

DES Solution 0520 – D2.6 Operational Service and Environment Definition (OSED) – Version 2

Deliverable ID:	D2.6
Project acronym:	U-AGREE
Grant:	101167187
Call:	HORIZON-SESAR-2023-DES-ER-02
Topic:	HORIZON-SESAR-2023-DES-ER2-WA1-4
Consortium coordinator:	UPV
Edition date:	15 September 2026
Edition:	01.02
Status:	Official
Classification:	PU

Abstract

This document presents the Final Operational Service and Environment Definition (OSED) for the U-AGREE project under SESAR 3 JU ER-02. 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.

Authoring & approval

Author(s) of the document

Organisation name	Date
UPV	26/06/2026
COLLINS	26/06/2026
CRIDA	26/06/2026
INECO	26/06/2026
ENGAGE	26/06/2026

Reviewed by

Organisation name	Date
ENGAGE	29/06/2026
CRIDA	29/06/2026
COLLINS	29/06/2026
DLR	29/06/2026

Approved for submission to the SESAR 3 JU by

Organisation name	Date
UPV	29/06/2026
EUROCONTROL	29/06/2026
EUROUSC ITALIA	29/06/2026
ENGage srl	29/06/2026
DLR	29/06/2026
COLLINS	29/06/2026
ENAIRE	29/06/2026
CRIDA	29/06/2026
INECO	29/06/2026
CRA	29/06/2026

Rejected by¹

Organisation name	Date

Document history

Edition	Date	Status	Organisation author	Justification
00.01	13/04/2026	Draft	UPV	New document
00.02	10/06/2026	Draft	UPV	Draft for internal review
00.03	22/06/2026	Draft	UPV	Resolution of comments to Ed. 00.02
01.00	29/06/2026	Official	UPV	Document for submission to the SJU
01.01	15/09/2026	Official	UPV	Document addressing SJU comments after the 1 st review round.

¹ Representatives of the beneficiaries involved in the project.

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U-AGREE

U-SPACE AIR AND GROUND RISK MODELS ENHANCEMENT

U-AGREE

This document is part of a project that has received funding from the SESAR 3 Joint Undertaking under grant agreement No 101167187 under European Union's Horizon Europe research and innovation programme.



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1 Executive summary

This document describes SESAR Solution 0520 – Integrated Risk Models for Unmanned Aircraft Systems (UAS) in U-space, developed within the U-AGREE project. Risk models are fundamental enablers of aviation safety, as they support the quantification of accident likelihood and severity, thereby providing the basis for identifying mitigation measures commensurate with the associated risk. In the context of UAS operations, state-of-the-art risk assessment methodologies have been developed by the Joint Authorities for Rulemaking on UAS (JARUS) through the Specific Operations Risk Assessment (SORA) framework, which addresses both ground risk, related to third parties on the ground being fatally injured by a UAS impact, and air risk, related to fatalities resulting from mid-air collisions.

Within this context, U-AGREE focuses on the portion of risk that can be mitigated through the provision of U-space services. More specifically, the project primarily addresses the hazard of mid-air collisions between UAS, as well as between UAS and manned aircraft. The assessment encompasses both airborne and ground-level consequences that may arise from such collision events. In addition, the solution considers other hazards where risk can be mitigated through the definition and enforcement of UAS geographical zones and the provision of U-space services. The solution therefore pursues a twofold objective: developing more accurate methods to quantify both the likelihood and severity of mid-air collisions and assessing the effectiveness of U-space services as risk mitigation mechanisms. The resulting framework enables the quantification of collision risk and the derivation of risk-based performance requirements for U-space services and associated Communication, Navigation and Surveillance (CNS) enablers.

The solution has been developed in close alignment with the SESAR U-space programme. In particular, it has been harmonised with the U-space sub-operating environments defined by the PEARL project [9] and the latest U-space Concept of Operations developed by the CORUS five project [10]. Furthermore, to facilitate early programme-level integration despite the low maturity targeted by the project, U-AGREE has produced architectural artefacts in accordance with the European Air Traffic Management Architecture (EATMA) framework developed by the AMPLE3 project [5].

In line with CORUS five, U-AGREE assumes a stepwise implementation of U-space driven by regulatory evolution. The solution addresses both the short-term and mid-term horizons. In the short-term, the project assumes the collaborative ecosystem established by Commission Implementing Regulation (EU) 2021/664 [11] and based on the provision of initial U-space services. In the mid-term, the introduction of enhanced strategic services and tactical conflict detection and resolution capabilities is expected to support higher traffic densities and increasingly complex operations. U-AGREE also assumes the progressive integration of e-conspicuous manned aircraft into U-space through the provision of strategic and tactical services, enabling a closer integration between manned and unmanned traffic.

The operational environment covered by the solution reflects the outcomes of the PEARL project and encompasses both controlled and uncontrolled airspace [9]. For uncontrolled environments, U-AGREE adopts the PEARL Class G no-U-space sub-operating environment as the baseline and the Class G U-space sub-operating environment as the target deployment scenario. Urban, suburban and rural environments are considered, together with operations both below and above the Very Low Level (VLL) limit of 500 ft above ground level [12]. The solution also covers terminal areas in controlled

airspace, assuming both baseline scenarios without U-space services and target scenarios where U-space services are available. In addition, U-AGREE considers the expected evolution of unmanned traffic from relatively low-density, low-complexity operations in the 2030 timeframe towards significantly more demanding traffic volumes and operational patterns by 2045 [9].

The risk models developed by U-AGREE are intended to support decision-making throughout the UAS operational lifecycle. In the long-term strategic phase, they provide quantitative evidence to support the designation of U-space airspace and the definition of associated operational constraints. In the pre-flight phase, they support operational risk assessments conducted under the SORA methodology, enabling UAS operators to account for the safety benefits provided by U-space services. Furthermore, the models provide a scientific basis for the development of Standard Scenarios (STS) and Pre-Defined Risk Assessments (PDRA), reducing the effort associated with obtaining operational authorisations.

The primary stakeholders impacted by the solution are the competent authorities responsible for U-space airspace designation and oversight, UAS operators, U-space service providers, and standardisation bodies. By enabling a more accurate quantification of collision risk and the effectiveness of mitigation measures, the solution contributes primarily to the SESAR Key Performance Area (KPA) of Safety [4]. In particular, it provides a scientifically grounded framework for deriving risk-based performance requirements for U-space services and associated CNS enablers, thereby supporting evidence-based decisions on the level of safety that can be achieved in different operational environments.

In addition, the solution contributes to the Capacity and Access & Equity KPAs [4]. By enabling competent authorities to quantify the safety benefits delivered by different combinations of U-space services and operational constraints, the solution supports the safe accommodation of higher traffic densities and more complex operations. At the same time, it facilitates proportionate access to airspace by allowing operational limitations and service requirements to be tailored to the actual level of risk, rather than relying on conservative assumptions. This provides a more robust basis for balancing safety objectives with airspace availability and operational flexibility. Furthermore, U-AGREE assesses the impact of U-space airspace limitations and constraints on the Security and Environment KPAs, particularly through the use of UAS geographical zones established to address specific security and environmental concerns.

U-AGREE targets Technology Readiness Level (TRL) 2 at the exit Maturity Gate [8], corresponding to the formulation of a SESAR concept. Within this scope, the project has successfully developed an integrated framework of risk models addressing both the likelihood and severity of mid-air collisions, together with methods for quantifying the risk reduction provided by U-space services. While the target maturity of the project remains TRL 2, the proposed concepts have also been analytically exercised through mathematical modelling and fast-time simulations in representative operational scenarios defined in accordance with [6]. These activities provide initial evidence supporting the feasibility and applicability of the proposed approach and contribute to reducing uncertainties associated with future maturation steps.

The results obtained indicate that the proposed risk models can provide a sound basis for risk-informed U-space airspace design, streamlined operational authorisations, and future standardisation activities. At the same time, they highlight several areas requiring further research in subsequent SESAR innovation phases. Firstly, the accuracy of advanced risk assessments is inherently dependent on the availability of risk-driving data (e.g. dynamic population density and accurate sheltering information),

together with traffic and operational data of corresponding accuracy, representativeness and timeliness. Nevertheless, the availability of high-quality, representative and up-to-date data remains limited in many operational environments. Secondly, further work is needed to characterise the effectiveness of advanced U-space mitigation mechanisms, particularly those supporting tactical conflict detection and resolution during the in-flight phase and their interaction with airborne Detect and Avoid (DAA) capabilities, including Remain Well Clear (RWC) and Collision Avoidance (CA) functions.

These challenges are expected to be partially addressed by follow-on SESAR projects, including RAXUS and DIFFERENT, both scheduled to start in September 2026. Nevertheless, additional research will still be required to assess the safety benefits of highly automated traffic management concepts, including dynamic rerouting, advanced tactical deconfliction, and trajectory-based operations enabled through the combined use of ground-based and airborne capabilities. Such concepts are expected to play a key role in supporting the long-term integration of large-scale unmanned traffic into non-segregated airspace.

2 Introduction

2.1 Purpose of the document

The purpose of this OSED is to describe the operational concept, environment, stakeholders and expected performance contributions associated with SESAR Solution 0520 – Integrated Risk Models for Unmanned Aircraft Systems (UAS) in U-space. The document defines how the proposed risk modelling framework is intended to support risk-informed decision-making throughout the UAS operational lifecycle, including U-space airspace designation, operational authorisations and the definition of risk-based performance requirements for U-space services and associated CNS enablers. Furthermore, the OSED establishes the operational assumptions, use cases and deployment scenarios underpinning the solution, thereby providing the foundation for subsequent requirements definition, architectural development, validation activities and future maturation within the SESAR innovation pipeline.

2.2 Scope

This OSED covers SESAR Solution 0520 – Integrated Risk Models for Unmanned Aircraft Systems (UAS) in U-space. The primary scope of the solution is the assessment and mitigation of the risk associated with mid-air collisions between UAS, as well as between UAS and manned aircraft. In particular, the solution addresses the quantification of collision likelihood and severity, the assessment of the effectiveness of U-space services and other mitigation measures, and the derivation of risk-based performance requirements for U-space services and associated CNS enablers.

The solution is applicable to both controlled and uncontrolled operating environments and covers the U-space sub-operating environments defined by the PEARL project, including Class G and Terminal operating environments with and without U-space services [9]. Urban, suburban and rural environments are considered, together with operations below and above the VLL limit. The solution addresses both the short-term and mid-term U-space implementation horizons, consistent with the assumptions established by the CORUS five Concept of Operations [10].

The risk models are intended to support strategic decision-making processes, including U-space airspace designation, the development of operational risk assessments, and the definition of performance requirements for U-space services. The solution also supports the evaluation of the safety, capacity and access benefits that may be achieved through different combinations of U-space services and operational constraints.

Although the core focus of the solution is mid-air collision risk, the scope also includes other hazards where they can be mitigated through the definition of UAS geographical zones and the provision of U-space services supporting compliance with, and protection of, those zones. This includes, for example, hazards related to infringements of UAS geographical zones or operational constraints established to protect people, infrastructure, sensitive areas or other airspace users. Hazards that cannot be mitigated through U-space services or through the definition and enforcement of UAS geographical zones remain outside the scope of this solution.

2.3 Intended readership

This document is intended for stakeholders involved in the design, regulation, implementation, validation and future evolution of U-space. In particular, it is addressed to competent authorities responsible for U-space airspace designation and oversight, UAS operators conducting operational risk assessments, U-space service providers, and organisations involved in the specification and deployment of CNS capabilities supporting U-space services.

The document is also intended for SESAR Solution Pack users, including operational concept developers, system architects, requirements engineers and validation teams, as it provides the operational basis for the derivation of requirements, architectural artefacts and validation activities. Furthermore, the OSED may be of interest to standardisation bodies, regulatory organisations, academic institutions, research organisations and future innovation projects seeking to further mature risk-based approaches to U-space airspace design, service performance definition and operational authorisation processes.

Readers are expected to be familiar with the fundamental concepts of U-space, the European regulatory framework governing UAS operations, and the principles of risk assessment methodologies such as SORA.

2.4 Background

The development of SESAR Solution 0520 builds upon a substantial body of work produced within SESAR and by the wider UAS and Air Traffic Management (ATM) communities. This work spans the definition of U-space operational concepts, the development of risk assessment methodologies, the identification of hazards and operational scenarios, and the establishment of architectural and validation frameworks supporting the integration of UAS into the European aviation system.

A major foundation for the solution is the Concept of Operations for European U-space developed by the CORUS family of projects [12], [13]. The original CORUS project established the initial operational vision for U-space and defined a progressive deployment roadmap based on increasing levels of service provision [13]. This work was subsequently extended by CORUS-XUAM, which addressed the integration of Urban Air Mobility (UAM) operations into the U-space ecosystem and further developed operational concepts for increasingly complex and dense traffic environments [12]. Together, these projects established many of the operational principles and service concepts upon which current U-space developments are based.

From a safety assessment perspective, U-AGREE builds upon the European regulatory framework governing UAS operations and U-space. Commission Implementing Regulation (EU) 2019/947 [14] establishes the regulatory framework for UAS operations and requires operators conducting operations in the Specific category to perform a risk assessment as part of the operational authorisation process [4]. The primary methodology supporting such assessments is the Specific Operations Risk Assessment (SORA), developed by the Joint Authorities for Rulemaking on Unmanned Systems (JARUS) [15]. SORA introduced a structured approach to assessing both ground and air risks associated with UAS operations and remains the principal methodology supporting operational authorisations within Europe. The outputs of SORA are also instrumental in the development of Standard Scenarios (STS) and Pre-Defined Risk Assessments (PDRA), which aim to streamline

operational authorisation processes for recurring types of operations. U-AGREE extends this body of knowledge by further developing the modelling of mid-air collision risk and the quantification of the risk reduction that can be achieved through the provision of U-space services.

In parallel, EUROCONTROL has developed guidance material for Airspace Risk Assessment (ARA), providing methodologies to assess the safety implications of introducing U-space airspace and associated operational constraints [16]. ARA is particularly relevant to U-AGREE, as one of the intended applications of the proposed risk models is to support evidence-based U-space airspace designation and the definition of associated operational constraints. Additional background is provided by the European Safety Risk Management (E-SRM) framework, which establishes common principles and processes for safety assessment across the European ATM system [17].

Within SESAR, several projects have addressed aspects of collision risk modelling, airspace design and risk mitigation that are directly relevant to U-AGREE. The BUBBLES project developed methodologies for the quantitative assessment of collision risk in U-space and introduced risk-based approaches to airspace design and service performance evaluation [18]. In particular, BUBBLES developed models to estimate collision likelihood and severity and investigated the relationship between traffic density, operational constraints and target levels of safety, providing an important foundation for the work performed in U-AGREE. DACUS further contributed to the understanding of the spatial distribution of collision risk by developing methods to identify collision-risk hotspots within the airspace, thereby supporting risk-informed airspace design and operational planning [19]. AMULED investigated concepts for the integration of UAS with heterogeneous performance capabilities and introduced segregation strategies based on aircraft performance characteristics, providing valuable insights into risk mitigation mechanisms that can be considered when defining operational constraints and airspace structures [20].

The identification of operational scenarios, hazards and operational constraints considered by U-AGREE has also benefited from several large-scale demonstration and validation activities. In particular, U-ELCOM has generated operational experience from the deployment and validation of U-space services across multiple European countries [21]. Similarly, CORUS X-UAM, EALU-AER and BURDI have provided valuable insights into operational use cases, stakeholder interactions, hazard identification and the practical challenges associated with the implementation of U-space concepts in representative operational environments [22], [23]. The operational evidence and hazard analyses generated by these projects have been considered when defining the operational scenarios and assessing the applicability of the proposed risk models.

