Operational Service and Environment (OSED) – Version 1

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Abstract

This document presents the initial Operational Service and Environment Definition (OSED) for the U-AGREE project under SESAR 3 JU ER02. It focuses on defining the operational service and environment necessary for integrating U-space services to support UAS risk mitigation at TRL2. Key elements include operational scenarios, stakeholders, technical enablers, and regulatory aspects. Challenges such as ATM integration, U-space scalability, and coordination with manned aviation are identified, guiding future refinements for safer and more efficient U-space deployments.

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U-SPACE AIR AND GROUND RISK MODELS ENHANCEMENT

U-AGREE

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Table of contents

List of tables

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List of figures

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1 Executive summary

This document presents the initial Operational Service and Environment Definition (OSED) for the U-space Air and Ground Risk modEls Enhancement (U-AGREE) project within the SESAR 3 JU ER02 framework. It provides a preliminary definition of the operational and technical environment applicable to the integration of U-space services for risk mitigation in unmanned aircraft system (UAS) operations at TRL2.

As a first iteration, this OSED outlines the conceptual framework and key elements necessary for the progressive development of U-space risk assessment models. It focuses on safety, security, privacy, and environmental considerations, setting the groundwork for further refinement in subsequent phases.

This initial OSED serves as a foundation for further iterations, supporting the structured maturation of U-space services in alignment with SESAR objectives. The **key elements** of this iteration are:

- **Operational and Technical Environment:** The document details preliminary U-space operational scenarios, addressing different airspace classifications, air traffic interactions, and early-stage integration with Air Traffic Management (ATM) systems.

- **Key Assumptions:** This phase assumes the availability of foundational U-space services, such as network identification, geo-awareness, flight authorization, and traffic information, to support UAS operations.

- **Impacted Stakeholders and Performance Contributions:** The identified stakeholders include regulatory authorities, air navigation service providers (ANSPs), U-space service providers (USSPs), and UAS operators, with an expected impact on airspace safety, operational efficiency, and regulatory compliance.

- **Maturity Status:** At TRL2, this concept is in an exploratory phase, focusing on initial validation through simulations and theoretical analyses rather than full-scale deployment.

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2 Introduction

2.1 Purpose of the document

This document defines the OSED for the U-AGREE project under the SESAR 3 JU ER02 initiative at Technology Readiness Level 2 (TRL2). As part of the SESAR solution lifecycle, this OSED represents a key technical deliverable at TRL2, supporting the progressive maturation of the U-AGREE solution.

The purpose of the final version of the OSED will be to establish a comprehensive description of the operational service and environment in which the U-AGREE solution will be implemented, providing stakeholders with a structured framework for its development and validation. It will define the operational concept, actors, interactions, and constraints relevant to the project, forming the foundation for subsequent validation and industrialization phases.

The U-AGREE solution, identified with the ID 0520 (Integrated risk models for UAS in the U-space), is defined as follows:

> *Integrated risk models for UAS in the U-space as an extension of the Specific Operations Safety Assessment (SORA) model, which allow to more accurately link UAS operations with their multidimensional harmful effects on safety, security, privacy and the environment in the very low level (VLL), taking into account the mitigating effect of U-space services.*
>
> *The solution targets U-space airspace volumes in uncontrolled very low-level airspace where UAS operations supported by U-space services will take place.*
> *Integrated risk models for UAS in the U-space will provide benefits in terms of increased capacity and reduction in greenhouse gas emissions, with positive impact on safety and security.*

Then, the U-AGREE project aims to enhance risk models associated with UAS operations by integrating considerations of safety, security, privacy, and environmental impact. The project focuses on developing a framework that supports airspace risk assessments required by U-space regulations, while also enhancing the SORA methodology. By incorporating U-space services as risk mitigation mechanisms, U-AGREE aims to reduce the regulatory burden on operators and facilitate broader deployment of UAS operations.

This initial version of the OSED provides state-of-the-art details with regards of the existing risk assessment processes both for the authorisation of UAS operations (mainly, SORA), and for the definition of U-space airspaces in Europe (mainly, ARA - Airspace Risk Assessment). In addition, it details relevant operational scenarios where U-AGREE solution could be implemented. These scenarios are charactered by being realistic at short-term, and by having differences on the key hazards that should be taken on board as part of the enhanced risk assessment proposed by U-AGREE.

In summary, focusing on the operational scenarios' description, this initial OSED outlines:

- The operational environment applicable to U-AGREE, including airspace characteristics, traffic conditions, and infrastructure considerations.

- Representative scenarios for the implementation of the solution, highlighting potential risks and mitigation strategies.
- Hazards and risk considerations, addressing safety, security, privacy, and environmental factors that influence U-space operations.

Final OSED will also include:

- Generalization of the operational environment and concept applicable to U-AGREE, describing the key actors, their roles, and their interactions within the U-space framework.
- System requirements and performance criteria, defining the conditions necessary for the effective integration of the U-AGREE solution into U-space services.

This document serves as a reference for relevant stakeholders, including civil aviation authorities, common information service providers, ANSPs, and USSPs.

2.2 Scope

This document defines the OSED for the U-AGREE project within the SESAR 3 JU ER02 framework. The purpose of this first iteration is to establish a preliminary definition of the operational context, stakeholders, use cases, and technical enablers relevant to the early development stages of the U-AGREE solution.

As an early-stage OSED, this document provides an initial assessment of the operational, regulatory, and technical considerations associated with the deployment of U-space services for risk mitigation in UAS operations. It focuses on:

- The operational environment, including airspace classifications, traffic characteristics, and interaction with existing ATM systems.
- Key stakeholders and their roles within the U-space ecosystem, including regulatory authorities, ANSPs, USSPs, and UAS operators.
- Representative operational scenarios that reflect various U-space deployments, highlighting potential risks and mitigation strategies.
- Integration of U-space services and risk assessment models to enhance safety, security, privacy and environmental sustainability in UAS operations.
- Technical and regulatory enablers required for the deployment of the U-AGREE solution within different U-space environments.

2.3 Intended readership

This document is intended for a broad range of stakeholders involved in the development, implementation, and oversight of U-space operations and airspace risk assessment within the SESAR 3 JU ER02 framework. The key stakeholders addressed in this document are:

- **Regulatory Authorities (e.g., Civil Aviation Authorities, SESAR 3 JU, EASA, AESA)**: To assess the alignment of the U-AGREE solution with regulatory frameworks and its impact on U-space airspace designation and operations.
- **Air Navigation Service Providers (ANSPs):** To understand how the U-AGREE solution can help to quantify and mitigate the risk of UAS operations in controlled airspace.
- **Common Information Service Providers (CISPs)**: To understand the integration of risk models as part of authorisation processes within U-space airspaces, and the role of the centralized actors in this process. and U-space services into existing air traffic management structures.
- **U-space Service Providers (USSPs)**: To explore the application of the U-AGREE solution for enhancing safety, security, and compliance of U-space operations, and how U-space services provided by USSPs are mitigating the risks for UAS operations in U-space airspace.
- **UAS Operators and Industry Stakeholders**: To evaluate the potential impact of U-AGREE's risk assessment framework on operational efficiency and regulatory compliance, by facilitating the U-plans approval process and ensuring safety.
- **Research and Academic Institutions**: To contribute to the advancement of risk assessment methodologies and integration of artificial intelligence into U-space safety mechanisms.

2.4 Background

2.4.1 ARA - Airspace Risk Assessment

The European Commission Implementing Regulation (EU) 2021/664 mandates that an ARA must support the decision to designate any U-space airspace.

An ARA evaluates the risks related to UAS operations in a specific airspace, and outlines measures to mitigate those risks. 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 to reduce risks to an acceptable level.

A key driver of these assessments is the requirement to evaluate and mitigate safety risks such as the air and ground risks. However, considerations related to security, privacy, and environmental issues may also necessitate appropriate risk mitigation measures.

An ARA comprises three main phases: Preparation, Reference Scenario, and Assessment.

- **Preparation phase:** this phase defines the scope of the assessment, assembles the core and support teams, and gathers preliminary information, including regulations, which will serve as the basis for data collection in the Reference Scenario phase.
- **Reference Scenario phase:** this phase provides the context for the change to the functional system (in this case, the designation of U-space airspace) and it will later be used as a basis for assessing safety, security, privacy and environmental concerns. It aims to provide a comprehensive description of the airspace under study at the time of assessment. This includes how UAS operations are managed before the implementation of U-space airspace,

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the various sources of risk to be considered, the stakeholders affected by the change, and the applicable regulations.

- **Assessment phase:** this phase begins with the development of a Concept of Operations (ConOps) describing the proposed changes to the current airspace and how the planned U-space airspace would function. The Assessment phase then analyses the safety, security, privacy and environmental risks to flight, people, and infrastructure resulting from the change to the functional system described by the ConOps. The safety risk assessment will establish a safety argument related to the designation of the U-space airspace and its impact on current air operations. An initial set of safety criteria (acceptable level of safety) will be described. The output of the safety assessment during the ARA includes a set of safety requirements, such as airspace constraints, UAS capabilities and performance requirements, and U-space services performance requirements, after analysing both Air and Ground Risks.

2.4.2 SORA - Specific Operations Safety Assessment

The advent of UAS has represented a great challenge for aviation authorities, worldwide, because the number, type and characteristics of the operations with unmanned aircraft are commonly very different than in manned aviation. Therefore, although UAS operations should be as safe as those in manned aviation, they require proportionate risks mitigation according to the level of risk involved, the operational characteristics of the unmanned aircraft concerned and the characteristics of the area of operation. To cater with the different requirements linked to the different types of UAS operations, Commission Implementing Regulation (EU) 2019/947 established three categories of operations: the 'open', 'specific' and 'certified' categories.

Operations in the 'open' category are very limited in the risks posed for people on the ground and other airspace users, so they can be developed without any operational authorisation from the National Aviation Authority. On the contrary, operations in the 'certified' are so complex that they need to demonstrate the fulfilment of requirements related to the airworthiness, the organisations and the persons involved in the operation of UAS, similarly to how these requirements are demonstrated in manned aviation.

Most UAS operations fall in the 'specific' category, which requires an operational authorisation issued by the competent authority to be performed, based on the acceptance of the adequate mitigation of the risks of the operation. To develop the necessary operational risk assessment, European Union Aviation Safety Agency (EASA) considers as an acceptable means of compliance the SORA methodology, developed by Joint Authorities for Rulemaking on Unmanned Systems (JARUS).

SORA is a risk assessment methodology to establish a sufficient level of confidence that a specific operation can be conducted safely. It allows the evaluation of the intended concept of operation and a categorization into 6 different Specific Assurance and Integrity Levels (SAIL), recommending operational safety objectives to be met for each SAIL.

The SORA methodology is a ten steps process, summarised in Figure 1. This process provides a systematic guidance to evaluate the risks related to a given operation and then provides proportionate requirements that an operation should meet to ensure a Target Level of Safety (TLS) is met.

