the Section 4 Lessons Learnt and Recommendations

3.5.3 Coordination with ATM

Procedural interface ATM/U-space is envisaged to be implemented in some scenarios where the U-space is in controlled airspace. According to Regulation (EU) 2021/665, when U-space airspace is in controlled airspace, ATSPs shall ensure the following:

- Provision of manned air traffic information: ATSPs must provide this data to the USSPs or, where appropriate, to the CISP. It is important to note that the provision of this data is dynamic airspace information and, therefore, the requirements to be set in the Service Level Agreement (SLA) to be established between the ATSP and the USSP/CISP must be suited to allow the USSP/CISP to provide this air traffic information with a periodicity of 5 seconds and an availability of 99%, as defined in AMC1 Article 5(1)(f) of the Regulation (EU) 2021/664.

  The agreement to be made with ATSPs for the provision of manned aviation information should address at least the issues of:

  - Data availability: Considering that the provision of information to UAS operators must be carried out with an availability of 99%.

  - Data continuity: Considering that the provision of information to UAS operators must be done every 5 seconds.

  - Data integrity: The protocol and data format by which both parties commit to send/receive the information must be defined.

  - Data accuracy: An acceptable margin of deviation or error in the provision of data by the ATSP must be defined.

- Define provision/provide DAR information: ATSPs and USSPs (or CISPs where appropriate) should define the Dynamic Airspace Reconfiguration (DAR) procedure whereby UAS operations in a U-space in controlled airspace are limited temporarily to allow manned aviation circulation.

  According to the experience acquired during the implementations in the different Clusters, a DAR procedure must address aspects such as:

  - Designation of the ATC personnel who will interact with the digital tool to apply DAR and send the information to the affected stakeholders, defining how will they activate/deactivate areas of a U-space volume, and including both the means by which they will deactivate/activate them and the times necessary to it.

  - Concept of operation during the DAR depending on the ATC unit in which it is carried out, defining which ATC personnel will be in charge of carrying out the procedure, and linking their actions with the times necessary for the ATM/U-space interaction defined above.

  - Estimated time for DAR: The recommended times for the dynamic reconfiguration of the airspace to be carried out safely must be defined in the procedure, leaving a sufficient margin of time for unmanned aviation to vacate the airspace before it is DAR effective. The effectiveness and guarantee of segregation largely depends on the time available to UAS operators to react based on the performance of the UAS they operate.

    According to EASA Guidance Material (non-mandatory) the ATC unit is expected to issue an alert as soon as possible and ensure a recommended time window of 10 minutes before application, plus 2 minutes once the restriction is lifted. activate.

  - Contingency plan: Joint contingency actions must be defined between the ATSP and the USSP/CISP that allow maintaining acceptable security levels for manned and unmanned aviation when non-nominal situations occur during the DAR.

  - It will be necessary to coordinate with the ATSP how U-space information will be displayed to ATC personnel. Ideally, it is preferable to integrate the ATS/U-space interface in the control working position (CWP). Another important point to coordinate with the ATSP is to agree on a colour code to represent the information displayed related to the U-spaces states (activated/non activated), so that both from the ATC side and the U-space side, it is clearly understood when a U-space is in active status and when it is free for manned aviation.

In addition to the definition of the DAR procedure, it is necessary to provide adequate training for the ATC personnel who will have to apply these DAR procedures during U-space operations. This is an important factor to be taken into account during U-space implementation, as the training of ATC personnel involves long periods of time.

A good technique to speed up the learning process for ATC personnel is to include U-space and U-space operational dissemination campaigns during the DAR prior to the start of the training period for ATC personnel.

When U-space airspace is designated in uncontrolled airspace traffic information on manned aircraft is not provided by the ATSP as the primary source, but is obtained from other sources, in particular through the electronic conspicuity of manned aircraft.

*For more information about the experience regarding Coordination with ATM, see the Lessons Learnt LL.STAND 6, LL.STAND 10, **Error! Reference source not found.**, LL.AUT 4, LL.AUT 5, LL.AUT 6, LL.SYS 12 and the Recommendation RECO.AUT 6, RECO.SER 3 in Section 4 Lessons Learnt and Recommendations*

3.5.4 Coordination with Law enforcement and Authorities

Regulation (EU) 2021/664 in the Article 5 states that static and dynamic airspace restrictions defined by the relevant authorities shall be made available as part of the common information services of each U-space airspace.

The GM to Regulation (EU) 2021/664 identifies the authorities which should be granted to provide information to, and retrieve information from the CIS provider, with the same data quality, latency and protection levels, which include Law Enforcement and Military Authorities, but also other relevant authorities or organisations (e.g. State agencies, municipalities, nature protection authorities, rescue coordination centres, GNSS services, aerodrome/heliport/vertiport operators, meteorological agencies).

Through these interfaces with U-space, Authorities must be able to establish, even in real time, permanent or temporary restrictions, limiting the volume of airspace within the U-space airspace where UAS operations can take place.

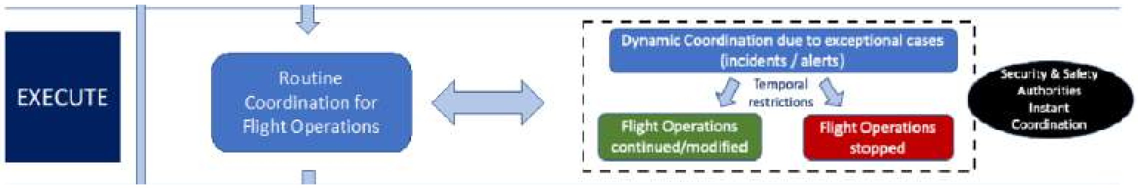

Figure 7. Coordination with authorities for the execution phase of the U-space deployment

In parallel, Regulation (EU) 2019/947 rules that Member States may establish UAS geographical zones, i.e., portions of airspace that facilitate, restrict or exclude UAS operations in order to address risks pertaining to safety, privacy, protection of personal data, security or the environment, arising from UAS operations. Additionally, this Regulation states the Competent Authority must make available the information on UAS geographical zones in a common unique digital format.

These UAS geographical zones are defined by the aforementioned relevant authorities and organisations, in order to control the UAS operations in sensitive areas, as populated zones, environmental protection areas, etc. Generally, the operations of UAS in these areas are not completely forbidden, but subject to previous coordination with the relevant authority (for example, Law Enforcement and Municipalities). However, although the information about these areas is provided in a common database by the Member State, the coordination with the responsible authority or organisation has to be made by means of specific procedures and data formats for each one of them; for example, some authorities request to send the data of the requested UAS operation through an online form, other ones demand and email and a PDF document, etc. Moreover, the coordination to perform the operations have to be made several days prior to the flight, usually from 5 to 20 days before.

For more information about the experience regarding Coordination with Law Enforcement and Authorities, see the Lessons Learned LL.AUT 2 and the Recommendations RECO.AUT 1, RECO.AUT 2, RECO.AUT 3 in Section 4 Lessons Learnt and Recommendations

3.6 Social and environmental impact

Implementing U-space will introduce changes with environmental and societal implications. While the main objective of U-space is to enable the safe, efficient and scalable integration of unmanned aircraft systems (UAS) in airspace, its deployment may cause side effects that need to be assessed by relevant measures, in particular an adequate regulatory environment. It is important to measure EU citizens' willingness to accept this new mode of aviation and analyse their possible concerns and expectations related to safety, security, privacy, and environmental impact.

From an environmental point of view, the concentration of drone operations, especially in urban or environmentally sensitive areas, can lead to increased noise exposure, potential wildlife disturbance and visual pollution. UAS platforms are electrically powered and therefore can contribute to reduced emissions compared to conventional transport alternatives; however, the cumulative impact of high-density operations, as well as the supporting ground infrastructure required (e.g. communication, navigation and surveillance systems) must be evaluated and compared with available alternatives.

Social impacts are equally relevant. Public perception of drone operations may be negatively affected by concerns about privacy, data protection, security and airspace equity. The proximity of UAS to populated areas, combined with their ability to carry high-resolution sensors, increases the risk of perceived or actual intrusion into private spaces. This can undermine public perception of the right to privacy.

In 2021 EASA published a new document entitled "Study on the societal acceptance of Urban Air Mobility in Europe" [41]. This report was created based on the best knowledge of the involved parties at the time of writing. However, due to the fast pace of this emerging industry the stated content might have changed since then. For more information, check the EASA IAM HUB.

Further information can be found by consulting the work carried out in the SESAR projects ImAFUSA, which focuses on assessing societal acceptance of U-space operations, and MUSE, which develops tools to measure the social and environmental impact of UAM in urban areas.

Additionally, as part of U-ELCOME project, a survey has been conducted in Spain and results are presented in the **Appendix G Social Acceptance survey**

4 Lessons Learnt and Recommendations

In this section all the lessons learnt and recommendations drawn during the project will be depicted. Then, throughout the document, these will be referred when applicable. Additionally, Lessons Learnt and Recommendations are contextualised in the table and linked to the applicable sections. In some cases, more than one section is mentioned.

Lesson learnt: “Experience drawn from past activities that should be actively taken into account in future actions and behaviours.”

Recommendation: “Advice about what is the best thing to have or do”. Recommendations are suggestions that, while valuable, do not yet have the level of maturity, consensus, or supporting evidence required to be considered best practices. They often serve as guidance for improvement or input for future development.

Category	ID	Description
Standardisation	STAND	Lesson learnt and Recommendations as a result of a gap in the standards based on operational experience
Regulation	REG	Lesson learnt and Recommendations as a result of a gap in the regulation based on operational experience
Authorities	AUT	Lesson learnt and Recommendations regarding authorities, responsibilities and governance
Airspace Risk Assessment	ARA	Lesson learnt and Recommendations regarding the process of performing the Airspace Risk Assessment to declare a U-space airspace
Certification	CERT	Lesson learnt and Recommendations regarding the process of certification
Systems	SYST	Lesson learnt and Recommendations regarding the systems functioning learnt during the operations

Services	SER	Lesson learnt and Recommendations regarding the U-space services functioning learnt during the operations
Communication, Navigation and Surveillance	CNS	Lesson learnt and Recommendations regarding CNS systems and coverage during the operations

Table 6. Categories of Lessons learnt and Recommendations

4.1 STANDARDISATION

LL/RECO ID	Title	Description	Chapter(s)	Source
Lessons Learnt				
LL.STAND 1	Lack of standardisation between USSPs and Ground Control Station manufacturers	UAS are made up of a combination of platform and ground control station. The Ground Control Stations provided by the manufacturer and due to the novelty and lack of obligation of the U-space to be connected, it does not incorporate the representation of U-space data. From this we deduce the need for a standard that facilitates the connection of a ground station to multiple USSPs. Having two separate laptops increase RP workload and may require assistance by another crew member (although its presence may not be necessary for the intended operation) in gathering info from U-space. *(see RECO.STAND 4, RECO.SER 12, RECO.SER 13)*	*2.1Regulation and Standards* *3.4.5.1 UAS Required equipment*	U-ELCOME Project
LL.STAND 2	Need to standardise notifications between USSPs and operators	Experience from U-space implementation showed that operators receive service notifications through diverse systems and formats, leading to inconsistencies and reduced situational awareness. There is a need to establish a standardised interface to deliver all U-space notifications	*2.1Regulation and Standards*	U-ELCOME Project

		directly to the operator's HMI, ensuring timely and consistent communication. *(see RECO.STAND 2)*		
LL.STAND 3	Lack of standards for integration of U-space services within the GCS GUI	There is a lack of standards for integration of U-space services within the GCS graphical user interface.	*2.1Regulation and Standards* *3.4.5.1 UAS Required equipment*	U-ELCOME Project
LL.STAND 4	Lack of standardisation in the painting of UAS zones and U-space airspaces in an HMI	There's a lack of information regarding how the UAS geographical zones and U-space airspaces should be presented on the screen depending on the multiple variables defined in the ED-269 or ED-318 and how to filter the information available. This standardisation may improve the readability by operators which use multiple USSPs. There is a consensus that ED-318 should not address this representation of geo-zones in user interfaces. A separate standard focusing on human factors and UI considerations may be more appropriate.	*2.1Regulation and Standards* *3.5.2.3 Flight Execution*	U-ELCOME Project
LL.STAND 5	Exchange of data between USSPs in an indirect way	One of the requirements for the certification of USSPs is the exchange of information with other USSPs, for which there is currently no commonly accepted model for how this information should be exchanged, especially in indirect communication architectures.	*2.1Regulation and Standards* *3.4.3.1 USSP Certification*	U-ELCOME Project

LL.STAND 6	Challenges in Standardizing Pilot Interfaces for Dynamic Airspace Reconfiguration in U-space	Although the transmission of the DAR as a CISP geozone to USSPs is standardized through the ED-318, there is no standard on how this information should be displayed to pilots by USSPs. It would be useful for this new standard to explain how to display the alert to pilots, what type of message it should include, and whether it should include additional instructions, as flight campaigns have shown that without prior training, operators are unable to react quickly or correctly. *(see RECO.SER 6)*	*2.1Regulation and Standards* *3.5.3 Coordination with ATM*	U-ELCOME Project
LL.STAND 7	Debate on Vertical Reference Standards for UAS Flight Authorisations in Complex Terrain	There is no consensus on the best vertical reference for defining the lower and upper limits of UAS flight authorisations. According to ASTM 3548, the reference should be WGS-84; however, using height above ground level offers significant benefits for operations at very low levels (below 500 ft). For wide UAS flight authorisations, setting vertical limits based on the WGS-84 ellipsoid often results in the flight volume intersecting with the terrain, especially when the topography is complex. *(see RECO.SER 3)*	*2.1Regulation and Standards*	U-ELCOME Project
LL.STAND 8	Geographical data exchange service	In the ED-269 standard, as well as the ED-318 standard, there are no additional fields foreseen to add metadata linked to the U-space airspace.	*2.1Regulation and Standards*	BURDI Project
LL.STAND 9	Flight Authorisation standard	The ASTM F3548-21 standard lacks the flexibility to share more data than strictly stated in the regulation EU2021/664.	*2.1Regulation and Standards* *3.5.2.2Flight Authorisation*	BURDI Project

LL.STAND 10	Dynamic Airspace Reconfiguration	The dynamic airspace reconfiguration that is issued from the ATS unit via an ATM system should be communicated through the CISP to the USSPs. Communication between ATSP and CISP is not standardised. The approach taken within the BURDI project is to provide for each ATS unit an entry queue at the CISP infrastructure on which ED-269 compliant U-space blocks (predefined U-space subdivision blocks) can be communicated. This approach allows the geographical data resulting from DAR activities to be automatically included in the geographical data stream. Whenever a certain U-space airspace volume is located within controlled airspace, the new DAR related geographical data shall automatically be included without the need for the USSP to set up a separate DAR-related geographical data collection subscription.	*2.1Regulation and Standards* *3.5.3 Coordination with ATM*	BURDI Project
LL.STAND 11	Integration of surveillance data in the USSP	There is currently a lack of standardisation regarding how surveillance information collected from various antennas (e.g., radar, ADS-B) is integrated into U-space Service Providers (USSP) platforms. Although some basic data exchange principles exist, the absence of a unified and widely adopted standard negatively impacts interoperability between different USSPs and surveillance systems. This inconsistency can lead to challenges in data sharing, system compatibility, and the timely availability of accurate surveillance information for drone traffic management and situational awareness. As a result, operational safety and efficiency may be compromised. *(see RECO.STAND 3)*	*2.1Regulation and Standards* *3.3.1.3 Surveillance*	U-ELCOME Project
LL.STAND 12	Clear separation between operational	Lack of clear separation between operational and technical definitions in U-space developments has caused misalignments and delays. Structuring	*2.1Regulation and Standards*	U-ELCOME Project

	and technical definitions	the process into an OSED followed by an ICD ensures consistency, interoperability, and easier stakeholder coordination. *(see RECO.STAND 1)*		
Recommendations				
RECO.STAND 1	Separate Standardization efforts into OSED and ICD	When defining any U-space system or service standard, the development process should be systematically divided into two key components: the Operational Services and Environment Definition (OSED) and the Interface Control Document (ICD). This separation facilitates clear traceability between operational needs and technical implementation, supports modularity and interoperability, and allows different stakeholders (e.g., operational experts vs. system engineers) to contribute within their area of expertise. By first establishing the OSED, stakeholders can agree on the operational context, roles, performance requirements, and constraints—before delving into technical interface details. The subsequent ICD then translates the operational needs into concrete, standardized interface definitions, ensuring alignment with the OSED and compatibility across different systems and providers. This approach enhances transparency, reduces ambiguity, supports certification and regulatory alignment, and accelerates harmonisation at both national and pan-European levels.	*2.1Regulation and Standards*	U-ELCOME Project
RECO.STAND 2	Need to standardise notifications between USSPs and operators	It is recommended to develop and implement a standardised interface for delivering U-space service notifications, such as Conformance Monitoring alerts, UAS Flight Authorisation status, Geo-awareness updates, and Traffic information, directly to the operator's Human-Machine Interface (HMI). This would ensure consistent, timely, and integrated	*2.1Regulation and Standards* *3.5.1 Architecture*	U-ELCOME Project

		communication between U-space systems and operator platforms, enhancing situational awareness and operational safety.	3.5.2.3 Flight Execution	
RECO.STAND 3	Common standard for e-conspicuity	It is recommended to develop and adopt a common standard for electronic conspicuity (e-conspicuity) to support the safe integration of manned and unmanned aircraft in shared airspace. A harmonised approach will enable mutual airspace awareness, facilitate interoperability between systems, and enhance the effectiveness of U-space services such as strategic deconfliction and tactical conflict resolution.	2.1Regulation and Standards 3.5.1 Architecture 3.5.2.3 Flight Execution	U-ELCOME Project BURDI Project
RECO.STAND 4	Need for standard to integrate USSP in the GCS	It is recommended to develop and implement a standardised protocol for integrating U-space service provider (USSP) data into Ground Control Stations (GCS). This protocol should ensure interoperability across different platforms and manufacturers, enhance situational awareness for remote pilots, and improve overall operational effectiveness and safety.	2.1Regulation and Standards ? Aircraft and systems	U-ELCOME Project

Table 7. STAND Lessons Learnt and Recommendations

4.2 REGULATION

LL/RECO ID	Title	Description	Chapter(s)	Source
		Lessons Learnt		
LL.REG 1	Non collaborative UAS	The current regulation does not address how to deal with non-collaborative UAS nor non-conspicuous airspace users within U-space. *(see RECO.REG 1)*	*2.1 Regulation and Standards*	U-ELCOME Project
LL.REG 2	Means to publish information	Article 5.5 of Regulation 664 requires that access to common information services be granted to competent authorities, air traffic service providers, U-space service providers and UAS operators on a non-discriminatory basis, including the same levels of quality, latency and data protection, but does not define how and by what means this information is to be made public. *(see RECO.REG 2)*	*2.1 Regulation and Standards* *3.4.1 Common Information Service*	U-ELCOME Project
LL.REG 3	Limitations in e-conspicuity implementation	Regulation (EU) 2021/666 stablishes the requirements that all manned aircrafts not subject to air traffic control must comply with if they want to operate inside U-space. However, at this level of implementation, it cannot be guaranteed the performance of the e-conspicuity infrastructure and e-conspicuity equipment given that there are no standards for such purpose yet. *(see RECO.STAND 3)*	*2.1Regulation and Standards* *3.4.6 Manned aircraft*	U-ELCOME Project
LL.REG 4	Situational awareness responsibility if provided by API	According to AMC3 to Article 7(2) "The USSP should ensure that the information that may affect safety is efficiently conveyed transmitted to UAS operators, allowing them to take the necessary, appropriate actions to ensure safety in a timely manner". This situational awareness is	*2.1Regulation and Standards*	U-ELCOME Project

		ensured by the USSP HMI under the cover of their certificate. However, when services are delivered through an API, the responsibility for ensuring this safety-critical information reaches UAS operators remains unclear.		
LL.REG 5	ISO 9001	As an ISO 9001 certificate is not considered as an AMC (but rather as a GM) under IR (EU) 2017/373 (having regard to the certification of ANSPs), SkeyDrone considers such requirement to be a GM as well under the U-space regulation.	*2.1Regulation and Standards*	BURDI Project
LL.REG 6	Occurrence reporting by operators	Regulation (EU) 2021/664 (Article 15.1.d) defines event reporting mechanisms for USSPs and CISP but does not address UAS Operators, who are key actors in U-space operations. In practice, some UAS Operators may report events directly to competent authorities without involving the USSP, similar to general aviation pilots in ATM. *(see RECO.AUT 5)*	*2.1Regulation and Standards* *3.5.2.4.1 Occurrence Investigation and Reporting*	U-ELCOME Project
Recommendations				
RECO.REG 1	National procedures to deal with non-collaborative UAS	It is recommended that when needed Member States establish national procedures for the detection and management of non-collaborative UAS, leveraging existing law enforcement mechanisms. These procedures should be integrated into the U-space operational concept through coordination between authorities and law enforcement even if such activities remain outside the current U-space regulatory scope.	*2.1Regulation and Standards*	U-ELCOME Project
RECO.REG 2	National guidance on access to common information services	It is recommended that national authorities should define the means access to common information services. Such guidance should define acceptable technical interfaces (e.g. APIs, web portals), access control procedures, and data protection requirements, ensuring non-discriminatory access with consistent levels of quality and latency for all	*2.1Regulation and Standards*	U-ELCOME Project

		authorised users, including competent authorities, ANSPs, USSPs, and UAS operators.		
RECO.REG 3	Conformance Monitoring service should be mandatory	It is recommended that the Conformance Monitoring service be designated as a mandatory U-space service, given its critical role in ensuring the safety of operations and maintaining situational awareness.	*2.1Regulation and Standards* *3.5.2.3 Flight Execution*	U-ELCOME Project
RECO.REG 4	Training about U-space	It is recommended to require mandatory training on U-space for operators before conducting operations within U-space airspace. This would ensure a minimum level of knowledge regarding roles, responsibilities, and technical procedures.	*2.1Regulation and Standards* *3.4.7 Training*	U-ELCOME Project
RECO.REG 5	Practices from ATM could be used	It is recommended to leverage Air Traffic Management (ATM) practices for special operations (e.g. "State flights") and adapt them to the U-space environment, especially for accommodating non-standard or exceptional missions.	*2.1Regulation and Standards* *3.5.2.3Flight Execution*	U-ELCOME Project
RECO.REG 6	Coexistence of manned and unmanned in U-space	It is recommended to reassess the regulatory approach to manned flights in U-space, particularly in controlled airspace. In some U-space areas, manned aircraft presence is relatively frequent, and a smoother integration model between manned and unmanned aviation should be promoted accordingly.	*2.1Regulation and Standards* *3.5.2.3Flight Execution*	U-ELCOME Project
RECO.REG 7	Clear and shared definition of the word vicinity and proximity	The results of the demonstrations show that it is possible to develop separation standards crew aircraft-uncrewed aircrafts using initial segregation based on PANS-OPS surfaces that safeguard the instrument flight procedures (in this case Shannon Airport). A segregated airspace volume from the surface up to 1,000 feet, separated from crewed aviation, proved sufficient to ensure the safety of UAS operations.	*2.1Regulation and Standards*	ÉALÚ-AER Project