U-AGREE has been developed within the SESAR 3 programme and maintains close alignment with ongoing transversal and complementary activities. The project has been closely coordinated with CORUS five, its sibling project responsible for the development of the latest U-space Concept of Operations [10], ensuring consistency between the proposed risk models and the operational assumptions underpinning future U-space deployment. In particular, CORUS five provides the operational lifecycle, stakeholder interactions and service concepts within which the U-AGREE risk models are intended to be applied. In addition, U-AGREE adopts the U-space sub-operating environments defined by the PEARL transversal project as the reference operational environments for its assessments [9]. These sub-operating environments provide the baseline and target deployment scenarios used throughout the analysis. From an architectural perspective, the solution has been aligned with the European Air Traffic Management Architecture (EATMA) framework and the architectural guidance developed by the AMPLE3 transversal project [5] to facilitate integration within

the broader SESAR programme. The solution is also consistent with the regulatory framework established by Commission Implementing Regulation (EU) 2021/664 on a regulatory framework for the U-space [16].

Building upon these foundations, U-AGREE advances the state of the art by developing an integrated framework for quantifying mid-air collision risk, assessing the effectiveness of U-space services and other mitigation measures, and deriving risk-based performance requirements for U-space services and associated CNS enablers. In doing so, the project seeks to provide a consistent link between operational concepts, safety assessments, service performance and regulatory decision-making, thereby supporting the safe, scalable and equitable integration of UAS operations into European airspace.

2.5 Structure of the document

This document is organised in five main sections and one appendix:

- **Section 1** provides an Executive Summary of the document.
- **Section 2** introduces the document by defining its purpose, scope and intended readership, providing the necessary background, and presenting the terminology and acronyms used throughout the report.
- **Section 3** contains the Operational Service and Environment Definition (OSD) of the solution. It provides an overview of the solution, describes the operational environment in which it is intended to be applied, and presents the baseline and proposed operating methods.
- **Section 4** identifies the key assumptions underpinning the solution and defining its boundaries of applicability.
- **Section 5** lists the applicable and reference documents cited throughout the report.
- **Appendix A** provides additional information on stakeholder identification, stakeholder expectations and the Benefit Impact Mechanisms (BIMs) associated with the solution.

2.6 Glossary of terms

Term	Definition	Source
Abnormal Conditions	Operational conditions that deviate from the expected or planned behaviour of the system or airspace users.	[17]
Airspace Risk Assessment (ARA)	Structured process used to assess the safety implications of introducing or modifying an airspace structure, including the designation of U-space airspace.	[16]
Air Risk	The risk of fatalities resulting from a mid-air collision involving a UAS.	[15]

ATM U-space Shared Airspace (AUSA)	A generic airspace concept developed in the AURA project that can be dynamically delegated between ATM and U-space operations through Dynamic Airspace Reconfiguration (DAR) to support the safe integration of manned and unmanned traffic.	[49]
Collision Avoidance (CA)	Last-resort airborne capability intended to prevent a collision by issuing or executing collision avoidance manoeuvres.	[45]
Collision Likelihood	Probability that a mid-air collision occurs within a specified operational context and period of exposure.	[48]
Collision Severity	Measure of the consequences associated with a mid-air collision, typically expressed in terms of expected fatalities or equivalent safety impact.	[48]
Competent Authority	Authority designated by a Member State to perform the responsibilities established under the applicable U-space regulatory framework.	[11]
Conformance Monitoring	Process of determining whether an operation remains within its authorised operational limits and constraints.	[11]
Detect and Avoid (DAA)	Capability that enables an aircraft to remain well clear of and avoid collisions with other airspace users.	[45]
E-conspicuity	Capability of an aircraft to electronically broadcast information enabling its detection and identification by other airspace users or supporting systems.	[34]

Efficiency-Capacity Threshold	Level of demand that can be efficiently handled by the system. Ultimately, this threshold is also linked to safety, as the constraints that impact the flight efficiency are a direct consequence of the mitigation strategy.	[10]
Ground Risk	The risk of fatalities resulting from the impact of a UAS on people on the ground.	[15]
Hazard	Condition, event or circumstance that could lead to an accident or incident.	[31]
Integrated Risk Model	Framework combining models of hazard likelihood, hazard severity and mitigation effectiveness to quantify operational risk and support decision-making.	[17]
Innovative Air Mobility (IAM)	A new mode of air transportation encompassing the movement of passengers and goods using highly automated crewed and uncrewed aircraft, enabled by advanced air traffic management, U-space services, digitalisation and automation, and integrated into the wider aviation transport system.	[2]
Mid-Air Collision (MAC)	An accident where two aircraft come into contact with each other while both are airborne.	[46]
Mitigation Effectiveness	Degree to which a mitigation measure reduces the likelihood and/or severity of a hazard.	U-AGREE
National Supervisory Authority (NSA)	The national body or bodies entrusted by a Member State with the tasks under this Regulation (EU) 2024/2803 with regards to the implementation of the Single European Sky	[47]

Operational Constraint	Limitation imposed on operations within a given airspace to achieve specific safety, security or operational objectives.	[11]
Operational Risk Assessment	Process of evaluating the risks associated with a specific operation and identifying appropriate mitigation measures.	[15]
Pre-Defined Risk Assessment (PDRA)	Risk assessment established by a competent authority for a well-defined type of operation.	[29]
Remain Well Clear (RWC)	Condition in which sufficient separation is maintained between aircraft to avoid collision risk and prevent the need for collision avoidance manoeuvres.	[45]
Risk-Based Airspace Design	Airspace design approach in which operational constraints, service requirements and airspace structures are derived from quantified risk assessments.	[11]
Risk-Based Performance Requirement	Performance requirement derived from the contribution of a service or system to achieving a specified Target Level of Safety.	[11]
Risk-Driving Data	Data describing factors that influence the likelihood and/or severity of hazards, including traffic, operational, environmental and population-related information.	U-AGREE
Risk Mitigation	Measure intended to reduce either the likelihood or the severity of a hazard.	[31]
Safety-Capacity Threshold	Level of traffic load that can be safely handled by the system. This refers strictly to the residual risk at tactical level associated with the traffic load, including the potential negative impacts of high	[10]

	local traffic densities on tactical barriers.	
Safety Risk	Assessment in terms of the predicted probability (likelihood) and severity of the consequences of a hazard.	[48]
Specific Operations Risk Assessment (SORA)	Methodology developed by JARUS to assess risks associated with UAS operations in the Specific category.	[15]
Standard Scenario (STS)	Set of predefined operational conditions and mitigation measures for a specific type of UAS operation.	[29]
Strategic Deconfliction	Process of identifying and resolving potential conflicts before flight through planning and operational constraints.	[2]
Tactical Conflict Prediction and Resolution (TCD&R)	U-space service that identifies potential conflicts and supports their resolution during flight.	[10]
Target Level of Safety (TLS)	Maximum acceptable frequency of occurrence of a safety-related event.	[15]
UAS Geographical Zone	Portion of airspace established by a Member State where UAS operations are facilitated, restricted or excluded.	[29]
U-space Airspace	UAS geographical zone designated by a Member State where U-space services are provided.	[11]
U-space Service	Service relying on digital services and automation of functions designed to support safe, secure and efficient access to U-space airspace for a large number of UAS	[11]
U-space Service Performance Requirement	Minimum level of performance required from a U-space service to	[11]

	achieve the intended risk reduction.	
U-space Service Provider (USSP)	Entity providing one or more U-space services.	[11]
Very Low Level (VLL)	Portion of airspace extending from the surface up to 500 ft above ground level.	[12]

Table 1: Glossary of terms

2.7 List of acronyms

Term	Definition
ADS-B	Automatic Dependent Surveillance–Broadcast
AEC	Airspace Encounter Category
AGL	Above Ground Level
AIP	Aeronautical Information Publication
ANSP	Air Navigation Service Provider
API	Application Programming Interface
ARA	Airspace Risk Assessment
ARC	Air Risk Class
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Services
BIM	Benefit Impact Mechanism
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
C3	Command, Control, and Communications
CA	Collision Avoidance

CAA	Civil Aviation Authority
CIS	Common Information Services
CISP	Common Information Service Provider
CMS	Conformance Monitoring Service
CNS	Communications, Navigation and Surveillance
ConOps	Concept of Operations
CTR	Controlled Traffic Region
DAA	Detect and Avoid
DAR	Dynamic Airspace Reconfiguration
DME	Distance Measuring Equipment
DRID	Direct Remote Identification
EAR	Easy Access Rules
EGNOS	European Geostationary Navigation Overlay Service
EASA	European Union Aviation Safety Agency
EATMA	European Air Traffic Management Architecture
E-SRM	Expanded Safety Reference Material
EVLOS	Extended VLOS
FAS	Flight Authorisation Service
FL	Flight Level
FTE	Flight Technical Error
GA	General Aviation
GAS	Geo-awareness service
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System

GRC	Ground Risk Class
IAM	Innovative Air Mobility
ICAO	International Civil Aviation Organization
IFR	Instrumental Flight Rules
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
KPA	Key Performance Area
KPI	Key Performance Indicator
LUC	Light UAS Certificate
MAC	Mid-Air Collision
MG	Maturity Gate
MoC	Means of Compliance
NSA	National Supervisory Authority
NSE	Navigation System Error
NIS	Network Identification Service
NRID	Network Remote Identification
OE	Operational Environment
OSD	Operational Service and Environment Definition
OSO	Operational Safety Objective
PDRA	Pre-Defined Risk Assessment
PSR	Primary Surveillance Radar
RMZ	Radio Mandatory Zone
RPAS	Remotely Piloted Aircraft Systems
RTK	Real-Time Kinematic
RWC	Remain Well Clear

SAIL	Specific Assurance and Integrity Level
sCISP	Single CISP
SERA	Standardised European Rules of the Air
SESAR	Single European Sky ATM Research
SESAR 3 JU	SESAR 3 Joint Undertaking
SID	Standard Instrumental Departure
SORA	Specific Operations Risk Assessment
SRD	Short Range Device
SRIA	Digital European Sky Strategic Research and Innovation Agenda
SSR	Secondary Surveillance Radar
STAR	Standard Arrival Route
STS	Standard Scenario
TCD	Tactical Conflict Detection
TCR	Tactical Conflict Resolution
TIS	Traffic Information Service
TLS	Target Level of Safety
TMA	Terminal Manoeuvring Area
TMPR	Tactical Mitigation Performance Requirement
TMZ	Transponder Mandatory Zone
TRL	Technology Readiness Level
TSE	Total System Error
UAM	Urban Air Mobility
UAT	Universal Access Transceiver
UAS	Unmanned Aircraft System

USSP	U-space Service Provider
VFR	Visual Flight Rules
VHF	Very High Frequency
VLL	Very Low Level
VLOS	Visual Line of Sight
VOR	VHF Omnidirectional Range
VTZ	Vertiport Traffic Zone
WIS	Weather Information Service

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 Target Level of Safety (TLS), which represents what society considers to be '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 European Union Aviation Safety Agency (EASA) has adopted the SORA developed by JARUS, with some minor modifications. However, the SORA risk models basically consider the risk of individual operations. Therefore, some adaptation or evolution is necessary so that they can support broader processes, such as the airspace risk assessment required for the designation of U-space airspace. In this context, the proposed solution represents an improvement over current ATM practices by enabling a more comprehensive and scalable assessment of risks associated with UAS operations in U-space.

Advanced integrated risk models enhance capacity, safety, and security for Unmanned Aerial Systems (UAS) operations in U-space.

Current risk models, such as the Specific Operations Safety Assessment (SORA), are essential to aviation safety but have limitations in addressing the growing complexity of drone operations within U-space. These limitations make it challenging to ensure both safety and regulatory compliance in increasingly complex operational environments, potentially slowing down the safe and scalable deployment of drone services.

The proposed solution extends existing risk assessment approaches by introducing integrated risk models tailored to U-space. These models provide a more complete understanding of risks by linking drone operations with their potential impacts, including the risk of mid-air collisions (between drones or with manned aircraft), as well as broader impacts on security, privacy, and the environment. The solution also takes into consideration how U-space services, such as strategic and tactical conflict management, can contribute to reducing these risks.

To demonstrate the benefits, fast-time, large-scale simulations in realistic scenarios representative of relevant operational environments are used to showcase how the solution supports safer, more efficient, and more accessible drone operations. The expected outcomes of this approach are:

- Increased capacity, access, and equity for drone operations in U-space.
- Improved safety and security through a more comprehensive understanding of risks.
- More efficient and consistent assessment of drone operations.
- Support to regulatory evolution and standardisation.
- Enhanced public confidence in drone operations.

The U-AGREE solution integrates risk models linking UAS operations, the hazards they are exposed to, and their effects in terms of severity and probability. These risk models are developed and validated by means of simulations. The models link UAS operations with their multidimensional effects on safety, security, privacy, and the environment in U-space airspaces.

Based on these models, the project assesses how U-space services, along with specific capabilities or performance levels of the UAS, can mitigate such effects. Additionally, the risk models support the airspace risk assessment required by European regulation and contribute to more efficient approval processes for UAS operations.



Figure 1: SESAR Solution 0520 - Integrated risk models for UAS in the U-space (U-AGREE)

SESAR solution ID	SESAR solution title	SESAR solution definition	Justification
0520	Integrated risk models for Unmanned Aerial Systems (UAS) in the U-space	This solution delivers Integrated risk models for Unmanned Aerial Systems (UAS) as an extension of the Specific Operations Safety Assessment (SORA) model in	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

		<p>U-space airspaces, which allow to more accurately link UAS operations with their multidimensional harmful effects on safety (i.e., MAC between UAS and UAS or manned aircraft), as well as mitigating infringements that might negatively impact security, privacy and the environment, taking into account the mitigating effect of U-space services (e.g., strategic/tactical deconfliction).</p> <p>Integrated risk models for Unmanned Aerial Systems (UAS) in the U-space will provide benefits in terms of increased capacity, access and equity, while having a positive impact on safety and security.</p>	<p>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 [24].</p> <p>U-AGREE aligns with the European Green Deal by contributing to the reduction of greenhouse gas emissions through increased operational efficiency.</p> <p>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.</p>
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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 with respect to the SESAR Solution definition.

3.2 Detailed operational environment

3.2.1 Operational characteristics

3.2.1.1 Operational environment

The U-AGREE project is validated within the U-space Operational Environment (OE) as defined by the PEARL framework [9] and aligned with the SESAR2020 Operating Environment structure [5]. The operational and technical context addressed corresponds to airspace volumes supporting Unmanned Aircraft Systems (UAS) and initial Innovative Air Mobility (IAM) operations, where static or dynamic segregation may be required and where appropriate U-space services are provided.