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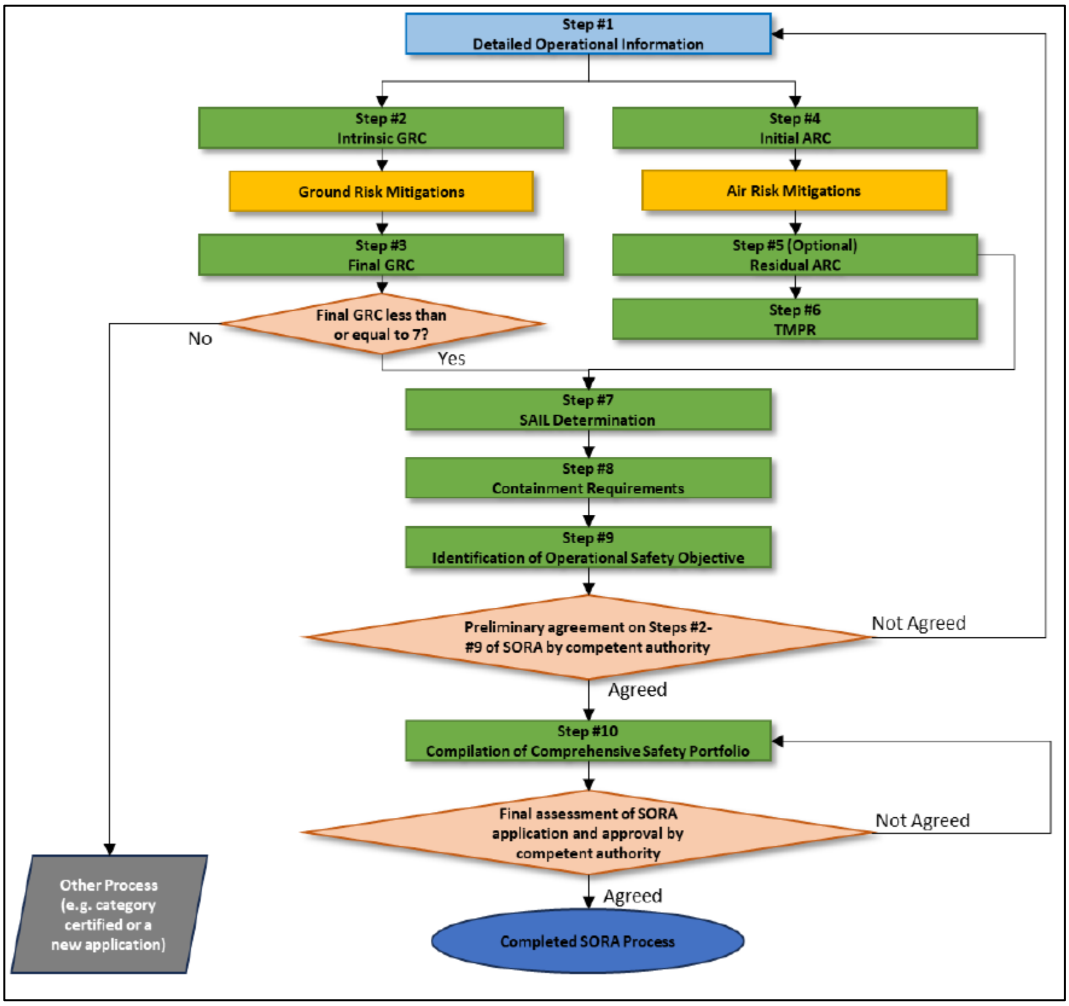

Figure 1. SORA process

SORA addresses individual operations conducted according to a ConOps defined by the UAS operator and addresses the risk of a collision on the ground due to a loss of control (ground risk) and the risk of an UAS colliding in the air with a manned aircraft (air risk). For a given operation, SORA applies a ground and an air risk model (detailed in annexes F and G to SORA, respectively) to determine intrinsic (unmitigated) ground risk classes (GRC) and initial air risk classes (ARC) and apply mitigation measures to get residual air and ground risk classes, which are then combined in a SAIL. Afterwards, UAS operators must go through 17 operational safety objectives (OSOs)2 demonstrating to show compliance with the required level of robustness depending on the SAIL. SORA was also applied by EASA to develop Standard scenarios (STS) and Pre-defined Risk Assessment (PDRA). In this context, mitigations used in STSs and PDRAs are considered as "operational limitations or conditions".

[2] Originally, in SORA V2.0 there were 24 OSOs identified, but 7 of them have been disregarded in SORA V2.5.

The main limitations of the SORA methodology are:

- The ground risk model described by SORA considers loss of control events as the only hazard with harmful effects on the ground. Moreover, SORA also considers fatalities on the ground as the only harmful effect on the ground of a loss of control, with an associated TLS of 10^{-6} fatalities per flight-hour (FAT/F-H).

- The air risk model only addresses the hazard posed by UAS to manned aircraft and considers mid-air collisions (MACs) as the harmful effect of this hazard. The model considers that any collision between any UAS and a manned aircraft will provoke the latter to fall to the ground with lethal consequences for all people on board. The associated TLSs are 10^{-7} MAC/F-H in uncontrolled airspace and 10^{-9} MAC/F-H in controlled airspace.

- The assessment of the collision risk is rather qualitative, and the proposed Tactical Mitigation Performance Requirements (TMPR) figures cannot be traced back to the required TLS. On top of that, the description of strategic mitigations is quite shallow, whereas tactical mitigations do not account for U-space to mitigate risk (SORA's tactical mitigations consist of a seamless process of remaining well clear plus collision avoidance aimed at keeping aircraft away from hazards by the near mid-air collision distance).

2.4.3 Future improvements

SORA and ARA need to be coordinated as the European Commission Implementing Regulation EU 2019/947 and EU 2019/945 apply within the designated U-space airspace.

The following section outlines the ongoing coordination between SORA and ARA in their future developments, addressing both air and ground risk considerations.

Air Risk

- Alignment in defining the different precursors to the accident (MAC) within U-space airspace considering both UAS vs Manned conflicts and UAS vs UAS conflicts
- Alignment in quantifying volume-based events (e.g., distance to the accident, time to collision and conditional probabilities), with special focus on Type 1 and Type 2 encounters as well as future Type 0 encounters (UAS-UAS). This includes establishing different target levels of safety for various encounter types
- Consideration and alignment on the severity of MAC and the potential harmful effect to people both on board and on ground
- Differentiation in Scope (reference by which air risk events and metrics are defined):
    - SORA evaluates the risk for an individual flight with respect to the airspace it is operating in
    - ARA assesses the risk for all flights within the airspace they operate in
- Strategic and tactical mitigations outlined in SORA are also aligned into the ARA method as possible mitigations for flights in the Specific Category.

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Ground Risk

When two UAS collide in the air, both aircraft are expected to fall to the ground, potentially causing harm to people. The models described in Annex F of SORA version 2.5 (developed by JARUS) serve as the primary reference for assessing third-party ground risk in ARA.

However, for ground risk, as well as for air risk, SORA approach/scope is different:

- SORA assesses ground risk for an individual flight, considering the population density as the one in the area during the moment an operation is conducted. The critical area is the one calculated for a specific UAS in the conditions that it is expected to operate
- ARA evaluates ground risk for all flights within the airspace they operate in, requiring population density and critical area assessments at a macro level. This may involve defining these parameters based on:
    - Worst case scenario (e.g., large UAS operating in the most populated area), or,
    - An average scenario (e.g., average values for population density and critical area and defining the expected demand using use cases)
- In order to obtain the TLS for third party ground fatalities due to UAS-UAS collisions as part of the ARA safety risk assessment, it would be recommended to align with the SORA 2.5 Annex F and consider the target level of safety for third party ground risk and apply an apportionment factor for fatalities due to UAS-UAS MAC.

Finally, coordination is required between **SORA operational volumes** and **U-space airspace 4D volumes**, including deviation thresholds, to ensure UAS flight authorisations align with the operational authorisations granted for Specific Category operations within U-space airspace.

2.5 Structure of the document

This document follows the **OSED template**, ensuring a structured approach to defining the operational and technical characteristics of the U-AGREE solution within the SESAR 3 JU ER02 framework. It provides a detailed description of the applicable operating environment, key stakeholders, relevant use cases, and critical assumptions that shape the solution's development and validation.

The document is organized into the following main sections:

- **Introduction**: Provides the purpose, scope, intended readership, background, and structure of the document.
- **Operational Service and Environment Definition (OSED)**:
    - Defines the SESAR solution and its role within the U-space ecosystem.
    - Describes the operational environment, including airspace classification, traffic characteristics, and integration with existing ATM systems.
    - Identifies key stakeholders, including regulatory bodies, ANSPs, USSPs, UAS operators, and other relevant aviation and security entities, detailing their roles and responsibilities in ensuring safe, efficient, and compliant operations.

- Presents representative scenarios, outlining different U-space environments where the solution will be validated and tested.
- Discusses risk and hazard considerations, addressing safety, security, privacy, and environmental challenges that the SESAR solution aims to mitigate.
- Specifies technical enablers, such as Communication, Navigation and Surveillance (CNS)/ATM infrastructure and U-space services, required to support the implementation of the proposed solution.
- Highlights expected benefits, including operational efficiency, enhanced safety, and regulatory compliance improvements.

- **Key Assumptions**: Lists the foundational assumptions necessary for the proposed solution, pending further validation at higher TRL levels.
- **References**: Includes applicable and reference documents that support the development and validation of the U-AGREE solution.

This structured approach ensures that all relevant aspects of the U-AGREE solution are comprehensively covered, facilitating alignment with SESAR objectives and supporting its progressive maturation through TRL advancements.

2.6 Glossary of terms

Term	Definition	Source of the definition
Airspace Risk Assessment	Evaluation of operational, safety and security risks that takes into account the required levels of safety performance as defined in the European Plan for Aviation Safety and the State Safety Program referred to in Articles 6 and 7 of Regulation (EU) 2018/1139, the type, complexity and density of the traffic, the location, altitudes or heights and the airspace classification	COMMISSION IMPLEMENTING REGULATION (EU) 2021/664
Visual Line of Sight (VLOS)	Type of UAS operation in which, the remote pilot is able to maintain continuous unaided visual contact with the unmanned aircraft, allowing the remote pilot to control the flight path of the unmanned aircraft in relation to other aircraft, people and obstacles for the purpose of avoiding collisions	EASA
Beyond Visual Line of Sight (BVLOS)	Type of UAS operation which is not conducted in VLOS	EASA

Extended Visual Line of Sight (EVLOS)	A UAS operation whereby the remote pilot maintains uninterrupted situational awareness of the airspace in which the UAS operation is being conducted via visual airspace surveillance through one or more human Visual Observers (VOs), possibly aided by technological means. The remote pilot has direct control of the UAS at all times.	EASA
Common Information Service Provider (CISP)	Actor that provides USSPs with the necessary information.	ENAIRE
Specific Operations Risk Assessment (SORA)	Methodology for the classification of the risk posed by a drone flight in the specific category of operations and for the identification of mitigations and of the safety objectives.	EASA
U-SPACE	Set of new services and specific procedures designed to support safe, efficient and secure access to airspace for large numbers of drones. These services rely on a high level of digitalization and automation of functions, whether they are on board the drone itself, or are part of the ground-based environment.	Blueprint

Table 1: Glossary of terms

2.7 List of acronyms

Term	Definition
ADS-B	Automatic Dependent Surveillance–Broadcast
AGL	Above Ground Level
AMC	Acceptable Means of Compliance
AMSL	Above Mean Sea Level
ANSP	Air Navigation Service Provider
ARA	Airspace Risk Assessment
ARC	Air Risk Class
ATC	Air Traffic Control

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ATM	Air Traffic Management
ATSU	Air Traffic Services Unit
ATZ	Aerodrome Traffic Zone
BVLOS	Beyond Visual Line of Sight
CISP	Common Information Service Provider
CNS	Communication, Navigation and Surveillance
ConOps	Concept of Operations
CTR	Control Zone
DAR	Dynamic Airspace Reconfiguration
DJI Aeroscope	Drone Detection System
DOP	Dilution of Precision
EASA	European Union Aviation Safety Agency
EBHN	Hoevenen Airfield
EBAW	Antwerp International Airport
EU	European Union
EVLOS	Extended Visual Line of Sight
FATO	Final Approach and Take-Off Area
FAT/FH	Fatalities per Flight Hour
FCFS	First Come, First Served
FLARM	Flight Alarm (Collision Avoidance System for General Aviation)
FL195	Flight Level 195 (19,500 ft)
FMCI	Future Mobility Campus Ireland
GA	General Aviation
GCS	Ground Control Station
GIS	Geographic Information System
GRC	Ground Risk Class

GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HEMS	Helicopter Emergency Medical Services
IAM	Innovative Air Mobility
ICD	Interface Control Document
INECO	Ingeniería y Economía del Transporte S.A.
IR	Implementing Regulation
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
JU	Joint Undertaking
KOM	Kick-Off Meeting
LPWAN	Low-Power Wide-Area Network
MAC	Mid-Air Collision
MTOM	Maximum Take-Off Mass
NRI	Network Remote Identification
OSED	Operational Service and Environment Definition
OSO	Operational Safety Objective
PDRA	Pre-defined Risk Assessment
SAC	Special Area of Conservation
SAIL	Specific Assurance and Integrity Level
SAR	Search and Rescue
SESAR	Single European Sky ATM Research
SID	Standard Instrument Departure
SORA	Specific Operations Risk Assessment
SRIA	Strategic Research and Innovation Agenda
STAR	Standard Terminal Arrival Route
STS	Standard Scenario

TRL	Technology Readiness Level
TLS	Target Level of Safety
TMPR	Tactical Mitigation Performance Requirements
U-AGREE	U-space Air and Ground Risk modEls Enhancement
U-space	Unmanned Traffic Management system for very low-level airspace
UAM	Urban Air Mobility
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
USSP	U-space Service Provider
UTM	UAS Traffic Management
VCA	Vertiport-Corridor-Airport
VFR	Visual Flight Rules
VLL	Very Low Level
VLOS	Visual Line of Sight
VO	Visual Observer
VTOL	Vertical Take Off and Landig

Table 2: List of acronyms

3 Operational service and environment definition (OSED)

3.1 SESAR Solution 0520 – Integrated risk models for Unmanned Aerial Systems (UAS) in the U-space: a summary

Risk models are essential for ensuring aviation safety, as they link potential hazards faced by aircraft to their quantifiable negative impacts. This connection allows for evaluating whether these risks are acceptable by establishing a threshold, usually called TLS, which represents what society consider is 'acceptably safe'.