RECO.REG 8	Responsibilities in the performance of the U-space services in third parties' systems	It is recommended that regulation clearly define the boundaries of responsibility between USSPs and UAS/GCS manufacturers regarding the performance of U-space services, to ensure accountability, safety, and interoperability.	*2.1Regulation and Standards*	U-ELCOME Project
RECO.REG 9	Crewed Traffic Detection outside U-space	As there is no e-conspicuity obligation for crewed traffic in uncontrolled airspace outside U-space airspace, the detection obligation by means of a 'minimum coverage area' imposed on USSPs would only make complete sense if it were to be associated with a corresponding Transponder Mandatory Zone (TMZ). It is a recommendation to EASA to correspond a TMZ to this 'minimum coverage area' imposed on USSPs.	*2.1Regulation and Standards*	BURDI Project
RECO.REG 10	Segregation Assurance	The recommendation is that the existing surveillance performance parameters that are applicable in controlled U-space airspace constitute as sufficient risk mitigation measures, that the creation of no-fly buffers within U-space airspace will not be required.	*2.1Regulation and Standards*	BURDI Project
RECO.REG 11	Deviation Threshold	The recommendation is to tag a drone a non-conformant when the drone leaves the deviation threshold (thus 4D UAS Flight Authorisation Volume) or when a drone fly's more than 5% of the expected flight time in the deviation threshold.	*2.1Regulation and Standards* *3.5.2.3Flight Execution*	BURDI Project
RECO.REG 12	Term Avoidance	It is recommended to consistently avoid the use of the term 'flight' when referring to the 'planned 4D volume' which by default is associated to the 'UAS operation'.	*2.1Regulation and Standards*	BURDI Project
RECO.REG 13	Additional AMC to clarify terminology	It is recommend to draft an additional AMC in which the link is made between the 'planned 4D volume' as used in the U-space Regulation (EU) 2021/664 versus the terminology used in the Regulation (EU) 2019/947, more particularly the terms 'flight geography', 'flight geography area', 'contingency area', 'operational volume' and 'ground risk buffer'.	*2.1Regulation and Standards*	BURDI Project

RECO.REG 14	Withdrawal Flight Authorisations 1	It is strongly recommend adding to the AMC/GMs that the USSP is allowed to end the UAS Flight Authorisation when there is a very strong reasonable assurance that the drone is no longer airborne and the UAS Flight Authorisation is ended. From experience we know that in certain use cases the pilot forgot to end the flight (which means the pilot is blocking the airspace and conformance-monitoring is triggered), another possibility could be a bug when the operator implements the API as allowed according to AMC4 Article 6(1)(b).	*2.1Regulation and Standards* *3.5.2.2 Flight Authorisation* *3.5.2.3 Flight Execution*	BURDI Project
RECO.REG 15	Withdrawal Flight Authorisations 2	It is recommended to add an AMC clearly stating that after activation the flight authorisation can no longer be withdrawn by the USSP but merely updated upon initiative triggered by the drone operator (i.e. by ending it and making a new one). This clarification is needed to resolve the ambiguity arising from the current wording of Article 6.6 of Regulation (EU) 2021/664, which allows the USSP to “introduce changes” during any phase of the flight, and GM2 to Article 10(10) point D, which could be interpreted as the USSP can only withdraw a flight authorisation prior to and not after flight activation. Without a clear regulatory interpretation, these provisions may lead to inconsistent operational practices and uncertainty regarding the allocation of responsibilities during the flight.	*2.1Regulation and Standards* *3.5.2.2 Flight Authorisation*	BURDI Project

Table 8. REG Lessons Learnt and Recommendations

4.3 AUTHORITIES AND RESPONSIBILITIES

LL/RECO ID	Title	Description	Chapter	Source
Lessons Learnt				
LL.AUT 1	Responsibility in the creation of UAS geographical zones	The need has been detected for local authorities to create UAS geographical zones that limit or warn of restrictions on the flight of drones, such as construction cranes, or areas temporarily limited by some type of local event. Authorities must be able to interact with U-space through established interfaces, in this context via the Geoawareness service, to dynamically manage and disseminate these airspace constraints. *(see RECO.AUT 3)*	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project
LL.AUT 2	Lack of predefined hierarchy in emergency situations	Experience in U-space emergency and special operations has shown that the lack of predefined responsibilities, operator authorizations, and prioritization rules can lead to delays, confusion, and safety risks. *(see RECO.AUT 1, RECO.AUT 2)*	*3.5.4 Coordination with Law enforcement and Authorities*	U-ELCOME Project
LL.AUT 3	Authorisation of foreign UAS operator	Cross-border UAS operations can face administrative challenges when local authorities require country-specific procedures or communication tools that foreign operators may not have access to. For example, in Italy, a PEC mail (certified mail) is necessary to submit an operation. To support safe and efficient operations across borders, U-space services should promote harmonised procedures and interoperable communication channels throughout the EU, reducing barriers for foreign operators and ensuring consistent access to airspace information.	*3.4.4.1General requirements*	U-ELCOME Project (Italian cluster)

LL.AUT 4	DAR procedure responsible	The Spanish cluster assigns responsibility for issuing the DAR to the tower supervisor. However, it has been observed that, particularly in single-position towers, this procedure may need to be carried out by any tower controller.	*3.5.3 Coordination with ATM*	U-ELCOME Project (Spanish cluster)
LL.AUT 5	ATCOs workload	In single-position control towers, concerns exist regarding the potential increase in workload for the controller, particularly if the DAR must be performed during peak traffic periods *(see RECO.AUT 6)*	*3.5.3 Coordination with ATM*	U-ELCOME Project
LL.AUT 6	ATCO experience with DAR procedure	The controllers reported that the procedure and the interface used during the Spanish cluster demos were easy to understand and apply. *(see RECO.AUT 7)*	*3.5.3 Coordination with ATM*	U-ELCOME Project (Spanish cluster)
LL.AUT 7	Reaction DAR time	Air traffic controllers (ATCO) are concerned about the reaction time to a DAR, but demos have shown that the reaction time is satisfactory for controllers in resolving the situation; however, it needs to be validated in an operational environment with unexpected situations. *(see RECO.AUT 7)*	*3.5.3 Coordination with ATM*	U-ELCOME Project
Recommendations				
RECO.AUT 1	Special operations submission	It is recommended that the Member State (MS), in collaboration with CISPs and USSPs, take responsibility for designating which operators are authorised to submit special operations.	*3.5.4 Coordination with Law enforcement and Authorities*	U-ELCOME Project
RECO.AUT 2	Levels of priority definition	It is recommended that the Member State, in coordination with the competent authorities, define operator levels and operation priorities for	*3.5.4 Coordination with*	U-ELCOME Project

		emergency response situations. This should include clear coordination and prioritization between manned and unmanned aircraft based on the specific emergency.	*Law enforcement and Authorities*	
RECO.AUT 3	Local authorities' role in defining UAS geographical zones	It is recommended that local authorities proactively define and publish UAS geographical zones with specific flight restrictions or cautionary warnings. These zones should account for temporary obstacles (e.g., cranes) as well as temporary limitations caused by local events, ensuring safer and better-informed drone operations.	*3.5.4 Coordination with Law enforcement and Authorities*	U-ELCOME Project
RECO.AUT 4	Local authorities' engagement	It is recommended that local authorities actively promote U-space to accelerate its implementation. Initiatives such as workshops and public dissemination activities should be considered to support this effort.	*3.1 Competent authorities and coordination mechanism*	U-ELCOME Project
RECO.AUT 5	Automation of occurrence reporting systems	It is recommended that occurrence reporting in U-space is publicly accessible and automated. To achieve this, authorities should prioritize the digitalization of their reporting systems. While UAS Operators typically notify events through agreements with their USSPs, some operators, similar to general aviation pilots in ATM, may report events directly to the competent authority without involving the USSP.	*3.1 Competent authorities and coordination mechanism*	U-ELCOME Project
RECO.AUT 6	Integration of DAR Functions into ATM Systems in Single-Position Control Towers	It is recommended to integrate DAR functionalities into existing ATM systems, especially in single-position control towers, to consolidate all relevant information on one interface, reduce workload, and maintain operational efficiency and safety.	*3.5.3 Coordination with ATM*	U-ELCOME Project
RECO.AUT 7	Recurrent trainings for ATCOs	It is recommended to provide targeted and recurrent training for air traffic controllers on DAR procedures, interfaces, and coordination workflows. Such training should be supported on a safety case and reflect different tower configurations and incorporate simulated scenarios to maintain	*3.5.3 Coordination with ATM*	U-ELCOME Project

		safety margins, confirm that reaction times remain satisfactory in operational conditions, and to reinforce controller acceptability of the procedures.		

Table 9. AUTH Lessons Learnt and Recommendations

4.4 ARA

LL/RECO ID	Title	Description	Chapter	Source
Lessons Learnt				
LL.ARA 1	Benefits of U-space implementation	One result of establishing U-space could be for more manned aircraft to carry ADS-B or other e-conspicuity devices that make them electronically visible to other users. Today, low-altitude manned aircraft frequently do not typically use ADS-B, making them invisible to tracking tools and the USSP, as their non-cooperative nature prevents real-time location tracking. However, while future U-space operations aim to incorporate e-conspicuity, the current situation poses safety risks, particularly in or near urban areas, where manned and unmanned aircraft may operate in close proximity.	*3.2.1 Preliminary study*	U-ELCOME Project
LL.ARA 2	Optimisation of ARA procedures	Early experiences with Airspace Risk Assessments (ARA) showed that initial processes could be further optimised. Opportunities were identified to improve airspace design, increase automation, align with manned aircraft operations, and strengthen stakeholder collaboration to enhance efficiency and consistency in ARA outcomes. *(see RECO.ARA 1, RECO.ARA 2, RECO.ARA 3, RECO.ARA 4, RECO.ARA 5, RECO.ARA 6, RECO.ARA 7)*	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project
LL.ARA 3	Telecom companies' involvement	It's clear the added value of having the mobile network companies involved in some way in the ARA process, but it is still uncertain how engage them to share its infrastructure and data to the ARA developers.	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project
LL.ARA 4	Coordination Mechanism and local U-space coordinator	Local stakeholders and authorities play a key role in the deployment of any U-space airspace. Such mechanism is not clearly defined and it's up to each Member State decide what is the best procedure in their case. The choice of a proper local U-space coordinator could reduce the workload during the	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project

		whole process. This local coordinator should be able to stablish quick and efficient communication channels with the local stakeholders that will be affected by the implementation of U-space.		
LL.ARA 5	ARA budget	The initial investment to gather data for the Airspace Risk Assessment and the lack of standardisation impose a problem that cannot be solved at this stage. *(see RECO.ARA 2)*	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project
LL.ARA 6	U-space airspace volume size	The size of the U-space airspace volume considered during the Airspace Risk Assessment should be defined considering the needs of the potential business cases identified and the operational needs and complexity of those drone operations. *(see RECO.ARA 1, RECO.ARA 3)*	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project
LL.ARA 7	ARA size vs complexity	Large volumes may enable more use cases and options for UAS operators potentially fostering the financial development of USSPs. However, it requires more coordination efforts with local authorities and increases the complexity of data gathering. *(see RECO.ARA 1)*	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project
Recommendations				
RECO.ARA 1	Scalable approach for U-space implementation	It is recommended that U-space implementation start with small and simple airspace volumes that can be scaled up over time. If larger volumes are considered, zones with minimal operational activity should be identified and potentially excluded to reduce coordination complexity and simplify data gathering, while still allowing for future expansion to support additional use cases and UAS operations	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project

RECO.ARA 2	Open-source tools	It is recommended to explore open-source methods and tools to collect and analyse data, in order to reduce costs during the early phases of Airspace Risk Assessment.	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project
RECO.ARA 3	Geometry of CTRs	It is recommended to reconsider the geometry of Controlled Traffic Regions (CTRs) when planning new U-space volumes. Adjusting boundaries can help reduce the need for frequent DARs and simplify airspace coordination.	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project
RECO.ARA 4	Digitalization of the process	It is recommended that the digitalization and automation of the ARA process be prioritized and implemented as soon as possible.	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project
RECO.ARA 5	Sectorization of U-space volume based on DAR	It is recommended that the sectorization of a U-space volume for DAR be designed in accordance with the existing manned aircraft use cases within that volume.	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project
RECO.ARA 6	ARA templates	It is recommended to develop scalable solutions for U-space implementation that can be adapted, replicated, and exported to other locations by assessing key characteristics of each area (e.g., ports, small/medium cities, airports), leading to the creation of standardized templates.	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project
RECO.ARA 7	Data checklists for stakeholders	It is recommended to enhance stakeholder collaboration to improve the quality of ARA outcomes. Creating checklists to anticipate stakeholders' specific information needs, preferred formats, and timing could significantly facilitate the ARA process.	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project
RECO.ARA 8	Restriction for C0 drones in the early stages	It is recommended that, during the early stages of U-space implementation, the restriction of C0 operations be considered during the ARA process to ensure safety. In the case that they fly in U-space, they shall meet the same requirements as the rest of the U-space users.	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project

RECO.ARA 9	Safety performance monitoring	It is recommended to conduct post-implementation safety performance monitoring for identifying and analysing risk mitigation measures, and for refining Airspace Risk Class (ARC) assumptions with empirical evidence, including the effectiveness and reliability of mitigations if well-proven through analysis, testing, or operational data.	*3.2.2 Airspace Risk Assessment* *3.2.5 Re-assessment process*	U-ELCOME Project

Table 10. ARA Lessons Learnt and Recommendations

4.5 CERTIFICATION

LL/RECO ID	Title	Description	Chapter	Source
Lessons Learnt				
LL.CERT 1	USSP Certification Challenges: Addressing Communication Readiness	It can happen that the certification process for a USSP begins even if there is no CISP with which it needs to communicate. Although there are standards for implementing such communication, such as ED-269, the certification process does not take into account whether these components can communicate correctly.	*3.4.3.1 USSP Certification*	U-ELCOME Project
LL.CERT 2	Readiness of certification actors	As the certification process is still in the first stages, not all stakeholders are ready yet. Specifically, for USSP certification, there are some risks including: - Lack of designated CISP and data exchange modality - ATSP not ready to validate DAR functionalities - No U-space available in the short term to provide services within the 6 months post certification deadline This results in additional difficulties, costs and delays to be certified. *(see RECO.CER 1, RECO.CER 2)*	*3.4.3.1USSP Certification*	U-ELCOME Project

LL.CERT 3	Safety expectations and constraints	The safety analysis to be produced as part of the USSP certification process (Safety Assessment and Safety Support Assessment) could face the following challenges: - the absence of U-space airspace designated and ARA, and therefore a real security constraints and criteria - the absence of clearly defined expectations from regulation and authorities.	*3.4.3.1USSP Certification*	U-ELCOME Project
Recommendations				
RECO.CER 1	Certification process	It is recommended to engage early with the competent authority to ensure alignment and clarify any ambiguities related to understanding and implementing the Regulation and associated AMCs/GMs.	*3.4.2.1 CISP Certification* *3.4.3.1USSP Certification*	ANRA
RECO.CER 2	Ensuring Certification Efficiency Through Stakeholder Coordination	It is recommended that, to avoid delays, additional costs, and coordination issues observed during the current process, all certification-related activities (including USSP, sCISP when applicable, and U-space airspace designation) be conducted in parallel whenever possible. This approach will enhance stakeholder readiness and improve adherence to certification timelines.	*3.4.2.1 CISP Certification* *3.4.3.1USSP Certification*	U-ELCOME Project
RECO.CER 3	Automatic testing to improve efficiency	To improve the efficiency and scalability of U-space certification and airspace integration processes, the use of automatic testing environments and simulated service interfaces should be actively encouraged. These tools can support new U-space service providers (USSPs) in demonstrating compliance with technical and performance requirements, validating their system behaviour in representative scenarios, and testing interoperability	*3.4.3.1 USSP Certification*	U-ELCOME Project

		with other U-space actors without requiring the immediate involvement of live counterparts such as CISPs, ANSPs, or other USSPs.		
RECO.CER 4	Operational consideration	Demonstrating the capability of the system to fail elegantly and meet scalability requirements, while being resilient, is key to ensuring that the highest levels of safety and compliance are guaranteed.	*3.4.3.1USSP Certification*	ANRA
RECO.CER 5	Human factors and training material	Human factors are mandatory to consider, even in highly automated systems. This includes clear usability requirements, user-friendly interfaces, and operator training guides.	*3.4.3.1USSP Certification*	ANRA

Table 11. CERT Lessons Learnt and Recommendations

4.6 SYSTEMS

LL/RECO ID	Title	Description	Chapter	Source
Lessons Learnt				
LL.SYS 1	Use of hook-on device solution instead of GCS integration solution, to transmit telemetry data from the UAS to the USSP	The solution of using a hook-on device is simpler, faster, and more accessible for a UAS operator, since an integration through GCS implies a software development work that falls on the operator's side and that is not affordable in most cases. Especially as long as there is no GCS standard integrated with USSP. *(see RECO.SYS 2, RECO.SYS 3, RECO.SYS 4)*	*3.4.5.1 UAS Required equipment*	U-ELCOME Project
LL.SYS 2	Advantages of using a tracker device solution	The advantage of choosing to use the tracker is that the device purchased by the operator is already integrated with the USSP from which the services are required. *(see RECO.SYS 2, RECO.SYS 3, RECO.SYS 4)*	*3.4.5.1 UAS Required equipment*	U-ELCOME Project
LL.SYS 3	Potential issues when using a hook-on device solution	Potential issues to be faced when using a hook-on device: 1. Potential problems with the data quality, especially altitude. 2. Issues with communications if installed on top of the drone 3. issues with GPS if installed below the drone, 4. may run out of battery, 5. cannot relay the drone state	*3.4.5.1 UAS Required equipment*	U-ELCOME Project

		6. Due to the weight of the device, in some cases, it cannot comply with the CE class marking anymore 7. It could pose electromagnetic problems *(see RECO.SYS 8, RECO.SYS 9)*		
LL.SYS 4	Incomplete automatization of communication over API	Communication between USSP and Ground Control Station realised over API is not automated completely.	*3.4.5.1 UAS Required equipment*	U-ELCOME Project
LL.SYS 5	Advantages of having the Network-ID service integrated into the GCS	The advantages compared to a tracker device: 1. the position sent to the USSP is the same the drone is using for navigation in the N-ID service 2. Access to more internal data such as emergency situations (required by N-ID service) which is difficult to have when using a hook-on device 3. If relying on the mobile network to communicate with the USSP, coverage tends to be better on the ground than during flight. 4. All the information from the USSP is available to the operator in one screen *(see RECO.SYS 2, RECO.SYS 3)*	*3.4.5.1 UAS Required equipment*	U-ELCOME Project
LL.SYS 6	Hook-on tracker devices may invalidate the UAS class label.	For aircraft whose maximum take-off weight is equal to their empty or minimum weight, adding a tracker would exceed the weight limit allowed by their class certification.	*3.4.5.1 UAS Required equipment*	U-ELCOME Project

LL.SYS 7	Coverage problems on Hook-on devices	Hook-on devices may encounter coverage problems since the mobile network is primarily designed for terrestrial use.	*3.4.5.1 UAS Required equipment* *3.5.2.3 Flight Execution*	U-ELCOME Project
LL.SYS 8	Installation of USSPs APPs in UAS command units	UAS command units may not permit the installation of non-original manufacturer software, limiting the possibility of providing a USSP APP alongside a GCS on the same screen.	*3.4.5.1 UAS Required equipment*	U-ELCOME Project
LL.SYS 9	Problems in the temporal synchronization of network ID messages.	The European regulation 664 requires the transmission of the timestamp at which the network ID report was generated. Issues have been identified when the originating system, typically the Ground Control Station or the onboard tracker, lacks proper synchronization of its internal clock. This results in network ID messages with incorrect timestamps, forcing some USSPs that evaluate the validity of this field to discard them.	*3.5.2.3 Flight Execution*	U-ELCOME Project
LL.SYS 10	Enhancing Network ID Accuracy: Evaluating Aircraft Status to Prevent False Conflicts	Evaluating whether the aircraft is in flight or on the ground before initiating the sending of network ID would be very useful. If network ID is sent while drones are being moved manually on the flight field, it can create situations of non-conformance or conflict with other aircraft when there is actually no conflict.	*3.5.2.3 Flight Execution*	U-ELCOME Project
LL.SYS 11	Buffer definition	While uploading the flight plan, only a single buffer value can be set (according to 1:1 rule). However, especially for long range mission where vertical profile may vary, it is suggested to upload in the system the buffer volume directly from the .kml file (as the system currently does for contingency volume).	*3.5.2.2 Flight Authorisation*	U-ELCOME Project

LL.SYS 12	Integration between the U-space interface and ATC	During a Spanish cluster exercise, controllers indicated a perceived need for integration between the U-space interface and air traffic control (ATC) systems. They noted that such integration could enhance coordination and situational awareness, particularly in airspace where manned and unmanned operations coexist. *(see RECO.AUT 7)*	*3.5.3 Coordination with ATM*	U-ELCOME Project (Spanish cluster)
LL.SYS 13	Change in the USSP software version must be carefully managed	When a major update of the USSP software is planned, it should be treated as a full project, including integration, testing, and training. Proper planning helps avoid delays and ensures smooth implementation.	*3.4.3 USSP*	U-ELCOME Project
Recommendations				
RECO.SYS 1	Structure ICD standard Development into 4 Coordinated Threads	When developing an Interface Control Document (ICD) for any U-space system or service, it is recommended the work is systematically divided into four coordinated threads to ensure clarity, consistency, and interoperability across implementations: 1. **Data Scope** – Define the operational purpose and boundaries of the data to be exchanged, including what information is necessary, why it is needed, and when it must be shared. 2. **Data Model** – Specify the structure, semantics, and relationships of the data elements to ensure a shared understanding across systems and stakeholders. 3. **Interfaces** – Define the technical means of data exchange, including protocols, communication patterns, message formats, and endpoints.	*3.4.3 USSP*	U-ELCOME Project

		4. **Service Requirements** – Capture the non-functional characteristics such as availability, performance (e.g., latency), security, and reliability expectations for the service delivering or consuming the data. This structured approach enables focused expertise in each domain, promotes traceability, and reduces ambiguity in implementation. It supports robust, scalable, and interoperable U-space services.		
RECO.SYS 2	GCS Tracker integration	It is recommended to simplify the operation of the tracker by integrating it into the Ground Control Station (GCS) application. Currently, the tracker is managed through an external app, which adds complexity. Integration would streamline operations, especially if the operational checklist includes activating the tracker from the GCS, making the overall process easier and more efficient.	*3.4.5.1 UAS Required equipment*	U-ELCOME Project
RECO.SYS 3	Integration of U-space Services into Third-Party GCS	It is recommended to consider that, until widely accepted standards are established, U-space services may not be fully integrated into the operator's chosen GCS. While the preferred approach is to have all services within a single application sharing the same screen, this should be treated as a transitional measure. Standardization processes should account for liability and implementation issues arising from USSP services integrated in third-party GCS platforms not directly provided by the USSP.	*3.4.5.1 UAS Required equipment*	U-ELCOME Project
RECO.SYS 4	Hook-on device loan service	In the first stages of U-space implementation, the possibility to loan Hook-on device could be envisaged to share cost among the drone community and to increase the use of the service.	*3.4.5.1 UAS Required equipment*	U-ELCOME Project