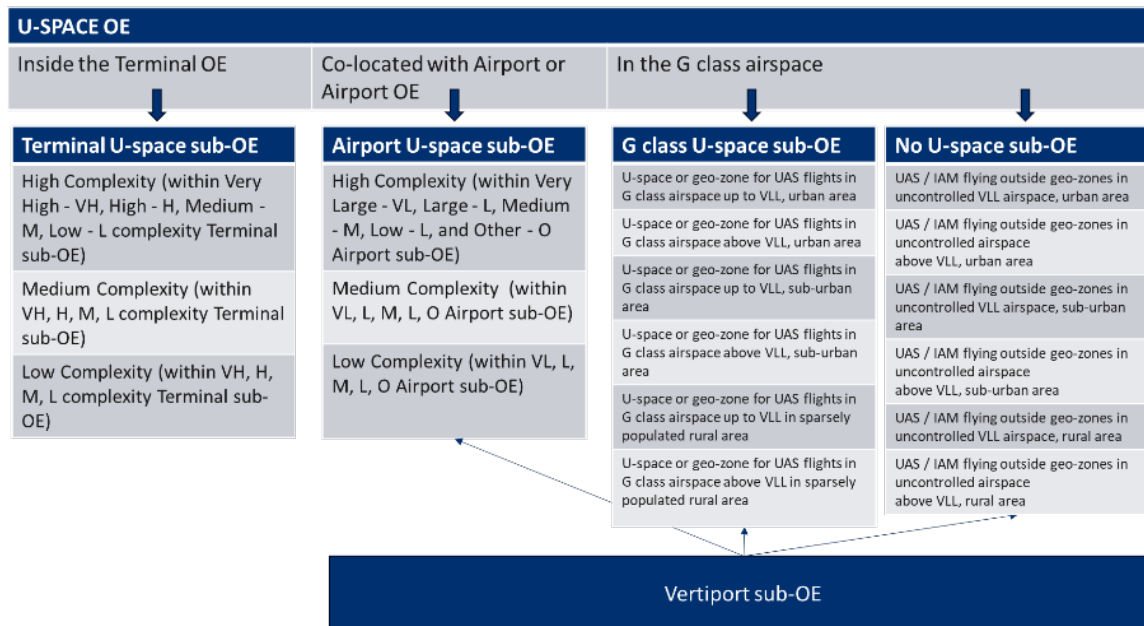


Figure 2: U-space operating environment (PEARL project [9])

In accordance with PEARL definitions, U-space airspaces and other geographical zones are considered equivalent to restricted areas according to the International Civil Aviation Organisation (ICAO) airspace terms, requiring dedicated procedures and services to ensure safe coexistence with manned aviation. The addressed operational environments encompass different levels of service support, ranging from environments where U-space services are available and coordinated with Air Traffic Services (ATS), to environments without U-space service provision, relying primarily on procedural rules and operator-based situational awareness.

The operational environment is defined not only by the airspace characteristics but also by the set of services available within it, ATS, U-space services, or the absence of such services.

The operational environment considered in U-AGREE is characterised by:

- Operations in Class G airspace, as well as portions of controlled terminal airspace – usually class C or D in Europe;
- Flight operations conducted both below and above VLL;
- Different ground urbanisation levels, including dense urban, mixed urban–suburban, and sparsely populated rural areas;
- Proximity to aerodromes and controlled airspace, introducing interactions with manned aviation procedures;
- Mixed traffic environments involving UAS and manned aircraft.

Depending on altitude, surrounding airspace structure, and traffic density, the prevailing safety concern may shift between ground-related risk (particularly relevant below VLL in urbanised areas) and air-related risk (notably above VLL and in the vicinity of controlled airspace or aerodrome traffic zones).

3.2.1.1.1 Overview of sub-operating environments in scope

Based on the PEARL classification, U-AGREE addresses the following sub-operational environments (Sub-OE):

G Class U-space sub-operating environment

This sub-operating environment corresponds to U-space airspace established within uncontrolled Class G airspace, covering urban, sub-urban and sparsely populated rural environments at both VLL and above-VLL operations.

From a technical perspective, this sub-OE assumes the availability of U-space services supporting traffic information exchange, airspace awareness and conflict management, while accommodating different ground risk profiles driven by population density and land use. This sub-operating environment constitutes the primary context for large-scale UAS deployment and enables the assessment of the proposed capabilities under varying operational complexities within uncontrolled airspace.

Terminal U-space sub-operating environment

This sub-operating environment includes U-space airspace established within portions of controlled airspace, such as control zones (CTR) or terminal areas (TMA), under the responsibility of ATS operational units.

It is characterised by closer interaction with manned aviation, the presence of structured arrival and departure procedures, and increased airspace complexity. In this environment, U-space services coexist with ATS-provided services, requiring procedural consistency and information coordination to support safe operations.

G Class no U-space sub-operating environment

This sub-operating environment represents volumes of uncontrolled Class G airspace outside U-space or other geographical zones, where UAS operations are conducted without dedicated U-space service provision.

It includes urban, sub-urban and rural environments at both VLL and above-VLL altitudes and absence of U-space specific service support. The inclusion of this sub-OE allows U-AGREE to assess the applicability and robustness of the proposed capability in environments where U-space service provision is unavailable, thus providing a baseline for future deployment phases and operational contexts.

3.2.1.1.2 Detailed description of the identified sub-operating environments.

The sub-operating environments identified in Section 3.2.1.1.1 are described in terms of the following factors:

- Airspace characteristics.
- Traffic.
- Environmental conditions.
- Hazards and risks.

Airspace characteristics

G Class no U-space and U-space sub-operating environments

Class G is the most usual type of low-altitude airspace. No Air Traffic Service other than Flight Information is provided there to either Instrumental Flight Rules (IFR) or Visual Flight Rules (VFR) manned operations. Both U-space and no U-space sub-operating environments defined in class G airspace will be laterally surrounded by either class G or class C/D airspace when they are close to aerodromes or terminal areas.

The VLL airspace used as a reference for the definition of the ceiling of U-space airspaces has been defined by the CORUS project [12] as the airspace, from the surface upwards, in which manned aviation is not expected to operate except when necessary for take-off or landing, or with the permission of the competent authority.

This limit can be quantified according to the Standardised European Rules of the Air (SERA) [25]:

SERA.5005 f

Except when necessary for take-off or landing, or except by permission from the competent authority, a VFR flight shall not be flown:

- (1) over the congested areas of cities, towns or settlements or over an open-air assembly of persons at a height less than 300 m (1000 ft) above the highest obstacle within a radius of 600 m from the aircraft;*
- (2) elsewhere than as specified in (1), at height less than 150 m (500 ft) above the ground or water, or 150 m (500 ft) above the highest obstacle within a radius of 150 m (500 ft) from the aircraft.*

Since the SERA defines different lower limits for VFR operations depending on the land use of the overflown area, specific VLL values should be used for urban/suburban areas (1) and rural (2) areas as illustrated in Figure 3.

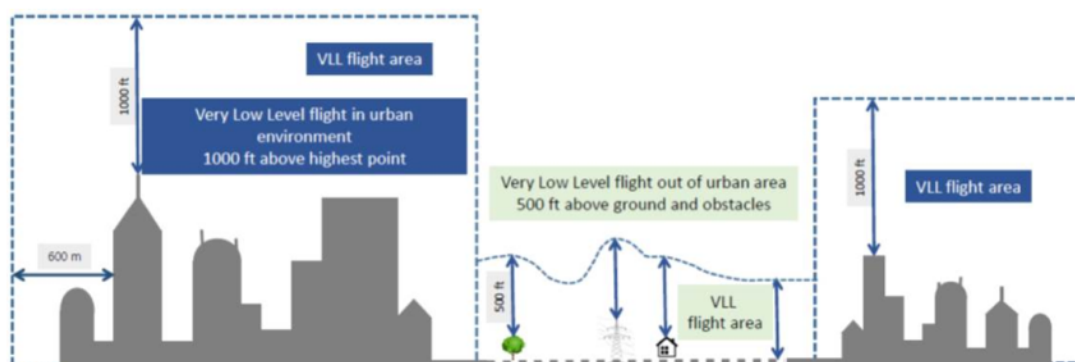


Figure 3. VLL Flight Areas (Source: ED-267 [50].)

On the other side, the EASA recommends in the Easy Access Rules (EAR) for the U-space [26] that U-space airspaces are designated by Member States in the short term below 150 m (500 ft) above the ground or water level (which roughly corresponds to the lower VFR limit in rural areas according to the SERA [25] and is quite more conservative than that limit in urban areas). Nonetheless, nothing

precludes national civil aviation authorities (CAA) from designating U-space airspaces above such limit. In fact, the same Agency envisages that as the U-space framework evolves, U-space airspaces could be extended above the 500 ft limit. Due to the lack of an agreed definition of the VLL limit, U-AGREE adopts the more conservative figure derived from the EAR for U-space, namely 150 m (500 ft).

When extended above the VLL, U-space airspaces designated within Class G airspace will be bounded by the lower limit of the overlying controlled airspace. While there are no uniform criteria, in practice CTRs are controlled from the surface, whereas TMAs have stepped lower limits that typically range from about 1,000 ft to 5,000 ft depending on the sector. These areas are usually classified as Class C or D. Class A at lower altitudes is rare in Europe and mainly found in specific TMAs (e.g. London TMA) or in upper airspace, but not in CTRs. Class E is commonly used outside CTRs and TMAs in some European countries, though its use is not uniform across Europe. A buffer, tailored to reduce the risk of mid-air collision arising from interactions between UAS and manned IFR aircraft operating near the upper bound of U-space, should be applied.

Currently, there are no agreed fixed structures in Class G airspaces. With the roll out of the U-space, two types of structures are envisaged in the CORUS Concept of Operations (ConOps) Ed. 4.0 [2]

- Layers, with a similar purpose than Flight Levels (FL) in manned aviation: facilitating the vertical separation between aircraft and ordering the traffic flow by allocating specific layers to aircraft with similar performance, thereby supporting more efficient lateral separation.
- Fixed 4D routes or corridors between specific locations to facilitate, for instance, urgent transportation of medical assets between hospitals, or Urban Air Mobility (UAM) between urban vertiports. These routes could be permanent (e.g., for UAM purposes) or activated on demand (e.g., a medical emergency). Type #2 UAS operations under the EASA certified category will be conducted along pre-defined routes in U-space airspaces, according to the Agency's regulatory roadmap [27].

Terminal U-space sub-operating environment

Terminal U-space airspaces are primarily designated within controlled airspace, typically Class C or D, and in certain cases Class A in the vicinity of major airports. It may extend into the surrounding low-level airspace, which is commonly Class G. Instrument procedures tend to concentrate IFR traffic along predefined flight paths within Terminal Areas. VFR operations are conducted in accordance with published visual flight procedures and aerodrome information. Contingency procedures, such as missed approach procedures, are also defined and apply to specific segments of the CTR and TMA.

Concerning the U-space airspace structure, layers and corridors can be used in Terminal U-spaces for the same purposes as in the case of Class G U-space airspaces. Furthermore, the U-space airspace should be defined as an assemble of volumes that can be individually deactivated to facilitate the application of the Dynamic Airspace Reconfiguration (DAR), as detailed in Section 3.2.3.

Traffic characteristics

Manned air operations must follow either Instrumental Flight Rules (IFR) or Visual Flight Rules (VFR), as defined by the ICAO Annex 2 [28] and in SERA [27]. VFR flights are conducted with visual reference to the external environment, enabling pilots to maintain separation from other aircraft and obstacles, unless they are flying in airspace classes A-C. IFR flights are conducted in accordance with instrument

procedures and Air Traffic Control (ATC) clearances, using onboard CNS systems, with separation and obstacle clearance ensured through the ATM system and published minima.

According to the EU regulation [29], UAS operations may be conducted under visual line of sight (VLOS), extended visual line of sight (EVLOS), or beyond visual line of sight (BVLOS). Under VLOS, the remote pilot maintains continuous unaided visual contact with the unmanned aircraft, enabling direct control of its flight path and the expected ability to avoid collisions with other aircraft, people and obstacles. Under EVLOS, the remote pilot maintains situational awareness of the surrounding airspace through one or more visual observers, who provide visual surveillance of the aircraft, while retaining direct control of the UAS. Under BVLOS, operations are conducted without continuous visual contact, relying instead on onboard systems and external services to ensure safe navigation, separation and collision avoidance.

Commission Implementing Regulation (EU) 2019/947 [14] defines three categories of UAS operations with increasing level of risk: (1) open, (2) specific, and (3) certified. Lowest risk operations in the open category can be conducted without previous operational authorisation, but meeting specific operational conditions that lead to three subcategories:

- A1: Operations close to people using C0 and C1 UAS, with very low mass/energy. C0 may be flown over people; C1 allows only incidental overflight of uninvolved persons but no intentional flight over crowds.
- A2: Operations close to people using C2 UAS, requiring a minimum horizontal separation from uninvolved persons (typically 30 m, reducible to 5 m in low-speed mode).
- A3: Operations away from people using C3 and C4 UAS, requiring operations in areas free from uninvolved persons and at a safe distance from residential, commercial, industrial, and recreational areas.

Operations in the certified category encompass those taking place over assemblies of people using UAS with a characteristic dimension of more than 3 meters, carrying people or dangerous goods. UAS used in certified operations are subject to certification according to Commission Delegated Regulation (EU) 2019/945 [30]. The EASA envisages three types of UAS operations in the certified category [27]:

- Type #1: International flight of certified cargo drones conducted IFR in airspace classes A-C and taking off and landing at aerodromes.
- Type #2: Drone operations in urban or rural environments using pre-defined routes in airspaces where U-space services are provided. This includes operations of unmanned drones carrying passengers (e.g., air taxis) or cargo (e.g., parcel delivery).
- Type #3: Operations as in type #2 but conducted VFR with VTOL capable aircraft with a pilot on board. Air taxi operations will be conducted under type #3 in the short to mid-term.

Operations that do not fall within the open or certified categories are classified as **specific**. In this category, operations are subject to a risk-based approach, requiring an operational authorisation from the competent authority. The authorisation process relies on the SORA methodology developed by JARUS, which results in a Specific Assurance and Integrity Level (SAIL) ranging from I to VI. For practical reasons, SAIL levels are commonly grouped into low (I–II), medium (III–IV), and high (V–VI) risk categories.

Manned traffic characteristics in G Class sub-operating environments (both U-space and no-U-space).

Manned traffic characteristics in uncontrolled airspace (Class G) are primarily driven by altitude-dependent operational practices, proximity to terminal areas, and the surrounding environment. Significant differences are observed between operations below and above the VLL, defined as 500 ft above ground level in the U-AGREE context, as well as between rural and urban/semi-urban contexts and between Class G airspace located in the vicinity of terminal areas and more isolated regions. The operational environment is characterised by the absence of positive control, a high degree of operational flexibility, and variability in traffic composition, behaviour and performance.

Below VLL (≤ 500 ft), traffic is almost exclusively conducted under VFR and is typically associated with specialised operations such as aerial work, emergency services, and helicopter activities. In isolated Class G areas, particularly in rural environments, traffic density is very low, and operations are highly mission-driven (e.g. agriculture, infrastructure inspection), resulting in variable, non-linear trajectories and low predictability. In contrast, in Class G airspace located near terminal areas, particularly in urban and semi-urban environments, traffic may be locally more concentrated due to helicopter operations and other low-level activities interfacing with terminal traffic. While the operational environment remains weakly structured in both cases, complexity in isolated areas is primarily driven by trajectory variability and limited situational awareness, whereas in areas close to terminal airspace it is additionally influenced by traffic convergence, environmental constraints, and the need to operate in proximity to more structured flows. Aircraft typically operate at low speeds, generally below 120–140 knots.

Above VLL (> 500 ft), Class G airspace accommodates a broader mix of traffic, predominantly under Visual Flight Rules (VFR), with a proportion of IFR operations, particularly for transit to and from controlled airspace. In isolated Class G environments, traffic density remains low and spatially dispersed (although subject to seasonal variations in some cases), with relatively stable en-route trajectories and limited interaction between aircraft. The resulting complexity is low to moderate and mainly driven by traffic heterogeneity rather than interaction intensity. Conversely, in Class G airspace located in the vicinity of terminal areas, traffic density is typically higher, with increased interaction between VFR traffic (including training and leisure flights) and IFR traffic entering or exiting controlled airspace. This leads to a more dynamic and interaction-driven environment, with reduced predictability and tighter margins. The operational environment becomes moderately structured due to the influence of nearby terminal flows, although it remains less constrained than controlled airspace. The traffic mix is heterogeneous, including light aircraft, helicopters, turboprops and occasional jets, resulting in a wide range of operating speeds, typically between 100 and 250 knots.

Manned traffic characteristics Terminal U-space sub-operating environments.