As UAS operations continue to expand, there is an urgent need to develop new risk models to evaluate the potential hazards associated with these activities. The EASA has adopted the SORA developed by the JARUS, with some minor modifications. However, the SORA risk models basically consider the risk of individual operations. Therefore, some improvements are necessary so they can support ARA process for the designation of U-space airspaces.

In order to identify the specific needs that the EASA might have in that regard, the U-AGREE consortium conducted two synchronization activities with the Agency, before and during the stakeholders meeting held on 30th January 2025. As a result of such activities, the following needs were identified:

- The EASA would have a quantitative threshold to identify the need of designating a U-space airspace for the sake of the safety or air operations. This kind of U-space airspaces pursue the mitigation of the risk posed by MAC between UAS or between UAS and manned aircraft. The SORA ground and air risk models can be used to estimate the probability and severity of a MAC. However, since that model is operation-oriented, is not enough to estimate the risk on the ground due to regular UAS operations in a particular airspace. For that purpose, the probability of a MAC between UAS and UAS and manned aircraft is also needed. Whereas collision risk models for encounters UAS-manned aircraft are defined in SORA Annex G, there is no collision risk model for UAS-UAS encounters. Though JARUS will address that collision risk model in upcoming editions of Annex G, that work is in a rather preliminary stage. Therefore, U-AGREE will build on the collision risk developed by the BUBBLES project (an extension of the Endoh's gas model) and will synchronize with JARUS to keep the final project's collision risk model aligned with JARUS' one.

- Furthermore, in order to define a threshold in terms of acceptable risk, a measure of what is deemed 'acceptable' is needed. SORA ground risk model uses a TLS of 10^{-6} fatalities per flight hour (FAT/FH) due to UAS loss of control leading to a crash into the ground. There is no agreed TLS for the effects of MACs involving just UAS, but from the discussions held with. JARUS during the stakeholders' workshop it seems that MAC effects are expected to be one order of magnitude less severe than the effects of direct impacts due to loss of control events. Therefore, a TLS of 10^{-7} FAT/FH will be assumed as a baseline figure by U-AGREE to determine the threshold requested by the EASA.

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- Moreover, the EASA expressed their concern with regards to the attempt of developing quantitative estimations of the effects of U-space services failures on the safety of air operations in a U-space airspace. However, since U-AGREE will focus on the performance of U-space services as mitigation barriers in normal and abnormal conditions (i.e., success approach to the Safety Assessment), such concern does not affect the project.

- An additional point of interest put up by the EASA consists of a more accurate characterization of the sheltering effect of building for UAS heavier than 25 kg Maximum-Take-off Mass (MTOM). The current model of SORA 2.5 considers sheltering applicable only for UAS up to 25kg of MTOM without requiring any evidence of sheltering effectiveness to the applicant. Instead, above this threshold, applicants are required to analytically prove that sheltering is effective given the actual MTOM of the UAS. The project should therefore investigate if a higher MTOM threshold can be used to automatically accept sheltering as a ground risk mitigation.

The solution U-AGREE aims to develop will integrate risk models linking the UAS operations, the hazards they are exposed to and their effects in terms of severity and probability. These risk models will be developed and validated by means of simulations (TRL2). The models will link the operations of UAS with their multidimensional harmful effects on safety, security, privacy, and environment in the VLL.

Figure 2. SESAR Solution 0520 - Integrated risk models for UAS in the U-space (U-AGREE)

Based on those models, the project will **assess** how U-space services, along with specific capabilities or performance levels of the UAS, could mitigate such effects. Additionally, the risk models will support the airspace risk assessment required by European regulation and they will lead to swifter specific category operation approval processes.

There are several key steps to follow in the development of risk models. The **first step** is to define representative scenarios in which UAS operations could occur in the short to mid-term and to identify the hazards associated with these operations. Input from stakeholders is essential for identifying these scenarios. During the stakeholders' workshop U-AGREE team steered the discussion on six candidate scenarios. Each of them was assessed in terms of relevance and representativeness based on the expected missions and expected hazards. As a result of the workshop, four of them (detailed later in this document) were prioritised. Those scenarios present a variety of hazards whose potentially negative effects (not only in terms of safety) have been tackled on a qualitative basis through the provision of U2 U-space services (those set out in regulation IR (EU) 664/2021) and by means of the definition of UAS geographical zones as per Art. 15 of IR (EU)947/2019. U-AGREE will first build on those results by assessing the quantitative mitigation effect of those barriers on the effects of the hazards identified in the selected scenarios. Next, the project will assess (also quantitatively) the contribution of U3 U-space services to the mitigation of those effects and their impact on the capacity of the scenarios considered by U-AGREE. Some preliminary outcomes that can be drawn from the break down sessions of the workshop are:

- Depending on the set of hazards, a **taxonomy of U-space airspaces** can be done, identifying how U-space services will mitigate the identified risk in each element of the taxonomy.

- U-AGREE solution as a mechanism to verify the **compliance of SORA risk-related assumptions** that were done when submitting and getting the SORA approval. As an example, UAS operators describe the weather conditions under which they are expecting to operate (that are aligned with the weather-related limitations defined by UAS manufacturers), however they don't have proper mechanisms to verify before in the day of operations that weather conditions are as expected. The quantification of the risk considering forecast weather conditions (and in particular wind) could be part of the U-AGREE scope. SORA has a wide scope, and not all aspects could be verified. Need to determine which ones are those SORA assumptions that will be verified by U-space (and at what price).

- U-AGREE solution as a method **to quantitatively assess the U-space services contribution to reduce the ARC** to ARC-B according to SORA 2.5.

- Check consistency of TMPR. For BVLOS flights taking place with a residual ARC-b or higher, SORA requires to implement Tactical Mitigations with a given level of performance. According to the Acceptable Means of Compliance (AMC) to Regulation 664/2021, wherever U-space will be implemented the residual ARC will be set to ARC-b thus imposing the implementation of specific tactical mitigations. The U-AGREE project should investigate if **(a)** the current requirements included in SORA for Tactical Mitigations at ARC-b are fulfilled by existing U-space services (e.g. Traffic Information to fulfil the requirement of detecting at least 50% of the manned aircraft in the volume) or **(b)** there are gaps to be filled by new services (e.g. tactical deconfliction) or **(c)** there SORA TMPR requirements need to be changed/adapted for U-space airspaces.

- **Noise and impact on wildlife as part of the risk assessment** (although no consensus was reached on this topic). Regarding these elements, U-AGREE will need to consider the superposition of the effect of multiple UAS generating noise, and not only the noise related to each UAS isolated.

Once scenarios are selected, the **next step** is to identify the hazards that may arise within them and determine which of these hazards could be mitigated through the provision and use of U-space. Bearing in mind these hazards, risk models will be developed to quantify the unmitigated risk associated with each one. Subsequently, a mathematical model will be created to illustrate how U-space services might mitigate the risks linked to these hazards. Lastly, the risk models will be integrated into a U-space simulator to calculate the collision rates, both unmitigated and mitigated.

SESAR solution ID	SESAR solution title	SESAR solution definition	Justification
0520	Integrated risk models for Unmanned Aerial Systems (UAS) in the U-space	Integrated risk models for Unmanned Aerial Systems (UAS) in the U-space are an extension of the Specific Operations Safety Assessment (SORA) model, which allow to more accurately link UAS operations with their multidimensional harmful effects on safety, security, privacy and the environment in the VLL, taking into account the mitigating effect of U-space services. The solution targets U-space airspace volumes in uncontrolled very low-level airspace where UAS operations supported by U-space services will take place. Integrated risk models for Unmanned Aerial Systems (UAS) in the U-space will provide benefits in terms of increased capacity and reduction in greenhouse gas emissions, with positive impact on safety and security.	The U-AGREE solution is crucial for ensuring the safe and efficient integration of U-space with the Air Traffic Management (ATM) system, a challenge identified in the Digital European Sky Strategic Research and Innovation Agenda (SRIA). This solution assesses the impact of U-space services and determines whether these services can enable safe and efficient operations of unmanned aircraft without adversely affecting the operations of other airspace users [SRIA 3.4]. U-AGREE aligns with the European Green Deal by contributing to the reduction of greenhouse gas emissions through increased operational efficiency. Additionally, U-AGREE aligns with the innovative research initiatives of SESAR 3 JU by improving risk modelling in U-space. It aims to develop more accurate air-risk and ground-risk models while considering various scenarios and variables.

Table 3: SESAR Solution 0520 - Integrated risk models for UAS in the U-space: scope

3.1.1 Deviations with respect to the SESAR solution definition

No deviations have been identified at this point from existing SESAR solutions.

3.2 Detailed operational environment

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3.2.1 Operational characteristics

The objective of this section is to identify and describe a **minimum set of representative scenarios** (e.g., en-route flights over urban populated areas or flights along power lines in the countryside, operations in vertiports with more than one final approach and take off area – FATO –, in the vicinity or an airport, etc.) where UAS operations could take place in the short-to-mid terms, and then, identify the hazards due to such operations.

U-AGREE identified in the Grant three initial scenarios representative of U-space deployments. In addition, a 4th scenario was identified during the U-AGREE kick of meeting (KOM):

1. Densely populated area in controlled airspace including at least one vertiport with more than one FATO (representative of large cities).

2. Medium density populated area in uncontrolled airspace (representative of medium-size cities).

3. Sparsely populated area in uncontrolled airspace but with recurrent Visual Flight Rules (VFR) flights (representative of rural areas where UAS and General Aviation (GA) aircraft are used for agricultural activities or inspection of power lines or telecommunication facilities, in the vicinity of protected natural spaces).

4. U-space airspace that includes corridors facilitating Urban Air Mobility (UAM) operations between two remote locations.

U-AGREE has performed a **holistic approach to classify the most representative scenarios**, putting the emphasis on their feasibility in the short-to-mid terms, and also in differences that they may present with regards to the associated hazards and how they can be solved by means of the provision of U-space services to mitigate effects on people, infrastructures, or the environment. It is important to highlight that U-AGREE will not only consider hazards with safety implications but also potential negative effects of UAS operations on security, privacy, and the environment, as outlined in the guidelines for conducting the ARA before designating any airspace as U-space airspace.

U-AGREE will research on scenarios that are being considered by other U-space on-going projects and classify them according to an initial set of **potential influence factors** over the hazards that could exist in a U-space airspace. Good examples of these factors influencing the risk are the expected demand, type of drone missions, population density, obstacles and buildings, presence of critical infrastructures sensitive to direct ground impacts of UAS, or environmentally sensitive areas, among others.