RECO.SYS 5	Traffic information display	It is recommended that the HMI traffic information display clearly differentiates between different types of aircraft and traffic situations by using distinct colours and shapes. Specifically, the display should distinguish between: • Manned and unmanned aircraft, • Collaborative and non-collaborative traffic, • Various aircraft configurations.	3.4.3 USSP	U-ELCOME Project
RECO.SYS 6	CNPC ground radio solution as reliable C2 link	It is recommended to integrate the CNPC (Control and Non-Payload Communications) system into the USSP ecosystem to allow UAS operators to monitor the real-time status of the Command and Control (C2) link. This integration should include information on which CNPC the unmanned aircraft is connected to and details about the link quality. Furthermore, CNPC systems should support seamless switching between multiple ground stations to ensure uninterrupted, low-latency C2 communications during long-range BVLOS operations. This enhances communication reliability, maximizes operational performance, optimizes airspace utilization, and increases U-space capacity.	3.3.1.1Communications 3.4.5.1UAS Required equipment	ÉALÚ-AER Project
RECO.SYS 7	Lower latency transmission through CNPC ground radio as C2 link in comparison with 4G/LTE	It is recommended to prioritize the use of CNPC ground radios over 4G/LTE links for latency-sensitive communication, as demonstrations have shown CNPC provides superior coverage, availability, and infrastructure monitoring, resulting in lower latency transmission and higher reliability.	3.3.1.1Communications 3.4.5.1UAS Required equipment	ÉALÚ-AER Project
RECO.SYS 8	External tracking devices vertical reference	It is recommended to clarify the vertical referential used by the external tracking device when working with telemetry. The vertical datum against	3.4.5.1UAS Required equipment	U-ELCOME Project

		which telemetry is provided by external tracking devices (hook-on device) may vary from one tracker to another and is often not clearly indicated. This can lead to conversion errors, resulting in discrepancies between the drone's actual altitude and the altitude as interpreted by the network identification service and thus in mistakes from the conformance monitoring service. If alignment on altitude reference cannot be assured, lateral separation should be applied in the meantime.		
RECO.SYS 9	Tracking Device Data Exchange Dynamics	It is recommended that, beyond the data format and transmission technology, the dynamic behaviour of the tracking device, such as its update rate and latency, is considered as a key parameter. The USSP must provide traffic information while complying with a maximum data latency and frequency. This performance can only be achieved if the tracking device (or equivalent equipment) also meets certain performance criteria.	*3.4.5.1 UAS Required equipment* *3.5.2.3Flight Execution*	U-ELCOME Project

Table 12. SYS Lessons Learnt and Recommendations

4.7 SERVICES

LL/RECO ID	Title	Description	Chapter	Source
Lessons Learnt				
LL.SER 1	Lack of digitization of third-party coordination	Currently, there is no digital mechanism to crosscheck third-party permits for accessing restricted or conditional areas in U-space. As a result, U-space service providers (USSPs) must either implement alternative verification methods or rely solely on operator declarations, which may compromise the robustness and reliability of the authorisation process. *(see RECO.SER 1)*	*3.5.2.2 Flight Authorisation*	U-ELCOME Project BURDI Project
LL.SER 2	Use of SWIM Yellow Profile for cybersecurity matters	The adoption of the SWIM Yellow Profile is fully compatible with widely accepted web service standards, including RESTful APIs for synchronous communication and AMQP 1.0 for asynchronous messaging interfaces.	*3.3.1.1Communications*	U-ELCOME Project
LL.SER 3	Dynamic population density maps from telecom providers data	Telecom providers can offer valuable data such as dynamic population density maps and network coverage maps, which: - Enhance operational safety in U-space by helping to define possible UAS operations - Permitting UAS operators to avoid densely populated areas or adjust the hours of their operations according to the fluctuating population density in an area. - Helps to define possible drone business cases at U-space	*3.5.2.1Flight preparation* *3.5.2.3Flight Execution*	U-ELCOME Project

		This information should be considered as guidance rather than absolute truth and should be complemented with additional data, as the population may be protected by shelter.		
LL.SER 4	Performance of the Conformance Monitoring service	The functionality of Conformance Monitoring is significantly reduced if we cannot ensure that alerts reach all users. Therefore, its usefulness will largely depend on whether it is mandatory or not, according to the outcome of the ARA. *(see **Error! Reference source not found.**)*	*3.5.2.3Flight Execution*	U-ELCOME Project
LL.SER 5	Dynamic Airspace Reconfiguration challenges	Dynamic Airspace Reconfiguration (DAR) allows airspace structures and restrictions within U-space to be temporarily modified in response to changing operational or safety needs, as foreseen in Regulation (EU) 2021/664. Early trials demonstrated both the operational benefits and the complexity of coordinating such changes across multiple stakeholders, including ANSPs, U-space service providers (USSPs), common information service providers (CISPs), and drone operators. *(see RECO.SER 3, RECO.SER 4, RECO.SER 5, RECO.SER 6, RECO.SER 11)*	*3.5.2.3 Flight Execution*	U-ELCOME Project
LL.SER 6		In VLOS operations, the Pilot in Command (PIC) must maintain visual focus on the aircraft, which limits the amount of attention they can give to information displayed on the USSP's screen. This limitation is even greater when the USSP relies on an external add-on device (e.g., a tracker) that is not integrated into the GCS. *(see RECO.SER 8)*	*3.5.2.3 Flight Execution*	U-ELCOME Project

Recommendations				
RECO.SER 1	Digitization of third-party coordination	It is recommended to digitize third-party operating authorisations (e.g., permits issued by external authorities for restricted zones) and integrate them into the Flight Authorisation Service. This would streamline approval processes and enhance safety in sensitive areas. With this implementation, when an UAS operator request a new flight authorisation, the USSP would check, using the data provided by the CIS, what coordination processes would be required and would send the request to the concerned authorities and organisations. In the short term, the USSP could as a proxy for the UAS operator, enabling the provision of the documents required by the authorities through its platform.	*3.5.2.2 Flight Authorisation*	U-ELCOME Project
RECO.SER 2	Detailed terrain and obstacle information provision in Flight Preparation	It is recommended having detailed terrain and obstacle data during the flight preparation phase. This would enhance flight planning by allowing operators to better assess operational risk, especially when submitting U-plans in complex environments.	*3.5.2.1 Flight preparation*	U-ELCOME Project
RECO.SER 3	DAR geometry	In the early stages of U-space DAR implementation, it is preferable to apply it to airspace volumes extending down to the surface rather than to specific corridors, as this simplifies procedures and minimizes risk.	*3.5.3 Coordination with ATM*	U-ELCOME Project
RECO.SER 4	DAR Procedures	It is recommended to first define unified DAR procedures applicable to any U-space airspace defined within controlled airspace by the ATSP, and later on, based on the specific requirements of the U-space airspace, particularised DAR procedures may be defined applicable to each ATC unit. This ensures a more gradual implementation and the definition of more similar DAR procedures between different ATSPs and the USSP/CISP, streamlining U-space implementation within controlled airspace.	*3.3.1.1 Communications*	U-ELCOME Project

RECO.SER 5	Definition of several alternative landing points in the flight plan	It has proven to be very beneficial to define several alternative landing points in the flight plan, in order to be able to finish the operation at the moment the DAR warnings (e.g, pop-up) appears in a faster way. For example, an initial, intermediate and final point in the flight plan.	*3.5.2.1Flight preparation* *3.5.2.3 Flight Execution*	U-ELCOME Project
RECO.SER 6	DAR process and alerts	It is recommended that the implementation of a Dynamic Airspace Reconfiguration (DAR) follow a two-step approach. The first step should provide advance alerts to operators indicating that a DAR will soon be activated, allowing them to prepare accordingly. The second step is the actual enforcement of the reconfiguration. It is also recommended that geo-awareness notifications during DAR events go beyond simple on-screen displays. To ensure the operator's attention, these alerts should include pop-up messages or audible signals. Importantly, the alerts should communicate not only the nature of the airspace change but also its consequences—such as possible revocation or modification of the flight authorisation. Additionally, when a drone approaches a restricted area, the system should prompt the pilot with clear and attention-grabbing alerts, guiding them to take the appropriate action (e.g., request access or exit the area). This approach improves situational awareness and supports safe and compliant operations during airspace reconfigurations.	*3.5.2.3 Flight Execution*	U-ELCOME Project
RECO.SER 7	U-space services as a mitigation	It is recommended to consider U-space services as potential mitigations in the air risk assessment (ARA) during the SORA process. The integration of U-space services into risk assessments can help reduce the residual risk and justify more efficient operations.	*3.4.4.3 Safety Assessment*	U-ELCOME Project
RECO.SER 8	Special needs for VLOS operations.	It is recommended to support VLOS operations by incorporating simple, audible alerts and intuitive interfaces in the USSP services. Given that the	*3.4.3 USSP*	U-ELCOME Project

		pilot must visually monitor the aircraft, they cannot continuously interact with screens, especially when using external devices like trackers not integrated into the GCS.		
RECO.SER 9	Traffic information notifications to operators	It's preferable for traffic information to include proximity notifications between operator aircraft and surrounding ones. These notifications could be triggered by user-defined parameters or during the ARA process and could be textual, acoustic, or directly on the map indicating conflicting aircraft.	*3.5.2.3 Flight Execution*	U-ELCOME Project
RECO.SER 10	Conformance monitoring notifications to operators	It is recommended to enhance conformance monitoring service by including clear visual and acoustic notifications for specific drones displayed within the traffic information system, helping operators quickly identify which aircraft is under alert.	*3.5.2.3 Flight Execution*	U-ELCOME Project
RECO.SER 11	Coordination in advance to avoid the DAR's 10 minutes activation time for emergencies	It is recommended that emergency operation plans include pre-coordination with ATSPs to avoid delays due to the 10-minute activation time required for DARs. Early coordination can facilitate faster airspace access in urgent situations.	*3.5.2.3 Flight Execution*	U-ELCOME Project
RECO.SER 12	USSP and UAS manufacturers cooperation	It is recommended to promote close collaboration between USSPs and UAS manufacturers to ensure seamless integration of U-space services into the GCS interface, thereby enhancing usability and reducing the need for external applications.	*3.4.3 USSP* *Aircraft and* systems	U-ELCOME Project

RECO.SER 13	Accuracy of U-space data in the HMI	Drone/GCS manufacturer should be responsible for the accuracy and the quality of the data presented in the GCS sourced from the USSP	*Aircraft and* systems	U-ELCOME Project

Table 13. SER Lessons Learnt and Recommendations

4.8 CNS

LL/RECO ID	Title	Description	Chapter	Source
Lessons Learnt				
LL.CNS 1	Coverage of 4G/LTE	Despite the integration solution selected, poor 4G/LTE coverage significantly impacts the reliability of U-space services, particularly the transmission and availability of Network ID, potentially compromising timely communication with the USSP and overall operational performance. *(see RECO.CNS 1, RECO.CNS 3, RECO.CNS 4, RECO.CNS 5, RECO.CNS 6, RECO.CNS 7)*	*3.3.1.2 Navigation* *3.5.2.3 Flight Execution*	U-ELCOME Project
LL.CNS 2	Tracker coverage	There are some locations where tracker with mobile network is not enough to track the UAV due to coverage reduction. Rural areas or places with mountains. *(see RECO.CNS 4)*	*3.3.1.2 Navigation* *3.5.2.3 Flight Execution*	U-ELCOME Project
Recommendations				
RECO.CNS 1	Network-id communication channel to the USSP	When feasible and if properly managed, Network ID data may be transmitted from both the aircraft and the Ground Control Station (GCS) to ensure redundancy and diversity	*3.5.2.3 Flight Execution*	U-ELCOME Project
RECO.CNS 2	CNS performance requirements	CNS performance requirements for U-space should be defined by means of a Safety Assessment and included as part of the Airspace Risk Assessment.	*3.2.2 Airspace Risk Assessment*	U-ELCOME Project

RECO.CNS 3	Cellular networks are the most feasible for exchanges	Cellular networks are considered the most feasible technology for air-to-ground and air-to-air data exchange in U-space, given their current deployment availability and cost-effectiveness. However, it is important to properly monitor the coverage, especially in remote areas.	*3.3.1.1Communications* *3.5.2.3 Flight Execution*	U-ELCOME Project
RECO.CNS 4	Using the GCS to Forward Drone Data in Areas with Poor Cellular Coverage	In rugged terrain, drones may occasionally lose cellular coverage, affecting their ability to transmit data directly to the USSP using a tracker. In such cases, it is recommended to use the C2 link to relay the drone's position and network ID to the Ground Control Station (GCS) and forward this information to the USSP via the GCS, since typically the coverage is more stable on the ground.	*3.3.1.1Communications* *3.5.2.3 Flight Execution*	U-ELCOME Project
RECO.CNS 5	Communications monitoring	Air/Ground communications coverage should be constantly monitored to identify potential performances reduction with regard to the nominal situation and, in that case, provide contingency measures.	*3.5.2.3 Flight Execution*	U-ELCOME Project
RECO.CNS 6	Ensure communication infrastructure existence	USSP must ensure the existence of communication infrastructure to receive Network Remote ID. They can host the infrastructure or sign agreements with telecommunications companies.	*3.3.1.1Communications*	U-ELCOME Project
RECO.CNS 7	Connectivity abroad	When operating in other countries, it is necessary to verify the coverage of roaming and local network providers to ensure reliable connectivity.	*3.3.1.1Communications*	U-ELCOME Project

Table 14. CNS Lessons Learnt and Recommendations

5 From Lessons learnt to Implementation: Key Recommendations

The successful deployment of U-space depends not only on compliance with regulatory frameworks and technological readiness, but also on the adoption of operational strategies proven to be effective in real-world situations. This section presents a set of key recommendations for U-space implementation derived from the lessons learned and recommendations presented above. Each of these key recommendations is based on operational experience and offers practical insights for future U-space implementation initiatives. Although quantitative recommendations are still limited, this collection reflects current knowledge and aims to support current and future U-space implementers.

Standardisation and Interoperability

- Standardise communications between USSPs and operators through APIs, enabling the implementation of the required functionality for the six regulated U-space services within the Ground Control Station or any HMI of the operator's choice used to receive U-space information during flight operations.
- Ensure interoperability of e-conspicuity systems by using a common standard that allows seamless identification and tracking of both manned and unmanned aircraft.
- Promote the integration of pre-flight planning tools developed by drone manufacturers into U-space systems. While this functionality will eventually be provided by USSPs, improving the interoperability of currently deployed tools is essential to support safe and efficient operations.

Regulatory Framework and Responsibilities

- Mandate the use of Conformance Monitoring as a safety-critical service, especially in dense or complex airspaces.
- Establish mandatory U-space training for all UAS operators before flying in designated U-space areas.
- Adapt best practices from ATM (Air Traffic Management), such as handling of State Flights or emergency procedures, into the U-space regulatory framework.
- Ensure consistent integration of manned aircraft into U-space, especially in airspaces where their presence is routine (e.g., near airports).
- Proper allocation of responsibilities between USSPs, UAS operators and UAS manufacturers regarding service performance, particularly when using third-party equipment.

Authorities and Governance

- Automate and digitalise occurrence reporting systems, allowing seamless and transparent safety monitoring for all stakeholders.
- Engage local authorities through workshops and targeted communication efforts, encouraging them to act as enablers for local U-space implementation.

- Define clear responsibilities for authorising special operations, ensuring cooperation between Member States, USSPs, and Common Information Service Providers (CISPs).
- Establish operator and mission prioritisation protocols in coordination with emergency services, especially during crisis response.

Airspace Risk Assessment (ARA)

- Use data-driven exclusion of low-activity zones when defining U-space volumes to reduce unnecessary restrictions.
- Digitalise and automate the ARA process to improve scalability, reproducibility, and stakeholder collaboration.
- Design sectorisation of U-space volumes based on real manned traffic patterns to optimise airspace design.
- Use location-specific ARA templates to facilitate replication across similar operational environments (e.g., ports, airports, cities).
- Create stakeholder data checklists to ensure timely and consistent provision of inputs during the ARA process.
- Align C0 drone requirements with those of other users when operating in U-space, particularly in early implementation phases.

Certification

- Engage early with the competent authority to ensure alignment with commonly agreed timescales and clarify any ambiguities related to understanding and implementing the Regulation and associated AMCs/GMs.
- Conduct, when possible, certification processes for USSPs, CISPs, and U-space airspace designation in parallel to reduce delays and streamline deployment.

System Design and Integration

- Integrate the Network ID service directly into the Ground Control Station (GCS) to transmit the drone's position and other regulatory data. This approach minimizes the need for additional hardware and reduces the operator's workload, contributing to more efficient and streamlined operations.
- Define acceptable timing discrepancies for Network ID messages to avoid false rejections by USSPs due to minor timestamp issues.
- Transmit Network ID data from both aircraft and GCS when possible, and enable a GCS-to-USSP fallback in low cellular coverage areas to ensure redundancy and continuous traffic awareness

U-space services and Operations

- Digitalize third-party flight authorisation processes and automate the cross-checking of information such as operator IDs and geo-zone access permissions. This facilitates seamless integration with USSP services and reduces processing delays.
- Provide detailed obstacle and terrain data to support safe and efficient U-plan submissions.
- Implement multi-step DAR alerts including clear, attention-catching pop-ups or acoustic signals that explain implications and guide operator response.
- Consider using U-space services as risk mitigations in operational risk assessments, especially in high-risk or complex environments.
- Prioritise audible and intuitive alerts for VLOS operations, ensuring pilots maintain situational awareness without overloading visual attention.
- Deliver real-time weather updates during BVLOS flights, particularly for headwind monitoring and flight range optimisation.
- Promote joint development of interfaces between USSPs and UAS manufacturers to ensure consistent and usable HMI integration.
- Ensure accuracy of U-space data displayed in GCSs, assigning this responsibility to the drone/GCS manufacturer when third-party systems are used.
- Coordinate emergency operations ahead of time to avoid the 10-minute DAR activation delay that may hinder critical responses.

CNS Infrastructure

- Promote the development and adoption of standards for integrating secondary surveillance data (e.g., SSR ADS-B, ADS-L 4 SRD-860, ADS-L 4 Mobile) into U-space platforms. This ensures interoperability, timely data availability, and improved situational awareness for safe and efficient U-space operations.
- Define CNS performance requirements as part of the safety and risk assessment processes according to airspace characteristics.
- Monitor communication coverage in real time, especially in mountainous or remote areas, and implement contingency plans as needed.
- Verify and ensure connectivity abroad, accounting for potential roaming or network incompatibilities.

6 Conclusions and further development

The implementation of U-space has been significantly accelerated by the DSD projects carried out across Europe over the past two years. These projects have explored a wide range of operational scenarios and achieved notable progress. Several CISPs and USSPs have been certified to date, one CISP through the BURDI project, and one CISP and one USSP through the U-ELCOME initiative. Additionally, another CISP and USSP are at an advanced stage of the certification process. Progress has also been made in the designation of U-space airspace, with ongoing procedures in Italy, Spain and Belgium. These advancements have been supported by the development of key collaboration procedures with authorities and a strong effort to align strategic objectives across stakeholders.

Extensive flight campaigns in operational environments in five countries have helped to gather experience and lessons learnt, and recommendations have been made to improve and accelerate the process in future developments. However, there are still significant challenges that need to be addressed, including gaps in technology, regulation, standards and integration with manned aviation. Furthermore, more research is needed to maintain progress as implementation begins in new areas of Europe. Due to the early stage of deployment and the limited availability of historical data, there is still a lack of quantitative results and defined performance thresholds, which limits the ability to assess effectiveness and guide regulatory evolution.

Ongoing research is essential to maintain momentum as U-space transitions from concept to operational reality in European regions. It is important to recognise that research and development in this field is inherently iterative. As technology and the regulatory environment evolve rapidly, approaches must be continuously evaluated, experimented with, and refined. Solutions that are effective today may become inadequate tomorrow, necessitating adaptability and innovation.

Annex I. Finished projects and Annex II. Ongoing projects present the completed and ongoing projects related to the field as a basis for the reader to understand what has been worked on and what are the main topics of interest for the progress of U-space. Even with all the work that has been done until now, many questions are not fully answered yet and sometimes new topics arise during the research and development of these questions. Below, some of these research questions are presented.

Communications, Navigation and Surveillance (CNS)

CNS is the core of the performance of any airspace, including a U-space airspace. It is expected that U-space will rely on common technologies for the development and deployment of any U-space airspace. However, we do not know yet whether these technologies can handle the increasing traffic of UAS while we maintain the desired level of safety. The questions to be answered include for example:

- Infrastructure. Is the current infrastructure enough to provide services for all the expected traffic in U-space? Do we need specific infrastructure only for U-space? For example, a GBAS system dedicated to U-space.
- Communication. What is the performance of the technologies proposed for U-space? There are many different solutions that could be used, e.g. 3G, 4G, LTE, 5G, 6G, Bluetooth, Wi-Fi, Satellite.
- Navigation. What is the performance of the navigation system commonly used for UAS? GNSS, IMUs, Wi-Fi, etc.

- Surveillance. We expect manned aircraft coming in and out of U-space airspace, specifically in airspace class G. IR 2021/666 gives multiple options on the means used to track manned aircraft, but which one is optimal is not clear yet.

Conflict management

In this initial version of U-space, the conflict management is done at the strategic phase of the flight while at the tactical phase, only information to support the operator is provided.

The following list represents topics that could be used to further develop the conflict management in U-space:

- Tactical conflict detection and resolution
- Separation management
- Collision avoidance systems. On board the UAS (ACAS/TCAS like system) or on the ground as a service of the USSP.
- New flight rules for UAS.

Security

How can we prepare U-space traffic against unlawful actions? (Spoofing, jamming, electromagnetic interferences, etc). Several topics that should be developed for the security of U-space are:

- Non-collaborative UAS detection. In this case, we should distinguish between a UAS which has lost control of the operation and is not cooperative anymore and a rogue UAS. Furthermore, the system should be able to identify the UAS that are flying under the U-space rules from the ones that are not.
- Counter UAS systems. Detection systems are not enough for a secure airspace, tools to take down rogue UAS must be developed and integrated in U-space.

U-space above VLL

At some point in the future, we might want to expand the U-space airspace boundaries beyond VLL which means we will need to fully integrate UAS traffic and manned traffic in the same airspace.

The integration of IFR UAS traffic is already ongoing through the world, but the topic to be discussed is whether the U-space airspace traffic should follow IFR rules, a whole new set of flight rules specifically developed for such purpose (Digital Flight Rules) or if both could be used.

Dynamic information tools

Information needed to carry out some operations is either not available or difficult to get. Further development is expected to get dynamic information that can help the operator in the flight Preparation process. Such information could include, among others:

- Density population maps
- GNSS coverage

- Mobile network coverage
- Vessels traffic monitoring tools
- Real time weather tools
- EM interferences

Common Altitude reference system

Regarding the common altitude reference system, there are still open points that need to be tackled in order to ensure safe operations in U-space. The topics to be developed are:

- What is the optimal sensor to measure altitude at Very Low Level? Barometers, GNSS, radio altimeters or a combination of all of these.
- The difference between the ellipsoid provided by WGS84 and the Mean Sea Level (MSL).
- Digital Elevation Models for U-space.
- The creation of a new datum for U-space or the update of a previous one.

These open questions represent just a selection of the many challenges that remain to be addressed as U-space moves toward full operational deployment and the need for continued research, development, and collaboration across multiple domains. They illustrate that, despite the important advancements made by recent DSD projects, the development and implementation of U-space remains an evolving challenge. The transition to fully operational environments requires continued investment in research, technological innovation, and regulatory alignment.

U-space services for crewed and passenger carrying aircraft

The focus of U-ELCOME was on the implementation of U-services within U-space airspace for UAS. However, continued and future research should investigate potential benefits and implications of offering basic or advanced services also to crewed aircraft such as VCA (vertical take-off and landing capable aircraft) with pilot on board, for UAS of the certified category (e.g. remotely piloted VCA for passengers or cargo transport), and for general aviation.