Manned traffic characteristics in sub-operating environments defined in terminal areas heavily depend on the terminal's complexity. Very High Complexity Terminal Airspace Operating Environments are characterised by traffic conducted almost entirely under IFR, with VFR traffic being negligible or operationally segregated. Traffic demand is extremely high, resulting in continuous arrival and departure flows and sustained peak traffic conditions. The operational environment is highly structured, with multiple converging and diverging trajectories associated with multi-runway

operations. Complexity is primarily driven by the intensity of interactions between aircraft and the need for tightly constrained sequencing with reduced separation margins. The traffic mix is largely homogeneous and dominated by jet aircraft, operating at relatively high speeds, typically in the range of 220 to 300 knots, with extensive use of speed management to maintain stable and predictable flows.

High Complexity Terminal Airspace Operating Environments are characterised by predominantly IFR traffic, with a limited presence of VFR and general aviation operations. Traffic demand is high, with recurrent peak periods and structured traffic flows, although not continuously saturated. The operational environment includes interacting arrival and departure streams and is influenced by runway configuration constraints. The traffic mix includes both jet and turboprop aircraft, leading to moderate heterogeneity in performance. Aircraft typically operate at speeds between 180 and 280 knots, requiring dynamic sequencing and speed adjustments to ensure efficient flow management.

Medium Complexity Terminal Airspace Operating Environments are characterised by a balanced mix of IFR and VFR operations, with a significant contribution from regional and general aviation traffic. Traffic demand is moderate and variable over time, resulting in non-continuous and less structured traffic flows. The operational environment exhibits increased variability in aircraft trajectories and operational intent. Complexity is driven less by traffic density and more by heterogeneity in aircraft performance and behaviour. The traffic mix comprises regional jets, turboprops and light aircraft, resulting in a wider dispersion of operating speeds, typically between 120 and 250 knots.

Low Complexity Terminal Airspace Operating Environments are characterised by low traffic demand, with sporadic or isolated aircraft movements. Operations typically include a mix of IFR and VFR traffic, often with a strong presence of general aviation. The operational environment is weakly structured, with limited interaction between aircraft, although localised increases in complexity may occur in specific situations such as training activities. The traffic mix is primarily composed of light aircraft and turboprops, operating at relatively low speeds, generally between 80 and 180 knots, with only occasional higher-speed IFR traffic.

Unmanned traffic characteristics in G Class no U-space sub-operating environment.

In Class G environments without U-space services, UAS traffic is characterized by low density and operations predominantly conducted under Visual Line of Sight (VLOS) within the Open category (A1-A3). Safe interaction with manned aircraft relies entirely on the remote pilot's "see and avoid" capability. Beyond Visual Line of Sight (BVLOS) operations are exceptional and require specific SORA authorizations with low SAIL levels (I-II). Trajectory predictability is minimal as flights are largely tactical or mission-driven without centralized digital supervision.

Unmanned traffic characteristics in G Class U-space sub-operating environment.

The implementation of foundational U-space services, specifically Flight Authorization (FAS), Network Identification (NIS), and Geo-awareness, enables a more structured environment.

- **Short-term (2030-2045):** Traffic is limited to **Low and Medium complexity** (up to 401 movements per day, according to [9]). Operations are a mix of VLOS and BVLOS, primarily within the Specific category.
 - **Urban/Sub-urban:** Higher concentration of delivery (including medical cargo) and security operations, requiring tighter geo-fencing and strategic deconfliction.

- **Rural:** Focus on linear inspections and agriculture with lower interaction levels. Despite the distributed nature of operations, strategic coordination remains necessary for extended BVLOS trajectories.
- **Mid-term (beyond 2045):** Evolution towards **High and Very High complexity** (>401 movements per day) with increasing levels of automation.

Unmanned traffic characteristics in Terminal U-space sub-operating environment.

Traffic characteristics in Terminal U-space are defined by the volume of daily movements and the technical feasibility according to the regulatory horizon [11], [9].

- **Short-term (2030)**
 - **High complexity: Not Applicable (N/A).** Based on EU Regulation No 2021/664 and PEARL common assumptions, operations **exceeding 400 movements/day** are not considered safely feasible for the 2030 horizon.
 - **Medium complexity:** Characterized by **121 to 401 movements per day**. Traffic consists of a mix of regional logistics and specialized aerial work. Coordination with manned IFR/VFR terminal flows is mandatory, often requiring prioritized access for manned emergency or commercial traffic.
 - **Low complexity:** Characterized by **0 to 120 movements per day**. Sporadic or isolated UAS movements, primarily in the vicinity of smaller regional aerodromes, with limited interaction and simple deconfliction requirements.
- **Mid-term (2045)**
 - **High complexity:** Characterized by **401 to 700 movements per day**. This environment involves high-density, highly structured UAS flows. It requires advanced coordination and traffic management capabilities to ensure the safe integration of dense unmanned traffic with high-intensity manned IFR arrival and departure operations.
 - **Medium complexity: 121 to 401 movements per day.** Evolution towards more autonomous and predictable trajectories compared to the short-term.
 - **Low complexity: 0 to 120 movements per day.** Similar to short-term volumes but with improved integration and situational awareness through mature U-space services.

Environmental conditions

Weather

Weather is a cross-cutting factor that affects all the sub-operating environments within the scope of U-AGREE. Due to the particular characteristics of unmanned aircraft, they are heavily impacted by challenging weather conditions. According to the Commission Implementing Regulation (EU) 2021/664, weather elements that can affect UAS airworthiness encompass:

- **Wind conditions:** Wind direction (clockwise from true north) and speed (m/s), including gusts.
- **Visibility and cloud conditions:** Visibility (in metres or kilometres) and cloud ceiling (height of the lowest broken or overcast layer above ground level).
- **Thermodynamic conditions:** Air temperature and dew point.

- **Weather phenomena:** Indicators of convective activity and precipitation.
- **Pressure conditions:** QNH, including the geographical area of applicability.

Most of these parameters constitute key environmental factors affecting all sub-operating environments considered in the project. However, wind conditions in urban environments may present additional challenges due to the interaction between atmospheric flow and the built environment. This interaction can induce complex flow phenomena such as mechanical turbulence, wind shear, channelling effects along urban canyons, and the formation of vortices around obstacles. As a result, wind fields at very low levels are highly heterogeneous, with local accelerations and frequent gusts that differ significantly from the more laminar and predictable conditions typically observed in open or rural or sub-urban areas. These effects reduce the predictability of wind conditions and may have a direct impact on operational performance and stability, particularly for low-altitude operations.

The electromagnetic environment

The electromagnetic environment across the considered sub-operating environments is characterised by the superposition of multiple emission sources, whose density, power and variability depend on the surrounding context (urban or rural), altitude, and proximity to terminal areas. These factors determine the overall spectral occupancy, noise floor and susceptibility to interference.

In **urban environments**, the electromagnetic environment is dominated by a high density of emitters, including cellular networks, short-range devices and unintentional radiators, resulting in broad spectral usage and strong spatial and temporal variability. In **rural environments**, the density of emitters is lower, and the environment is generally more homogeneous; however, high-power sources such as broadcasting transmitters and high-voltage electrical infrastructure may generate locally significant emissions and contribute to the noise floor.

In areas near or within **terminal airspace**, both urban and rural environments are further influenced by aeronautical systems, which introduce structured and often high-intensity emissions in specific frequency bands. These sources can locally dominate the radiofrequency environment and increase spectral congestion, particularly in zones of traffic convergence. In contrast, isolated environments far from terminal areas exhibit lower spectral occupancy and fewer interaction effects, although localised emissions may still occur due to high-power infrastructure.

At **very low altitudes**, the electromagnetic environment is more dynamic and less predictable due to proximity to ground-based sources and the influence of obstacles, which may introduce shadowing and multipath effects. In this context, all environments are more vulnerable to intentional interference phenomena such as **jamming and spoofing**, particularly affecting GNSS-based positioning and navigation. Urban and terminal-adjacent environments are especially susceptible due to high emitter density and signal distortion, while rural environments may experience localised but potentially strong interference from high-power sources. Jamming may degrade or interrupt signal reception, whereas spoofing may introduce misleading information, increasing uncertainty in navigation performance.

Overall, the electromagnetic environment ranges from **dense, heterogeneous and highly variable** in urban and terminal contexts to **sparser, more homogeneous but locally influenced** in rural and isolated areas, with varying levels of exposure to interference and intentional disruption.

Wildlife

Smaller aircraft in VLL operations are more vulnerable to wildlife strikes than conventional aviation due to flying at wildlife-abundant heights during all of their flights and due to smaller or even no requirements to prove impact resistance. Drones and eVTOLs emit little noise, hence, it is more difficult for wildlife to perceive these airspace users as potential opponents and initiate timely avoidance manoeuvres. Some territorial species even may perceive these slow, quiet and small flying objects as intruders and actively attack them.

On a different note, from the aviation environmental impact point of view, given the limited impact requirements for electric Vertical Take-off and Landing aircraft (eVTOL), not to speak of smaller drones without such requirements, combined with their low-level flight altitudes, a large number of adverse effects for wildlife has to be expected for their operations. These can be dangerous for wildlife if crossing migration paths. Along the day, can be dangerous for bats or for wildlife that fly from the places where they look for food to their nesting area and vice versa. Besides, many operations of drones and eVTOLs lead over urban areas which further increases the overall risk of wildlife strikes, since these areas are attractive to many wildlife species.

Hazards and risks

Identification of hazards.

The ICAO defines a hazard as *“a condition or an object with the potential to cause or contribute to an aircraft incident or accident”* [31]. The ICAO details the hazards an aircraft must be separated from in the Global ATM Operational Concept (GATMOC) [32], which encompass:

- other aircraft,
- terrain,
- weather,
- wake turbulence,
- incompatible airspace activity and,
- when the aircraft is on the ground, surface vehicles and other obstructions on the apron and manoeuvring area.

Since U-AGREE does not address Vertiport or Airport U-space sub-operating environments, it is assumed that wake turbulence generated by manned aircraft or large Remotely Piloted Aircraft Systems (RPAS) powered by conventional fuel engines will not affect UAS operating within the considered U-space airspaces.

This assumption is supported by the operational context: in Terminal U-space sub-operating environments, heavy IFR traffic is expected to remain segregated from UAS operations. Similarly, in U-space airspaces located within uncontrolled Class G airspace, the separation distances maintained between lighter VFR traffic and UAS for safety purposes are considered sufficient to prevent any adverse effects from wake turbulence.

This assumption is made in light of the current lack of sufficient data to support a comprehensive assessment and should therefore be revisited in future research activities.

With regard to hazards associated with apron and manoeuvring areas, these are considered outside the scope of U-AGREE, as the project does not address either the Vertiport or Airport sub-operating environments.

Conversely, given that UAS operations are expected to take place at lower altitudes and in closer proximity to the surface than manned aviation, terrain, buildings, and other obstacles constitute relevant sources of collision risk. Nevertheless, the modelling of such hazards is highly dependent on the availability of accurate and up-to-date geographical and obstacle data, which are often unavailable or incomplete. Consequently, obstacle- and terrain-related hazards are not explicitly considered within the U-AGREE risk assessment framework and are instead identified as an area requiring further investigation.

Considering these assumptions, U-AGREE has identified the list of hazards presented in Table 4.

Hazard ID	Description
HAZ01	UAS loss of control resulting in a crash into the ground.
HAZ02	UAS conflicting trajectories resulting in a Mid-Air Collision (MAC) and a subsequent crash into the ground.
HAZ03	UAS and manned aircraft conflicting trajectories resulting in a MAC in uncontrolled airspace.
HAZ04	UAS and manned aircraft conflicting trajectories resulting in a MAC in controlled airspace.
HAZ05	UAS infringement of airspace-wide or geographical zone-specific constraints.
HAZ06	Wildlife strike on an airborne UAS.

Table 4: Hazards inherent to aviation identified by U-AGREE according to the GATMOC

HAZ01 and HAZ02 address the hazard posed by UAS operations to people on the ground, as well as to critical infrastructures. HAZ03 and HAZ04 represent the hazard UAS pose to manned aircraft. HAZ05 covers a broad range of hazards, since UAS geographical zones can be defined by a number of reasons (safety, security, environment and/or privacy).

Since U-AGREE focuses on risks that can be mitigated by means of the provision of U-space services, HAZ01 falls out of the project's scope. In the case of the Specific category, this hazard is managed by means of SORA assessments, whereas for Certified operations the risk is mitigated through the certification process. This risk is considered negligible for operations in the open category. The risk posed by HAZ02 to HAZ06 can be effectively mitigated by using U-space services with a given level of performance.

In addition to the hazards, U-AGREE has identified abnormal conditions that can make the accidents provoked by the hazards in Table 4 more likely. Notice that weather has been identified as an abnormal condition that contribute to the loss of control rather than a hazard.

Ab. cond. ID	Description
ABN01	Adverse weather conditions affect the capability of the UAS to fly the intended trajectory.
ABN02	Adverse communication conditions affect the capability of the remote pilot to control the UAS.
ABN03	Adverse GNSS conditions affect the capability of the remote pilot to control the UAS.
ABN04	Adverse communication conditions affect the capability of providing U-space services with the required performance.
ABN05	Adverse GNSS conditions affect the capability of providing U-space services with the required performance.
ABN06	A manned aircraft in state of emergency enters the U-space airspace.
ABN07	Adverse weather conditions (e.g., high temperature, low humidity and strong wind) can amplify the consequences of a UAS ground impact by increasing the likelihood and severity of secondary effects such as wildfires.

Table 5: Abnormal conditions identified by U-AGREE

Risk-driving factors.

While hazards are qualitative by nature, risk consists of the quantification of the level of harmfulness of the effects of accidents or incidents caused by the hazards. Risk is estimated as a combination of likelihood and severity. In aviation, severity is usually measured as the number of airborne fatalities resulting from an accident. However, in the case of UAS, as most of the operations will not involve the transportation of people, the harmful effect to people on the ground affected by a UAS accident is the predominant effect, although in some cases damage to property or disruptions in the provision of critical services needs also to be considered.

U-AGREE has identified different factors that govern both the severity and the likelihood of accidents due to the hazards in Table 4, that can be aggravated under the abnormal conditions listed in Table 5. Factors that influence the likelihood of an accident are listed in Table 6, while those affecting the severity of the accident are listed in Table 7.

ID	Factors impacting accident likelihood	Description	Categories/Scale
1	Variability of UAS Types	Measures the diversity of UAS capabilities and its impact on traffic management.	<ul style="list-style-type: none"> - Low Variability: Simplifies management. - Medium Variability: Occasional adjustments needed. - High Variability: Requires complex strategies for overtaking and trajectory adjustments.

ID	Factors impacting accident likelihood	Description	Categories/Scale
2	CNS capabilities in the area	Support infrastructure available for UAS in terms of communication, navigation, and surveillance.	<ul style="list-style-type: none"> - 5G. - GNSS. - Others, e.g., radar systems, as per aeronautical and environmental needs outlined in the ARA framework.
3	Air Traffic Density for UAS	Level of concentration of UAS in specific areas	<ul style="list-style-type: none"> - 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.
4	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.	<ul style="list-style-type: none"> - 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 manned aviation, demanding active deconfliction measures and coordination protocols.
5	Airspace Type	Defines the level of regulation and control in the area of operation.	<ul style="list-style-type: none"> - 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.
6	Weather Conditions	Climatic factors that may affect UAS operations.	<ul style="list-style-type: none"> - 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.
7	Type of Mission Permitted	Level of automation authorized for UAS operations in the area.	<ul style="list-style-type: none"> - 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

ID	Factors impacting accident likelihood	Description	Categories/Scale
			for more range than VLOS but not as extensive as BVLOS.
8	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).	<ul style="list-style-type: none"> - 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.
9	Flexibility of U-plans	Assesses whether the UAS operation's U-plan is fixed for the entire mission duration or has undefined segments requiring dynamic adjustments based on environmental conditions or operational objectives.	<ul style="list-style-type: none"> - 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), requiring real-time adjustments and replanning as per operational needs.
10	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.	<ul style="list-style-type: none"> - 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.