The **U-space projects that are identified** as source of information for the representative scenarios are:

- **DACUS and BUBBLES**, already finished SESAR exploratory research projects that conducted risk assessment in complex urban environments. Then, there could be some similarities with the use case 1 initially proposed by U-AGREE.
- **U-ELCOME**, and in particular the U-space airspace of Benidorm where the ARA is being performed. This is also an urban environment such as the one proposed by U-AGREE use case 1.
- **BURDI**, and in particular the U-space airspace around the port of Antwerp, similar to the use case 2 proposed by U-AGREE.

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- **ÉALÚ-AER**, and in particular the U-space airspace around the international airport of Shannon, Ireland. This scenario aligns with case 2, as it involves low-density peri-urban and rural areas within Class-C controlled airspace.
- **OPERA and EUREKA** are considering representative scenarios with corridors among distant cities. These could be good representative scenarios for U-AGREE use case 4.

Once having an initial set of scenarios and related influence factors, U-AGREE will present the **results to relevant stakeholders** (such as civil aviation authorities, aviation safety agencies and common information service providers) for the final selection of the most representative ones.

Finally, U-AGREE will develop **complete scenario descriptions** applying a simplified version of the approach set out in the ARA guidelines

In order to perform a comprehensive analysis of the representative operational scenarios identified in U-AGREE, it is essential to consider a set of influence factors that may impact safety, security, privacy, and the environment within a U-space airspace. These factors provide a framework for assessing risks associated with UAS operations in different environments and circumstances. Key aspects include operational environment characteristics such as air traffic density, CNS capabilities, population density, and coexistence with manned aviation, among others. The table below outlines the most relevant influence factors, categorized and described in terms of their potential impact on risk management within U-space airspace operations.

N	Influence factor on safety, security, privacy or environment	Description	Categories/Scale
1	Types of UAS allowed to operate	Classification of permitted UAS in the area based on size, weight, and operational capability.	- Micro (≤ 250g). - Small (250g - 2kg). - Medium (2kg - 25kg). - Large (> 25kg).
2	Variability of UAS Types	Measures the diversity of UAS capabilities and its impact on traffic management.	- Low Variability: Simplifies management. - Medium Variability: Occasional adjustments needed. - High Variability: Requires complex strategies for overtaking and trajectory adjustments.
3	CNS capabilities in the area according to USSP	Support infrastructure available for UAS in terms of communication, navigation, and surveillance.	- 5G. - GPS. - GNSS. - Others, e.g., radar systems, as per aeronautical and environmental needs outlined in the ARA framework.
4	Population Density	Level of concentration of people in the operational area.	- Low: Sparse population, posing lower risk of harm in case of incidents. - Medium: Moderate population, requires some risk mitigation measures. - High: High population density, necessitating

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N	Influence factor on safety, security, privacy or environment	Description	Categories/Scale
			stringent safety protocols and possibly limiting UAS operations.
5	Air Traffic Density for UAS	Level of concentration of UAS in specific areas	- Low: Minimal UAS activity in the area, making management simpler. - Medium: Moderate number of UAS operations, requiring standard traffic management procedures. - High: High frequency of UAS operations, necessitating advanced management strategies to prevent conflicts.
6	Type of Environment	Classification of the area based on urbanization and land use.	- Residential: Predominantly housing and local services. - Agriculture: Mainly agricultural land with minimal infrastructure. - Industrial: Factory and manufacturing zones with high infrastructure density. - Office: Areas focused on business and administrative buildings. - Retail: Shopping areas, with increased human traffic. - Public Services: Areas dedicated to services like healthcare, education, or government facilities.
7	Sheltering Factor	Measures the level of protection provided by the environment to reduce exposure to risk. High sheltering indicates areas with substantial protective structures (e.g., solid buildings), while low sheltering indicates open spaces with minimal protection.	- High: The environment contains dense and solid structures, such as robust buildings or roofs, offering significant protection for both people and drones, greatly reducing the likelihood of direct impact in the area. - Medium: The environment provides some level of protection, such as partial roofs, trees, or smaller structures, which moderately reduce the risk but do not provide full coverage. - Low: The area is almost entirely exposed, with no significant barriers to limit the risk of impact, such as open fields, public squares, or wide streets with no nearby constructions.
8	Coexistence or Probability of Coexistence with Manned Aviation	Indicates the potential for interaction or conflict with manned aircraft, such as paragliders, gliders, or other light aircraft.	- Low Probability: Minimal chance of interaction, typically due to controlled airspace segregation. - Medium Probability: Occasional overlap in airspace usage, requiring situational awareness and coordination. - High Probability: Frequent overlap with

N	Influence factor on safety, security, privacy or environment	Description	Categories/Scale
			manned aviation, demanding active deconfliction measures and coordination protocols.
9	Presence of Critical or Restricted Areas	Identification of sensitive infrastructure that may require additional security measures.	- Hospitals: Health facilities where UAS operation might pose risks or disrupt sensitive environments. - Airports: High-risk areas requiring strict separation of UAS operations. - Data Centers: Critical infrastructure with increased security protocols. - Energy Infrastructure: Facilities essential for power distribution, often protected by regulations. - Prohibited Zones: Areas where UAS operation is legally restricted. - Restricted Zones: Limited access zones, typically requiring authorization. - Danger Zones: Areas with inherent risks to UAS operation, requiring specific operational adjustments. - Controlled/Uncontrolled Airspace: Areas with distinct air traffic management procedures.
10	Airspace Type	Defines the level of regulation and control in the area of operation.	- Controlled: Managed by air traffic authorities, where UAS operations require authorization. - Uncontrolled: Less regulated, but UAS must adhere to standard operating guidelines to avoid conflicts.
11	Weather Conditions	Climatic factors that may affect UAS operations.	- Stable Weather: Low fluctuation in weather, favourable for continuous UAS operation. - Variable Weather: Moderate fluctuations in climate requiring periodic monitoring. - High Incidence of Wind/Rain/Fog: Frequent adverse conditions necessitating adaptive measures or operational adjustments.
12	Type of Mission Permitted	Level of automation authorized for UAS operations in the area.	- VLOS (Visual Line of Sight): Operator must maintain visual contact with the UAS. - BVLOS (Beyond Visual Line of Sight): UAS operates beyond direct visual range, requiring advanced navigation and communication capabilities. - EVLOS (Extended Visual Line of Sight): Extended line-of-sight operations, allowing

N	Influence factor on safety, security, privacy or environment	Description	Categories/Scale
			for more range than VLOS but not as extensive as BVLOS.
13	Presence of Natural or Artificial Obstacles	Elements in the area that may pose a risk to operations.	- Rugged Terrain: Natural obstacles such as mountains or hills. - Tall Buildings: High-rise structures that may interfere with UAS navigation. - Power Towers: Utility infrastructure that poses a collision risk. - Temporary Obstacles: Construction cranes or other temporary structures that can affect flight paths.
14	Operational Priority	Indicates differences in the level of priority and planning of UAS operations, affecting their ability to be restructured and the associated risk level.	- Urgent: Critical operations with high priority, such as emergencies or rescue missions, with limited flexibility for restructuring. - High Priority: Important operations with time constraints, like medical deliveries, with some adjustment capacity. - Planned: Pre-scheduled operations, such as infrastructure inspections, which can be rescheduled or diverted with minimal impact.
15	Operational Diversity	Evaluates the variety of types of UAS operations in an area and how it affects management and prioritization, including strategies like "First Comes, First Served" (FCFS).	- Low Diversity: Predominantly operations of the same type (e.g., all urgent or high priority), which can complicate effective prioritization. - Medium Diversity: Balanced mix of urgent, planned, and low-priority operations, allowing for more flexible and effective management. - High Diversity: Wide variety of operations with different urgency and planning levels, allowing FCFS strategies to optimize management.
16	Flexibility of Flight Plan	Assesses whether the UAS operation’s flight plan is fixed for the entire mission duration or has undefined segments requiring dynamic adjustments based on environmental conditions or operational objectives.	- Fixed Plan: The flight plan is fully defined from the start, with set routes and times that do not require adjustments. - Semi-Flexible Plan: The flight plan is mostly fixed, but some segments allow minor adjustments based on conditions (e.g., slight changes in priority). - Flexible/Undefined Plan: The flight plan has segments with undefined duration or trajectory, dependent on external factors (e.g., inspections with variable duration),

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N	Influence factor on safety, security, privacy or environment	Description	Categories/Scale
			requiring real-time adjustments and replanning as per operational needs.
17	Transport of Goods or Non-Fixed Elements	Evaluates whether the UAS operation involves the transport of cargo or elements with properties that may affect stability, manoeuvrability, or flight safety due to their non-fixed or variable nature.	- No Cargo or Fixed Elements: No cargo is transported, or items are securely fixed and do not affect manoeuvrability. - Fixed/Moderately Variable Cargo: Fixed cargo is transported, with possible minor variations (e.g., liquids in fixed tanks). - Variable Cargo/Non-Fixed Elements: Non-fixed elements or cargo with variable properties are transported (e.g., items that may shift within the load, packages, food), requiring continuous manoeuvrability adjustments and increasing operational risk.

Table 4: Influence Factors – U-AGREE

3.2.2 Representative scenarios

The representative scenarios identified in U-AGREE were selected to encompass a diverse range of operational conditions, ensuring comprehensive coverage of potential U-space environments. These scenarios reflect different levels of airspace complexity, operational challenges, and safety considerations.

Each scenario was analysed based on the factors described on Section 3.2.1 and was formulated with inputs from project partners and refined through stakeholder workshops. The aim was to establish a framework that not only represents current operational realities but also anticipates future developments in U-space deployment.

3.2.2.1 Scenario Selection Methodology

The methodology followed for the selection of representative scenarios in U-AGREE was based on a collaborative approach involving the project partners and key stakeholders. The process was designed to ensure that the selected scenarios are both representative of real-world U-space deployments and aligned with the operational and safety considerations relevant to the project.

To begin with, all participating partners in the U-AGREE project were requested to provide detailed descriptions of the scenarios they deemed relevant for analysis. These descriptions included an overview of the operational environment along with the key characteristics listed in the table developed in the previous section. The descriptions were expected to cover various aspects such as air traffic density, CNS capabilities, population density, coexistence with manned aviation, and presence of critical or restricted areas, among other features. Additionally, partners were asked to identify the main hazards associated with their proposed scenarios and their potential impact on operations within a U-space airspace.

The initial set of scenarios defined for evaluation was:

- Urban U-space operations in uncontrolled airspace.
- U-space BVLOS operations in low-density peri-urban and rural areas within Class-C.
- Dynamic U-space operations for infrastructure inspection.
- Medical transport operations from suburban to urban areas.
- U-space corridors for Vertical Take-off and Landing (VTOL) capable aircraft (VCA) traffic.
- U-space corridors exclusively for controlled and urban environments.

Once all the scenario proposals were collected, a dedicated workshop was organized with relevant stakeholders, including representatives from air navigation service providers, aviation regulatory bodies, aerospace research institutions, urban air mobility experts, and civil aviation authorities from different countries. The objective of this workshop was to refine the selection process by incorporating expert insights and ensuring that the chosen scenarios align with both regulatory and operational priorities.

The workshop was structured into three breakout sessions, each focusing on specific aspects of the scenarios. Participants were provided with supporting materials, including scenario presentations, whiteboards, markers, and post-it notes for face-to-face sessions, while an online session utilized the Miro board platform. The discussions in these sessions aimed to:

- Assess the completeness of the proposed scenarios, ensuring no critical elements were omitted.
- Evaluate the representativeness of the scenarios in real-world U-space operations and suggest necessary adjustments.
- Identify hazards that were overlooked or not adequately addressed.
- Highlight any additional relevant operational issues within the scenarios.

During the workshop, stakeholders were given the opportunity to review the proposed scenarios and provide their expert opinions on their relevance and representativeness. They were encouraged to highlight key aspects they considered crucial for U-AGREE, as well as to raise any concerns or suggest modifications to the proposed scenarios. The interactive format of the workshop allowed for a dynamic exchange of ideas, where participants could ask questions, challenge assumptions, and identify the strengths and weaknesses of each scenario.