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8 List of Acronyms

Acronym	Definition
5G	Fifth Generation Mobile Network
ADS-B	Automatic Dependent Surveillance–Broadcast
AESA	Agencia Estatal de Seguridad Aérea (España)
AMC	Acceptable Means of Compliance
ANSP	Air Navigation Service Provider
ARA	Airspace Risk Assessment
ARC	Air Risk Class
ASTM	American Society for Testing and Materials
ATC	Air Traffic Controller
ATSP	Air Traffic Service Provider
ATM	Air Traffic Management
BP	Best Practice
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
CAA	Civil Aviation Authority
CISP	Common Information Service Provider
CNPC	Control and Non-Payload Communications
CNS	Communications, Navigation and Surveillance
CONOPS	Concept of Operations
CTR	Control Zone
DSD	Digital Sky Demonstrator
EASA	European Aviation Safety Agency
GCS	Ground Control Station
GM	Guidance Material
GNSS	Global Navigation Satellite System

GRC	Ground Risk Class
ISO	International Organization for Standardization
LL	Lesson Learnt
LTE	Long Term Evolution
MoC	Mean of Compliance
MS	Member State
NSA	National Supervisory Authority
PDRA	Predefined Risk Assessment
PIC	Pilot In Command
RECO	Recommendation
RP	Remote Pilot
RTK	Real Time Kinematics
SAC	Safety Criteria
SAIL	Specific Assurance Integrity Level
SESAR	Single European Sky ATM Research Programme
SESAR 3 JU	SESAR3 Joint Undertaking
SORA	Specific Operational Risk Assessment
STS	European Standard Scenario
SWIM	System Wide Information Model
TRL	Technology Readiness Level
TS	Technical Specification
UAM	Urban Air Mobility
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
USSP	U-space Service Provider
UTM	UAS Traffic Management
VLOS	Visual Line of Sight

Table 15. List of Acronyms

Appendix A Deployments Solution Table

In the following table, the solutions implemented by U-ELCOME, BURDI and ÉALÚ-AER in certain key topics are presented:

	U-space services implemented	Architecture	Network ID solution	E-conspicuity solution	Coordination manned-U-space in uncontrolled airspace	DAR implementation	External surveillance systems (non-cooperative detection)	USSP certification	CISP certification	U-space airspace designation	STAND applied
U-ELCOME Project **Spanish cluster**	Flight Authorisation Network Identification Geo-awareness Traffic Information Conformance Monitoring	s-CISP (Indirect USSP communication)	Integration with the GCS via API Hook-on device (Tracker)	ADS-B (not fully integrated in CIS) Trackers onboard of manned aircraft	Notify before access U-space and creation an emergency zone (similar to DAR)	Digital interface (managed by supervisor/ATCo)	No	Ongoing	Ongoing	Ongoing	ED-269
U-ELCOME Project **Italian cluster**	Flight Authorisation Network ID Geo-awareness	s-CISP (Indirect USSP communication)	Integration with the GCS via API Hook-on device (Tracker)	ADS-B (not fully integrated in CIS) Trackers onboard of	Notify before access U-space and creation an emergency zone (similar to DAR)	Coordinated centrally from a IAM coordination centre	Aeroscope antenna to protect NFZ	Yes	Yes	Ongoing	ED-269 ASTM F3411 22a

	Traffic Information Conformance monitoring (locally implemented USSP)			manned aircraft							
U-ELCOME Project **French cluster**	Flight Authorisation Network Identification Geo-awareness Traffic Information Conformance monitoring	No CISP	Thales ScaleFlyt RemoteId	Segregated airspace	Segregated airspace	No ATM-UTM coordination	Senhive Antenna CERBAIR Antenna	Yes (Innov'ATM)	N/A	No	ASTM F3411 ED-269
BURDI Project	Flight Authorisation Network Identification Geo-awareness Traffic information	s-CISP	Direct connection between GCS and USSPs GCS telemetry API Network Remote ID (N-RID), with	ADS-B Out ADS-L 4 SRD 860 Smartphone App	USSPs own detection of crewed traffic	Digital interface (managed by supervisor/ATCo)	ADS-B ADS-L 4, SRD-860 compliant Mobile telecommunication compliant	Ongoing	Yes	Yes	Asterix 062 ASTM F3411-22A ASTM F-3548-21

	Conformance monitoring Weather		use of mobile network Direct Remote-ID (D-RID), by means of antenna infra (e.g. Cx-compliant drone)				with ADS-L 4 MOBILE				ASTM WK73142 ED-269 ED-282 ED-318 ER-031
ÉALÚ-AER Project	Flight Authorisation Network Identification Geo-awareness Traffic Information Conformance Monitoring	sCISP (Indirect USSP communication)	DroneTag (Tracker) CNPC5000 Radio on-board of UAS Integration with UAS Cloud with APIs.	ADS-B fully integrated in CIS. Skyler Radar Solution	Collaborative interface with digital approval for clearance with Stakeholder (Geo-manager, ATCO..) available through USSP-CISP	Not implemented yet	Skyler Radar	No	No	No	ED-269 ASTM - F3411

Table 16. Deployments Solution

Appendix B Architecture

In the following diagram, an example of centralised architecture used in the Spanish and Italian clusters encompassing Common information services and other centralised capabilities and the required exchanges with USSPs is presented.

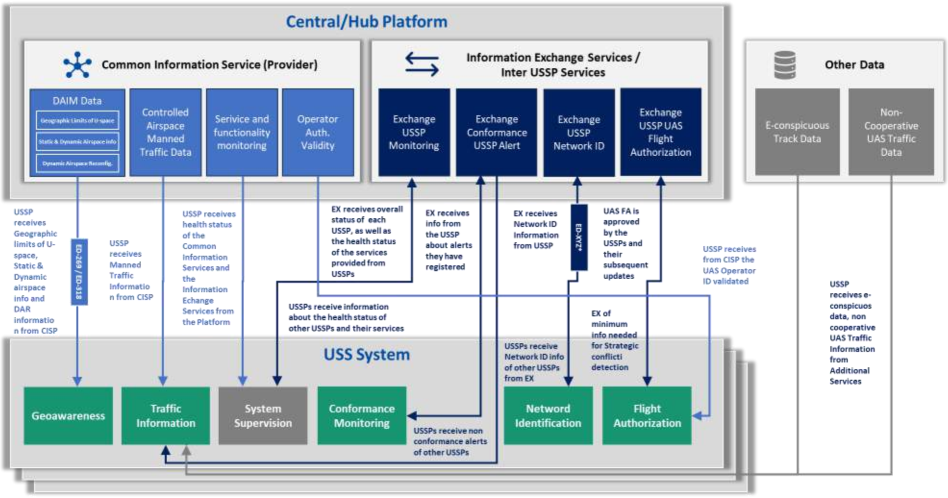


Figure 8. Example of centralised architecture and exchanges

The following sections present more detailed implementation architecture from different countries.

B.1 Example 1: U-ELCOME Spain cluster

As shown in Section 3.5.2, the general architecture followed within the framework of the project is an architecture based on the existence of a central platform that includes both a module for the provision of common information services and a specific module to enable the indirect exchange of information between USSPs. This architecture can be seen in the following Figure:

The architecture followed within the Spanish cluster itself does not differ much from the generic architecture used in U-ELCOME, as shown in the following Figure:

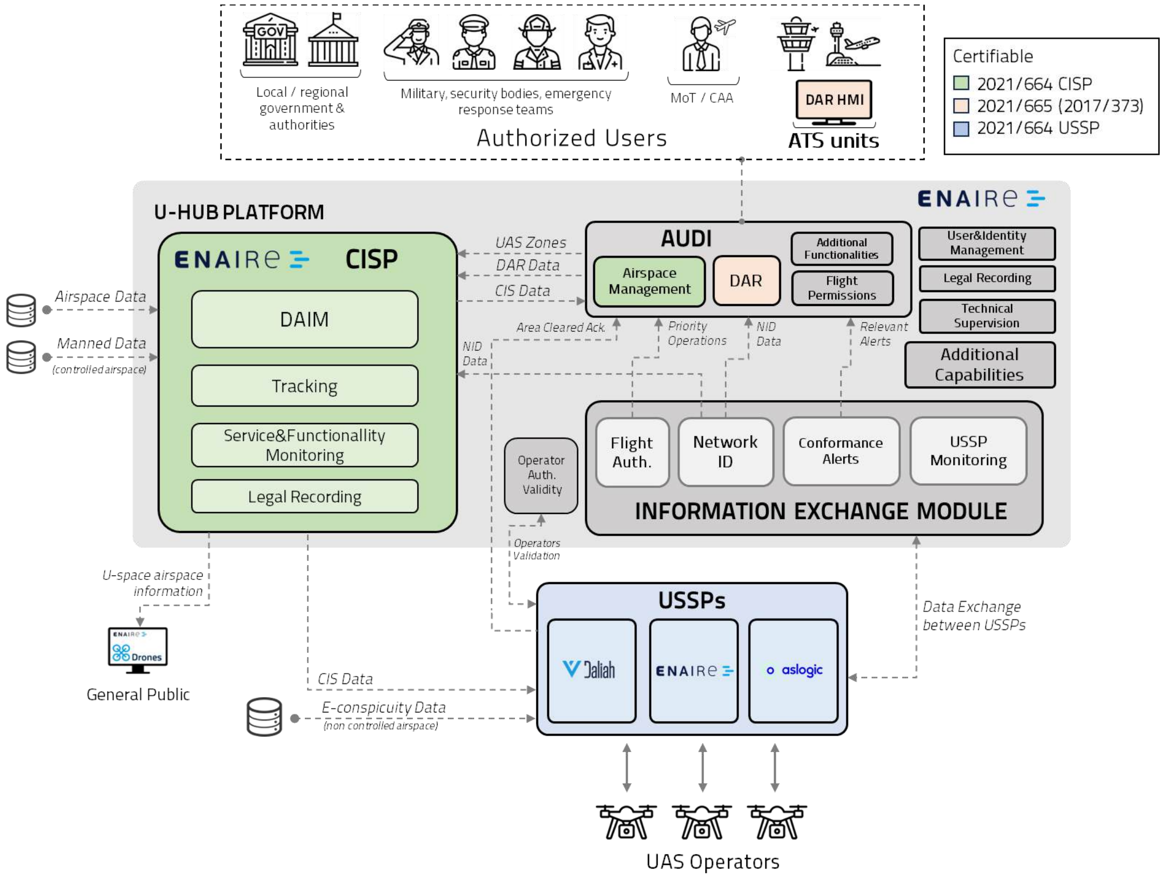


Figure 9. Spanish cluster architecture and exchanges.

B.1.1 ENAIRE U-Hub Platform Modules

The central platform corresponds to what would be the ENAIRE U-Hub platform, which is composed of:

- A Module for the provision of common information services, ENAIRE CISP, which is the module through which ENAIRE will be certified as single CISP in Spain.
- The indirect exchange of information between USSPs (and between USSPs and other authorised users) is done through the Information Exchange Module. This Module, although hosted within ENAIRE U-Hub, is not part of ENAIRE's certificate as CISP, but it is provided by ENAIRE as an external agent without being certified. It will be the USSPs who, through the relevant service-level agreements (SLAs) and as part of their contracted activities, will include the use of this module within their certificate as USSPs, in order to comply with Article 7.5 of Regulation (EU) 2021/664. This indirect information exchange is based on the EUROCAE ED-339 standard, still under consultation by the date of publication of this document.
- Additionally, within ENAIRE U-Hub, there is a Module to allow access and reception of information to Authorised Users, the AUDI Module (Authorised Users Digital Interface). This module has a series of functions, among which the Airspace Management functionality stands out (trough which Authorities will be able to create and edit UAS zones, such as emergency zones within a U-space, for example). This functionality will be certified based on Regulation (EU) 2021/664. Another important functionality is the one that allows ATSPs to perform the

Dynamic Airspace Reconfiguration (DAR). This functionality will be certified based on Regulation (EU) 2021/665 which amends Regulation (EU) 2021/373. This AUDI Module also allows the management and coordination with the responsible authorities to obtain or refuse the necessary flight permission to access certain UAS zones that require it. The use of this AUDI Module within the project is explained in more detail in **Appendix F Coordination with local authorities.**

- Finally, it has its own user management, legal recording and service monitoring functionalities, as well as additional non-certification capabilities that may be developed in the future, as regulation progresses.

B.1.2 USSPs Integration to the ENAIRE U-Hub Platform

The main benefit of the U-space architecture deployed in Spain from the point of view of USSP integration is that USSPs only have to integrate with one entity, in this case, with the ENAIRE U-Hub platform.

Through the ENAIRE U-Hub platform, ENAIRE provides the CIS services in Spain, as well as the U-space interface with ATC. Likewise, it is through a dedicated module of this platform that the inter-USSP information exchange services are provided.

In other U-space implementations carried out through architectures other than the one implemented in Spain, USSPs must reach agreements and integrate with different entities (other USSPs, ANSP, ATSP...) while in this case all the information is received from a single integration. This same architecture concept is also being replicated in most European Union countries, such as Italy or Belgium.

A.2.1.1. Information to be provided by the New USSP to ENAIRE U-Hub

For connecting to ENAIRE U-Hub, the new USSP should provide the following values:

- FlightPlan URL: URL offered by the USSP for the U-HUB to obtain information related to: Permission Request/UAS flight authorisation/Permission Update/Clearance Update/Issues report.
- Health Status Check URL: URL offered by the USSP for the U-HUB to obtain the USSP status (heath check).
- Authentication/Authorisation URL: URL offered by the USSP for the authentication/authorisation service.
- Oath2 User: Client ID to use in the authentication/authorisation USSP Service, created specifically for the U-Hub.
- Oath2 Pwd: Client Secret to use in the authentication/authorisation USSP Service, created specifically for the U-Hub.

A.2.1.2. Requirements for USSP to receive information from ENAIRE U-Hub

As shown in section A.2.1, the ENAIRE U-Hub platform interacts with the U-space service providers (USSPs) sharing common information services with them as well as the USSPs in Spain share information with each other through specific and independent modules within the platform.

The main modules of this centralised platform are:

- Common Information Services (CIS): provides to USSPs information regarding to the manned traffic operating with an air traffic control service by the ANSP along with the UAS geographical zones, including the U-space airspaces and their definitions.
- Information Exchange Module (IXM): provides interoperability between USSPs to share the key information to properly operate within a U-space airspace.
- Authorised Users Digital Interface (AUDI): allows USSPs to communicate that the area is free of UAS in order to activate a DAR.

A.2.1.3. Requirements for USSPs to connect to the CISP Module of ENAIRE U-Hub

1) Geo-awareness Information – Drone Aeronautical Information Service

The Drone Aeronautical Information Management (DAIM) covers the messages shared between U-Hub and USSPs in terms of geo-awareness information as per Implementing Regulation (EU) 2021/664 states. Thus, the USSPs are able to provide the geo-awareness service to their operators.

The following interfaces, presented in the next table, define the interaction between U-Hub platform and the USSPs to provide the proper data. These interfaces follow the EUROCAE ED-269 standard.

Data	Protocol	Provider	Consumer
Retrieve UAS zones	API-REST	ENAIRE U-Hub	USSP
Update UAS zones	AMQPS1.0	ENAIRE U-Hub	USSP

Table 17. Geo-awareness information exchange U-Hub-USSPs

2) Manned traffic information

According to Article 5.2 of Implementing Regulation (EU) 2021/664 the Common Information Service Provider (CISP) shall provide to the USSPs the manned traffic. This data provision is provided by the interface defined in the following Table:

Data	Protocol	Provider	Consumer
Manned	AMQPS1.0	ENAIRE U-Hub	USSP

Table 18. Manned traffic information exchange U-Hub-USSPs

3) **Operator Validation**

The ENAIRE U-Hub provides an interface to check the validity of the operator requesting a flight plan to the USSP. In order to do this task, the ENAIRE U-Hub checks the operator identification against AESA's operator's registry. The interface is defined with the following information.

Data	Protocol	Provider	Consumer
Operator data	API-REST	ENAIRE U-Hub	USSP

Table 19. Operator validation information exchange U-Hub-USSPs

4) **Health Status Service**

The U-Hub monitors its own services status to notify the USSPs within any U-space airspace about any degradation or even failure of the U-Hub services. The U-Hub provides a service to request this information to the USSPs so that they can call it whenever they need an update of the status. Interfaces definitions are presented in the next table:

Data	Protocol	Provider	Consumer
ENAIRE U-Hub Health	API-REST	ENAIRE U-Hub	USSP

Table 20. Health status information exchange U-Hub-USSPs

5) ATM Interface

This section describes the interface dedicated to notifying when a Dynamic Airspace Reconfiguration (DAR) volume is clear of owned UAS. The USSPs use this interface when the sector is already free of UAS flights operated under the USSP. This action is done through the following interface:

Data	Protocol	Provider	Consumer
Area Cleared	API-REST	ENAIRE U-Hub	USSP

Table 21. DAR information exchange U-Hub-USSPs

A.2.1.4. Requirements for USSPs to connect to the Information Exchange Module of ENAIRE U-Hub

1) Network Identification Exchange

The Network Identification Exchange (NIX) is the mechanism for USSP interoperability to share between them the Network Identification messages as per Implementing Regulation (EU) 2021/664. This service is made of two different interfaces:

- On the one hand, there is an interface dedicated to receiving the Network Identification messages from the USSPs.
- On the other hand, the U-Hub provides the Network Identification messages to the other USSPs within the U-space airspace.

These interfaces are shown in the following table:

Data	Protocol	Provider	Consumer
USSPs N-ID	AMQPS1.0	ENAIRE U-Hub	USSP

Table 22.Network ID information exchange between Information Exchange Module-USSPs

2) Flight Authorisation Exchange

The UAS Flight Authorisation Exchange (FAX) provides a mechanism for USSP interoperability so that they can share accepted UAS flight authorisations and the updates on their states. This service, allocated in the U-Hub, provides different interfaces as shown in the following table:

Data	Protocol	Provider	Consumer

UAS flight authorisation	API-REST	ENAIRE U-Hub	USSP

Table 23.Flight Authorisation exchange between Information Exchange Module-USSPs

3) Conformance Alerts Exchange

The Conformance Alerts Exchange (CFX) allows the USSPs to share the conformance alerts raised by their systems. This service is allocated in the U-Hub, and it acts as a switch for USSPs interoperability. This service provides two different interfaces based on events:

- USSPs alerts: it is an interface defined in the Exchange Module of the U-Hub architecture. This interface is responsible for sharing the alerts received from one USSP to the other USSPs within the system.
- Alerts: it is an interface used to receive in the U-Hub the alerts coming from the USSPs.

The following table presents the interfaces:

Data	Protocol	Provider	Consumer
USSPs alerts	AMQPS1.0	ENAIRE U-Hub	USSP

Table 24.Conformance alerts exchange between Information Exchange Module-USSPs

4) USSP Monitoring Exchange Service

According to EASA AMCs & GMs amending the Implementing Regulation (EU) 2021/664 the USSPs shall share the status of their own services to other USSPs operating in the U-space airspace. In this case, this interoperability is done through the USSP Monitoring Exchange (UMX). Interface definition is presented in the next table:

Data	Protocol	Provider	Consumer
USSPs Health	API-REST	ENAIRE U-Hub	USSP

Table 25.U-space services Status exchange between Information Exchange Module-USSPs

A.2.1.5 Contact with the Spanish CISP – ENAIRE

For more information about the system or the integration process, it is possible to contact ENAIRE (the Spanish ANSP) to inquire about the ENAIRE U-Hub platform and the available data, including CISP, DAR, and inter-USSP information.

B.2 Example 2: U-ELCOME Italian cluster

Based on the applicable regulation framework D-Flight developed several services available in different solutions as follows:

- D-Flight UTM platform (d-UTM): it manages UAS operations safely, economically and efficiently through the provision of the UTM services such as (UAS and operators) registration, declaration, geo-awareness with the possibility to anticipate services such as network identification, flight authorisation and traffic information where relevant (at national level as well) in the same solution. Currently in the Italian deployment some obligation to provide UAS operation planning for the entire territory for BVLOS is in the national instantiation of European regulations (UAS-IT)

- Where U-space Airspace and EU regulation framework 2021/664 is applied
    - D-Flight CIS platform (d-CIS): it is a single trustworthy source of Airspace information inside U-space airspace. It is compliant with the European centralised approach where a single national provider is designated by the Member state. The platform is complemented to provide services to national stakeholders (not UAS operators) such as authorities and relevant ATSUs.
    - D-Flight USS platform (d-USS): designed to support safe, secure and efficient access to U-space airspace for a large number of UAS; it is as well complemented with surveillance supporting infrastructure. It is focused on the provision of the 4 mandatory U-space services. Ongoing initiatives are running to procced step-by-step to complete the portfolio

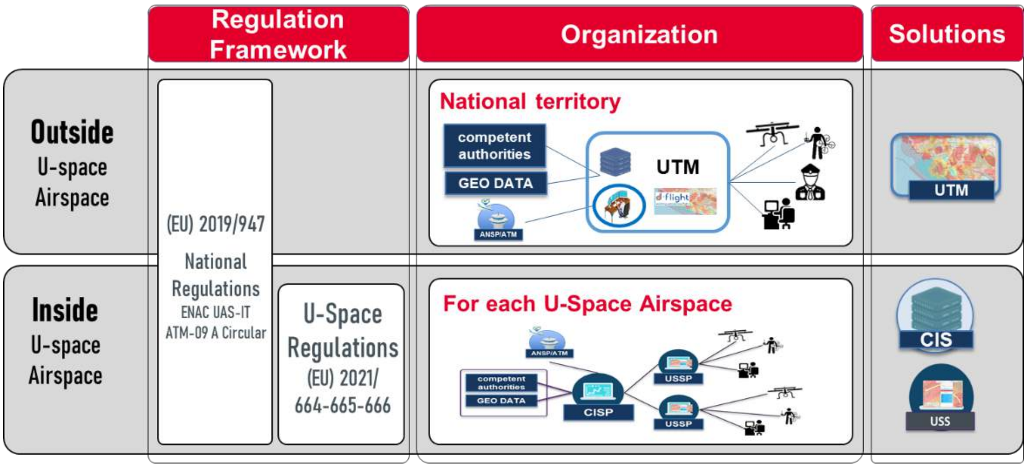


Table 26. D-flight UTM/U-space solutions overview

As reported in the Italian UTM regulation, d-flight is recognized as a national UTM platform, it provides the main regulated services required by Regulation (EU) 945/947, such as the geo-awareness service, UAS operator registration, operational declaration, geo-awareness, Identification, Flight Authorisation. Being operative since 2017, d-flight platform is operated and continuously maintained according to working methods and procedures field proven (layered technical supports - from L1 to L3- , updates of common information in the database e.g. static and dynamic aeronautical data, corrective maintenance process). Procedures and working methods are customisable according to specific roles, responsibility and local needs.

At the forefront for the construction of U-space in Italy is considered as the key element for the safe use of drones in every context and for every type of missions. D-Flight also provides the interface service with ATM, through the so-called **IAM Coordination service**, which is a service to enable the procedural interface and coordination between ATC and U-space ecosystems.

B.3 Spain-Italy Architecture Harmonisation analysis

The architecture and harmonisation analysis focuses on the implementation of the geo-awareness service, taking the ED-269 standard as a reference framework. Both the Spanish and Italian clusters have adopted this standard, introducing specific adaptations primarily driven by the gaps and ambiguities identified within the standard itself. These singularities highlight the need for further alignment and refinement to ensure consistent and interoperable service deployment across different implementations.