Table 6: Factors impacting accident likelihood – U-AGREE

ID	Factors impacting accident severity.	Description	Categories/Scale
1	Types of UAS allowed to operate	Classification of permitted UAS in the area based on size,	<ul style="list-style-type: none"> - Micro ($\leq 250g$). - Small (250g - 2kg).

ID	Factors impacting accident severity.	Description	Categories/Scale
		weight, and operational capability.	<ul style="list-style-type: none"> - Medium (2kg - 25kg). - Large (> 25kg).
2	Population Density	Level of concentration of people in the operational area.	<ul style="list-style-type: none"> - 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 stringent safety protocols and possibly limiting UAS operations.
3	Type of Environment	Classification of the area based on urbanization and land use.	<ul style="list-style-type: none"> - Residential: Predominantly housing and local services. - Agriculture/forest: Rural areas with limited infrastructure, comprising cultivated or natural land, and characterised by weather-dependent flammability. - 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.
4	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.	<ul style="list-style-type: none"> - 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.
5	Presence of Critical or Restricted Areas	Identification of sensitive infrastructure that may require additional security measures.	<ul style="list-style-type: none"> - Hospitals: Health facilities where UAS operation might pose risks or disrupt sensitive environments. - Airports: High-risk areas requiring strict separation of UAS operations. - Data Centres: Critical infrastructure with increased security protocols. - Energy Infrastructure: Facilities essential for

ID	Factors impacting accident severity.	Description	Categories/Scale
			<p>power distribution, often protected by regulations.</p> <ul style="list-style-type: none"> - 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.
6	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.	<ul style="list-style-type: none"> - 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.
7	Transport of dangerous goods	Evaluates whether the operation involves the transport of dangerous goods.	<p>From Commission Implementing Regulation (EU) 2019/947, Art. 2(11): (a) explosives (mass explosion hazard, blast projection hazard, minor blast hazard, major fire hazard, blasting agents, extremely insensitive explosives); (b) gases (flammable gas, non-flammable gas, poisonous gas, oxygen, inhalation hazard); (c) flammable liquids (flammable liquids; combustible, fuel oil, gasoline); (d) flammable solids (flammable solids, spontaneously combustible solids, dangerous when wet); (e) oxidising agents and organic peroxides; (f) toxic and infectious substances (poison, biohazard); (g) radioactive substances; (h) corrosive substances.</p>

Table 7. Factors impacting accident severity– U-AGREE

Risk-driving factors in G Class no U-space sub-operating environment.

In this environment, risk is characterized by a lack of digital infrastructure and a reliance on the remote pilot's visual capabilities.

- **Factors impacting accident likelihood:**

- **CNS capabilities (ID 2 in Table 6):** Limited to basic GNSS; absence of network identification, C2 relying on dedicated radio links. Linked to ABN02 and ABN03 impacting HAZ02, HAZ03 and HAZ05.
- **Weather Conditions (ID 6 in Table 6):** High vulnerability to unexpected wind or visibility changes due to lack of real-time local weather data. Linked to ABN01 impacting HAZ02, HAZ03 and HAZ05.
- **Type of Mission (ID 7 in Table 6):** Predominance of VLOS; risk increases significantly in exceptional BVLOS missions without technical mitigations. Linked to HAZ02, HAZ03 and HAZ05.
- **Flexibility of Flight Plan (ID 9 in Table 6):** High; trajectories are often tactical and uncoordinated, leading to low predictability. Linked to HAZ02, HAZ03 and HAZ05.
- **Factors impacting accident severity:**
 - **UAS Size and Kinetic Energy (ID 1 in Table 7):** Typically focused on small/medium UAS (Open category). Linked to HAZ02 impacted by ABN02 and ABN03.
 - **Population Density (ID 2 in Table 7):** Generally low (rural/isolated areas), which inherently limits the ground risk. Linked to HAZ02 impacted by ABN02 and ABN03
 - **Type of Environment (ID3 in Table 7):** Agricultural or natural spaces with minimal protective structures. Linked to HAZ02 impacted by ABN02, ABN03 and ABN07

Risk-driving factors in G Class U-space sub-operating environment.

This environment introduces higher complexity due to urban density and the variety of automated services.

- **Factors impacting accident likelihood:**
 - **CNS capabilities (ID 2 in Table 6):** Reliance on 5G and Network Identification; risk of signal shielding or RF interference in urban canyons. Linked to ABN02, ABN03, ABN04 and ABN 05 impacting HAZ02, HAZ03 and HAZ05.
 - **Air Traffic Density – UAS (ID 3 in Table 6):** High concentration of operations increases the frequency of potential conflicts. Linked to HAZ02 and HAZ03.
 - **Operational Diversity (ID 8 in Table 6):** Multiple mission types (logistics, security, HEMS) operating simultaneously Linked to HAZ02 and HAZ03.
 - **Operational priority (ID10 in Table 6):** Operations conducted under under FCFS (First Come, First Served) or priority rules. Linked to HAZ02.
- **Factors impacting accident severity:**
 - **Population Density (ID 2 in Table 7):** Medium to high; increased exposure of uninvolved persons. Linked to HAZ02.
 - **Sheltering Factor (ID 4 in Table 7):** Variable; risk is higher in open public squares (low sheltering) compared to dense residential blocks with robust roofing. Linked to HAZ02.
 - **Presence of Critical Areas (ID 5 in Table 7):** Proximity to data centres, hospitals, and energy distribution points. Linked to HAZ02.

Risk-driving factors in Terminal U-space sub-operating environment.

Risk in this sub-OE is driven by the critical interface between unmanned systems and commercial/manned aviation.

- **Factors impacting accident likelihood:**
 - **Variability of UAS Types Airspace Type (ID 1 in Table 6):** High heterogeneity in performance (speed and climb rates) making separation management more complex. Linked to HAZ03 and HAZ04.
 - **Coexistence with Manned Aviation (ID 4 in Table 6):** High probability of interaction with commercial IFR flows and VFR training flights. Linked to HAZ03 and HAZ04.
 - **Airspace Type (ID 5 in Table 6):** Controlled environment where any UAS deviation poses a high risk to ATM operations. Linked to HAZ03 and HAZ04.
 - **Operational Priority (ID 11 in Table 6):** Frequent presence of urgent missions (e.g., medical transport or emergency response) that require immediate restructuring of other flight plans. Linked to HAZ03 and HAZ04.
- **Factors impacting accident severity:**
 - **UAS Size and Kinetic Energy (ID 1 in Table 7):** Potential use of larger, certified UAS for cargo or passenger transport (Type #2/#3), increasing the kinetic energy in case of impact. Linked to HAZ02, HAZ03 and HAZ04.
 - **Presence of Critical Areas (ID 5 in Table 7):** Proximity to airport runways, fuel farms, and navigation aids (ILS/VOR). An incident here can lead to massive service disruptions. Linked to HAZ05.
 - **Transport of Goods (ID 6 in Table 7):** Risks associated with the release of cargo (e.g., medical supplies or parcels) over sensitive airport perimeter areas. Linked to HAZ03 and HAZ04.

3.2.1.2 Key operational characteristics

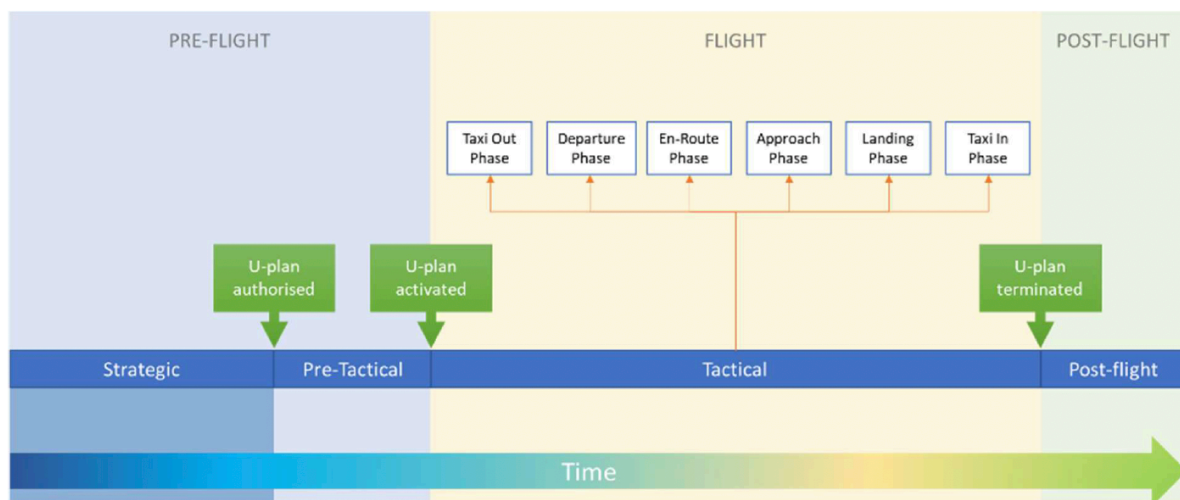


Figure 4. Timeline of a UAS operation, according to the CORUS five ConOps [10]

Figure 4 illustrates the different phases that make up a UAS operation.

Phase		Typical operational activities
Pre-flight	Strategic – long term	<ul style="list-style-type: none"> • Airspace design & redesign. • Designation of a single common information service provider (sCISP), if applicable. • Certification of U-space Service Providers (USSPs). • Obtaining an operator's register number. • Obtaining an operator's licence/certificate (if appropriate).
	Strategic	<ul style="list-style-type: none"> • Developing a plan for a flight, selecting & configuring aircraft & crew. • Specific Operations Risk Assessment (SORA), Pre-defined Risk Assessment (PDRA), obtaining a Light UAS Certificate (LUC), if needed. • Seeking permission to enter airspace/overfly (if needed). • Contingency planning.
	Pre-tactical	<ul style="list-style-type: none"> • Demand capacity balancing. • Pre-flight de-confliction.
Tactical – in-flight		<ul style="list-style-type: none"> • Activation. • Aviation (contingencies). • Termination.
Post-flight		<ul style="list-style-type: none"> • Logging. • Reporting (as required). • Maintenance. • Performance assessment.

Table 8. Main operational activities that take place over the execution of a UAS operation.

Considering the definition of the U-AGREE solution in Section 3.1, which focuses on the assessment of the risk posed by UAS and mitigation barriers enabled by U-space services, Operational activities directly related to the U-AGREE solution are emphasised in bold font in Table 8 and further described in the following paragraphs, leading to the definition of the U-AGREE Operational Scenarios at the end of the section.

Airspace design and redesign

The Competent Authority performs an airspace risk assessment, leading to the definition of:

- UAS capabilities and performance requirements,
- the U-space services performance requirements, and

- the applicable operational conditions and airspace constraints.

Competent Authorities will apply the EUROCONTROL's Extended Safety Reference Material (E-SRM) [17] to conduct the airspace risk assessment targeting safety. Figure 5 illustrates the three phases this methodology consists of:

- **Definition phase:** the first set of Safety Criteria (defined in terms of proxies related to mitigation of hazards inherent to aviation) are determined also at that stage from a preliminary safety impact assessment of the change.
- **Specification phase:** the safety specification is derived to meet the safety criteria, and the risk analysis is conducted at this stage. Safety criteria could be refined, and additional safety criteria could be identified in terms of proxies related to operational hazards following the hazard identification and analysis (HAZID).
- **Design phase:** the design phase is relative to the high-level design. The safety assessment and related assurance process will derive safety requirements covering both success and failure aspects to meet the safety specification.

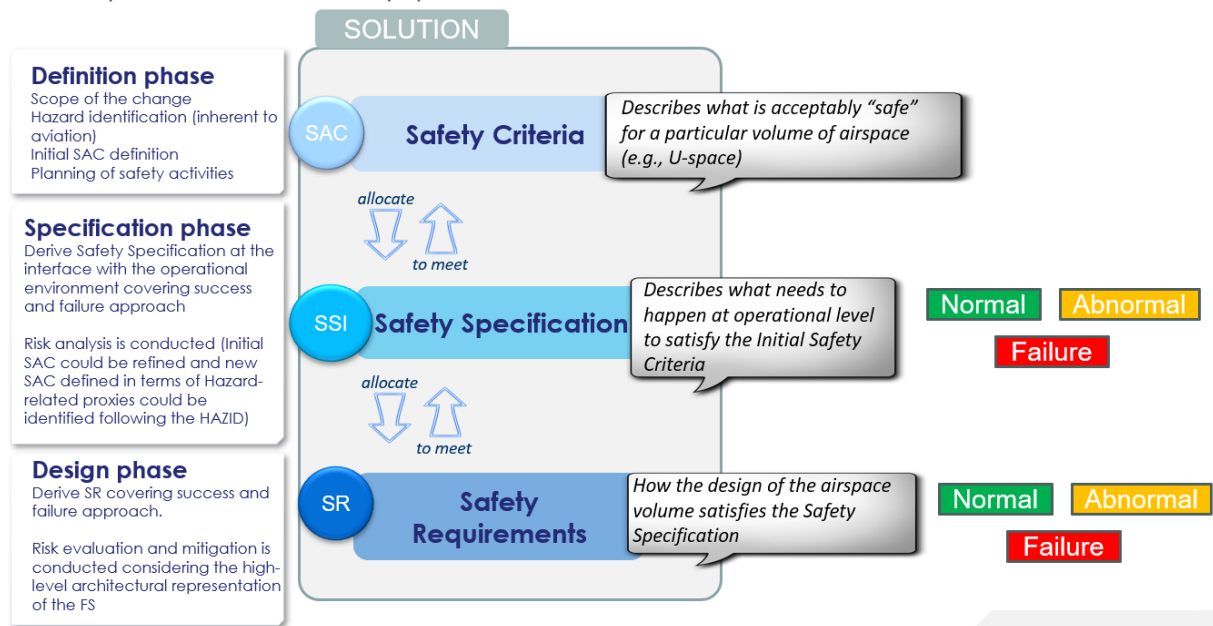


Figure 5. E-SRM method process for the safety assessment in ARA [16]

The E-SRM addresses the impact on safety of any change to the functional system that supports aviation operations. **U-AGREE addresses two changes to the functional system.** The **first one** consists of the **roll out of initial U-space services according to the Implementing Regulation (EU) 2021/664** and the accompanying documents ([33], [34], [26]), while the **second one** will consist of the application of an **advanced, Machine-Learning powered, enhancement** of the U-space consisting on upgrades to the services already defined by the Implementing Regulation (EU) 2021/664 **and the roll out of new advanced services**, the tactical conflict prediction (TCP) and tactical conflict resolution (TCR) **aligned with** the latest published version of the **CORUS ConOps (Ed. 4.0)** [2] and, to the maximum practical extent, to the new ConOps Ed. 5.0 currently under development within the CORUS five project [10], as well as with the temporal deployment horizons described therein.

The safety assessment will encompass a broader approach considering safety from two perspectives:

- **First**, the impact on safety of the change to the functional system is assessed under the assumption that it operates as intended. This assessment takes into account existing hazards inherent to aviation that are affected by the change. *Operating as intended* means functioning under normal or abnormal environmental conditions, but without any failures of the functional system. The objective is to demonstrate that the concept is intrinsically safe in the absence of failures.
- **Second**, the impact on safety of the change to the functional system is assessed under a failure-based approach—that is, by considering any relevant malfunction of the modified functional system. This assessment should address both the new hazards introduced by the change and the existing hazards that may be influenced or exacerbated by it.

Being an Exploratory Research project targeting a TRL2, **U-AGREE will limit the safety assessment to the definition and specification phases.**

The E-SRM approach bases the safety assessment process on Integrated Risk (Accident-Incident) Models, which are composed of mitigation barriers and accident precursors.