Through this participatory process, a consensus was reached on which scenarios were most representative of the expected U-space operational environments. The selected scenarios were those that best captured the diversity of challenges and operational conditions that U-AGREE seeks to address. The feedback gathered during the workshop was instrumental in finalizing the following set of representative scenarios, described in section 3.2.2:

- Urban U-space operations in uncontrolled airspace [Section 3.2.2.2.1], associated with case 1.
- U-space BVLOS operations in low-density peri-urban and rural areas within Class-C [Section 3.2.2.2.2], associated with case 2.
- Dynamic U-space operations for infrastructure inspection [Section 3.2.2.2.3], associated with case 2.
- Medical transport operations from suburban to urban areas [Section 3.2.2.2.4], associated with case 1.

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By employing this methodology, U-AGREE ensured that the scenario selection was not only based on theoretical assumptions but also validated by industry experts and stakeholders with real-world operational experience. This approach strengthens the credibility of the selected scenarios and enhances their applicability in assessing the risks and benefits of U-space deployments in different environments.

3.2.2.2 Scenario Descriptions and Risk Mitigation

3.2.2.2.1 Urban U-space operations in uncontrolled airspace

This scenario explores the establishment of a U-space airspace in Benidorm, aimed at providing a safe and efficient operational environment for multiple simultaneous UAS operations. The Benidorm U-space is one of the goals of the project U-elcome, a 3-year project, launched in 2022 and coordinated by the **EUROCONTROL Innovation Hub** that involves 51 European partners. Given Benidorm's status as a high-density touristic city with numerous hotels, rental apartments, and second residences, it presents unique challenges in air risk and ground risk management, particularly within an uncontrolled airspace (Class G).

Figure 3. Aerial view of Benidorm - Urban U-space operations in uncontrolled airspace scenario

The implementation of U-space services in this environment is intended to facilitate drone operations in areas where they were previously limited due to safety and regulatory constraints. The designated U-space airspace encompasses the urban area of Benidorm, extending slightly into the surrounding periurban, unpopulated, and coastal areas. This creates a complex airspace environment, where extreme population density in certain areas transitions to unpopulated zones along the shore.

As illustrated in the diagram below, Figure 4, the entire U-space area is set at a common altitude of 275m Above Mean Sea Level (AMSL), ensuring a minimum 150m Above Ground Level (AGL) volume for safe drone operations across all designated zones.

Figure 4. Geographical delimitation of the Benidorm U-space area - Urban U-space operations in uncontrolled airspace scenario

3.2.2.2.1.1 Operational Characteristics

This U-space airspace is designed to accommodate a wide range of **UAS operations**, including:

- **Beyond Visual Line of Sight (BVLOS) missions** for long-range drone operations.
- **Multiple simultaneous Visual Line of Sight (VLOS) operations**.
- **Autonomous flights with varying levels of automation**, including operations under **non-certified categories**.

While the airspace is classified as Class G (uncontrolled), there are instances where manned aviation may enter the designated U-space area. In such cases, it is expected that these aircraft will be equipped with electronic conspicuity (e-conspicuity) devices, ensuring their visibility to other airspace users and minimizing the risk of conflict.

3.2.2.2.1.2 U-space Architecture and Governance

The U-space airspace in Benidorm will operate under a centralized architecture, with a CISP facilitating the flow of operational data between USSPs, privileged users, ANSPs, and other relevant stakeholders.

In Spain, ENAIRE has been designated as the national CISP, responsible for providing trusted, high-quality, accurate, and secure all common information for U-space stakeholders in all U-space airspaces within the country. In the context of Benidorm's U-space, ENAIRE will also act as the ANSP, although its role in this environment is limited given that the airspace is entirely outside controlled areas.

3.2.2.2.1.3 Designated Testing Areas

Flight tests related to U-space services have already been conducted in specific areas of **Benidorm**, as depicted in the Figure 5.

Figure 5. Testing areas for U-space operations in Benidorm - Urban U-space operations in uncontrolled airspace scenario

These areas are classified into three distinct **testing environments**:

- **Yellow Zone:** Heliport (Suburban Area) – Designed for testing drone operations in semi-urban environments.
- **Blue Zone:** Urban Lab (City Centre) – A controlled testing space surrounded by skyscrapers, used for validations and experimental drone flight trials.

Red Zone: Beach Area – An open environment suitable for diverse drone operations. The types of missions developed in each area are:

Type of mission	Testing areas		
	Beach	Urban (Lab)	Heliport (Suburban)
Logistics		X	X
Recreative	X	X	
Security/Emergency	X	X	
Photography	X	X	
Surveillance/Traffic monitoring	X	X	X

Table 5: Type of missions - Urban U-space operations in uncontrolled airspace scenario

3.2.2.2.1.4 Environmental and Regulatory Considerations

Several factors impact the operational feasibility of U-space in Benidorm, including:

- **Touristic Environment:** High fluctuations in population density due to seasonal tourism.
- **Diverse Land Use:** A combination of dense urban environments, periurban areas, and unpopulated coastal zones.

- **Proximity to Natural Areas:** Inclusion of Serra Gelada Natural Park (P.N. Serra Gelada) within the U-space boundaries.
- **Weather Conditions:** The region benefits from a mild microclimate, with minimal restrictions expected on UAS operations, except for wind gusts generated by skyscrapers.
- **Class G Airspace:** As an uncontrolled airspace, it lacks CNS services, requiring U-space services to enhance situational awareness and coordination.

3.2.2.2.1.5 Identified Hazards and Risk Mitigation through U-space Services

The implementation of a U-space airspace in Benidorm introduces multiple operational challenges due to its dense urban environment, coexistence of manned and unmanned aviation, and the diversity of UAS operations. Ensuring safe and efficient UAS integration requires identifying key hazards and implementing appropriate U-space services to mitigate risks. The following table summarizes the main hazards, their associated risks, and the mitigation strategies employed:

Hazard	Details	Associated metrics	Related U-space services
High Population Density	Benidorm's urban environment, characterized by skyscrapers and tourism, increases the risk of ground impact incidents. Tall structures also contribute to GPS signal loss, communication disruptions, and artificial wind gusts affecting flight stability.	Number of incidents related to signal interference, frequency of navigation errors, (deviations from planned flight paths due to incorrect positioning, loss of GPS accuracy, or misinterpretation of waypoints) rate of unauthorized flight deviations.	Geo-awareness. Conformance monitoring.
Presence of Critical Infrastructure	The proximity of hospitals, ports, and schools requires geo-awareness measures to prevent unauthorized drone activity in restricted areas.	Number of incursions into restricted zones, compliance rate with geo-awareness advisories.	Geo-awareness. Conformance monitoring.
Manned Aviation Entry into Uncontrolled Airspace	Potential airspace conflicts between crewed and uncrewed aviation require Traffic Information and Network Identification services to ensure awareness and prevent collisions.	Number of airspace conflict alerts, response time to deconfliction manoeuvres, percentage of manned aircraft equipped with electronic conspicuity.	Traffic information. Network identification.
Diversity of UAS Operations	The coexistence of BVLOS, VLOS, and autonomous flights increases complexity, requiring effective detect-and-avoid capabilities. UAS Flight	Approval rate of BVLOS flight requests, number of detect-and-avoid activations, conflict resolution success rate.	UAS Flight Authorization.

Hazard	Details	Associated metrics	Related U-space services
	Authorization services help manage operations and reduce risks.		
Urban Infrastructure Interference	Tall buildings and dense infrastructure can impact CNS performance, leading to gaps in communication and navigation coverage. Wind gusts generated by skyscrapers can destabilize drone operations. U-space services must provide real-time weather information for operational planning.	Rate of communication outages, navigation precision in dense urban areas, number of reported signal dropouts.	Geo-awareness. Conformance monitoring.

Table 6: Key Hazards and Mitigation Strategies for U-space Operations in Benidorm - Urban U-space operations in uncontrolled airspace scenario

The successful implementation of U-space services in Benidorm plays a critical role in mitigating the risks identified in the previous section. These services enhance situational awareness, improve coordination between UAS and manned aviation, and ensure regulatory compliance, ultimately enabling safe and efficient drone operations in an uncontrolled urban environment:

- **Enhancing Airspace Awareness**: Traffic Information, Geo-awareness and Network Identification services provide real-time updates on airspace activity, ensuring that both UAS operators and manned aviation pilots can detect and avoid conflicts. This is particularly important in uncontrolled Class G airspace, where manned aircraft may not always be under active air traffic control.
- **Reducing Ground Risk Exposure**: The integration of Geo-awareness services ensures that drones operate within designated areas and avoid restricted zones such as hospitals, ports, and schools. By continuously monitoring compliance, these services minimize the likelihood of unauthorized overflights and potential ground incidents.
- **Improving CNS Performance in Urban Areas**: Urban infrastructure and high-rise buildings in Benidorm can interfere with Global Positioning System (GPS) signals and cause communication disruptions. The Benidorm U-space airspace compensates for these limitations through advanced CNS capabilities, such as redundant positioning technologies and enhanced connectivity solutions that maintain reliable tracking and navigation for unmanned and manned traffic.
- **Supporting BVLOS and High-Autonomy Operations**: The use of UAS Flight Authorization services facilitates complex drone operations, particularly BVLOS missions, by providing pre-approved flight plans and dynamic adjustments based on real-time airspace conditions. This service is crucial for enabling scalable UAS operations in urban environments.
- **Ensuring Compliance and Operational Efficiency**: The implementation of automated compliance checks within U-space services ensures that drone operations adhere to regulatory frameworks and flight authorizations. This reduces operational delays, prevents regulatory violations, and fosters trust between UAS operators and authorities.

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Despite these advantages, some challenges remain:

- **CNS limitations:** Multipath effects and signal loss in dense urban areas require improved positioning technologies.
- **Scalability:** Increasing drone traffic demands enhanced U-space infrastructure for seamless management.
- **Integration with manned aviation:** Coordination in Class G airspace remains complex, especially for emergency aircraft.
- **Regulatory evolution:** Adapting to evolving European ATM policies is essential for U-space harmonization.
- **Weather risks:** Wind gusts near skyscrapers can disrupt flights, requiring better meteorological integration.
- **Public acceptance:** Addressing concerns on noise, privacy, and security is key to community support.

3.2.2.2.2 U-space BVLOS operations in low-density peri-urban and rural areas within Class-C

ÉALÚ-AER is a Digital Sky Demonstrator project that propose deploying and demonstrating an end-to-end Collins Aerospace **U-space infrastructure** to enable **UAS BVLOS operations** at the Future Mobility Campus Ireland (FMCI) vertiport next to International Shannon Airport, Ireland, which is one of the largest airports at Ireland.

Shannon connects to Limerick, which is the third largest city in Ireland, representing Limerick area, therefore, an urban area. It is connected through the Shannon River estuary, which can be considered unpopulated/sparsely populated area, making it easier to obtain Operational Authorisation over that area lowering the Ground risk for the SORA. Being the majority of the intended operation area Class-Airspace but Limerick city, make it easier to lower the Air risk, being all GA aircraft over the area identified by transponder, but make it more complex to accommodate and designate an U-space without affecting the existing ATM traffic, and also the equipment and performance requirements of the UASs that will be taking-off/landing at the FMCI's vertiport, will be more strict.