B.3.1 Authentication

The ED-269 standard defines the communication framework for geo-awareness services between CISPs (Common Information Service Providers) and USSPs (U-space Service Providers), specifying the use of RESTful APIs over common network protocols. Given that these communications rely on internet-based infrastructures, robust cybersecurity measures are essential to protect the data exchange.

While ED-269 recommends the use of basic authentication, Implementation 1 adheres to this approach, transmitting user credentials directly within each request. In contrast, Implementation 2 employs a more secure method using Bearer tokens, which encapsulate authentication information in a time-limited token, avoiding the need to transmit user credentials with every request. Although this approach offers improved security, it diverges from the ED-269 recommendation, highlighting how different implementations have interpreted and extended the standard to address perceived cybersecurity gaps.

B.3.2 Retrieving Geographical Information

The procedures for retrieving UAS Geographical Zones are largely aligned between Implementation 1 and Implementation 2. Both systems implement similar mechanisms for retrieving zone data, managing subscriptions, and receiving real-time updates. These functionalities are based on the ED-269 standard, which provides detailed guidance for handling UAS Geographical Zone information.

However, notable differences arise in the handling of U-space airspaces, primarily because ED-269 does not prescribe a standardised method for retrieving this type of data. As a result, each implementation has adopted a custom approach. Implementation 2 includes a dedicated endpoint to retrieve all U-space airspaces along with their associated UAS Geographical Zones. In contrast, Implementation 1 requires two separate endpoints: one for retrieving U-space airspaces and another for retrieving UAS Geographical Zones.

Further variation exists in how each implementation manages request filters. For instance, Implementation 2 does not require a filter body when retrieving UAS Geographical Zones, while Implementation 1 mandates its inclusion. Additionally, in Implementation 2, all zones are republished with each AIRAC cycle, requiring precise filter dates to ensure correct cycle targeting. In contrast, Implementation 1 does not follow AIRAC republishing cycles, making the filter's start date less critical.

These implementation choices reflect differing operational strategies and address gaps or ambiguities within the ED-269 standard, underscoring the need for further harmonisation to achieve full interoperability across systems.

B.3.3 UAS Geographical Zones Data Model

For the UAS geographical zones the use of the **otherReasonInfo** field varies across implementations due to the lack of defined values in the ED-269 standard. In Implementation 1, the field is limited to two specific values "DAR" and "U-Space"—both directly related to U-space activities. In contrast, Implementation 2 adopts a broader interpretation, allowing multiple values such as "CTR," "ATM03-PARACHUTE," "NOTAM," "NFZ," and "USPACE," many of which extend beyond the U-space domain.

B.3.4 U-space Airspace Data Model

Implementation 2 defines a greater number of U-space-related fields within the **extendedProperties** field compared to Implementation 1. The ongoing proposal to update the ED-269 standard seeks to standardise these U-space airspace fields, which are currently incorporated as extended properties in both implementations. This effort aims to improve consistency and interoperability across different systems by formalizing these attributes within the standard.

In January 2025, EUROCAE published **ED-269 Change 1**, which addresses the need to avoid confusion between ED-269 and ED-318. The current **ED-318** *Technical Specification for Geographical Zones and U-space Data Provision and Exchange*, published in January 2024, defines new technical specifications covering:

- data format
- data requirements, and
- data exchange

which replace Chapter 8 "UAS Geographical Zone Data Model," Chapter 9 "Geofencing Information Service Interface," and Appendix 2 "Information Definition and Data Structures" of ED-269, rendering these chapters of ED-269 obsolete for U-space.

B.3.5 Dynamic Airspace Reconfiguration Data model

The following comparison between the two implementations addresses the use of the **otherReasonInfo** field in relation to the ED-269 standard. Both implementations utilize the value **"DAR"** for this field; however, this value is not standardised or explicitly defined within the ED-269 specification. This indicates a practical alignment between implementations despite the absence of formal guidance in the standard, highlighting potential areas for standardisation to improve interoperability.

In Implementation 1's CISP, a convention has been established to trigger the deletion of a DAR by sending the same DAR with an end time set earlier than its start time, signalling its removal. In Implementation 2's CISP, the deletion procedure is not clearly defined and relies primarily on the end date-time parameter to determine validity. Similarly, the ED-269 standard does not specify how deletion of such entries should be handled, resulting in ambiguity and differing interpretations across implementations.

B.4 Example 3: BURDI Project

B.4.1 CISP

In the framework of the BURDI project, and in line with existing Belgian U-space legislation, the U-space ecosystem is based on the centralized model with skeyes (the Belgian ANSP) acting as designated single CISP.Skeyes will ensure the collection and distribution of the relevant operational data within all U-space airspaces designated over Belgium, including for the BURDI project.

The CISP is established for USSPs and data providers to easily distribute and collect the relevant operational data required for the safe and efficient delivery of U-space services. By providing its services, the CISP creates a network of U-space eco-system participants. These participants are:

- USSPs
- ANSPs, providing geo-awareness data resulting from DAR and relevant traffic information regarding manned aircraft
- BCAA, as relevant competent authority and owner of specific required information (e.g. list of certified USSPs, UAS geographical zones description, limits of U-space airspace)
- Meteorological data providers
- Other relevant data providers or organisations (e.g. Belgian Defense, Ministry of Internal Affairs for law enforcement purposes, municipalities, rescue coordination centres, aerodromes, etc.)

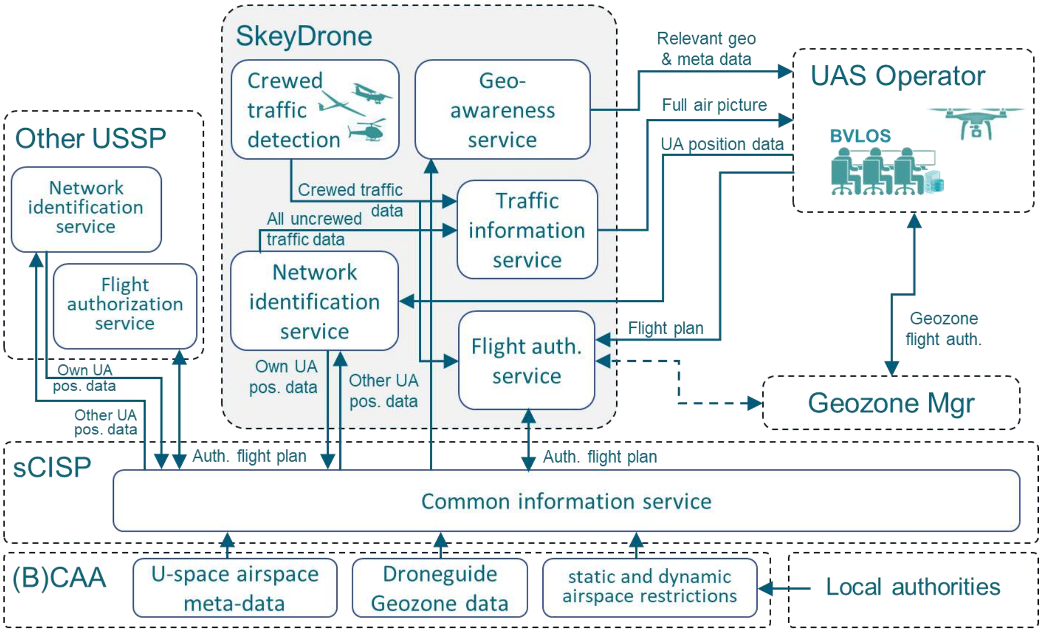


Figure 10.BURDI architecture involving the four mandatory U-space services

B.4.2 USSP

The USSPs operational environment will evolve over time in function of both its strategic business objective and the availability of U-space airspaces to operate in. The operational environment in the scope of BURDI consists of the first Belgian U-space business ecosystem within which Common

Information Services (CIS) are offered in a centralised way by a single CIS provider (see Figure 11 below).

The existence of the first U-space airspace in uncontrolled airspace in Belgium has been triggered by the BURDI project and exists between ground and 500ft AGL and has the same lateral boundaries as the Antwerp geo-zone associated with the Port of Antwerp Bruges (PoAB), excluding the overlap with the CTR of the Antwerp airport (EBAW).

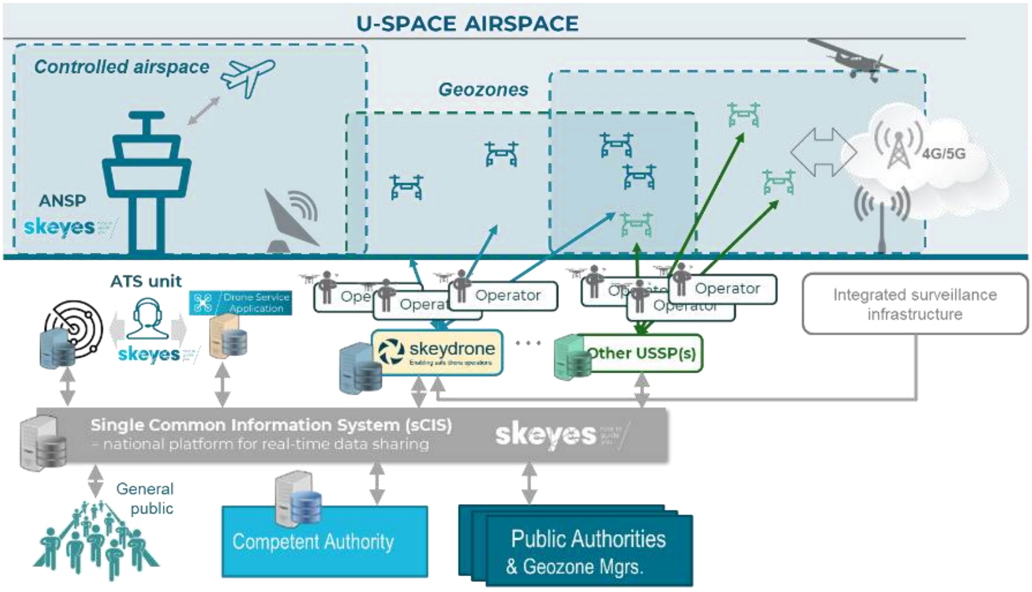


Figure 11: BURDI USSP operational environment

For a more in-depth overview of the BURDI project, please refer to the BURDI deliverables regarding the CISP, USSP, ARA, Coordination mechanism, Standards, and Regulations implementation. For a general overview of the BURDI project, please refer to the BURDI Harmonisation Report.

Appendix C Transition to U-space operations

C.1 Example 1: Italy

The transition to U-space operations is exemplified by the Italian Cluster experience with the designation of the U-space airspace of San Salvo. A well-defined roadmap plays a crucial role in facilitating the development and deployment of U-space services while ensuring seamless coordination among all relevant stakeholders. The Italian model effectively implements this process through three key phases: the establishment of a restricted area, the implementation of a U-space Sandbox, and the full deployment of U-space.

C.1.1 Phase 1: Establishing a Restricted Area

The first step in transitioning to U-space operations involves the definition and **publication of a Restricted Area (ROMEO Area)** in the Aeronautical Information Publication (AIP). This designated airspace provides a controlled environment for the initial deployment of UAS operations, enabling regulatory authorities and stakeholders to establish operational parameters and conduct comprehensive risk assessments. This foundational phase is characterized by:

- The publication of the restricted area, with clearly defined geographical boundaries and operational limitations;
- Initial coordination with key authorities, including air navigation service providers (ANSPs), civil aviation authorities, and other airspace users;
- The development of preliminary operational procedures and air traffic management (ATM) coordination mechanisms.

Within the Italian Cluster, this phase materialized through the establishment of the R700 San Salvo U-space, published as part of the AIRAC cycle. Prior to the publication of the restricted area, an **Airspace Risk Assessment (ARA) was conducted**—an essential preparatory step. The ARA process facilitated:

- The delineation of geographical boundaries and operational constraints for U-space airspace;
- The identification of required services and technological infrastructure;
- The development of coordination procedures with other airspace users and stakeholders.

C.1.2 Phase 2: Implementation of a U-space Sandbox

The second phase focuses on the creation of a **U-space Sandbox**, which serves as a dedicated testing and validation environment prior to full-scale deployment. This phase is particularly critical as Common Information Service Providers (CISPs) and U-space Service Providers (USSPs) undergo certification. The U-space Sandbox allows stakeholders to evaluate U-space services, validate technological solutions, and refine operational procedures in a controlled setting. Key aspects of this phase include:

- The initial deployment of U-space services;
- Active engagement with industry stakeholders to assess technological capabilities;
- The establishment of data-sharing mechanisms between CISP, USSPs, and other relevant entities;
- Iterative testing to refine operational procedures and enhance interoperability.

C.1.3 Phase 3: Full Deployment of U-space

The final phase entails the complete implementation of U-space, ensuring the seamless integration of UAS operations into controlled airspace through certified service providers and standardised procedures. This stage marks the operational maturity of the U-space ecosystem, enabling safe, efficient, and scalable drone operations. The main components of this phase include:

- The certification and full-scale deployment of CISPs and USSPs;
- The integration of U-space operations with manned aviation;
- Continuous monitoring and optimization of U-space services based on operational feedback.

This structured, phased approach has ensured a smooth and risk-mitigated transition from initial restricted operations to the full-scale deployment of U-space. By progressively introducing controlled environments for testing and refinement, the Italian Cluster experience serves as a valuable model for the broader implementation of U-space, optimizing stakeholder coordination and facilitating a seamless integration into the aviation ecosystem.

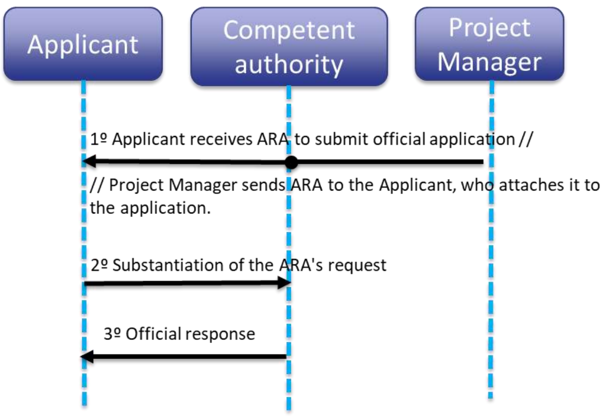
C.2 Example 2: Spain

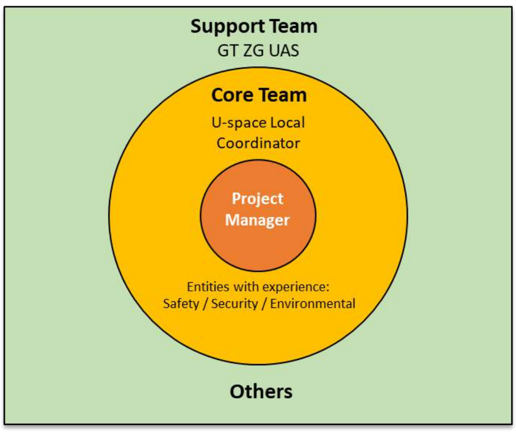
The Example 2 describes the experience that the Spanish cluster is gaining in the designation of the Benidorm U-space has been used to prepare this section.

To ensure efficient development and deployment of services in this area, it is essential to have a well-defined roadmap that facilitates coordination between all parties involved. The Spanish cluster follows this approach through three key phases: the publication of U-space and other geographic areas, the implementation of a U-space test environment and the full deployment.

C.2.1 Phase 1. Publication of U-space and other geographic areas.

Firstly, once the ARA has been prepared by the Project Manager, it is submitted to the Competent Authority, which in turn sends it to the applicant together with the relevant rectification requirements, if necessary. Once these requirements have been met, the Competent Authority will issue an official response to the applicant regarding the approval of the ARA and it will be possible to proceed with the publication of the U-space.





Once this process is completed, the U-space will be published in the AIP, where the effective date and the performance requirements to be met by USSPs, operators and other affected users will appear. These performance requirements relate, for example, to the U-space services required to operate, types of drones allowed, types of operations allowed, etc.

Furthermore, depending on the type of airspace where this volume has been declared, there will be two possible cases, controlled airspace and uncontrolled airspace. Thus, according to Regulation (EU) 2021/665 and 2021/666, the interaction of manned aviation with U-space will be different in each case.

In the case of uncontrolled airspace, until the integration of e-conspicuity technology, the U-space will be defined as an area restricted to manned aviation, whose management will be in charge of the Geo-zone Manager (defined according to the U-space). The Geo-zone Manager has to be an authority recognized by the Competent Authority to be able to digitally publish temporary UAS Zones through AUDI. This Geo-zone Manager is responsible for responding to the needs of manned aviation by publishing a temporary zone that limits the use of UAS, allowing the airspace to be free for manned aircraft. It should be noted that this is a temporary solution until e-conspicuity technology is fully developed and deployed.

On the other hand, in controlled airspace, for the application of the DAR by ATC, in the first instance a single sector will be defined within each U-space. The DAR procedure may be applied to this single sector in order to allow the passage of manned aviation. The person in charge of coordinating this process will be the supervisor or controller (ATCO) according to the ANSP of that controlled airspace. It is important to note that, in the future, a more detailed sectorization of the entire defined U-space is planned, as recommended in Regulation 664/2021 (partial cancellations). So that, in case it is necessary to apply a DAR, only part of the U-space will be affected and not all of it.

Finally, in the event that it is necessary to define new restricted, prohibited or special areas within the U-space airspace itself, as a consequence of its implementation, they will be published in this first phase.

C.2.2 Phase 2. Validation environment

In this phase, it is necessary to satisfy the requirements defined during the ARA, and which are contained within the “U-space Compliance Report for USSPs”. This document reflects the special requirements that USSPs must meet in order to operate in the newly published U-space, as well as how to demonstrate compliance. These requirements may go beyond the USSP's own certification requirements, which is why they are included in a separate document.

On the other hand, it is recommended that access to this document be made available by Competent Authority linked to the U-space. The content of this document will serve as a justification of the service provision capability, indicating the fields needed to validate the USSP certification requirements and the compliance with the ARA requirements, which will allow its operation in that U-space.

Compliance Reports must be generic, e.g., one for controlled airspace and one for uncontrolled airspace. In addition, they must include all the specific aspects and requirements that apply to that U-space (coverage, altitudes, type of operation, etc.). In order to comply with these requirements, USSPs must perform validation tests in a real environment to verify that they receive information from their customers, exchange information with other USSPs, as well as other necessary actions correctly, thus complying with the ARA requirements.

On the other hand, if a foreign USSP wishes to operate in the U-space, it must be able to integrate with national platforms. For example, in Spain, the USSP would have to integrate with ENAIRE as the single CISP, comply with the U-space compliance report and perform the validation tests included in that report.

Finally, the requirements defined in the “U-space compliance report for USSPs” should be in line with the USSP capabilities defined in Regulation (EU) 2021/664, so that they can comply with them, extend their certificate or outsource additional services.

C.2.3 Phase 3. Full deployment

The approving body for this “U-space Compliance Report for USSPs” will be the Competent Authority. However, in order to comply with the requirements of this report, it may be necessary to have the approval of the NSA as specified below:

- If the issues raised in the Compliance Report do not require the certification of new services or functionalities by the USSP, beyond those already contemplated in the U-space regulations, the Competent Authority will be in charge of giving the confirmation that it can operate.

- If, on the other hand, some requirements raised in the Compliance Report have an important influence on the safety of operations, and therefore require the USSP to be certified for new services or functionalities for which it was not certified (for example, if a service considered optional in the regulations is considered mandatory to operate in that U-space), the NSA shall be the one to approve those specific requirements of the Compliance Report, being in any case the Competent Authority the one in charge of the final approval of the Compliance Report.

C.3 Example 3: Belgium (BURDI Project)

The first BURDI U-space airspace is in uncontrolled airspace associated to a region with a high demand for BVLOS UAS flights, i.e. the port of Antwerp Bruges (PoAB) port area in Antwerp which is currently already covered by a UAS Geographical Zone (Figure 12). This geographical zone has the same lateral and vertical boundaries as the EBR54 restricted zone which reaches from ground to 1000ft AMSL.

The geo-zone has a number of access conditions in function of the flight category and the relevant subzone, e.g. only flights in the Specific category based on a SORA or LUC with a UAS equipped with an Flight Termination System (FTS) allowed in the very high risk SEVESO subzone.

There is furthermore an over-arching obligation for all UA operators to use the PoAB UTM platform (powered by Unifly) to request and obtain individual strategic flight authorisation and notify take-off and landing at tactical level.

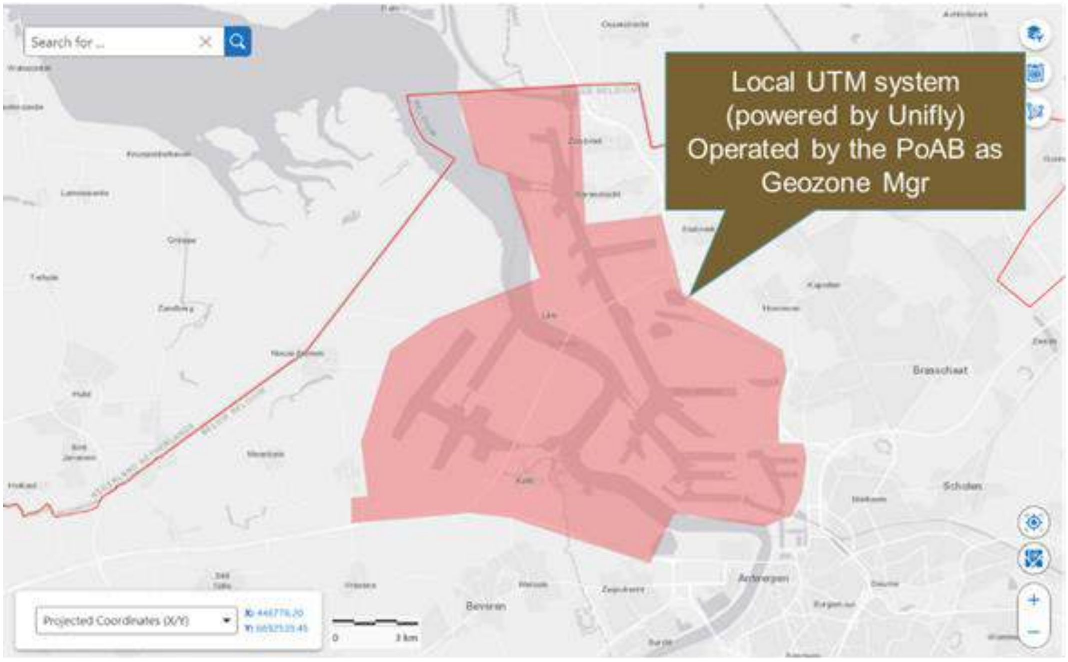


Figure 12: Port of Antwerp Bruges geo-zone

The geo-zone will continue to exist next to the newly designated U-space airspace. The PoAB geo-zone has overlap with several other geo-zones, including the CTR of Antwerp International Airport (Figure 13).