Although the risk assessment should address safety, security, privacy, and environmental protection, U-AGREE assumes that assessments related to security, privacy, and environmental protection have already been performed. These assessments are expected to result in the definition of specific operational conditions (e.g., maximum acceptable noise levels) and airspace constraints, notably through the establishment of UAS geographical zones with associated access conditions.

Under this assumption, the potential negative impacts of UAS operations in terms of security, privacy, and environmental protection are mitigated within U-space primarily through the enforcement of these constraints, in particular by reducing the likelihood of infringements of UAS geographical zones.

Additional measures, such as the retention of telemetry data to support law enforcement or interoperability with counter-UAS (C-UAS) systems, are considered outside the scope of U-AGREE due to project constraints.

Pre-flight risk assessment

According to Commission Implementing Regulation (EU) 2019/947, UAS operators must identify and assess the risks associated with their operations. When an operation falls within the Specific category, operators are required to obtain an operational authorisation based on the outcome of a risk assessment conducted in accordance with the SORA methodology developed by JARUS.

To this end, the operator must develop a Concept of Operations (ConOps) describing the intended mission and perform an initial assessment of both ground and air risks. Within the SORA framework, ground risk refers to the probability of fatalities among people on the ground resulting from a UAS crash caused by a loss-of-control event. Based on this evaluation, the operation is assigned a Ground Risk Class (GRC) according to a discrete scale comprising seven categories. Operators may subsequently apply mitigation measures to reduce the initial risk level and provide evidence supporting the effectiveness of such mitigations.

Following the ground risk assessment, a similar process is conducted for air risk. Within the SORA framework, air risk refers to the likelihood of a mid-air collision (MAC) between a UAS and a manned aircraft. It should be noted, however, that MACs involving only UAS, as well as their potential effects on third parties on the ground, are currently not addressed by state-of-the-art SORA risk models. The

assessment is based on a qualitative estimation of the initial air risk associated with the operation, expressed through the ARC, ranging from ARC-a to ARC-d in increasing order of risk. As with ground risk, operators may apply strategic mitigations to reduce the residual air risk, which may subsequently be further mitigated through tactical measures with a required level of performance.

Finally, based on the residual ground and air risks, the operation is assigned a Safety Assurance and Integrity Level (SAIL), which determines the means by which the operator must demonstrate compliance with the sixteen Operational Safety Objectives (OSOs).

The preparation of the required documentation typically takes several weeks for operators, while the competent authorities responsible for issuing the authorisation may require several additional months to deliver a decision, which may not necessarily be favourable. To alleviate the burden on both operators and authorities, the regulatory framework provides several simplified pathways, including the use of Standard Scenarios (STS), Pre-Defined Risk Assessments (PDRA), and, for advanced operators, a Light UAS Operator Certificate (LUC). All these mechanisms rely, to varying extents, on the underlying SORA risk models.

3.2.2 Roles and responsibilities

The operational scenarios described in this OSED involve the application of the U-AGREE risk models to support safety assessments associated with the designation of U-space airspaces and the authorisation of UAS operations. The identified roles are aligned with the SESAR Common Taxonomy and Architecture Modelling Framework.

Actors directly involved in the use of the U-AGREE risk models

Competent Authority (CA)

The Competent Authority is the primary actor in the airspace-designation scenarios. It is responsible for assessing the suitability of a given airspace for the establishment of U-space and for defining the associated operational conditions, constraints and performance requirements. Within the U-AGREE concept, the Competent Authority applies the risk models to assess the collision risk associated with different traffic densities, operating environments and mitigation configurations, and to determine the set of measures required to achieve the applicable TLS.

U-space Coordinator

The U-space Coordinator supports the safe and efficient operation of the U-space airspace through the coordination of U-space service provision and the monitoring of the operational environment. The U-space Coordinator may use operational and safety-related information to verify operational assumptions, assess system performance and support the continuous improvement of U-space operations.

UAS Operator (UAS OP)

The UAS Operator is the primary actor in the operational-authorisation scenarios. It is responsible for conducting the risk assessment required to support operations in the Specific Category, including SORA-based assessments where applicable. Within the U-AGREE concept, the UAS Operator may use the risk models to quantify collision risk, evaluate the effectiveness of mitigation measures and demonstrate compliance with the applicable safety objectives and regulatory requirements.

Actors indirectly affected by the outcomes of the risk assessment

U-space Service Provider (USSP)

The USSP is responsible for providing U-space services within designated U-space airspaces. Although it does not directly use the U-AGREE risk models, the performance requirements derived from the risk assessment process may influence the characteristics and performance levels that the provided services must achieve.

Air Navigation Service Provider (ANSP)

The ANSP provides air traffic services and contributes to the safe integration of manned and unmanned aviation activities. While the ANSP is not directly involved in the application of the risk models, the outcomes of the assessment may influence airspace design, operational procedures and coordination mechanisms between conventional ATM and U-space environments.

Other Airspace Users

Manned aircraft operators and other UAS operators may be affected by the operational conditions, constraints and mitigation measures derived from the risk assessment process. However, they are not direct users of the U-AGREE risk models.

Human Factors Considerations

The U-AGREE risk models are intended to support decision-making and do not replace the responsibilities of the actors involved. The Competent Authority and the UAS Operator remain responsible for the decisions and assessments derived from the model outputs. The concept assumes that the results are presented in a manner that supports consistent interpretation and that responsibilities remain clearly allocated among stakeholders. Particular attention shall be paid to situations involving partial implementation of U-space services, mixed levels of equipage or heterogeneous operational environments, where incorrect assumptions regarding the availability or effectiveness of mitigation mechanisms could lead to inconsistent safety assessments.

3.2.3 CNS/ATS description

CNS

The availability of communication, navigation, and surveillance heavily depends on the type of sub-operating environment.

CNS in Terminal U-space sub-operating environment.

Terminal airspaces form part of controlled airspace and, as such, CNS services are provided therein by the responsible Air Navigation Service Provider (ANSP) in accordance with the applicable regulatory and certification requirements. Communications within terminal airspace rely primarily on air-to-ground and air-to-air voice communications provided by the Aeronautical Mobile Service operating in protected VHF frequency bands. Aircraft operating within Terminal Manoeuvring Areas (TMAs) and Control Zones (CTRs) are required to maintain continuous radio communication with the relevant Air Traffic Services (ATS) unit using the frequencies published in the Aeronautical Information Publication (AIP). In some cases, portions of terminal airspace may additionally be designated as Radio Mandatory Zones (RMZs).

Terminal airspace is generally structured around RNAV or RNP navigation specifications, requiring aircraft operating under IFR to be equipped with certified navigation systems. Most IFR arrival and departure procedures (e.g. SIDs and STARs) are nowadays based on Global Navigation Satellite Systems (GNSS), predominantly Global Positioning System (GPS), while conventional ground-based navigation aids, such as Distance Measuring Equipment (DME) and Very High Frequency (VHF) Omnidirectional Range (VOR) systems, provide contingency support in the event of GNSS degradation or disruption caused by natural phenomena or intentional interference. It should be noted that, unlike GALILEO authenticated services, standard civil GPS signals do not provide signal authentication capabilities and are therefore particularly vulnerable to spoofing.

With regard to VFR operations, although visual reference outside the cockpit remains the primary and legally binding means of navigation, GNSS receivers and navigation applications running on portable electronic devices are widely used as situational awareness aids. Such devices and applications are not necessarily certified, as their use does not relieve pilots of their obligation to conduct the flight by visual reference in accordance with applicable flight rules.

Terminal areas are designed to ensure the surveillance performance necessary to support the ATS level of service associated with the applicable airspace classification and operational complexity. Dual coverage by Mode S secondary surveillance radars (SSR) is common across European terminal airspaces, while high- and very high-complexity terminal areas generally benefit from significantly greater levels of overlapping Mode S coverage. In addition, these terminal areas are usually covered by at least one Primary Surveillance Radar (PSR). ADS-B receiving stations, either standalone or collocated with conventional surveillance infrastructure, are also being progressively deployed throughout Europe. Although not primarily intended for ATS provision, non-cooperative sensors, including specialised radars and electro-optical/infrared systems, are increasingly deployed at European airports as part of counter-UAS capabilities.

Aircraft operating under IFR with a maximum certificated take-off mass exceeding 5,700 kg, or with a maximum cruising true airspeed capability greater than 250 kt, are required to carry a Mode S transponder with ADS-B Out capability in accordance with Commission Implementing Regulation (EU) 2023/1770. IFR aircraft not meeting these criteria are nevertheless required to be equipped with a Mode S transponder. In many European States, portions of terminal airspace are designated as Transponder Mandatory Zones (TMZs); consequently, aircraft operating in TMZs under VFR within such airspace shall be required to carry and operate a transponder (unless specific arrangements with the controlling authority), which is typically, although not necessarily, a Mode S transponder.

Airborne CNS equipment used in both IFR and VFR operations must comply with the applicable EASA Certification Specifications, including CS-ACNS [35].

Unlike conventional terminal airspace operations, U-space operations are based on highly digitalised and network-enabled service provision architectures.

In accordance with Commission Implementing Regulation (EU) 2021/664, U-space airspaces may be established within either controlled or uncontrolled airspace. Irrespective of the underlying airspace classification, U-space operations rely on a cooperative operational environment in which UAS are required to maintain a digital connection with a USSP.

The implementation of this digital connection — whether directly provided by the USSP or developed by the UAS operator through an Application Programming Interface (API) exposed by the USSP — is

outside the scope of this document, as is the underlying communication technology supporting such connectivity. Nevertheless, the competent authority designating the U-space airspace is expected to define the associated performance requirements applicable to the interface between the UAS operator and the USSP.

U-space communications are primarily based on terrestrial mobile communication networks, including public and/or dedicated cellular infrastructure (e.g. 4G/LTE and 5G). These networks are expected to support the digital connectivity between the UAS and the USSP, as well as the exchange of operational information between U-space services and UAS operators. The achievable level of service is strongly dependent on the local telecommunications infrastructure and network deployment density and therefore varies according to the operational environment.

In urban areas, where dense cellular coverage and high-capacity 4G/5G deployments are typically available, U-space communications are expected to achieve high levels of availability, low latency, and high data throughput, supporting near-real-time exchange of tactical information. In sub-urban areas, coverage is generally expected to remain sufficient for nominal U-space operations; however, variations in signal quality, potential capacity constraints, and intermittent coverage degradation may occur, particularly at lower altitudes or in complex radio environments. In rural or sparsely populated areas, coverage may be fragmented or limited to legacy networks, resulting in reduced performance levels and a higher reliance on multi-network roaming or hybrid communication solutions. In such environments, U-space operational design may need to account for reduced communication performance through increased reliance on strategic deconfliction and more conservative separation minima.

UAS navigation systems are primarily based on Global Navigation Satellite Systems (GNSS). These systems may leverage space-based augmentation services, such as the European Geostationary Navigation Overlay Service (EGNOS), as well as ground-based augmentation techniques, including Real-Time Kinematic (RTK) positioning. Although ground-based augmentation techniques can provide very high positioning accuracy, they do not inherently guarantee navigation integrity; integrity assurance requires the use of appropriately capable receivers and augmentation services such as EGNOS. Competent authorities are therefore expected to establish navigation performance requirements for UAS operations, as navigation performance directly affects the overall safety of operations within U-space airspace.

With regard to UAS equipage, Commission Delegated Regulation (EU) 2020/1058 establishes Direct Remote Identification (DRID) requirements for class C1, C2 and C3 UAS intended for operations in the open category, as well as for class C5 and C6 UAS intended for operations in the specific category below 120 m. The applicable means of compliance for DRID is provided by standard EN 4709-002:2023 [36], which specifies broadcast-based remote identification mechanisms relying on Bluetooth (legacy) or Wi-Fi technologies in compliant with the IEEE 802.11 Wireless LAN standards family.

Surveillance within U-space airspace is primarily cooperative in nature. UAS provide their three-dimensional geodetic position, velocity information (ground speed and track), and operational status (including contingency or emergency states) through the digital connection established with the USSP to which they are connected. This functionality is commonly referred to as Network Remote Identification (NRID). USSPs exchange surveillance-related information through network identification services in order to establish and maintain a common operational picture of UAS traffic within the U-space airspace. In some jurisdictions (e.g. Spain), DRID requirements may be partially relieved within

U-space airspace where equivalent identification objectives are already achieved through NRID services.

Manned aircraft operating within U-space airspace and not subject to air traffic control instructions are assumed to be electronically conspicuous (“e-conspicuous”) in accordance with Commission Implementing Regulation (EU) 2021/666. E-conspicuity may be supported through different surveillance technologies, including:

- Automatic Dependent Surveillance – Broadcast (ADS-B), operating either on 1 090 MHz Extended Squitter (1090ES) or on 978 MHz Universal Access Transceiver (UAT) according to [37]; or
- Automatic Dependent Surveillance – Light (ADS-L) based on Short Range Device technology in the 860 MHz band (SRD860), as specified in [38].

Non-cooperative surveillance capabilities may also be available in certain U-space airspaces, particularly through the reuse of third-party surveillance systems originally deployed for other purposes (e.g. counter-UAS systems) or through dedicated deployments established specifically to support U-space operations.

Where available, surveillance information originating from Air Traffic Service (ATS) units is required to be made available to USSPs through the Common Information Services (CIS) established in accordance with Commission Implementing Regulation (EU) 2021/665.

CNS in G Class U-space sub-operating environment.

In Class G airspace below the VLL, for manned aviation operations, CNS capabilities are generally limited and highly heterogeneous, reflecting the absence of regulatory requirements for certified airborne equipment and the sparse provision of ground-based surveillance and communication infrastructure. Communications are primarily based on direct air-to-air voice coordination using the Aeronautical Mobile Service VHF band where available, or on self-separation principles supported by visual awareness. In many areas, especially at very low altitudes, radio coverage from ATS units may be intermittent or unavailable, and pilots may operate without continuous ATS communication.

Navigation in VLL operations is predominantly based on visual reference to the ground and terrain features, supported by non-certified GNSS-based devices and mobile applications used for situational awareness only. Such devices do not provide certified navigation performance and do not relieve pilots from the requirement to maintain visual meteorological conditions and separation from terrain and obstacles. Surveillance in VLL Class G airspace is largely non-existent from an ATS perspective, with limited or no reliance on cooperative surveillance systems; situational awareness is therefore primarily based on visual acquisition and procedural awareness of local traffic patterns.

In Class G airspace above Very Low Level, for manned aviation operations, CNS capabilities progressively improve, although they remain largely dependent on voluntary equipment and national implementation policies. Communications with Air Traffic Services, where provided, are typically based on VHF voice services, although continuous coverage is not guaranteed outside designated service volumes. In certain areas, particularly in proximity to controlled airspace or within Transponder Mandatory Zones (TMZs), radio communication and transponder carriage requirements may apply in accordance with national Aeronautical Information Publication (AIP) provisions.

Navigation above VLL remains primarily based on visual reference for VFR operations, while IFR operations rely on certified GNSS-based navigation systems complemented by ground-based NAVAIDs where available. The use of GNSS is widespread among VFR operators for situational awareness, although such systems are not certified for navigation purposes unless installed in accordance with applicable airworthiness requirements. Surveillance in Class G airspace is generally limited; however, cooperative surveillance coverage may be available in specific areas through secondary surveillance radar or ADS-B ground stations, particularly in proximity to controlled airspace boundaries or within locally designated surveillance coverage volumes.

As stated above, CNS capabilities supporting UAS operations in U-space airspaces are not affected by whether the underlying airspace is designated as controlled or uncontrolled. A relevant distinction, however, concerns the availability of surveillance and traffic information on manned aviation operating outside controlled airspace. In U-space airspaces established in uncontrolled airspace, information on manned aircraft will primarily rely on e-conspicuity data directly collected by USSPs, except in areas in proximity to controlled airspace where surveillance coverage and ATS information services are typically more comprehensive, enabling the sharing of information on manned aircraft through the CIS.