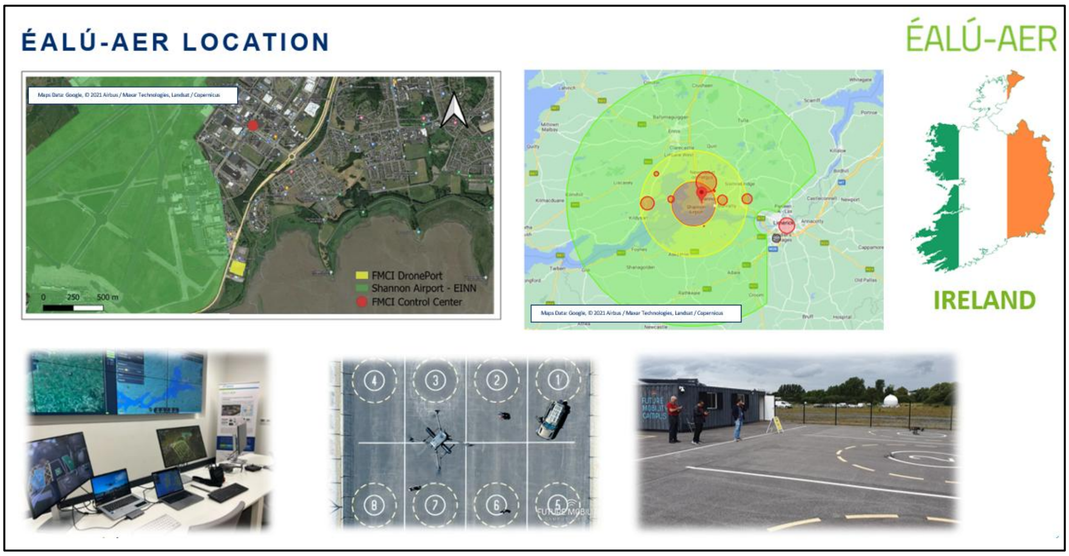

Figure 6. Aerial view of Shannon, Ireland - U-space BVLOS operations in low-density peri-urban and rural areas within Class-C

3.2.2.2.2.1 Operational Characteristics

- U-space inside existing **Controlled Airspace.**
- **Transiting** actual **Class C – Class G airspace.**
- Mainly **BVLOS** Operations at **International Airport** environment.
- **Low-Density Peri-urban and Rural Areas.**
- **U-space infrastructure** available.
- **UAM** and **drone delivery** use cases.
- **Mostly Automatically flights** with varying levels of automation.

The U-space at Shannon-Limerick area is looking to enable and enhance the safety of BVLOS operations in the area and will allow for different variety of UAS models.

Due to the characteristics of the airspace in this U-space volume, it is necessary to create different areas with distinct requirements for UAS operations, as this will be more limited close to the Airport at FMCI vertiport, as well as in those areas in Limerick city where the population density is higher.

Figure 7. Example of key routes - U-space BVLOS operations in low-density peri-urban and rural areas within Class-C

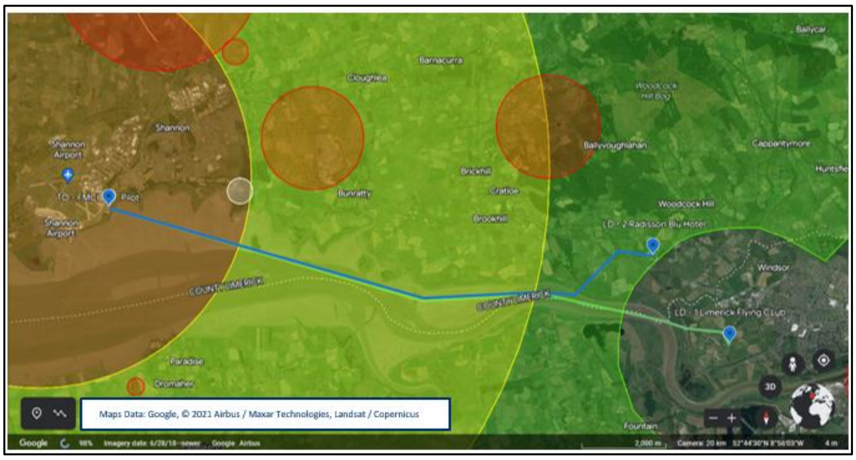

Figure 8. Transition from Class C to Class G airspace - U-space BVLOS operations in low-density peri-urban and rural areas within Class-C

The U-space infrastructure that is represented in Figure 9 comprehends:

- **Secure Backhaul Network:** AGN, to exchange secure data across systems.
- **USSP platform:** Collins Airspace Services – USS Client
- **CISP platform:** Collins Airspace Services – ATS Client
- **Ground surveillance Radar:** Skyler® Radar
- **CNPC solution as reliable C2 link:** CNPC5000 radios.

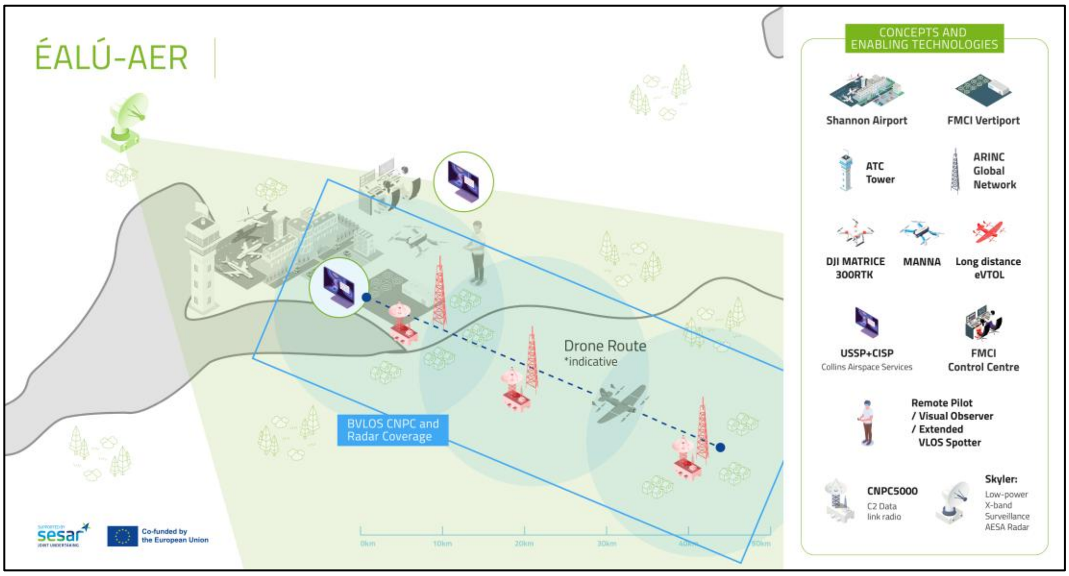

Figure 9. CNS Infrastructure Architecture - U-space BVLOS operations in low-density peri-urban and rural areas within Class-C

3.2.2.2.2.2 Environmental and Regulatory Constrains

Several factors impact the operational feasibility of U-space at Shannon Area, including:

- **Class C Airspace:** It will be usual for manned aircraft to enter this U-space airspace (there are occasional VFR traffics on the area, Ryanair Pilots Training, and non-regular Police and Search and Rescue - SAR- flights) being close to the airport. In these cases, they must be equipped with e-conspicuity devices that makes them visible to other users of this airspace.
- **Weather conditions:** Between Shannon and Limerick, the weather is often influenced by Ireland's mild maritime climate. It typically features frequent cloud cover, moderate winds, and occasional rain, with visibility conditions varying due to mist or fog, especially during early mornings or after rainfall. These factors are critical for aviation, affecting take-offs, landings, and drone operations in the area, therefore, some restrictions might apply.
- **Special Natural Areas of conservation:** Lower Shannon Estuary is considered a special area of conservation (SAC 002165), therefore an appropriate screening of the special area of had been performed to determine if a full assessment is needed. With the parameters of the flights in terms of average altitude, platforms, speed, etc. This had been performed, and the conclusion was that it won't affect this area, and an appropriate assessment is not required as far as the characteristics of the flights doesn't drastically change. If dangerous-good are transported, there should follow the proper regulatory requirements.
- **Diverse Land Use:** The planned U-space covers the city of Limerick and Shannon River estuary, as well as the FMCI vertiport close to Shannon Airport. Geographically, it is a mix of periurban and unpopulated environment; with higher population density in small certain areas (Limerick city) that suddenly turns into 0 as they end along the Shannon River.

3.2.2.2.2.3 Identified Hazards and Risk Mitigation through U-space Services

Hazard	Details	Associated metrics	Related U-space services
Presence of Critical Infrastructure	The proximity of the Airport and the presence on the Controlled Airspace, requires geo-awareness measures to prevent unauthorized drone activity in restricted areas.	Number of incursions into restricted zones, compliance rate with geo-awareness advisories.	Geo-awareness
Weather Conditions	High Incidence of Wind/Rain/Fog: Frequent adverse conditions necessitating adaptive measures or operational adjustments.	Number of Flight Operations disrupted and declared emergency due to a weather forecast that wasn't accurate.	Weather Information
SID (Standard Instrument Departures) STARs (Standard Terminal Arrival Routes)	Shannon Airport handles commercial airliners, business jets, and cargo flights that follow strict SID/STAR procedures. DAR (Dynamic Airspace Reconfiguration) allows temporary restriction of UAS operations when high-density SID/STAR traffic is expected and enables strategic deconfliction by only approving drone flights that don't interfere with SID/STAR operations.	Number of Dynamic Airspace Reconfigurations for an inbound/outbound aircraft from/to Shannon Airport need to disrupt the U-space airspace.	Dynamic Airspace Reconfiguration Flight Authorisation
MAC with Manned Aviation activity	Potential airspace conflicts between crewed and uncrewed aviation require Traffic Information and Network Identification services to ensure awareness and prevent collisions.	Number of airspace conflict alerts, response time to deconfliction manoeuvres, percentage of manned aircraft equipped with electronic conspicuity.	Traffic Information Network Identification
CNS infrastructure	The requirements in the precision of the GNSS as well as C2 link reliability, requires of the proper U-space services to plan the route accordingly from the strategic phase, as well during the tactical	Number of alerts in loss of comms or GNSS, for how much time, and average latencies. Number of detections during flight of non-cooperative aircraft by surveillance equipment.	Navigation Coverage information Flight Authorisation Surveillance Data Exchange. Communication Coverage Information

Hazard	Details	Associated metrics	Related U-space services
	phase to ensure the Operator is provided with the necessary link metrics. As well as the surveillance of the airspace for non-cooperative aircrafts.		

Table 7: Key Hazards and Mitigation Strategies for U-space BVLOS operations in low-density peri-urban and rural areas within Class-C scenario

The success of U-space Services at Shannon Airport locations plays a critical role in mitigating the risks identified in the previous section. These services enhance the situational awareness, helping integration of BVLOS drone operations into controlled airspace environment while maintaining safety with manned aircraft movements. The U-space infrastructure described in this section plays a key role in safeguarding these BVLOS operations.

- **Improved airspace safety and conflict avoidance:** Reduces the likelihood of airspace violations, mid-air conflicts and potential disruptions to crewed aviation.
- **Enhanced BVLOS operational approval and Compliance automation:** Flight Authorization Service automates approvals, reducing the need for manual Air Traffic Control (ATC) coordination. Faster regulatory approvals for BVLOS flights, leading to scalable and repeatable drone operations.
- **Increased operational efficiency for drone missions:** Optimizes flight planning, reducing delays and maximizing mission success
- **Lower Workload for ATC & ANSPs:** Minimizes the burden on Shannon ATC by automating UAS traffic.
- **Enabling advanced drone operations (IAM, Medical Deliveries, etc):** Supports the future integration of IAM in Shannon.

Despite these advantages, some limitations remain:

- **Coordination with ANSP and ATC:** Some services such as automated flight authorization or dynamic airspace management, may not be available or integrated with ATM systems.
- **E-conspicuity:** Availability of e-conspicuity devices are limited yet.
- **Tactical conflict resolution:** If a manned aircraft deviates unexpectedly into U-space airspace, a drone operator may have limited time to react. Automated rerouting mechanisms are not yet standardized across different U-space implementations.
- **Data accuracy and Latency issues:** U-space services rely on various data sources (e.g. GNSS, LTE, U-space feeds), but data accuracy and latency can impact safety. There are certain limitations:
    - GPS errors or signal loss may affect drone positioning.
    - Latency in traffic updates may delay deconfliction actions.
- **U-space services cost:** Service fees for U-space access, data processing, or real-time conflict resolution could be expensive for frequent BVLOS operations.

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- **Scalability concerns:** If multiple drones operate in the same airspace near Shannon, ensuring safe separation while avoiding possible incursions and Manned aviation conflicts adds complexity.