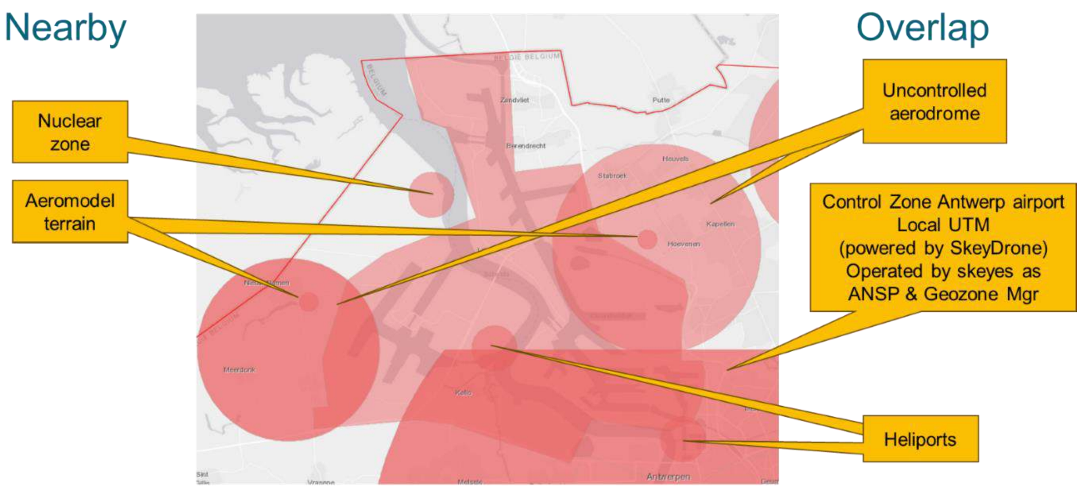


Figure 13: Port of Antwerp Bruges geo-zone overlapping other geo-zones

A zoom-in on the overlap between the existing PoAB geo-zone (GND – 1000ft AMSL), the CTR controlled airspace (GND – 2500FT) and the planned U-space airspace (GND – 500ft AGL) in the form of a vertical cross-section can be found in Figure 14 below.

The U-space airspace will co-exist in overlap with the PoAB geo-zone with (largely) the same lateral boundaries but limited in vertical height to 500ft AGL.

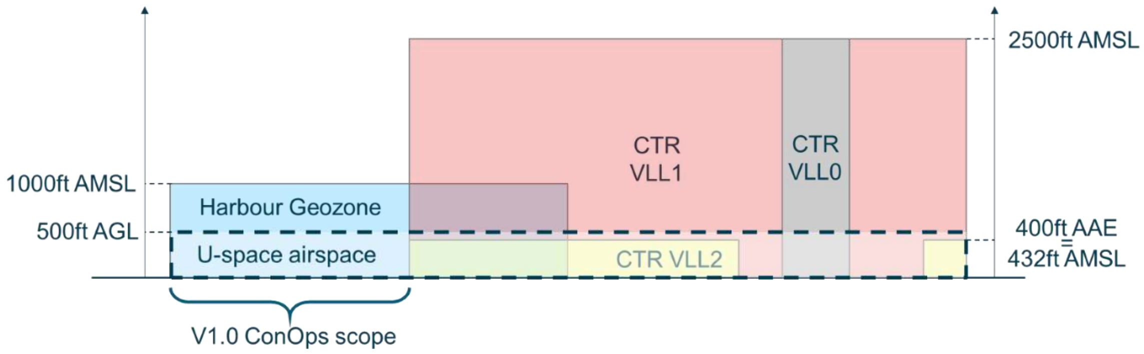


Figure 14. U-space airspace overlap cross-section

The initial U-space airspace geographical scope used in the BURDI project can be found in Figure 15 below.

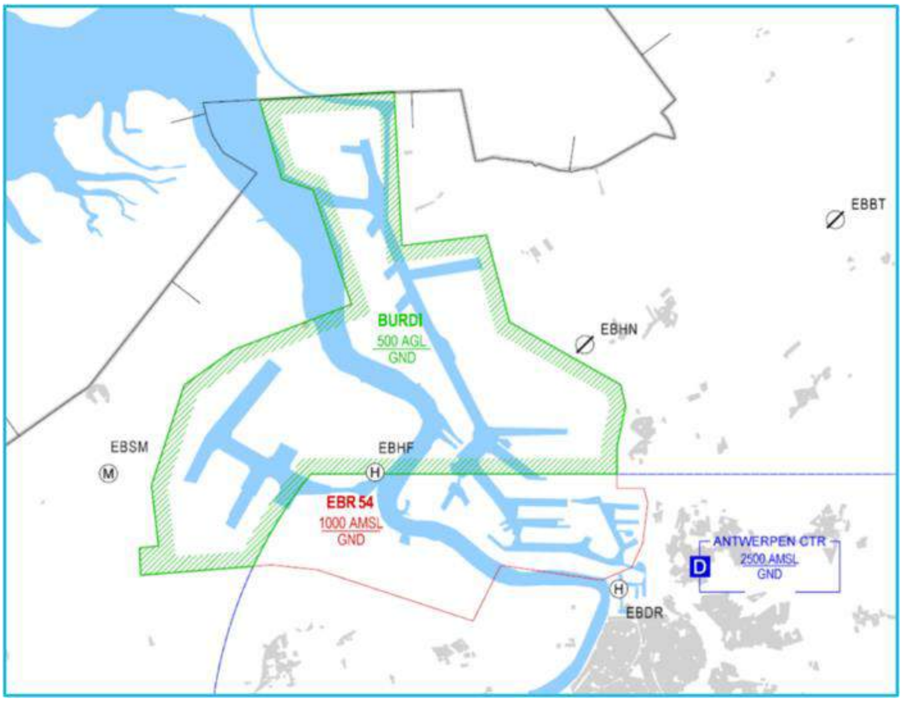


Figure 15: Initial U-space airspace geographical scope BURDI

For a more in-depth overview of the BURDI project, please refer to the BURDI deliverables regarding the CISP, USSP, ARA, Coordination mechanism, Standards, and Regulations implementation. For a general overview of the BURDI project, please refer to the **BURDI Harmonisation Report.**

Appendix D U-space impact on Specific Operational Risk Assessment (SORA)

There are some Operational Safety Objectives (OSOs) that are prone to be affected by U-space:

- OSO #08 – Operational procedures are defined, validated and adhered to. UAS operator should take into consideration the following assumptions:
    - Contingency procedures may be standardized with minimum performance criteria, but UAS operators can propose alternatives for approval if they cannot comply. These procedures might be different depending on the characteristics of the U-space airspace.
    - Emergency procedures are expected to be common across UAS operators and similar across U-space airspaces.
    - DAR is considered an abnormal situation as it is implied in the AMC/GM of the Regulation (EU) 2021/664 in which the U-space airspace design should be done so that the request for a DAR is something exceptional and not common.
    - The interactions with manned aircrafts in U-space located within uncontrolled airspace might be classified in different ways depending on the U-space airspace design:
        - Structured U-space, i.e. manned aircrafts have predefined corridors for their flights. Encounters are considered abnormal situations, as flight paths should be strategically deconflicted.
        - Free route U-space, i.e. manned aircrafts only need to be e-conspicuous for entering U-space. Encounters are considered normal situations, requiring UAS to self-deconflict using traffic information.
        - Managed free route U-space, i.e. manned aircrafts must notify in advance their intention to enter U-space. This notification does not impose them any specific requirement as it is only required to ensure the separation between UAS and manned aircrafts. Encounters are considered abnormal situations as the UAS operators are warned in advance about the presence of a manned aircraft.
    - In the current state of U-space, developing valid procedures for each possible situation might be out of the scope. An incremental approach should be considered to tackle this problem.
    - Task 8.3 "Recommendations for U-space Contingency Management" of U-ELCOME WP8 might be used as reference material for the UAS operator.
- OSO #09 – Remote crew trained and current. Since U-space affect the ConOps of all UAS operators, additional training will be required to safely fly inside U-space. There are two types of training:

  - U-space concept and rules: Training provided by entities designated by the Member State.
  - USSP platform: Provided by each USSP that operates within that U-space. In the Human Performance Assessment Plan from U-ELCOME, many UAS pilots have reported a greater workload (situational awareness and platform use) to their routine operations. Training should take into consideration this situation.

- OSO #13 – External Services supporting UAS operations are adequate to the operation. Each service functionality and its safety relation are described next:
  - Network Remote Identification service is the tactical core service of U-space as it is the service that allows to see and be seen by the other involved actors. NRI directly feeds the traffic information service allowing all airspace user to understand what is happening inside the U-space airspace (improving the situational awareness) and help them to make appropriate decisions with regards to other users. The ATC (or any other person responsible) also use the NRI service to acknowledge that there are no UAS flying after a DAR request.
  - Traffic Information Service is the service that allows UAS operators to fly in BVLOS without an actual DAA system onboard. This service is fed by two different systems, the NRI service and the e-conspicuity information. Losing this service means that the UAS operator completely lose its situational awareness thus creating a huge safety risk in the operation.
  - UAS Flight Authorisation Service is the strategic core service of U-space as it is the service that automatically deconflict the planned operation with other airspace users that might have also planned an operation or that are currently flying. This service also alerts the UAS operator when its flight plan has been modified (due to a tactical conflict) or withdrawn (for example by a DAR) so that they can take appropriate measures.
  - Geo-awareness service impact on safety will depend on the location of the U-space airspace. In uncontrolled airspace its effect on safety would be limited since geo-awareness is a feature that many UAS can already provide by themselves but if the U-space is located in controlled airspace (665 apply), without the geo-awareness service the ATC would lose the capability to request a DAR (by definition a DAR is a UAS zone) thus not ensuring the segregation between UAS and manned aircrafts. In some Member States, this service is also used by the authorities to create forbidden UAS zones due to an emergency.
  - U-ELCOME WP3 deliverable “Demo Report” could be used by the UAS operator to demonstrate that the required performance is achieved.

- OSO #19 – Safe Recovery from Human Error. While this OSO is considered applicable to U-space, currently there is no guidance material that can be provided to the UAS operator.

- OSO #20 - A Human Factors evaluation has been performed and the Human-Machine Interface (HMI) found appropriate for the mission. This OSO is especially sensitive to the integration of the UAS GCS and the USSP as it would imply a modification of an already tested system of the manufacturer (the GCS).

  - U-ELCOME WP3 is developing a Human Performance Assessment Plan that includes an evaluation of the HMI used during the mission. This document will be published at the end of the U-ELCOME project.

UAS operators whose operations are BVLOS must know that U-space can also be used to partially comply with the qualitative TMPR functions defined by the SORA. These qualitative functions are:

- Detect function. Everyone is required to be cooperative inside U-space, the compliance with this function is trivial. Operator remains responsible for continuously monitoring the situation.
- Decide function. In the current state of the U-space implementation in U-ELCOME, the decide function cannot be completely fulfilled only with the use of U-space services as there are two different requirements that must be complied by the UAS operator:
  - Determine whether a manned aircraft or a UAS might cause a conflict with the current flight plan or trajectory. The compliance with this requirement is achieved through the alerts the USSP must send to the UAS operator if there is nearby traffic that it should be aware of.
  - Define a new trajectory (or flight plan) that would resolve the conflict between aircrafts. This is the requirement that currently is out of the scope of the U-space implementation in U-ELCOME.
- Feedback Loop function. The requirements for the feedback loop functions are lower than the traffic information service requirements, the compliance with this function is also trivial.

Appendix E Coordination mechanism

E.1 Spanish Cluster

E.1.1 Introduction and members

Coordination mechanisms serve to develop the ARA. This is based on Article 18.f of Regulation (EU) 2021/664: "The competent authorities shall establish a mechanism to coordinate with other authorities and entities, also at the local level, the designation of U-Space airspace, the establishment of airspace restrictions for UAS within U-Space airspace and the determination of U-Space services to be provided in U-space airspace." The process has been carried out according to the methodology proposed by EUROCONTROL, Expanded Safety Reference Material (e-SRM), used for the evaluation of U-space airspaces. In addition, three working groups have been established for this process: the Project Manager, the CORE TEAM and the SUPPORT TEAM. On the one hand, the Project Manager in Spain is ENAIRE (since it is the main ANSP in the country and because it has the capacity to carry out these tasks, according to the designation of RD 517/2024).

As for the CORE TEAM, its members must be selected at the beginning of each ARA project. ENAIRE's proposal establishes that this CORE TEAM must have fixed members, which include ENAIRE, AESA and the Local U-space Coordinator. In addition, other entities may be incorporated according to the specific characteristics of each U-space area. These additional entities will have a workload and responsibilities commensurate with their level of involvement in the project. Examples of optional entities could be ministries, port authorities, universities, research centres, local authorities, among other U-space actors. On the other hand, within the CORE TEAM, in each U-space candidate airspace, the PCU(s)-Unified Point(s) of Contact- involved will designate entities with expertise to review aspects related to safety, security or environment. In some cases, these entities may come from the General State Administration, regional administrations (CCAA) or even local administrations, depending on who has the competence.

Finally, there must be a SUPPORT TEAM, which will be larger than the CORE TEAM. This team will bring together other entities participating in the project with less involvement. The main function of the SUPPORT TEAM will be to provide and collect data, conduct interviews among groups of interest for the implementation of U-pace and perform other local coordination tasks.

E.1.2 Responsibilities of the members

Each of the groups defined above will have specific responsibilities.

Project Manager responsibilities (orange area, figure below): ENAIRE is responsible for carrying out the ARA.

CORE TEAM responsibilities (yellow area, figure below):

- Provide useful information to ENAIRE in view of its ARA development activity (this task is mainly focused on the figure of the U-space Local Coordinator).
- Advise ENAIRE in the development and revision of the ARA through periodic meetings, where the progress of the project will be monitored. This task will be carried out mainly by the entities with experience within the group.

SUPPORT TEAM responsibilities (green area, figure below):

- Providing the necessary data, either through their experience and expertise in specific areas, or acting as a liaison between the CORE TEAM and the general public, when necessary, with the objective of supporting the realisation of the ARA. These actions will always be performed at the request of the CORE TEAM.
- Advise the CORE TEAM on issues that may arise within the CORE TEAM, always at the request of the core team.

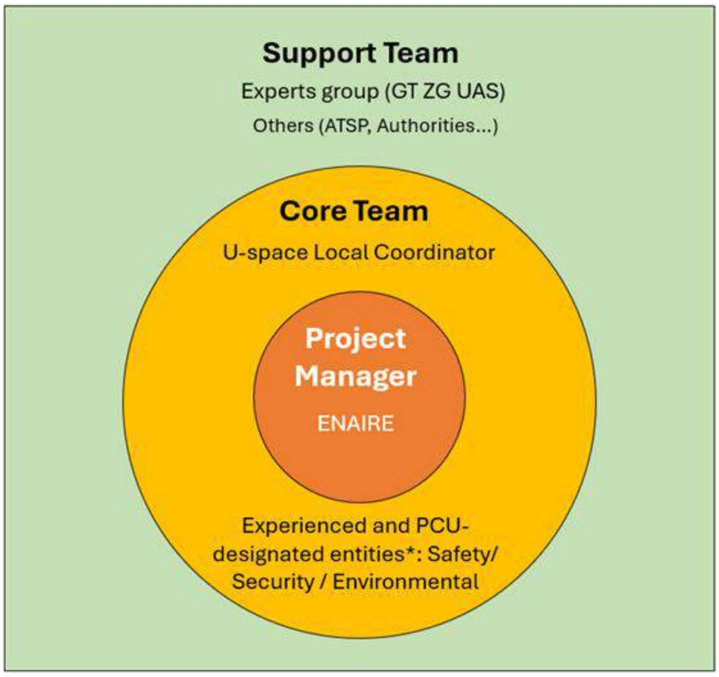


Figure 16. Responsibilities in the Spanish ARA team

E.1.3 Methodology

As mentioned above, the methodology followed for the creation of the ARA is the one proposed by EUROCONTROL, the Expanded Safety Reference Material **(e-SRM),** which is developed in several phases, as shown in the following figure.

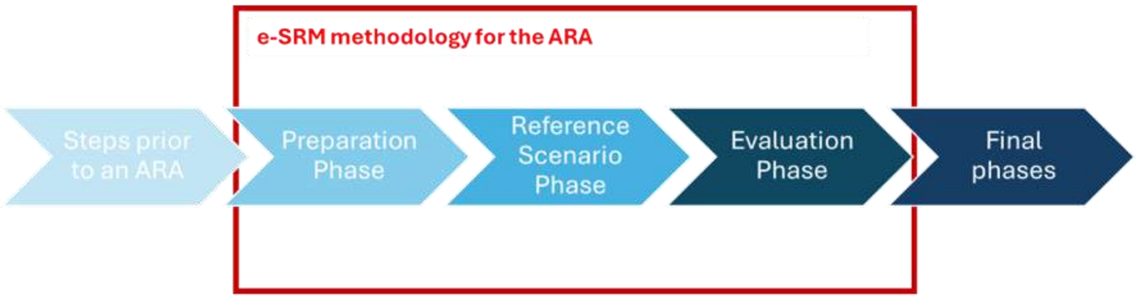


Figure 17. e-SRM methodology for the ARA

Section Airspace Risk Assessment discusses the ARA procedure, and this section is intended to address the deadlines to be met, as well as the actions to be taken to carry out the **process** explained in the mentioned section. In addition, this is the process being followed in the **development of the Benidorm**

ARA, the first Spanish U-space. On the other hand, it has been established that all the phases described below should last a maximum of 22 weeks.

First, outside the ARA procedure, the following must be done:

1. **Reasoned request:** to be made by the applicant to the PCU/DGAC (Directorate General of Civil Aviation) being optional for the participation of the SUPPORT TEAM (within the SUPPORT TEAM, the responsible for this action will belong to the UAS GZ WG, which is a group of experts in charge of the study for the establishment of UAS geographic zones in Spain). At this point, the competent authority, which in Spain is CIDETRA (Interministerial Committee between Defense and Transportation) decides whether to open the procedure ex officio or not. Finally, the application is reviewed by DGAC to detect possible corrections/erroneous aspects.
2. **Response to the applicant**: it is carried out by the competent authority, in Spain it will be DGAC, on behalf of CIDETRA.
3. **Request for initiation of the ARA:** this is done by the applicant to ENAIRE. This leads to the initiation of the ARA procedure.

Secondly, the preparation phase takes place, in which the following must be carried out:

4. **CORE TEAM and SUPPORT TEAM proposal:** this proposal is made by ENAIRE's specialized ARA team to the SUPPORT TEAM (within the SUPPORT TEAM, the responsible for this action will belong to the UAS GZ WG). This proposal must define both the participating organisations and the profiles required for each action, in accordance with the criteria established.
5. **Validation of both teams:** the SUPPORT TEAM (within the SUPPORT TEAM, the responsible for this action will belong to the UAS GZ WG) will respond to ENAIRE with the validation of both the CORE TEAM and the SUPPORT TEAM. In addition, this response leads to the start of the project.
6. **Scope document:** ENAIRE will submit the scope document to the CORE TEAM, this must include the airspace, structure and regulations.
7. **Scope document validation:** the CORE TEAM will respond to ENAIRE with the corresponding validation of the scope document.

Thirdly, the reference scenario phase takes place, in which the following should be performed:

8. **Data request to affected local and national stakeholders:** ENAIRE will make this request to the CORE TEAM, which will be in charge of consulting with the SUPPORT TEAM.
9. **Receipt of data applicable to the reference scenario:** the SUPPORT TEAM will be in charge of responding to the CORE TEAM with the answer to the previous request and the latter will be in charge of communicating it to ENAIRE.
10. **Reference scenario proposal:** ENAIRE will make a proposal of a possible reference scenario to the CORE TEAM.
11. **Validation of the reference scenario:** the CORE TEAM will reply to ENAIRE with the validation of the previous proposal.

Fourth, there is the evaluation phase, in which the following actions must be carried out:

12. **Proposed safety, security, privacy and environmental analysis:** ENAIRE will perform this analysis and send it to the CORE TEAM for validation.

13. **Validation of the safety, security, privacy and environment analysis:** the CORE TEAM will be in charge of responding to ENAIRE with the validation of the previous proposal.
14. **Contribution of comments to the draft ARA:** a process of comments to the draft ARA will be carried out between ENAIRE and the SUPPORT TEAM (within the SUPPORT TEAM, the responsible for this action will belong to the UAS GZ WG).
15. **Review of comments for the validation of the ARA:** Review of the comments for the validation of the ARA, between ENAIRE and the CORE TEAM.

It is important to note that items 14 and 15 are not performed only once, but it is a cyclic process until all comments are resolved.

16. **Delivery of final draft ARA:** ENAIRE delivers the final draft of the ARA to the SUPPORT TEAM (within the SUPPORT TEAM, the responsible for this action will belong to the UAS GZ WG).
17. **Closing of comments**: the SUPPORT TEAM (within the SUPPORT TEAM, the responsible for this action will belong to the UAS GZ WG) will be in charge of responding to ENAIRE with the closing of comments to the final draft.

From this point on, the ARA procedure is completed and the final phase of the e-SRM methodology simply remains to be addressed. Therefore, in the final phases after the ARA procedure, the following actions should be performed:

18. **Applicant receives the ARA:** ENAIRE sends the ARA to the competent authority, which in Spain is the DGAC, and the DGAC sends it to the applicant so that he/she can attach it to the official application.
19. **Correction of the ARA requirement:** If there is any aspect that needs to be modified, the applicant will correct any requirement and send it to the competent authority, which in Spain is the DGAC, who will be in charge of sending it to the SUPPORT TEAM (within the SUPPORT TEAM, the responsible for this action will belong to the UAS GZ WG).
20. **CIDETRA accepts the U-space designation:** the U-space must be approved by the competent authority, in Spain CIDETRA. This point ends with the response of the competent authority, in Spain CIDETRA, to the SUPPORT TEAM (within the SUPPORT TEAM, the responsible for this action will belong to the UAS GZ WG).
21. **Official response:** the SUPPORT TEAM (within the SUPPORT TEAM, the responsible for this action will belong to the UAS GZ WG) makes the official response of the U-space designation to the applicant.

Appendix F Coordination with local authorities

Within the Spanish cluster, the coordination/interaction of the Authorities in U-space could be done through the AUDI (Authorised Users Digital Interface) Module of the centralised ENAIRE U-Hub platform, as shown in **Appendix A.2.**

The Authorities' access to AUDI allows them (depending on their privileges) to perform the following functions:

- Create and edit UAS Zones, such as emergency zones within a U-space volume, through AUDI's Airspace Management functionality. This functionality will be certified based on Regulation (EU) 2021/664.
- Manage flight permissions necessary to access certain UAS zones that require a permit from the Authority in order to operate in them, through AUDI's Flight Permission functionality. However, since the development of U-ELCOME has not required a high involvement of the authorities nor is it a certifiable functionality based on the regulations applicable during the development of the project, this functionality has not been used, but occasional tests of its possible operation and utilities have been carried out.
- In addition, AUDI allows ATS personnel to perform Dynamic Airspace Reconfigurations (DAR), when the U-space is within controlled airspace. This functionality will be certified based on Regulation (EU) 2021/665 which amends Regulation (EU) 2021/373 and has been tested in real Demonstrations of the project with the 3 different Spanish ATSPs (ENAIRE, SAERCO and SKYWAY), validating its use in an operational environment.

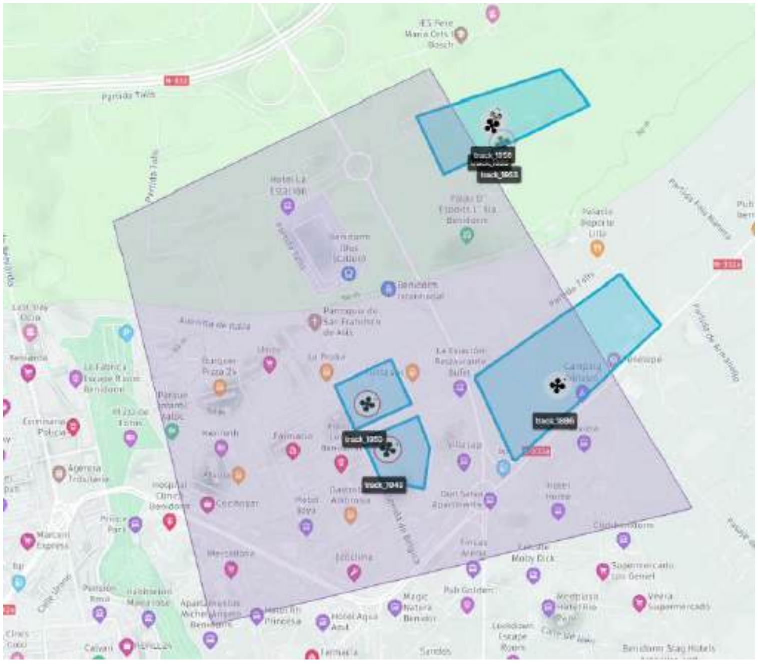


Figure 18. Example of an emergency area created during the Benidorm demo.