CNS in G Class no U-space sub-operating environment.

The description of CNS capabilities for manned aircraft operations in Class G airspace remains applicable in areas where no U-space airspace is designated, as these capabilities are not affected by whether manned operations take place within or outside U-space airspace.

In this type of sub-operating environment, no dedicated communication capability is required to support UAS operations, since no U-space services are provided. It should be noted that the command-and-control (C2) link between the ground control station and the unmanned aircraft remains outside the scope of the CNS concept.

Navigation capabilities based on GNSS remain consistent with those available within U-space airspaces, as access to GNSS services is not affected by whether a U-space airspace is designated. Surveillance information on UAS relies solely on the Direct Remote Identification (DRID) capability required by Commission Delegated Regulation (EU) 2020/1058. However, DRID was not designed as an enabler for the provision of traffic services, which limits the operational use of the associated information for tactical traffic management purposes.

Moreover, UAS operators do not have access to surveillance information on manned aviation based on e-conspicuity mechanisms, since the relevant provisions under Commission Implementing Regulation (EU) 2021/666 apply only within U-space airspaces. In addition, in the absence of Common Information Services, UAS operators will not receive surveillance data on manned traffic collected by Air Traffic Services units.

That said, underlying communication and surveillance capabilities supported by public mobile communication networks remain available, with performance levels depending on the operational environment (urban, sub-urban or rural), as previously described.

ATS services.

ATS services are provided depending on the type of operation and the airspace class in accordance with ICAO Annex 11 [39], regardless of whether there is a designated U-space. Table 9 provides detail on the ATS services provided per airspace class and type of operation.

Class	Type of operation	Separation provided	ATS SERVICES
A	IFR	ALL	Air Traffic Control
B	IFR	ALL	Air Traffic Control
	VFR	ALL	Air Traffic Control
C	IFR	IFR from IFR	Air Traffic Control
		IFR from VFR	
	VFR	VFR from IFR	Air traffic control for separation from IFR.
			Traffic information VFR/VFR (including collision avoidance advice upon request).
D	IFR	IFR from IFR	Air traffic control for separation from IFR.
			Traffic information about VFR (including collision avoidance advice upon request).
	VFR	NONE	Traffic information IFR/VFR and VFR/VFR (including collision avoidance advice on request).
E	IFR	IFR from IFR	Traffic control for separation from IFR.
			Traffic information about VFR flights, as far as practical.
	VFR	NONE	Traffic information, as far as practical.
F	IFR	IFR from IFR ^(a)	Air traffic advisory service.
			Flight information service.
	VFR	NONE	Flight information.
G	IFR	NONE	Flight information.
	VFT	NONE	Flight information.
(a) As far as practical.			

Table 9. ATS services per airspace class and type of operation.

U-space services.

Since the U-space concept was first sketched in the U-space blueprint ten years ago, its implementation was conceived as a stepwise process through increasing levels of connectivity and automation illustrated in Figure 6. The CORUS Five project has defined three time horizons driving the evolution of U-space from the foundation services (U1) and initial U-space deployment (U2) towards full integration (U4). These time horizons are associated with specific operational and regulatory milestones enabling progression to the next stage. Commission Implementing Regulation (EU) 2021/664 establishes the regulatory foundations for the short-term deployment of U-space,

prioritising safety over other performance dimensions such as capacity, equity and access. In the mid-term, new or amended U-space regulatory frameworks are expected to enable increased capacity, improved equity and access, and the progressive introduction of Innovative Air Mobility (IAM) operations through enhanced integration with the ATM framework. In the long term, further regulatory developments at ICAO level, including new flight rules and potentially new airspace classifications, are expected to enable the seamless integration of UAS and IAM operations into the ATM system.

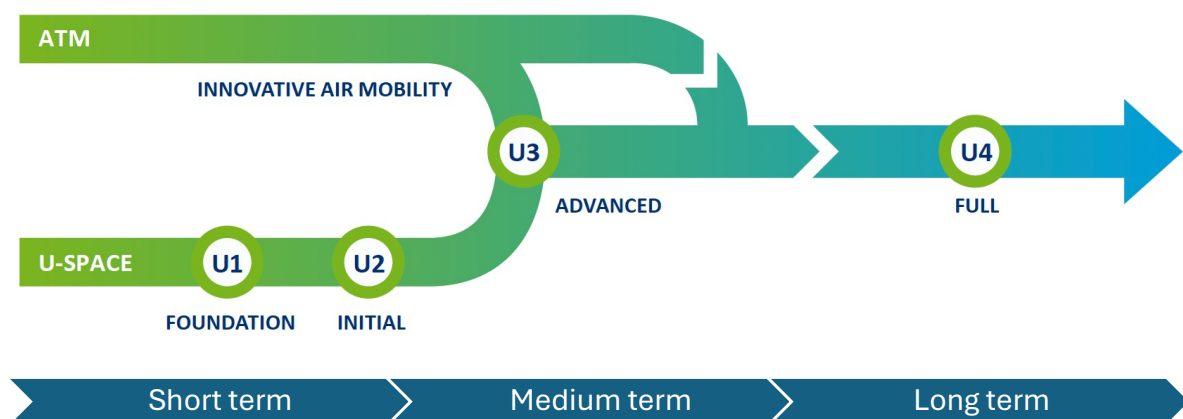


Figure 6. Evolution of the U-space concept and integration with the ATM framework (from the ATM Master Plan 2025 [40])

In line with this evolutionary U-space framework, U-AGREE addresses the short-term and mid-term horizons.

U-space airspaces in the short-term

U-space airspaces are UAS geographical zones designated by the state to facilitate the operations of UAS. U-space airspaces can be designated for safety, security, privacy or environmental protection reasons, based on the outcomes of an airspace risk assessment (ARA).

Within a U-space airspace, UAS operators must make use of a set of U-space services provided by certified U-space service providers (USSP). The required U-space services, as well as their required performance must be defined by the designating authority, along with the required UAS capabilities and performance. Only certified IFR operations IFR and the lowest risks operations in the subcategory A1 using UAS class C0 or equivalent are exempt from the use of U-space services.

Manned aircraft receiving ATC instructions must be segregated from UAS. Manned aircraft non receiving ATC instructions must be conspicuous to USSPs through any of the mechanism described in Section 3.2.3.

Minimum bundle of U-space services that shall be available in the short-term.

Common information services (CIS): member States shall provide the following data as part of the common information services for each U-space airspace:

- Horizontal and vertical limits of U-space airspace.

- Performance requirements for UAS and U-space services.
- A list of certified and active U-space service providers, including:
 - Identification and contact details.
 - U-space services provided.
 - Certification limitations, if applicable.
- Any adjacent U-space airspace(s).
- Geographical UAS zones defined within U-space airspace.
- Static and dynamic airspace restrictions defined by the competent authorities.

CIS may be provided by a single provider (sCISP) designated by the competent authority or in a decentralised manner. When designated, the single CISP must be certified.

Network identification service (NIS): shall continuously process the remote identity of the UAS throughout the entire duration of the flight and will provide remote identification of the UAS to the following authorised users in an aggregated manner:

- the general public as regards information that is deemed public in accordance with applicable Union and national rules;
- other U-space service providers in order to ensure the safety of operations in the U-space airspace;
- the air traffic services providers concerned;
- when designated, the single CISP;
- the relevant competent authorities (e.g. police/law enforcement agencies).

The NIS shall enable authorised users to receive messages containing the following information:

- the UAS operator registration number;
- the unique serial number of the unmanned aircraft or, if the unmanned aircraft is privately built, the unique serial number of the add-on;
- the geographical position of the UAS, its altitude above mean sea level and its height above the surface or take-off point;
- the route course measured clockwise from true north and the ground speed of the UAS;
- the geographical position of the remote pilot or, if not available, the take-off point;
- the emergency status of the UAS;
- the time at which the messages were generated.

Geo-awareness service (GAS): shall provide UAS operators with information on:

- Operational conditions and airspace limitations applicable within U-space airspace.
- UAS geographical zones relevant to U-space airspace.
- Temporary restrictions applicable to the use of airspace within U-space airspace.

Flight authorisation service (FAS): shall process Flight Authorisation Requests submitted by UAS operators according to the following workflow:

- Prior to the flight, the UAS operator shall request authorisation from the FAS.
- The request must define the trajectory using 4D containment volumes at 95%.

- The FAS shall verify that the request is complete and correct, that it is free of intersection in time and space with already approved authorisations (by any USSP), and that it does not infringe active restrictions in U-space airspace.
- For operations of the same priority, requests will be processed on a first-come, first-served basis.
- The FAS must notify the operator of the acceptance or rejection of the request. If rejected:
 - It must indicate the reason for rejection.
 - It may propose an alternative trajectory.
- If the request is accepted, the applicable deviation thresholds will be indicated.
- The FAS will take into account the available meteorological information.
- Before commencing the flight, the UAS operator shall request the activation of the flight authorisation.
- The FAS continuously monitors active restrictions and traffic information provided by ATS units and may update or withdraw previously approved authorisations (even after the flight has commenced).

Traffic information service (TIS): shall provide UAS operators with information on any detectable air traffic that may be near the position or planned flight path of the UAS.

The information will include both manned aircraft traffic and UAS traffic shared by other U-space service providers and relevant ATS units.

Traffic information will include:

- Position,
- Time of notification,
- Speed and heading, and
- Emergency status of the aircraft.

Upon receiving traffic information from the U-Space service provider, UAS operators will take the necessary measures to avoid any collision hazard.

Dynamic airspace reconfiguration (DAR): not being a U-space service in itself, the DAR is a mechanism instrumental to mitigate the collision risk between manned aircraft receiving ATC instructions and UAS by keeping them segregated. To this end, ATC units may temporarily limit the vertical and/or horizontal boundaries of U-space airspace or deactivate it entirely.

DARs are implemented in a stepwise manner:

1. In the transient stage, all UAS are instructed through their subscribed USSP either to exit the affected portion of the U-space airspace or to safely land, following their contingency procedures.
2. Subsequently, the responsible ATC unit shall publish a temporary U-space airspace restriction for UAS, through the CIS for that airspace, effective until the manned aircraft exits the U-space.
3. The FAS amends or withdraw Flight Authorisations approved but not activated.

Additional U-space services that can be required in the short-term.

Based on the outcomes of the ARA, competent authorities may require any or both of the following U-space services:

Weather information service (WIS).

This service:

- Will collect meteorological data from reliable sources.
- Will provide the UAS operator with weather forecasts and real-time meteorological information before or during the flight.

Conformance monitoring service (CMS).

This service checks real-time flight information against the approved flight plan. If any non-conformity is detected, the USSP alerts:

- The UAS operator of the non-conforming flight.
- Other aircraft.
- Other USSPs.
- The CISP, where applicable.
- Relevant authorities.

The USSP detecting the non-conformity must include information about the deviation in the traffic information it provides.

Pre-alerts can be generated when it is imminent that the UA will leave the authorised 4D volume. These pre-alerts are notified to the affected UAS operator.

Class G U-space airspaces in the mid-term

The CORUS and CORUS-XUAM projects introduced a classification of U-space airspaces which is not recognised by the U-space regulation but that the CORUS five project envisages them as the framework enabling ubiquitous Class G U-space airspaces, primarily defined in the VLL and further extended above this limit but still in uncontrolled, low air risk uncontrolled airspace.

U-space classes are defined by the services and aircraft capabilities available therein:

- Class X:
 - Network Identification Service.
 - Traffic Information Service.
 - Optionally, Geo-awareness and Weather information services.
- Class Y: the same as in class X plus:
 - Flight Authorisation Service.
 - Optionally, Conformance Monitoring.
 - Optionally, airborne Detect and Avoid (DAA) Remain Well Clear (RWC) and Collision Avoidance (CA) capabilities.

- Class Z: the same as in class Y plus:
 - Separation service.
 - Optionally, airborne CA.

In addition, CORUS five envisages a further subdivision of U-space classes based on different performance requirements, resulting in a more granular operational framework (e.g. from X1 to Z3) capable of accommodating the expected diversity of operational demand and deployment environments.

Common information services will be also available in the mid-term horizon U-space deployments. The information provided by the CIS will be expanded to support new services (e.g., applicable separation minima for separation provision, required navigation performance in terms of RNP specifications or vertiport/emergency land pads availability data).

The U-space separation service

The purpose of the U-space separation service is to maintain aircraft separation from hazards by at least the applicable separation minima. The U-space separation service comprises two distinct functions:

- Tactical conflict detection, consisting of the prediction of a potential loss of separation within a predefined temporal threshold (i.e. the look-ahead time).
- Tactical conflict resolution, consisting of the provision of resolution guidance to the airspace user in order to prevent the loss of separation. The nature of the guidance depends on the level of automation of the systems supporting the function.

Terminal U-space airspaces in the mid-term

In addition to the services that would be available in Class G U-space airspaces, U-AGREE envisages the evolution of the DAR towards a more dynamic and flexible mechanism enabled by AI-powered dynamic rerouting.

Although highly relevant, traffic management in or around Vertiport Traffic Zones (VTZ), based on sophisticated mechanisms such as the AUSA concept developed within the AURA project, is not considered herein due to the project limitations in terms of targeted TRL. Such mechanisms would require demonstration tools beyond the fast-time simulations considered by U-AGREE.

3.2.4 Applicable standards and regulations

Applicable regulations

Commission Implementing Regulation (EU) 2019/947. This regulation introduces the concept of UAS geographical zones, which is fundamental to the designation of U-space airspaces, and defines the three EASA operational categories: Open, Specific, and Certified. In addition, it establishes the requirement for operators to obtain an operational authorisation when conducting operations in the Specific category and lays down the requirements applicable to the risk assessment methodologies supporting such authorisations.

Commission Delegated Regulation (EU) 2020/1058. This regulation amends Commission Delegated Regulation (EU) 2019/945 and defines UAS classes C0 to C6, laying down technical requirements and operational constraints for each class, including requirements for direct remote identification and geo-awareness capabilities. Furthermore, it establishes the requirement for UAS operators to register and, where applicable, for individual UAS to be registered.

Commission Implementing Regulation (EU) 2021/664. This regulation introduces the concept of U-space airspace as a specific type of UAS geographical zone and establishes the requirement to conduct an airspace risk assessment as the basis for its designation. Furthermore, it defines the mandatory and optional U-space services that may be provided within a U-space airspace, together with the Common Information Services (CIS). In addition, it lays down the obligations that UAS operators, U-space service providers (USSPs), and Common Information Service Providers (CISPs) must comply with when operating within a U-space airspace.

Commission Implementing Regulation 2021/665. This regulation amends Commission Implementing Regulation (EU) 2017/373 (ATM/ANS Regulation), introducing requirements for ATS providers in U-space airspaces designated within controlled airspace, including information sharing with USSPs and the use of Dynamic Airspace Reconfiguration (DAR) to segregate manned and unmanned traffic when required.

Commission Implementing Regulation 2021/666. This regulation amends Commission Implementing Regulation (EU) No 923/2012 (SERA) laying down the e-conspicuity requirement for manned aviation operating in U-space airspace in uncontrolled airspace.

Commission Implementing Regulation (EU) 2024/1111. This regulation amends Commission Regulation (EU) No 965/2012 (Air OPS Regulation), introducing operational requirements for Innovative Air Mobility (IAM) operations conducted with manned VTOL-capable aircraft (VCA).

Standards, Guidance Material and Means of Compliance

Easy Access Rules for Unmanned Aircraft Systems (Regulations (EU) 2019/947 and (EU) 2019/945). This EASA publication consolidates the regulatory framework applicable to UAS operations and products, including the provisions of Regulations (EU) 2019/947 and (EU) 2019/945, together with the associated Acceptable Means of Compliance (AMC) and Guidance Material (GM). It provides practical guidance for the implementation of the European UAS regulatory framework, covering aspects such as operational categories, operational authorisations, risk assessment methodologies, operator responsibilities, remote pilot competencies, and UAS technical requirements.