3.2.2.2.3 Dynamic U-space operations for infrastructure inspection

This scenario focuses on U-space operations for infrastructure inspection in the Port of Antwerp (Belgium), leveraging insights from the BURDI project. The Port of Antwerp serves as a key logistics and trade hub, positioned along the River Scheldt and operating as one of Europe's largest maritime gateways. Its strategic location near Antwerp International Airport (EBAW) and Hoevenen Airfield (EBHN) presents operational challenges due to the coexistence of manned and unmanned aviation, requiring advanced risk mitigation measures.

Given the complexity of this environment, ensuring safety and efficiency in UAS operations demands the integration of U-space services, coordination with aviation and port authorities, and robust monitoring systems to mitigate both ground and air risks.

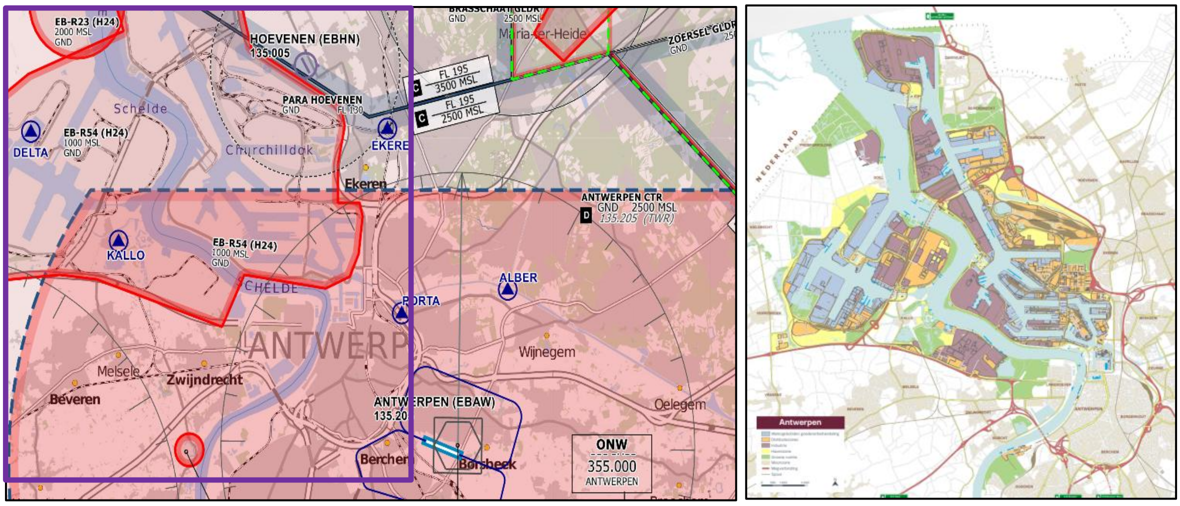

Figure 10. EBHN and EBAW next to geographical area of port, partly in CTR of EBAW. The violet rectangle frames the area of the port, enlarged in the image on the right.

3.2.2.2.3.1 Operational Characteristics

The anticipated UAS operations in the Port of Antwerp include:

- **VLOS** (Visual Line of Sight) and **EVLOS** (Extended Visual Line of Sight) operations within controlled airspace.
- U-space operations requiring authorized U-plans in accordance with **SORA** (Specific Operations Risk Assessment) guidelines.

3.2.2.2.3.2 Key operational characteristics

Since detailed information about the operations and environment of the **port of Antwerp** was unavailable, **an alternative approach** was taken. Data was sourced from a similar scenario with comparable requirements—the flight analyses conducted for the **port of La Spezia** (Italy) during the

EU-funded Labyrinth project. The environments have similar characteristics apart from the size difference.

Both ports are located adjacent to their respective cities. Each features a landscape filled with obstacles such as cranes, structures, high lampposts, windmills, buildings, and stacks of containers. Additionally, both ports have moving elements, including static and rail cranes, vessels navigating the area, and birds. Notably, near the Port of Antwerp, there is a significant migration and breeding site for many waterbirds and songbirds.

The main difference between those scenarios will probably come from the weather conditions, being La Spezia more susceptible to adverse conditions since it is directly located by the sea while the port of Antwerp is in an estuary. A difference in La Spezia is that the zone around it is a very important military area (named "Prohibited area - P2 - La Spezia"), and according to the Italian legislation the civil flights are prohibited from the surface up to FL195 height. Operations shall be subject to specific authorization according to procedures published by ENAC (the Italian Civil Aviation Authority). Due to this, a geofence was determined covering the military area, next to the port operations.

Category	Port of La Spezia	Port of Antwerp
Location	Adjacent to the city, directly by the sea	Adjacent to the city, located in an estuary
Landscape Obstacles	Cranes, structures, high lampposts, windmills, buildings, stacks of containers	Cranes, structures, high lampposts, windmills, buildings, stacks of containers
Moving Elements	Static and rail cranes, vessels, birds	Static and rail cranes, vessels, birds
Environmental Factors	Presence of seabirds	Significant migration and breeding site for waterbirds and songbirds
Weather Conditions	More susceptible to adverse conditions due to direct sea exposure	Less susceptible to adverse weather due to estuary location
Regulatory Restrictions	Located in a military area ("Prohibited area - P2 - La Spezia"), civil flights are prohibited up to FL195; operations require specific authorization	E-conspicuity mandatory for crewed aviation flying in U-space airspace
Location	Adjacent to the city, directly by the sea	Adjacent to the city, located in an estuary

Table 8: Comparison of the Port of La Spezia and the Port of Antwerp

The following tasks were required in the **port of La Spezia**:

- **Port security:** monitor the perimeter of the port. Identify potential threats or problems on the premises.
- **Port safety:** Monitor the correct position of loads, correct mooring of vessel, loading and unloading on trains, trucks and vessels.
- **Port maintenance:** Monitoring of equipment and infrastructures.
- **Port management of traffic:** ground traffic monitoring within the port areas.

- **Port staff training:** recording videos and images for staff training i.e., handling of load unit on cranes, controlling specific areas.
- **Control debris in water** after drag works.

Figure 11. Drone used in the flight tests in the port of La Spezia.

The drones utilized for these missions ranged from small (250g - 2kg) to medium-sized (2kg - 25kg) UAS, equipped with 5G connectivity, GPS, and GNSS for enhanced navigation and data transmission.

3.2.2.2.3.3 Environmental and Regulatory Constraints

In Belgium, VFR traffic operating in U-space airspace must be equipped with e-conspicuity devices to enhance visibility and situational awareness. In the case of La Spezia, part of the port was a military zone, protected by geofencing restrictions, ensuring that drones did not capture imagery in restricted areas.

Hazard	Details	Associated metrics	Related U-space services
Low Population Density	In a port environment we suppose low population density mainly represented by port workers. This risk will vary depending on the moment of the day. In the case of La Spezia, a helmet was mandatory in some areas but not in all the port.	Density of people in area with and without helmet. The number will depend a lot of the day/hour since it will be aligned with the working activity.	Geo-awareness
CNS Limitations	Interferences to the signals could be expected in the area of the port.	Number of lost packages. Detection and response time to unauthorized incursions. Efficiency of geo-awareness systems in port environments.	E-conspicuity Network Identification
Weather and Environmental Factors	Weather might be variable due to the temperate maritime climate, with occasional rain, wind, and fog that can affect	Effects of the weather in the accuracy to follow the pre-loaded trajectory, like amount of deviation, or impact in the time of arrival	Weather Information Conformance monitoring E-conspicuity Network Identification

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Hazard	Details	Associated metrics	Related U-space services
	operations, requiring monitoring for safety.	to the points of a 4D trajectory. Impact of the weather on the operational capacity of drones	Flight Authorisation
Interaction with Manned Aviation	Given the short distance from the airport and especially the airfield, we expect a moderate probability of airspace overlap. VFR flights and SAR flights may also operate at low altitudes. E-conspicuity should be used in these situations.	Number of near-miss events (or MAC to be more conservative), Altitude separation (ft).	Collaborative Interface with ATC Network Identification E-conspicuity Traffic Information Flight Authorisation
Presence of Critical or Restricted Areas	The airport in the case of Antwerp, that will require the separation of the UAS operations, or the military base in the example of La Spezia. Besides, in a commercial port, we will find sensitive areas, for example for fuel storage.	Number of infrastructures potentially flammable in the area in case of collision, like fuel tanks or storage of chemical substances. Number of hours during which a damaged critical ground infrastructure could not provide service (estimated time to be repaired).	Conformance monitoring Geo-awareness Network Identification E-conspicuity Traffic Information
Presence of Natural or Artificial Obstacles	In a port we can find lampposts, moving cranes, cables, and frequently big birds.	Bird density	Geo-awareness

Table 9: Environmental and regulatory constraints for Dynamic U-space operations for infrastructure inspection scenario

3.2.2.2.3.4 Operational Constraints and Risk Mitigation

One of the primary challenges in the **Port of Antwerp** is **airspace coordination**, given its proximity to controlled airspace and the high volume of ground and maritime operations. To mitigate these risks, U-space services will play a crucial role in:

- **Traffic Awareness**: Integration of **e-conspicuity solutions** to enhance situational awareness among manned and unmanned operators.
- **Flight Authorization**: Implementation of **UAS Flight Authorization Services** to ensure compliance with **U-space airspace structures**.
- **Geo-awareness and Conformance Monitoring**: Preventing unauthorized entry into restricted areas within the port.

Since the heights of the cranes were not accurately documented, test flights in La Spezia were conducted at altitudes under 120 m, allowing assessment of camera resolution for infrastructure inspection while ensuring compliance with local aviation regulations.

Figure 12. Flight test in the port of La Spezia, Italy (Project Labyrinth, 2023). The drone appears inside the blue circle.

To mitigate these hazards, the following U-space services will be utilized:

- **Network Identification.** The drones must report their position constantly at the frequency mandated by the air authority.
- **Geo-awareness.** Providing information about the location of obstacles, expected presence of people or restricted areas.
- **Traffic Information.** Service broadcasting the presence and location of other traffic, crewed or not, tracks and expected densities.
- **Flight Authorization.** The acceptance/rejection/modification of the U-plans will be impacted by constraints like no-fly zones or the ATC decisions with respect to the controlled areas.
- **Collaborative interface with ATC.** The mechanism to coordinate U-space operations and crewed aviation in controlled areas.
- **E-conspicuity.** In this case, the need of crewed aviation to constantly report its position (equivalent to the Network Identification for UAS) so that they can be detected and avoided while sharing U-space.
- **Conformance monitoring.** Service making use of the position reporting to check that the Unmanned Aerial Vehicle (UAV) follow their expected U-plan within a tolerated deviation. Otherwise, it would trigger the application of measures to avoid safety issues.
- **Weather information.** Will provide estimations or measurements of the weather conditions that could impact or prevent from the approval of the plan to the capability to follow faithfully the expected U-plan.

These services collectively contribute to:

- Monitoring and tracking drone operations to ensure compliance.
- Segregating UAS from crewed aviation, minimizing airspace conflicts.

- Providing real-time notifications for airspace incursions, allowing operators to maintain safe separation distances.

Despite the implementation of these U-space services, certain **challenges** remain:

- Low-altitude flights within the port require navigation between infrastructure such as lampposts, structures, and cables, which may pose challenges for drone sensors and collision-avoidance systems.
- Dynamic obstacles, including moving cranes and ships, introduce additional risks that require adaptive flight planning and real-time situational awareness.

3.2.2.2.4 Medical transport operations from suburban to urban areas

This operation represents the last part of one of the six very large demonstration conducted under the CORUS-XUAM project, designed to showcase how U-space services can support UAM operations. Before these demonstrations, a fully operational U-space infrastructure was not in place, and the project aimed to develop, test, and validate these services in real-world scenarios, demonstrating their effectiveness in integrating UAM with existing ATM systems.

The focus of the operation was last mile delivery of medical cargo from suburban to urban areas in the Apulia region of southern Italy, carrying out a BVLOS operation in controlled airspace covering 6 km.