Appendix G Social Acceptance survey

In preparation for the last validation campaign of 2025 in the Spanish cluster in U-ELCOME Project, INECO and ENAIRE developed a survey to measure the societal readiness of UAS operations in Spain. Before going into deeper details, it should be noted that the survey was focused mainly on gathering responses related to the perception of safety from people that is not related with the sector and so the questions were worded in a way that could be easier to understand for everyone. The questions were:

1. In relation to the world of drones, UAS and U-space, you are…
2. Compared to other means of transport (traditional and innovative), which do you think is safer, in terms of the likelihood of injury to a pedestrian?
    a. A drone is safer than an electric scooter
    b. A drone is safer than a motorbike
    c. A drone is safer than a car
    d. A drone is safer than a commercial aircraft
3. When you look at a drone in flight, how concerned are you about the following aspects of flight?
    a. Noise
    b. Privacy issues
    c. Fear of collision with another drone
    d. Fear of the drone falling to the ground
    e. Fear of drone causing injuries
4. How much do you think the following factors affect flight safety?
    a. The size of the drone (small, medium, large -for passenger-)
    b. The type of area over which the drone flies (populated, unpopulated, urban, natural, industrial areas...)
    c. Drone use cases (transport of packages, aerial work, transport of people, etc.).
    d. Proximity to an airport
    e. Presence of manned aircraft in the area
    f. The proximity of other drones
5. How acceptable would you find the probability of a drone accident with one fatality per year in Spain?

6. How acceptable would you find the probability of a drone accident with one fatality per month in Spain?
7. How acceptable would you find the probability of a drone accident without casualties (only material damage) per day in Spain?
8. How acceptable would you find the probability of a drone accident without casualties (only material damage) per month in Spain?
9. In his opinion, drones should be as safe as:
10. What level of safety should drones at least demonstrate to fly in populated environments?

In total, 367 answers were provided. The main characteristics of the surveyed individuals are the following:

- Gender distribution.
  - 60.03% of the respondents were men.
  - 34.33% of the respondents were women
  - 4.64% of the respondents preferred not to answer or they identified themselves as something different.
- Age distribution.
  - 9.81% of respondents are under 30 years old.
  - 13.35% of respondents are between 30 and 39 years old.
  - 29.43% of respondents are between 40 and 49 years old.
  - 35.15% of respondents are between 50 and 59 years old.
  - 12.26% of respondents are over 60 years old.
- Work/Occupation distribution.
  - 13.32% of respondents work in public administrations.
  - 20.65% of respondents work in aviation industry not related to UAS.
  - 23.91% of respondents work in the UAS industry.
  - 42.12% of respondents are not related to the UAS or aviation industry.

All the results can be found in the DEMOR. Hereunder are the key finding of the survey:

- 60.96% of the respondents believes that a UAS is at least as safe as a car. For more information about this answer, check table x which shows the fatality rate per transport mode in the EU.

- 69.52% of the respondents are not concerned or little concerned about the noise created by UAS during the flight. It is important to note that this answer was provided using Innovative Aerial Services operations as an example instead of Innovative Air Mobility operations.
- 72.15% of the respondents are quite or very concerned about privacy issues created by UAS operations. In fact, privacy issues are considered the most important topic with regards to UAS operations, 36.64% of the answers were very concerned against 27.94% of the answers that were very concerned about UAS causing injuries to people.
- Respondents related to “general public” were more willingly to accept a UAS accident that only caused material damage compared to respondents that comes from the sector. 62.94% of the “general public” answers considered this situation somewhat acceptable or better compared to 53.85% of the “non general public” answers that considered this situation somewhat acceptable or better.
- 87.28% of the respondents considered that UAS should be at least as safe as recreational aviation, commercial aviation or more than any other means of transport.
- There is a clear safety perception gap between different age ranges. While 87.5% of the respondents under 30 years considered that they could accept 1 accident with injuries to people per year, only 26.42% of the respondents above 60 years considered this situation acceptable.
- There is a safety perception gap between different genders. While 57.45% of the men respondents considered that they could accept 1 accident with injuries to people per year, this number was reduced to a 44% for the women respondents.

Transport mode	Fatalities per billion passenger kilometres (pkm)	Average speed (km/h)	Fatalities per billion passenger travel hours (pth)
Airline passenger (on EU territory)	0.06	457.1	27.4
Railway passenger	0.10	57.1	5.7
Bus/coach occupant	0.23	28.6	6.4
Car occupant	2.67	35.7	95.4
Powered 2-wheelers	37.80	31.9	1205.2

Table 27. Fatality rate per transport mode[5]

In parallel to the work done in the framework of the U-ELCOME project, Spanish CAA (DGAC) has launched the first Social Acceptance Survey on drones and UAS geographical zones. This survey is part of the National Action Plan for the Deployment of U-space (PANDU by its acronym in Spanish) but the results are not yet available for public dissemination. These results will be published in Portal for the Coordination of U-space in Spain

[5] Source NPA 2022-06 Introduction of a regulatory framework for the operation of drones — Enabling innovative air mobility with manned VTOL-capable aircraft, the IAW of UAS subject to certification, and the CAW of those UAS operated in the 'specific' category

Appendix H Security Assessment

This appendix reports an overview of (cyber)security risk assessment activities carried out within U-ELCOME Project in terms of:

- security concerns and needs;
- main assessment results;
- recommendations.

The assessment was performed using the SESAR Security Risk Assessment Methodology (SecRAM) [38] as the baseline, applied to the U-space pharmaceutical delivery use case from the Italian cluster. For the experimentation of the proposed security risk assessment methodology and the setup of the semi-automatic process, SecRAM material was expanded with additional guidance sources, including the Common Weakness Enumeration (CWE) [45] repository, delivered by MITRE, to support the automated identification of threat scenarios, and the OWASP Application Security Verification Standard (ASVS) , to support the automated selection of security controls. The subsequent sections describe in detail how SecRAM was implemented, leading to the results and lessons learnt presented here.

H.1 Security Concerns and Needs

In this document, the following definition of **resilience** is applied [38]: "*the ability to prevent disruptions, to prepare for and adapt to changing conditions and to respond and recover rapidly from disruptions to ensure the continuity of services during and after a disruption, at an acceptable performance level*". Such definition implies the design of resilient SESAR solutions by means of a two-stage process, made up of the following steps:

- **Prevent-Prepare** – Prevention is pursued by assessing the environment and the design of the solution. Controls are identified to address potential risks. Preparation for possible attacks is pursued by procedures and training of staff.
- **Respond-Recovery** – Response is focused on the secure delivery of services and data whilst being aware of the attack in progress. Recovery restores services, tools and systems in full operation after an attack.

These considerations shall apply also for the **cyber resilience** of SESAR solutions. Cyber resilience results from building **cybersecurity** (i.e., cyberattack avoidance) and **cyber defence** (i.e., cyberattack response and resolution) [39]. In detail, cybersecurity mechanisms aim at reducing the impact and likelihood of attacks by: (i) planning cyber risk-management activities; (ii) cyber-threat identification; (iii) cyber-threat prevention (i.e., eliminating cyber-threats at source or deterring attackers); (iv) protection and preparation (i.e., mitigating the risk of residual cyber-threats and preparing cyber-defence).

The aforementioned (cyber-)resilience needs are even more valid for the scope of U-space solutions, which shall guarantee their **self-protection**, i.e., they shall be designed in order to be protected and resilient. Indeed, risk-management mechanisms shall also bear on new cyber-threats [38], as in the case of U-space, which represents a set of **highly-exposed Cyber-Physical Systems (CPSs)**, with vulnerabilities potentially leading to several threat scenarios. Moreover, drone incidents may generate various type of disturbances, which may affect public spaces, critical facilities and the citizen's right to privacy [40]. These incidents may also compromise the social acceptance of U-space and Urban Air

Mobility (UAM), as confirmed by an EASA recent study [41]. This points out that security is a top concern for UAM social acceptance, and that there is a limited trust in its security and cybersecurity, especially for drones.

These considerations push the need to prioritize **U-space security** and adopt **security-by-design** approaches for:

- identifying and assessing security risks in current U-space services (primary assets and supporting assets);
- ensuring future solutions meet security requirements from the early design stages.

Lastly, only self-protection properties have been considered within U-ELCOME project, while **security collaborative support** has not been considered as a reference topic of the analysis. Thus, the assessment has not considered how U-space can (at least potentially) contribute to civil aviation security, or to national security and defence, or to law enforcement.

H.2 Assessment Main Results

This section briefly reports the current results of the analysis related to the Security KPA. Such analysis has aimed at experimenting the application of a **semi-automatic model-based (cyber)security risk assessment** in U-space to:

i. investigate and address the security issues of the U-space implementation in a given use case;
ii. lay the foundations for the future development of automated security-by-design approaches, supporting the delivery of secure solutions in U-space.

In detail, security results are being obtained through the following activities:

- the adoption of **SESAR Security Risk Assessment Methodology** (**SecRAM**) as a baseline for the security risk assessment process;
- the detailed definition of the (cyber)security objectives in line with SecRAM baseline;
- the selection of the **U-space pharmaceutical delivery** as a use case;
- the **domain analysis and modelling**, consisting in:
    - the extraction of U-space primary assets and U-space supporting assets;
    - the **security-driven model-based specification** of the reference system according to a proper formalism;
- the **impact assessment**, consisting in:
    - a manual impact evaluation on U-space primary assets;
    - a semi-automatic impact evaluation on U-space supporting assets, based on the security-driven model;
- the **threat modelling and risk analysis**, consisting in:
    - the **automated model-based identification of threat scenarios** for a preliminary definition of a **U-space threat scenario catalogue**;
    - the semi-automatic selection of security controls;
    - the evaluation of residual risk;

For the experimentation of the proposed security risk assessment methodology and for setting up the semi-automatic process, SecRAM material has been expanded with additional guidance material, such as: the Common Weakness Enumeration (CWE) repository, delivered by MITRE, to support the automated identification of threat scenarios; the OWASP Application Security Verification Standard (ASVS), to support the automated selection of security controls.

The following is a list of the current outcomes obtained from the analysis:

- Domain analysis and modelling
  - 73 U-space primary assets have been identified (37 service assets and 36 information assets).
  - 16 U-space supporting assets have been identified.
  - 20 U-space actors have been identified.
  - 27 U-space primary assets are employed in the reference use case.
  - 6 U-space supporting assets are employed in the reference use case.
  - A security-driven model of 38 nodes has been specified for the reference use case.
- Impact assessment
  - The following four primary assets are the most critical: (i) *U-plan Processing service*, which activates or withdraws the U-plan authorization after having made specific checks; (ii) *U-plan Processing information*, the information provided by the U-plan processing service; (iii) *Flight Authorization service*, which either provides a copy of the accepted U-plan, including information like unique identifier, or rejects it, providing an explanation of any problems; and (iv) *Flight Plan information*, the information provided by the Flight Authorization. Indeed, their impact is high for the compromise of confidentiality, integrity and availability for the branding and people impact areas, respectively. The results were foreseeable due to involved sensitive information.
  - The most critical supporting assets are the *UAV Traffic Management System* and the *UAV Operating System*. These outcomes were expected, as both systems host the most critical primary assets.
- Threat modelling and risk analysis
  - A total number of 58 threat scenarios has been identified.
  - The results show that *UAV Operating System* and *UAV Traffic Management System* are the two assets affected by the largest number of threat scenarios (11). Additionally, the outcomes confirm that they are the most critical supporting assets: indeed, on 11 threat scenarios, 10 are characterized by the maximum impact value (i.e., 5).
  - The security Overall Risk Level (ORL) results to be unacceptable due to the presence of high-impact threat scenarios, mainly related to a significant risk of information leakage, data tampering, and network eavesdropping.
  - Preliminary mitigations, based on the CWE and OWASP ASVS sources, have been identified to treat the risk and make the security ORL acceptable.

The preliminary results confirm the feasibility of applying automation-driven design principles for the automatic assessment and treatment of U-space security risks. To complete the methodology and enhance its flexibility and effectiveness, additional work is required also to complement the model-based view with data-driven techniques and tools, i.e., relying on Artificial Intelligence (AI), for supporting security experts in overcoming the limits of catalogue-based approaches.

H.3 Lessons Learnt

This subsection reports the main lessons learnt (i.e., "*experience drawn from past activities that should be actively taken into account in future actions and behaviours*") related to the analysis of U-space security aspects.

Lesson Learnt ID	Title	Description	Chapter	Source
LL.SEC 1	**Security-critical Primary Assets**	The following U-space primary assets are the most critical: U-plan processing service, U-plan processing information, flight authorization service; flight plan Information provision.	H.3.1	U-ELCOME project
LL.SEC 2	**Security-critical Supporting Assets**	The following U-space supporting assets are most critical: the UAV Traffic Management System and the UAV Operating System.	H.3.2	U-ELCOME project
LL.SEC 3	**Preliminary U-space Security Controls**	Preliminary security controls have been identified to mitigate non-acceptable security risks.	H.3.3	U-ELCOME project

Table 28. Lessons learnt for U-space security analysis.

H.3.1 Security-critical Primary Assets

Considering the combination of maximum impact levels of primary assets for the Confidentiality-Integrity-Availability (CIA) requirements, the following primary assets are the most critical:

- **UPlan Processing** service, which activates or withdraws the U-plan authorization after having made specific checks;
- **UPlan Processing** information, that is the information provided by the UPlan Processing service;
- **Flight Authorization** service, which either provides a copy of the accepted U-plan, including information like unique identifier, or rejects it, providing an explanation of any problems;
- **Flight Plan Information** provision, that is the information provided by the Flight Authorization service.

Indeed, their maximum impact is equal to:

- 3 for confidentiality requirement, where the maximum confidentiality-compromise level occurs for the Branding impact area;
- 5 for the integrity requirement, the maximum integrity-compromise level occurs for the People impact area;
- 5 for the availability requirement, where the maximum availability-compromise level occurs for the People impact area.

The results may be explained in light of the following considerations:

- UPlan Processing service and Flight Authorization service handle sensitive information, since they manage submitted U-plans;
- Flight Authorization service manages data involving the histories of all submitted U-plans that have not yet been archived, which are considered commercially sensitive;
- confidentiality compromises could lead to a damage to the brand;
- integrity or availability compromises may result in delivery delays, failed delivery, or even unauthorized modifications to the flight plan, that in their turn may result in catastrophic harm to people (also considering urgent safety-critical pharmaceutical deliveries).

H.3.2 Security-critical Supporting Assets

The results highlight that the **UAV Traffic Management System** and **UAV Operating System** are the most critical supporting assets. These outcomes were expected, as both systems host the most critical primary assets according to the model developed for the reference U-space solution.

H.3.3 Preliminary Security Controls

In the current SecRA, preliminary security controls have been identified as mitigation actions for non-acceptable threat scenarios (i.e., security risks), in line with the reference "Initialise" level of the process. Such mitigation actions have been defined extending SecRAM catalogue, and using CWE and OWASP ASVS repositories as a support. Furthermore, they represent the basis for the final security requirements to mitigate non-acceptable residual security risks.

The final specification of mitigations and security requirements require further analysis, also to contextualize security controls with respect to the technical specification of the U-space solution. Additional standard catalogues (e.g., MITRE CAPEC, NIST CSF, ENISA reports for threats related to Artificial Intelligence, etc.) may be further considered for the final specification.

H.4 Recommendations

This subsection reports the main recommendations (i.e., "*advice about what is the best thing to have or do*") related to the analysis of U-space security aspects.

The proposed recommendations are summarized in Table 29. The following subsections report the detailed considerations for each recommendation.

Recommendation ID	Title	Description	Chapter	Source
RECO.SEC 1	**U-space Automated Security Risk Assessment**	An automated methodology (process, formalisms, tools) may be defined for the SecRA of U-space solutions. Expected benefits: • reduce assessment error rates; • increase the time-efficiency of SecRA process; • limit the influence of subjective judgments in the assessments.	H.4.1	U-ELCOME project
RECO.SEC 2	**U-space Threat Scenario Catalogue**	A U-space Threat Scenario Catalogue may be built extending SecRAM catalogues with additional guidance provided by external relevant sources. Expected benefits: • enhance the comprehensiveness of vulnerability and threat determination for U-space assets.	H.4.2	U-ELCOME project
RECO.SEC 3	**U-space Security Collaborative Support**	Specific assessments may be introduced for evaluating U-space security collaborative support. Expected benefits: • enhance the comprehensiveness of U-space security analysis; • elicit specific U-space requirements related to the efficiency of security collaborative support for selected use cases.	H.4.3	EDA U-space Study [48]

Table 29. Recommendations for U-space security analysis.

H.4.1 Automated Security Risk Assessment

In general, classical risk assessment methods are impractical for establishing the dependability of automated systems [42]. Since the assessment is manually conducted, typically by a domain expert in the reference solution, the following drawbacks may occur:

- some or all dependencies between assets may not be identified;
- the assessor may choose wrong impact values for the assets;
- certain (crucial) threats or vulnerabilities may not be considered, leading to missing threat scenarios;
- two different specialists may have different opinions proposing different threat scenarios evaluations.

The aforementioned considerations apply even more for U-space, that is a large networked CPS and then exhibits complex inter-asset dependencies, which could be analysed by human experts only with:

- high error rates;

- a time-consuming process;
- different and subjective points of view.

Instead, complex security aspects should be assessed by capturing the system knowledge with proper modelling languages and data formats, to be reused in inference processes for repeatable and reliable assessments [43], [44].

In detail, **Automated Security Risk Assessment** (**Automated SecRA**) represents an implementation of a methodology relying on formalisms, techniques, and tools, to support the automation of all the following engineering steps: (i) impact assessment; (ii) risk identification; (iii) risk evaluations; and (iv) risk treatment.

In the case of U-space, such Automated SecRA shall exploit formal (i.e., unambiguous and standardized) specifications of the necessary concepts for:

- describing reference U-space solutions;
- analysing the related vulnerabilities, threats and security controls;
- evaluating impacts and risk levels, to prioritize risk-treatment efforts;
- possibly extracting knowledge from different sources, e.g., ENISA, MITRE, NIST CSF, etc. (see also next subsection).

H.4.2 U-space Threat Scenario Catalogue

One of the steps of SecRAM methodology performs the determination of threat scenarios for the assets involved in the analysed U-space solution. In this regard, a **U-space Threat Scenario Catalogue** may support this phase, gathering threats and weaknesses for the assets involved in U-space environment, thus preventing that some scenarios are not determined. Such catalogue is not currently included in SecRAM catalogues.

To build this extended catalogue, a *mapping-driven approach* may be implemented according to a process leveraging on the guidance material provided by SecRAM and on additional guidance provided the external relevant sources, such as:

- the Common Weakness Enumeration (CWE) catalogue, developed and maintained by MITRE [45];
- some ENISA references, which may be exploited as additional references, especially for the assessment of solutions relying also on AI within U-space [46], [47].

For example, with respect to the SecRAM material focusing on ATM domain, CWE provides a more comprehensive overview about cyber domain, proposing a weakness description with several levels of abstraction. In particular, although CWE focuses on weaknesses, some of them: on the one hand, allow to describe the threats; on the other hand, allow to define more threat scenarios.

Instead, ENISA references provide also a taxonomy of Machine Learning (ML) algorithms, and a detailed analysis of related threats and security controls, which could be used as a reference for extending the catalogue towards a detailed assessment of ML-based modules.

H.4.3 Security Collaborative Support

As anticipated in subsection H.1, the analysis has not considered security collaborative support as a reference toping, and no assessment has been carried out about how U-space can (at least potentially) contribute to civil aviation security, or to national security and defence, or to law enforcement. For a more exhaustive assessment, the security analysis shall consider also these aspects and the related use cases.

As highlighted in the U-space study for the European Defence Agency (EDA) [48], the development of drone operations creates security issues as there is currently no universally available solution to detect accidental or unlawful interferences of drone flights with sensitive assets. Thus, U-space self-protection is one of the most relevant topics. Moreover, in case the military decide to use U-space services and contribute to these services by sharing information with the USSPs, a negative impact is represented by the occurrence of additional cybersecurity risks, as military systems may be opened to external stakeholders, requiring appropriate processes and measures [48].

However, significant benefits could result from the military use of U-space, not only in terms of safety, but also in terms of efficiency for some specific use cases within joint air operations, air policing, and public service [48]. This implies a potential security collaborative support of U-space, that could be specifically assessed for some military or law-enforcement use cases.

Annex I. Finished projects

Bubbles. Defining the Building Basic Blocks for a U-space Separation Management Service. The BUBBLES project aims at defining separation minima and methods for unmanned air systems (UAS) flying in the very low-level airspace (VLL), to improve the overall performance and safety therein. BUBBLES follows an operation-centric, risk-based approach, assigning the separation minima and methods within the framework of the U-space Concept of Operation (ConOps) and the corresponding risk level assessed using standard methodologies like specific operations risk assessment (SORA).

CORUS. Concept of Operations for European U-space Services: The CORUS (Concept of Operation for EuRopean UTM Systems) project gathers experts from aviation (manned and drone), research and academia to develop a reference Concept of Operations (CONOPS) for UTM (UAS Traffic Management) in VLL airspace in Europe. Building on the state-of-the-art, CORUS will develop an operational concept enabling safe interaction between all airspace users in VLL considering contingencies and societal issues. The project was in charge of the delivery of the first U-space Concept of Operations.

CORUS-XUAM. Concept of Operations for European U-space Services- Extension for Urban Air Mobility. CORUS-XUAM is a 24-month VLD project that demonstrates how U-space services and solutions could support integrated Urban Air Mobility (UAM) flight operations, allowing eVTOLs/UAS and other airspace users (unmanned and manned) to operate safely, securely, sustainably and efficiently in a controlled and fully integrated airspace, without undue impact on operations currently managed by ATM. The project is proposed by the consortium that delivered the SJU CORUS U-space Concept of Operations (ConOps) in 2019, extended by the addition of UAM expertise.

DACUS. Demand and Capacity Optimisation in U-space. DACUS developed a demand and capacity balancing (DCB) decision-making process and designed a DCB concept of operations (ConOps) for U-space that takes account of key limiting factors for drone operations over the population. The project developed prototypes of the proposed solutions: A collision risk prototype quantified the air and ground risks as a limiting factor to determine the maximum number of drones in an urban area; a social impact prototype measured the visual and noise effects over the population as another limiting factor; and a route planning prototype considered the uncertainty of demand as part of the process. Because drone mission trajectories tend to be more dynamic than manned aviation, the system needs to deal with diverse and multiple changes that affect flight plans that can be received at short notice.

DIODE. D-flight Internet of Drones Environment. Drones operate across multiple sectors including medicine, agriculture, mapping, deliveries, inspection, and emergency services. They range over different terrain and display different characteristics. The DIODE project focused on demonstrating capabilities to safely manage multiple drones flying in very low-level airspace at the same time, while accomplishing multiple tasks and missions. The project worked on the assumption that each aircraft (manned and unmanned) will report its positions. In other words, the whole traffic is cooperative, and its complexity is therefore reduced.

DOMUS. Demonstration of Multiple U-space Suppliers. Ensuring drones operate safely alongside all other airspace users calls for advanced conflict detection between flight paths and reliable communications with the air traffic management system. By integrating already developed technologies and concepts around a federated architecture, members of the DOMUS consortium showed that initial and some advanced U-space services, including tactical de- confliction, are possible.

EuroDRONE. A European UTM Testbed for U-space. The safe integration of drones into manned airspace requires a universal platform connecting various stakeholders (drone operators, regulators, law enforcement agencies and product developers) and providing interoperability between different systems in a unified environment. EuroDRONE tested different concepts, technologies and architectures to promote the cooperation of the relevant stakeholders in an U-space environment. By using cloud software and hardware, the research experimented with U-space functionalities ranging from initial services to more advanced services such as automated detect and avoid. A series of demonstration flights in Missolonghi, Greece, helped to identify technology, architecture and user requirements necessary for U-space.

GEOSAFE. Geofencing for Safe and Autonomous Flight in Europe. The GEOSAFE research set out to establish state-of-the-art geofencing U-space solutions and to propose improvements and recommendations for future geofencing system definition. The project was based on a one-year long flight-test campaign, which assessed a number of commercially- available geofencing solutions in order to propose improved geofencing systems for tomorrow and technological improvements for drones. The research included 280 flight tests in France, Germany and Latvia, which tested representative situations that a drone will face in urban and rural areas. They covered a range of missions including agricultural operations, inspections, emergency events and deliveries.

GOF-USPACE. Finnish-Estonian “Gulf of Finland” very large U-space Demonstration. The safe operation of multiple drones in the same airspace relies on collaboration and data exchange between many different actors. A basic function of U-space is to bring situational awareness to all users and bridge the gap between manned and unmanned aviation by linking air traffic management information with unmanned traffic information, thus allowing operators and pilots access to common flight information. A flight information management system (FIMS) makes this possible by creating an interoperability architecture using standard protocols to exchange data.

ICARUS. Integrated Common Altitude Reference System for U-space. New methods and procedures are needed for the expected large numbers of drones that will operate in the VLL airspace, especially over cities where the existing altitude references cannot always address the challenges arising from flying near, or sometimes even below, ground obstacles. ICARUS carried out a thorough analysis of the challenges involved in drone operations conducted in VLL airspace, including a public survey, and gap analysis. With this information, the project defined a system architecture and prototype to validate the ICARUS concept of operations (ConOps).

INVIRCAT. IFR RPAS Control in Airports and TMA. Remotely piloted aircraft systems (RPAS) are among a growing number of new airspace users fulfilling commercial and military roles. As they are currently largely confined to segregated airspace, solutions need to be established that allow full integration of RPAS into non-segregated airspace. INVIRCAT focused on the integration of RPAS into the existing air traffic control (ATC) procedures and infrastructures within terminal manoeuvring areas (TMA) and airport environments under instrument flight rules (IFR).

PODIUM. Proving Operations of Drones with initial UTM. PODIUM carried out demonstrations at five operational sites in Denmark, France and the Netherlands during 2018 and 2019. The project tested the performance of pre-flight and in-flight services using different scenarios ranging from airport locations to beyond visual line of sight. The results were used to draw up recommendations on future deployment, regulations and standards.

SAFEDRONE. Maintaining the safety of air operations when drones and conventional aircraft share low-level airspace, close to an airport for example, will require a high degree of digitalisation and automation. The SAFEDRONE project sought to define and detail pre-flight services including electronic registration, electronic identification, planning and flight approval; as well as in-flight services such as geofencing, flight tracking, dynamic airspace information and automatic technologies to detect and avoid obstacles in order to demonstrate how to integrate manned aviation and drones into non-segregated airspace. The objective was to accumulate evidence and experience about the required services and procedures necessary to operate drones in a safe, efficient and secure way within U-space.

SAFELAND. SAFE Landing through Enhanced Ground Support. Advances in automation technology could mean that one day only one pilot is needed in the cockpit of commercial aircraft. Key requirements for the implementation of single-pilot operations (SPO) will be preserving the safety levels as in current multi-pilot operations and addressing risks such as in-flight pilot incapacitation. These safety requirements were at the core of the operational concept developed by SAFELAND, which aimed at supporting a single-piloted aircraft during the flight and landing in case the single pilot on board becomes incapacitated. The concept was predicated on the interaction of a ground-based operator working from a remote ground station position with on-board automation and air traffic controllers.

SAFIR. Safe and Flexible Integration of Advanced U-space Services for Medical Air Mobility. The SAFIR-Med project's vision is to achieve safe, sustainable, socially accepted and socially beneficial urban air mobility. SAFIR-Med represents all value chain actors and stakeholder as either project partner (ATC, USPs, operators, UAS manufacturers, cities) or formal associate partner (major customers, technology and service providers) at a representative international level.

USIS. U-space Initial Services. U-space relies on a higher level of automation than ATM. Many services are currently being developed and need to be validated and regulated to ensure safe and secure operations. USIS research sought to validate the services that will be provided by U-space service providers to drone operators and third parties, including the authorities in charge of the airspace, to demonstrate their readiness at a European level.

URClearED. A Unified Integrated RPAS Avionics Safety Suite. As more certified remotely piloted aircraft systems (RPAS) take to the skies to serve as vehicles for civil and military purposes, ensuring they carry out their business safely and securely becomes ever more important. The URClearED project addressed a key technological issue that will allow certified RPAS to carry out services, such as monitoring, surveillance, and cargo delivery, while sharing airspace with other users. URClearED investigated the concept of a remain-well-clear (RWC) function of a detect and avoid system for certified unmanned air vehicles flying instrument flight rules (IFR) in airspace classes D to G. Well below the typical cruise altitudes of commercial airlines, the airspace is used by small and medium-sized aircraft like helicopters, general aviation, and unmanned systems.

USEPE. U-space Separation in Europe. The USEPE project explored potential separation methods throughout the strategic and tactical flight planning phases, including defining the actors responsible for making decisions. The research considered which actor should be the predetermined separator (the drones themselves or the U-space system) throughout the strategic and tactical planning phases before defining a set of concepts to provide safe separation for different kinds of drones.

AIRPASS. Advanced Integrated RPAS Avionics Safety Suite. Drones of all shapes and sizes will provide services in the future, ranging from small medical deliveries, inspection services, and package deliveries, to larger urban taxis and remotely operated systems. To interact safely with all other airspace users and services, AIRPASS partners defined a high-level architecture for the onboard equipment they need to carry. This architecture considers communications, CNS systems, as well as technology specific to drone operations such as autopilot and detect and avoid systems.

CLASS. Clear Air Situation for UAS. Reducing the risk of conflict between airspace users becomes more important as more drones enter the airspace. The Clear Air Situation for uaS (CLASS) project examined the potential of ground-based technologies to detect and monitor cooperative and non-cooperative drone traffic in real-time. The consortium fused surveillance data obtained using a drone identifier and tracker, and holographic radar, to feed a real-time UTM display.

DREAMS. Drone European Aeronautical Information Management Study. The DREAMS project set out to identify gaps between existing information used by manned aviation and new needs coming from U-space. Unmanned aviation will require a comparable level of information with the same level of integrity and rel iability as manned aviation. In this respect, DREAMS assessed the present and future needs of aeronautical information to support the growth of unmanned aviation and ensure the safety of operations.

DroC2om. Drone Critical Communications. Drones rely on a high level of digitalisation to operate autonomously and depend upon datalink communications to achieve this. Command and control (C2) information needs to be reliably transferred in support of functions and specific procedures, enabling drones and manned vehicles to operate safely in the same airspace. The DroC2om project reviewed the capability of the existing cellular and satellite infrastructure that supports C2 datalink communications, using live flight trials and simulations to test availability and performance. The research led to the definition of an integrated communications concept incorporating cellular and satellite datalinks, which is contributing to EUROCAE and 4G/5G standardisation work.

IMPETUS. Information Management Portal to Enable the Integration of Unmanned Systems. The framework of the IMPETUS solution is based on a federated architecture with a layered distribution of responsibilities. It is made up of a central actor that provides a single point of truth of the airspace situation, an intermediate interface composed of multiple U-space service providers, and an external layer for the end users (drone operators). The IMPETUS platform supports testing of various U-space services.

SECOPS. An Integrated Security Concept for Drone Operations. Given the highly automated nature of drone operations, cyber security is particularly important and security risks in U-space need to be assessed and mitigated to an acceptable level. Secure drone operations need to be supported by a combination of different security functions at different levels in the drone end-to-end system, managed by a dedicated set of procedures and supported by clear regulations. By establishing an integrated security concept, drones can operate in accordance with appropriate procedures and regulations, while any drones that divert from their flight plan can be detected and acted upon. To this end, SECOPS defined an integrated security concept for drone operations, including addressing resistance of drones against unlawful interference, protection of third parties and integration of geofencing technology. The research reviewed technological options for both airborne and ground elements, considered legal, as well regulatory and social aspects.

TERRA. Technological European Research for RPAS in ATM. The current communications, navigation and surveillance (CNS) infrastructure is designed to support the needs of manned aviation. The requirements of the emerging drone sector are different and will rely on new and existing technologies to perform effectively. The TERRA project set out to identify relevant ground technologies and to propose a technical ground architecture to support drone operations.

VUTURA. Validation of U-space by Tests in Urban and Rural Areas. VUTURA focused on four major goals. These are: validating the use of shared airspace between existing, manned airspace users and drones; validating more than one U-space service provider providing U-space services in a specific airspace and the procedures needed to support drone flights; ensuring alignment of regulation and standardisation between SESAR developments and U-space service providers; and increasing the pace by which European cities and companies exploit emerging technologies related to drones. The goal was to improve the quality of life in cities, create concrete socio-economic outcomes and help European companies to take a leading position in the new smart city market.

TINDAIR - Tactical Instrumental Deconfliction And in-flight Resolution. The SESAR TINDAIR project set out to deliver a reliable tactical deconfliction service with a robust communication link to enable new aircraft types to be integrated safely into the skies alongside existing manned aviation and air traffic control. Innovative tactical deconfliction services were demonstrated in complex airspace.

Uspace4UAM. Uspace4UAM built on the CORUS project results and on operational and business experience already gathered in operational drone service implementations in Europe. It studied safety cases and their impact on system requirements, and looked at how regulation and standardisation can be set up to support innovators to build a sustainable business case while operating safely in a multi-modal transport network. This project set to deliver results that are of real interest to “early movers”, enabling them to bring a real market impact in the next few years. In order to prove that this was achieved, and that indeed the project laid a bridge between development and deployment, the project set to deliver a number of commercial contracts for the provision of fully automated drone services, and present solutions to identified gaps towards fully autonomous Urban Air Taxi services.

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

AURA - ATM U-space Interface (PJ.34). One of the main hurdles facing urban air mobility is the safe integration of drones into low-level airspace without impacting conventional air traffic operations. The AURA solution first sets about defining the requirements for U-space information exchange with airspace management before developing a new concept of operations and validating the data exchanges through System Wide Information Management (SWIM) to create this collaborative environment.

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

For more information, visit https://www.sesarju.eu/projects/portal

Annex II. Ongoing projects

The following list contains all the ongoing projects within the SJU related to U-space that are still ongoing at the time of writing this document.

U-ELCOME. U-space European Common Deployment. U-ELCOME project is aiming at the fully scalable market uptake of U1 and U2 U-space services through a set of tests and demonstrations in various operational environments and European locations. To do so, U-ELCOME develops, tests and demonstrates SESAR solutions in various across 15 locations distributed in Spain, Italy and France.

Combining digital and physical infrastructure capabilities, U-ELCOME aims to set up, deploy and demonstrate up to Technology Readiness Level 8 the following SESAR solution:

- Initial U-space implementation in controlled and uncontrolled airspace: This solution addresses the deployment of U-space services in an environment within controlled and/or uncontrolled airspace.

  It includes the deployment of U-space services as defined in the regulation IR (EU) 2021/664, IR (EU) 2021/665 and IR (EU) 2021/666 and complementary essential U1 and U2 services as well as the use of exchange services to facilitate safe and efficient UAS operations in U-spaces airspaces where UAS and e-conspicuous aircrafts would operate, and also in airspaces within both controlled and uncontrolled airspaces where U-space functionalities and services will apply. For controlled airspace, dynamic airspace reconfiguration is considered in the process of being fully implemented. These U-space services will be provided by integrated USSPs (U-space Service Providers) and/or CIS (Common Information Services).

  Performance benefits of this solution include enhanced situational awareness for UAS operators, reduced collision risks through strategic deconfliction and conformance monitoring and improved coordination between UAS and other airspace users. This is achieved by the implementation and deployment of U-space services and deploying them with the complete ecosystem required for U-space operations, which includes UAS and their operators/pilots, USSPs, CISPs, ATS (Air Traffic Service) and end users who will use the U-space services in conjunction with the existing air traffic management system for conventional aviation. The solution promotes the safe integration of UAS into uncontrolled and/or controlled airspace while ensuring overall airspace safety and efficiency and compliance with regulatory requirements and standards.

U-ELCOME project builds on the outcomes of the previous European projects bridging from research, through industrialisation to implementation; at the same time the U-ELCOME project works in compliance with Regulation 2021/664 on a regulatory framework for the U-space and related amended 2017-373 and 923/2012 regulations.

The project, working in close cooperation with EASA and other international and national authorities and organisations, will also contribute to the consolidation of standardisation and regulatory requirements of the proposed U-space services to further accelerate the deployment of relevant U1 and U2 services and U-space operations.

BURDI. Belgium-Netherlands U-space Reference Design Implementation.

The Belgium-Netherlands U-space Reference Design Implementation (BURDI) project aims to:

- implement a U-space airspace concept able to manage various, dense and complex UAS operations in controlled, uncontrolled and UAM environment
- make this implementation a reference to develop best practices, standardisation, harmonisation and/or interoperability requirements fostering operational deployment of U-space airspaces in Europe
- ensure that solutions to be deployed are economically sustainable and socially acceptable/supported for the benefit of the general public

BURDI project will be implemented around cities of Antwerp, Liège and Brussels where the proximity of international Airports, an active maritime Port and the proximity of the border with The Netherlands are considered as a relevant factor of development for UAS operations in multiple domains like delivery of goods, inspections, support to medical as well as security operations.

ÉALÚ-AER. Enhanced Automation for U-space/ATM Integration.

ÉALÚ-AER is a technology infrastructure integration and demonstration project. ÉALÚ-AER aims to establish Ireland's first Digital Sky Demonstrator, located at Future Mobility Campus Ireland's recently established vertiport site, in Shannon, Ireland. ÉALÚ-AER aims to:

- Prove feasibility, reliability and operational efficiency of transport services provided by various eVTOL (electric vertical takeoff/landing) aircraft for a variety of use cases and applications.
- Foster and accelerate the development of autonomous software solutions for the control, monitoring, data gathering/ orchestration and overall interaction and safety of eVTOL aircraft.
- Develop, deploy, and continually test/optimize the use of IAM (Innovative air mobility), rural/remote air transport/freight delivery, and U-space systems in support of eVTOL services.
- Develop, deploy, and refine operational systems in general eVTOL-based services across multiple use cases and political jurisdictions.
- Define possible Separation Standards Aircraft and UAVs in Controlled Airspace (Class-C Airspace) through partnership with IAA ANSP (future Air Nav Ireland).

This project saw the integration of a U-space technology platform as part of the FMCI operations site, which leveraged a world-class integrated U-Space technology solution that encompasses a U-space platform (Collins Airspace Services), a backhaul network (ARINC Global Network), Collins CNCP5000 radio as reliable C2 link equipment, and an advanced three-dimensional phased array radar (Skyler®). The project builds on technologies that have been matured world-wide in other UTM programs and 5 use cases were executed that capture the operational requirements, vehicle dynamics, and technology demonstrations associated with the projected near-term IAM (Innovative Air Mobility) services market.

An outline of these use- cases is listed below and are intended to operate in a compounding fashion to build upon prior phases and prior activities carried out in previous SESAR and external programs. Outputs of these operations are intended to inform and validate concept of operations, demonstrate, and validate the U- space architecture and pave a way for enhanced automation and U3, U4 services such as detect and avoid and dynamic capacity management. ÉALÚ-AER is intended to be an infrastructure platform that can be leveraged to support further developments through future SESAR programmes and work streams. The U-space technology solution being implemented in this project is intended to be modular and scalable and aligned with the proposed U-space architecture. ÉALÚ-AER features an integration effort that with advanced U-space, C2, and surveillance technologies from a leading aerospace systems integrator (Collins Aerospace), being brought together as part of a consortium that has leveraged Ireland's first vertiport (Future Mobility Campus of Ireland), the Irish ANSP (AirNavIreland) the operator of an international airport of Shannon (Shannon Airport Group), a leading research consultant for safety (Avtrain), security and human performance (Deep Blue), the Irish airspace regulator and Manna Drone representing the OEM (Original Equipment Manufacturer) and operator.

The ÉALÚ-AER consortium consists of active participants in international efforts to develop technologies and solutions to enable the AAM/IAM market.

AI4HyDrop- An AI-based Holistic Dynamic Framework for a safe Drone's Operations in restricted and urban areas. Drones are already used in an array of sectors, from agriculture, construction and surveillance to film-making, healthcare and emergency services. Given the scale and complexity of drone operations that are expected in the coming years, a holistic approach needs to be taken to managing the airspace. The project will develop a framework that incorporates various AI-based tools and associated information flows to enable future drone operations at scale. The proposed framework will represent a digital step change in ATM, using AI as a means to move to more automated U-space services.

ImAFUSA- Impact and capacity Assessment Framework for U-space Societal Acceptance. Citizens' confidence and acceptance is critical to the further development of the drone services market in Europe, especially urban air mobility (UAM). The project will develop an impact and capacity assessment framework for U-space societal acceptance to assist local authorities, other U-space stakeholders and users with the implementation of socially acceptable and beneficial urban air mobility in cities. The framework and its tools will address matters which influence public opinion, such as the environment (e.g. noise, visual pollution and air quality), and safety and socio-economics (e.g. affordability, accessibility, economic development, public space use and connectivity).

MUSE- Measuring U-Space Social and Environmental Impact. The project will develop a set of key performance indicators, methods and tools for the comprehensive and rigorous assessment of the impact of urban air mobility (UAM) operations on the quality of life in European cities, with particular focus on drone-generated noise and visual pollution. The project will develop a new toolset capable of generating accurate drone 4D trajectories in urban areas, modelling UAM's noise and visual footprints, high-resolution dynamic population mapping and calculation of population exposure indicators segmented by type of day and time of the day, citizens' sociodemographic profile, type of activity being performed and other relevant variables.

EUREKA- European Key solutions for vertiports and UAM. Air taxis are an exciting development in air mobility, but to get off the ground, these vehicles rely on infrastructure like vertiports and accompanying air traffic management procedures. The project will develop the complete arrival, departure and turnaround process for vertiports. The proposed solutions will take into account collaborative traffic management, how to deal with emergencies and disruptions and network flow and capacity management. The project will provide recommendations for regulation/standardisation and any information that will accelerate and harmonise the development of UAM, VTOL operations and vertiports across Europe.

OperA- Operate Anywhere. Innovative Air Mobility (IAM) has the potential to revolutionise last-mile transportation. To pave the way and accelerate market uptake, the project will validate complex IAM operations (piloted air taxi and unmanned cargo) in real-life air traffic control conditions, including contingency and non-nominal situations. It will specifically address air/ground integration and the critical transition from piloted towards automated flights, making use of several key autonomy-enabling technologies. In addition, it will ensure environmental sustainability compared to the next-best transport alternative, and enhance it, by optimising flight routing for minimum noise footprint and aircraft energy utilisation.

The OperA (Operate Anywhere) project will enable safe and efficient operations in all types of airspace (controlled, uncontrolled and U-space) and conditions by validating 3 different complex IAM - piloted air taxi and unmanned cargo - operations in real-life ATM conditions including contingency and non-nominal situations. It will stimulate the uptake of new sustainable Innovative Air Mobility services by addressing Air/Ground integration and the critical transition steps from piloted towards automated flights for 5 key autonomy-enabling technologies at TRL7 (Technology readiness levels). In addition, it will ensure environmental sustainability compared to the next best transport alternative, and enhance it, by optimising flight routing for minimum noise footprint and aircraft energy utilisation.

Ultimately, it will seek to accelerate the deployment of IAM by addressing necessary standardisation, regulation and roadmaps, in synchronisation with the ongoing certification of the three participating European IAM vehicles and ensure social acceptance by targeted communication and dissemination activities. All of this will be done through three distinct and well selected demonstration activities involving Europe’s most promising IAM OEMs (Original equipment manufacturer).

ENSURE- ATM-U-space Interface and Airspace Reconfiguration Service. Ensuring an interoperable and effective interface between unmanned and conventional traffic and air traffic control is critical for the delivery of the future Digital European Sky. This project aims to refine and complete the definition of a common interface and services for U-space and ATM. The project will develop a standardised data model, architecture and an operational methodology. The project will also develop a dynamic airspace configuration service to help ATC actors in charge of airspace reconfigurations to maintain traffic segregation and to avoid proximity between manned and unmanned aircraft within the designated U-space airspace.

SPATIO- U-Space Separation Management. Keeping aircraft safely separated is one of, if not the core function of air traffic management today. As larger numbers of unmanned aerial systems (UAS) take to the skies, separation management becomes more important to avoid mid-air collisions. The project will address separation between unmanned air vehicles, in particular, strategic and tactical conflict resolution services and the relationship between separation and capacity in U-space airspace.

SAFIR-Ready. The project aims to develop new U-space advanced services together with a central command and control centre (C2C), as well as an automated ground integration (Drone Cargo Port - DCP) to facilitate automated time-critical drone-based services for medical and non-medical use cases. Specifically, research will focus on a dynamic capacity management system (U3), detect and avoid algorithms (U3) and machine to machine communication and decision making (U4). The project will extend use cases to non-medical critical missions, such as shore to ship for the transport of materials and the inspection of railway and electric grids in case of unforeseen issues with the infrastructure (e.g. tree fallen on high tension cable).

U-AGREE. U-space Air and Ground Risk modEls Enhancement. The project aims to develop an integrated risk model linking the operations of unmanned aircraft (UAS) with some negative effects they may have with regard safety, security, privacy and environment. This risk model is intended to support the airspace risk assessments required by U-space European regulation as well as an amendment to SORA methodology so that risk can be quantitatively estimated, enabling digital implementations leading to swifter operational approval processes.

CORUS five. Development of the extended U-space Concept of Operations CORUS V5.0 - CORUS five. The project aims to extend and mature the SESAR U-space Concept of Operations for the integration of drones into controlled airspace. Building on the success of CORUS and CORUS XUAM, it willis expanding the scope to cover areas currently not included such as above very low level airspace and near controlled airports. The updated ConOps will include functionalities and U3/U4 services supporting U-space integration, and propose SESAR Solutions, flight rules, and airspace structure elements. It will address key concerns, including liability, the quality of digital terrain models, and the convergence of altitude references (Mean Sea Level vs. Above Ground Level). The ultimate goal is to publish the fifth edition of the U-space ConOps, enabling safe, green, and acceptable operations for both crewed and uncrewed aircraft.

For more information, visit https://www.sesarju.eu/projects/portal

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