The specific locations involved in this operation include:

- **Manduria Airfield**, located in a suburban area, is a private airfield located in Manduria. It serves as a base for general aviation, ultralight aircraft, and flight training activities. The airfield features a 900 m asphalt runway, hangars for aircraft storage, and maintenance facilities. It also supports aerial work operations, tourism flights, and pilot training programs. Positioned in the Apulia region, it plays a role in regional air mobility and aviation services.
- **Manduria "Marianna Giannuzzi" Hospital area**, located in an urban centre. The hospital does not have designated landing areas for UAVs. Therefore, for the purpose of this demonstration, a small green area near the hospital was utilized as a landing site.

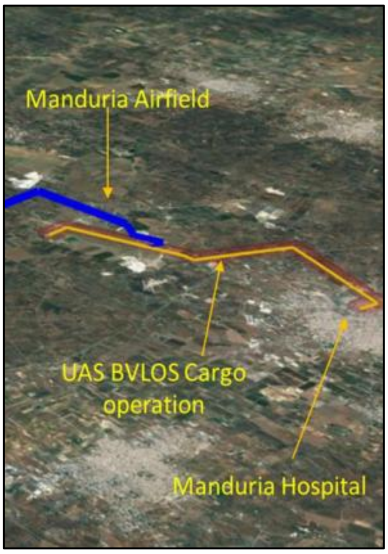

Figure 13. Last mile delivery trajectory

3.2.2.2.4.1 Operational Characteristics

The UAS used for last mile delivery is the Techno Sky UAS-PPL 612 PLUS EVO XL, depicted in Figure 14. This hexarotor UAS, with a MTOM under 25 kg, was granted a Project Certification by ENAC (Italian Civil Aviation Authority) for the demonstration.

Figure 14. Techno Sky UAS: PPL 612 PLUS EVO XL

UAS characteristics are outlined in **Errore. L'origine riferimento non è stata trovata.**. For this operation, the UAS operator and the drone were registered on the USSP platform, and upon completing the SORA assessment, the operation was authorized.

Technical Specifications	
MTOM	15 kg
Wingspan/max dimension	1.6 m
Wind resistance	12.5 m/s
Cruise speed	12.5 m/s
C2	2.4 GHz

Technical Specifications	
Range	4000 m
Endurance	15 min
Take off	Manual (RC) or automatic

Table 10: UAS Technical Specifications

To track the UAS during the last mile delivery, the UAS Traffic Management (UTM) Box Pollicino™ was used. The UTM Box Pollicino™ is a drone tracker based on LPWAN LTE technology, which implements remote identification service over the internet network. It is the first Remote Identification device conforming to the "Manifesto" for the development of U-space services in Italy. The tracker is compliant with EU Regulation 2021/664 and can be easily configured to work with different USSPs. In the default configuration the tracking service is linked to D-flight USSP by the exploitation of d-Flight ICD for connectivity. Information was then displayed on D-flight (Italian USSP) platform, as showed in Figure 15.

A commercial drone detection system, the DJI Aeroscope, was also used during the operation to identify non-cooperative drones, integrating information into the D-flight USSP platform, to enhance situational awareness and mitigate risks from uncooperative drones.

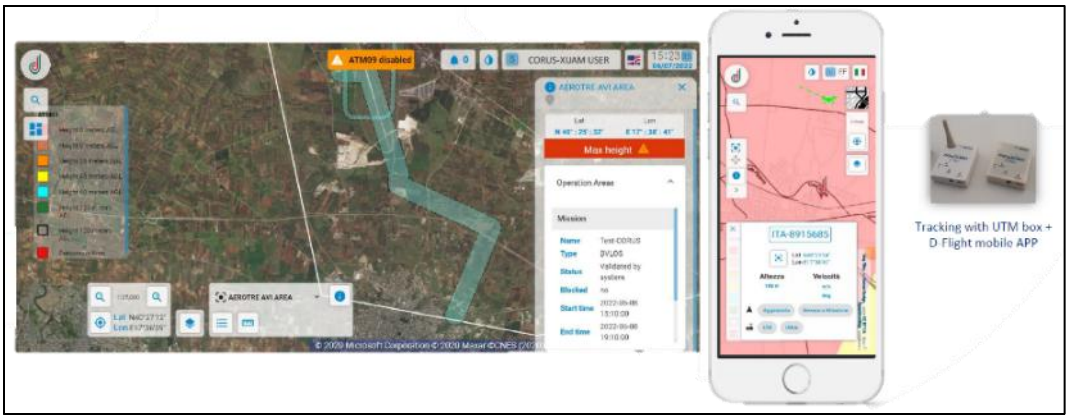

Figure 15. UAS Tracking Display on D-flight USSP Platform

The operation involved many stakeholders who collaborated for the success of the last mile medical cargo delivery, guaranteeing safety even in an urban environment. These are:

Stakeholder		Involvement
ANSP	ENAV (Ente Nazionale di Assistenza al Volo)	Involved in strategic phase for activities related to ATM (controlled airspace) and manned a/c operations in U-space (e.g. HEMS flights, VFR).
USSP	d-flight	Involved in provision of U-space services to related users in U-space.
Drone Pilot/Operator	d-flight / Technosky	Involved for the specific operation in BVLOS (last cargo delivery).

Airfield operator	Aerotre	Involved in management of ground operations and coordination related to Manduria Airfield.

Table 11: Stakeholder Involvement in Last-Mile Medical Cargo Delivery Operations

3.2.2.2.4.2 Environmental and Regulatory Constraints

The flight was conducted in controlled airspace, requiring an authorized U-plan and adherence to the SORA guidelines.

The operation took place beneath controlled airspace CTR 3 Grottaglie, as shown in **Errore. L'origine riferimento non è stata trovata.**Figure 16, where altitude limitations had to be strictly observed. The flight remained below 120 m in altitude, aligning with regulatory requirements.

Given the controlled nature of the airspace and the specific characteristics of the mission, a customized risk assessment was required instead of applying predefined standard scenarios. This tailored approach ensured an operational framework that effectively mitigated risks associated with urban air mobility in regulated environments.

Figure 16. Airspace CTR 3 Grottaglie

A key aspect of the risk assessment was the hospital's location in the city centre, as shown in Figure 17. This high-density urban setting necessitated a dedicated evaluation of potential hazards, particularly regarding overflight of populated areas. This consideration was fundamental to the SORA assessment, ensuring compliance with safety protocols for operations in densely populated environments.

Figure 17. Manduria "Marianna Giannuzzi" Hospital

3.2.2.2.4.3 Identified Hazards and Risk Mitigation through U-space services

The main hazards identified in this scenario are summarized in **Errore. L'origine riferimento non è stata trovata.**.

Hazard	Category	Details	Associated metrics	Related U-space services
High Population Density	Safety-related	Overflight of densely populated urban areas may pose risks in case of collision with buildings or critical infrastructures.	Population exposure rate, Potential impact radius in case of failure.	Geo-awareness, Conformance monitoring, Flight authorization
Presence of Critical or Restricted Areas		Hospitals and schools can be found in the urban environment.	Number of critical infrastructures, number of affected critical infrastructures in proximity	Geo-awareness Conformance monitoring, Flight authorization
CNS Limitations	Safety-related	Low 4G & 5G coverage in suburban areas can affect tracking capabilities. On the other hand, GNSS (e.g., GPS) can be unreliable in urban environments due to multipath effects and signal shadowing.	Dilution of Precision (DOP, both vertical and horizontal): minimum elevation, horizontal and vertical errors, maximum error estimates; Signal-to-Noise Ratio (SNR), GNSS	Geo-awareness Conformance monitoring

Hazard	Category	Details	Associated metrics	Related U-space services
			Availability Percentage.	
Weather and Environmental Factors	Safety-related Environment-related	Adverse weather conditions like strong winds, rain, or fog can impact flight safety and energy consumption. City architecture may amplify wind hazards, which can be mitigated through wind models and static maps. This can also have effects on battery management: stability is more difficult to maintain in a windy environment; therefore, energy consumption is higher.	wind speed, turbulence index, precipitation rate, visibility range. Energy consumption variation (%), impact of adverse weather on mission success rate.	Weather information, Flight authorization
Interaction with Manned Aviation	Safety-related	There could be potential conflicts with VFR (Visual Flight Rules) flights. Furthermore, HEMS flights could be present near the hospital and possible military helicopter activity on weekdays near the eastern side of the airfield, which could interfere with flight operations. In these cases, they should be equipped with e-conspicuity devices that makes them visible to other users of this airspace.	Traffic density (aircraft/ km^2), number of near-miss events (or MAC to be more conservative), Altitude separation (ft)	Traffic Information and Network Identification services

Table 12: Key Hazards and Associated Metrics - Medical transport operations from suburban to urban areas scenario

The demonstration applied various U-space services, including network identification, geoawareness, traffic information, and flight authorization. These services, provided by the Italian USSP *d-flight*, ensured compliance with regulatory requirements and improved operation safety.

- **Network e-identification:** Ensures continuous processing of remote UAS identification for the entire duration of the flight (registration number, UAS ID, UAS position and direction, remote

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pilot position, emergency status, timestamp). This was performed using hook-on devices, plugins in Ground Control Station (GCS), networked DRI antennas, and the d-flight app.
- **Geoawareness:** Provides UAS geographical areas relevant to U-space airspace, including static, dynamic, and temporary restrictions. It supports the operator in strategic flight planning, ensuring compliance with operational constraints.

    - **Traffic information:** Provides situational awareness by delivering real-time updates on additional visible air traffic near the UAS flight's intended location or route.
    The demonstration integrated:
        - Cooperative unmanned traffic with NRIs (Network Remote Identification).

        - Manned ADS-B / FLARM traffic detected by commercial terrestrial networks (e.g., FlightAware).
    - **Manned traffic with NRI conspicuity** (pilots using the d-flight app - aviator profile).
    - **Non-cooperating local unmanned traffic** detected via commercial drone detection systems (e.g., DJI Aeroscope).
    - **Link with ATSU for coordinated operations in ATZ / CTR airspace**.

- **Flight authorization**: Implemented in accordance with EU Regulation 2021/664, including:

    - **Flight authorization** (request and approval process).
    - **Flight activation** (request and confirmation of active operation).

- **Other services:** To ensure safe operation in each U-space airspace, other U-space services, such as the weather information service could be implemented.

To address the hazards identified in this scenario, a series of U-space services were implemented to enhance airspace awareness, ensure regulatory compliance, and improve operational safety.

- **Enhances Airspace Awareness:** Electronic conspicuity and real-time traffic updates reduce the risk of mid-air collisions.
- **Supports Compliance & Coordination:** Facilitates adherence to regulations and seamless integration with air traffic control.
- **Improves Navigation Accuracy:** GNSS monitoring and geofencing prevent unauthorized airspace intrusions.
- **Reduces Operational Risks:** Weather services and (Geographic Information System) GIS data aid in pre-flight risk assessment and decision-making.

The following points outline the main constraints and remaining challenges that need to be addressed for the successful implementation of outer space services in this scenario.

- **Coverage Gaps:** Inconsistent 4G/5G network availability affects real-time tracking.
- **Integration with Manned Aviation:** Requires further advancements to ensure seamless coordination with VFR and commercial flights.
- **Technological Constraints:** GNSS reliability is affected by urban environments, requiring alternative positioning methods. 5G could be a valid alternative for positioning, despite communication.

3.2.3 CNS/ATS description

Not applicable in this version of the OSED.

3.2.4 Applicable standards and regulations

Not applicable in this version of the OSED.

3.3 Detailed operating method

3.3.1 Previous operating method

Not applicable in this version of the OSED.

3.3.2 New SESAR operating method

Not applicable in this version of the OSED.

3.3.2.1 Use cases

Not applicable in this version of the OSED.

3.3.3 Differences between new and previous operating methods

Not applicable in this version of the OSED.

4 Key assumptions

Not applicable in this version of the OSED.

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5.1 Applicable documents

5.2 Reference documents

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Appendix A Stakeholder identification and benefit impact mechanisms (BIM)

A.1 Stakeholders identification and expectations

Not applicable in this version of the OSED.

A.2 Benefits impact mechanisms (BIM)

Not applicable in this version of the OSED.

EUROPEAN PARTNERSHIP

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