Easy Access Rules for U-space (Regulations (EU) 2021/664, (EU) 2021/665 and (EU) 2021/666). This EASA publication consolidates the applicable U-space regulations, Acceptable Means of Compliance (AMC) and Guidance Material (GM), providing guidance on the implementation of the European U-space framework and the associated operational, technical and service provision requirements.

ASTM F3411 – Standard Specification for Remote ID and Tracking. This standard defines the information exchange requirements for remote identification and tracking of unmanned aircraft, including network-based remote identification services widely used to support U-space and UTM ecosystems. It specifies the data elements, interfaces and performance requirements for sharing UAS identification and position information among authorised stakeholders through a federated, peer-to-peer architecture, without relying on a centralised data repository.

ASTM F3548 – Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability. This standard specifies the data models, interfaces and interoperability requirements supporting the exchange of operational intent and constraint information among UAS Service Suppliers (USSs). It enables strategic deconfliction and coordination of UAS operations through a distributed, peer-to-peer architecture in which service providers share relevant information directly without relying on a centralised authority.

ASTM F3442/F3442M – Standard Specification for Detect and Avoid (DAA) Systems. This standard specifies the performance requirements for Detect and Avoid (DAA) systems supporting BVLOS UAS operations. It defines the surveillance, alerting and manoeuvre support capabilities required to detect potential conflicts and maintain safe separation from cooperative and non-cooperative traffic in shared airspace.

EUROCAE ED-318 Technical Specification Geographical Zones and U-space Data Provision and Exchange. This standard specifies the information models and exchange requirements for geographical information supporting U-space and UAS operations, enabling the interoperable dissemination of UAS geographical zones, airspace constraints, obstacles and other geospatial data required for strategic planning and operational awareness.

EUROCAE ED-339 – NID Data Exchange ICD for Indirect Exchanges between USSPs and between USSPs and Authorised Users. This standard specifies the data models, message structures, communication protocols and interface requirements supporting the indirect exchange of Network Identification (NID) information among USSPs and authorised users. It enables the provision of NIS through a centralised information-sharing architecture compliant with the European U-space regulatory framework.

Emerging Standards

There are several standards that are currently under development within EUROCAE WG-105 that will be published by the end of U-AGREE and that will be relevant for the roll out of U-space services and enhanced UAS operations in the short term.

EUROCAE ED-347 (draft) – Technical Standard Defining the Interface Between the UAS Operator and the Network Identification service. This draft standard defines the data model, performance requirements and a non-prescriptive protocol for information exchange between UAS operators and USSPs supporting the provision of NIS. At the time of writing, the document is under Open Consultation and is expected to be published by the end of 2026.

EUROCAE ED-351 (draft) – UAS Flight Authorisation Data Exchange ICD for Indirect Exchanges between USSPs and between USSPs and Authorised Users. This draft standard specifies the data models, message structures, communication protocols and interface requirements supporting the indirect exchange of UAS Flight Authorisation (UFA) data among USSPs and authorised users through a centralised information-sharing architecture compliant with the European U-space regulatory framework. At the time of writing, the document is at the Comment Resolution process following the internal peer review. The expected publication date is Q4 2026.

EUROCAE ED-353 (draft) – OSD on UAS Flight Authorisation Service. This draft standard presents an overarching technical concept that describes the behaviour of the UAS FA Service in relation to the other U-space mandatory services, the coordination among USSPs to implement the UAS FA Service,

and the processing of dynamic airspace restrictions and limitations, including DAR, in the context of the UAS FA Service. At the time of writing, the document is under internal peer review. The expected publication date is Q3 2026.

3.3 Detailed operating method

3.3.1 Previous operating method

Nowadays, the operations of drones are regulated in Europe by EU Regulations 2019/947 and 2109/945. This operational framework classifies drone operations, depending on their risk nature, in three categories: Open, Specific and Certified. The operations considered in the scope of this OSED are mainly included in the Specific Category, although some operations in the Open and, eventually, in the Certified category can also take place.

Although Commission Implementing Regulations (EU) 2021/664, 2021/665 and 2021/666, which define the operation framework for U-space, entered into force on the 26th of January 2023, they are not effectively implemented and are considered outside the previous operating method. Instead, they fall within the scope of the Operational Scenario 1 in 3.3.2.

The Operating Method is shown in Figure 7, describing all the phases of the operation: Strategic, Pre-Tactical, Tactical and Post-Flight.

STRATEGIC PHASE

To develop an operation in Specific category, three different cases can occur:

- The operation is covered by a European Standard Scenario (STS): The operator only needs to submit a declaration to the National Authority of the state of registration.
- The operation is covered by Predefined Risk Assessment (PDRA): The operator needs to request the authorisation from the National Authority, through a simplified process.
- The operation does not lie on the two previous points: The operator will generically have to follow the following steps:
 - The operator develops the ConOps for its operation which will be the basis for the authorisation process.
 - The operator develops an Aeronautical Safety Assessment, for the proposed ConOps, developed with the SORA 2.5 methodology, and requests Authorisation from the National Supervisory Authority.
 - To mitigate the air risk, i.e., the possibility of encounters with manned aircraft, if the proposed operations are located in a U-space volume, the operator can take advantage of U-space services as a Tactical Mitigation; U-space, through e-conspicuity (in uncontrolled airspace) or ATC managed Dynamic Airspace Reconfiguration (in controlled airspace) and the Traffic Information service, ensures safe separation of drones with regard to manned aircraft.
 - Once reviewed and once the mitigation means and evidence are accepted, the National Safety Authority (NSA) provides an authorisation to the operator to fly in the requested conditions for that Specific Category operation.

PRE-TACTICAL PHASE

- Once authorised to fly by the NSA on the approved conditions, the operator analyses the area where the operation will have to take place and identifies restrictions to the flight (restricted airspace). To be able to fly, the operator coordinates with the different authorities in charge of those restricted areas (ANSPs, Police, Local Authorities, environmental agencies, etc.). This process may vary across different countries. Section 3.3.1 below provides insight on the implementation in several representative instances.
- Once coordinated, the operator is allowed to fly in those volumes, following the strategic and tactical coordination measures agreed in the SORA authorisation. If the operation is developed in a U-space airspace, the operator submits a Flight Authorisation request to the U-space Service Provider (USSP) which analyses its compatibility with other approved Flight Authorisations and with restricted areas (Geo-Zones) and, if there are no constraints, approves the flight.

TACTICAL PHASE

- The pilot starts the operation and ensures that the flight is developed following the measures agreed and that every risk is conveniently managed.

POST-FLIGHT PHASE

- The operator declares the end of the flight and completes the post-flight check lists.

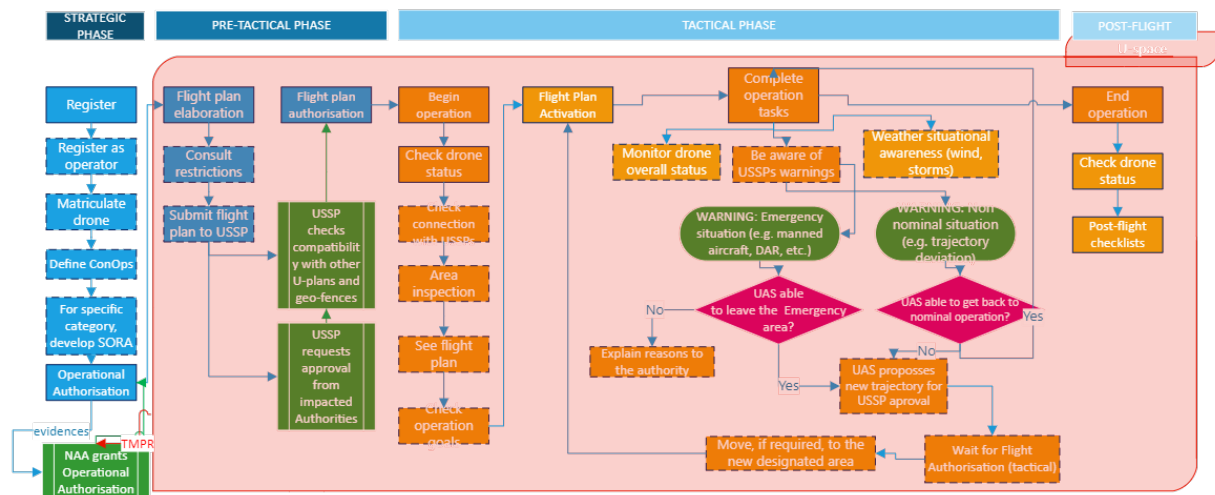


Figure 7: Current Operating Method

3.3.1.1 Operating UAS in Spain

In Spain, UAS flight operations are regulated primarily by Commission Regulation (EU) 2019/947 of 24 May 2019, on the rules and procedures applicable to the operation of unmanned aircraft, and by R.D. 517/2024 of 4 June, which develops the legal framework for the civil use of unmanned aircraft systems (UAS).

The UAS operator must properly plan their operation to avoid endangering their own flight or that of other airspace users. If they are to overlap with other airspace users, coordination of activities may be required.

ENAIRE Drones

The first step is to check whether the intended operation requires coordination. For this purpose, there is the online tool **ENAIRE Drones**, a platform designed for pilots and operators to consult airspace restrictions in real time. Most of Spanish airspace consists of "free" zones that present no constraints to UAS flight, as the risk of encountering other aircraft is very low.

Restrictions

Areas with restrictions on UAS flights are known as "UAS Geographic Zones" or "UASZs". The most common are those associated with the protection of controlled airspace, both civil and military, airports and heliports, and those areas designated in AIPs as prohibited, restricted, or dangerous. There may also be reservations of small areas of airspace that are segregated or restricted for aerial activities involving both manned and unmanned aircraft. An airspace segregation that encompasses an airfield will prevent other users from flying in it.

Need for Coordination

Flights within geographical areas surrounding aerodromes or heliports (civilian or military) must be coordinated with the airport operator or the corresponding ATS service provider, depending on the specific area of activity. ENAIRE Drones may be used to identify the contact with whom to coordinate. This coordination must be carried out well in advance of the flight to avoid affecting the operations of other aircraft, generally 10 days.

On the other hand, UAS operations are permitted in controlled airspace without coordination, provided they meet the following conditions simultaneously:

- VLOS operation
- Operation outside of designated UAS geographical areas in the vicinity of aerodromes or heliports, civil or military
- Maximum operating altitude of 60 m AGL

Therefore, within airspace controlled by ENAIRE, operations that do not meet any of the aforementioned conditions will be coordinated. If coordination with ENAIRE is required, the strategic and pre-tactical phases will be carried out using the online tool **ENAIRE Planea**.

Coordination Process

The planning request process is currently facilitated by ENAIRE's Airspace Operational Coordination Department (COOP, from the Spanish *Depto. Coordinación Operativa de Espacio aéreo*).

Prior to this coordination, an **Operational Risk Assessment and Mitigation (EARO, from the Spanish *Evaluación y Atenuación del Riesgo Operacional*)** must be carried out, analyzing the risks to the operation to be performed in controlled airspace. The EARO document only needs to be completed once, as it represents the agreement signed by both parties for the safe execution of the activities

outlined in that document. Once all the necessary tasks in the strategic phase have been completed, a UAS coordination request must be submitted through ENAIRE Planea or the contact indicated in ENAIRE Drones, completing the 'Activity Form' found in the application. The COOP will be responsible for specifying the conditions and requirements to be met once the operation has been coordinated.

The process described has fixed deadlines, which is especially important in the case of emergencies that fall under Article 44 of R. D. 1036/2017. Operators intending to operate in these situations have access to a specific channel with ENAIRE SYSRED that allows them to reduce these deadlines to less than 72 hours. If the intention is to fly in airspace that is not specifically ENAIRE's, it will be necessary to contact the other providers of that airspace, or none at all if it is uncontrolled airspace outside of ATZ and FIZ zones.

If an operator intends to fly in uncontrolled airspace, as is the case in Benidorm, there are still certain operations that, until the implementation of U-space, must be managed through ENAIRE. These include flights under a specific category whose operational authorization or Light UAS Operator Certificate (LUC) requires NOTAM/TSA/TRA publication. These are typically BVLOS flights that require a reserved area to ensure flight safety.

Furthermore, the operation must be coordinated with all the managers of the geographical areas affected by the activity, which can also be consulted through ENAIRE Drones.

Once the necessary arrangements have been made, the NOTAM/TSA/TRA for the operation can be requested from the Airspace Operational Coordination Department (COOP) through ENAIRE Planea.

With the arrival of U-space, BVLOS operations requiring a TSA or TRA can be carried out without these tools, since, by definition, other airspace users will maintain a safe distance from one another.

3.3.1.2 Operating UAS in Ireland

There are different cases when UAS operations do not require SORA at Ireland:

- Open Category:
 - A1
 - A2
 - A3
- Specific Category:
 - Declaration of Specific Standard Scenarios STS-01 or STS-02.
 - Light UAS operator Certificates (LUC)
 - Predefined Risk Assessment (PDRA)

Ireland follows the regulation *Easy Access Rules for Unmanned Aircraft Systems (Regulations (EU) 2019/947 and 2019/945)* [29] for any UAS operations, in accordance with the categories mentioned above.

EASA UAS Regulations aside, there are further restrictions that applies for Ireland, some of them depending on the location and conditions of the UAS operations, and can be classified:

- UAS Geographical Zones [41]

- Data protection requirements [42]
- Environmental restrictions [43]

Flying at UAS Geographical Zones:

As required by Commission Implementing Regulation (EU) 2019/947 article 15, UAS Geographical Zones at Ireland can be found in the common unique digital format at [41].

The coordination with relevant UAS Geographical Zone Authority for UAS operations is defined in the Irish Aviation Authority website, through a form labelled U.F.101 (current applicable version 13 from 04/11/2025) shown in Figure 8.

	Form No. U.F.101	Application for UAS Operation within a UAS Geographical Zone Restricted or Prohibited Area
	Version No. 13	
	Issue Date 04/11/2025	
	Page 1 of 4	

<small>This Form is for the use by UAS Operators when applying to the relevant UAS Geographical Zone Authority to conduct UAS Operations within UAS Geographical Zone Prohibited or Restricted Area*. Contact details available on https://www.iaa.ie/drones/uas-geographic-zones.</small>	
UAS Operations Application Form - UAS Geographical Zone Prohibited / Restricted Area	
UAS Operator Name	COLLINS AEROSPACE
UAS Operator Registration Number (16 digit)	IRL8937dhd8e47
Operational Authorisation Number <i>(if applicable, for Specific Category Operations) *</i>	323432432
Specific Assurance and Integrity Level (SAIL) / Pre-Defined Risk Assessment <i>(if applicable) *</i>	SAIL II
VLOS / BVLOS	BVLOS
UAS Model(s)	Rigitech-Eiger03
Remote Pilot(s) Name(s)	Javier Camacho
Mobile Phone Numbers, Primary	08389483
Mobile Phone Numbers, Alternate	09838372
UAS Geographical Zone ID	U6
UAS Geographical Zone Name	EID6 KILWORTH, CO. CORK
Description of the Area (townland, landmark, etc.)	Townland
Maximum Altitude (AMSL)	120
Maximum Height Above Ground Level (AGL)	120
Proposed Date(s) & Time(s) (Local)	10:25
Duration (HH:MM)	00:15

Figure 8. Form U.F.101 used in Ireland for coordinating with relevant UAS Geographical Zones Authorities [41].

Normally, the UAS Geographical zones within Class-C airspaces in Ireland follows the European color-code depicted in the image below, with the special following conditions:

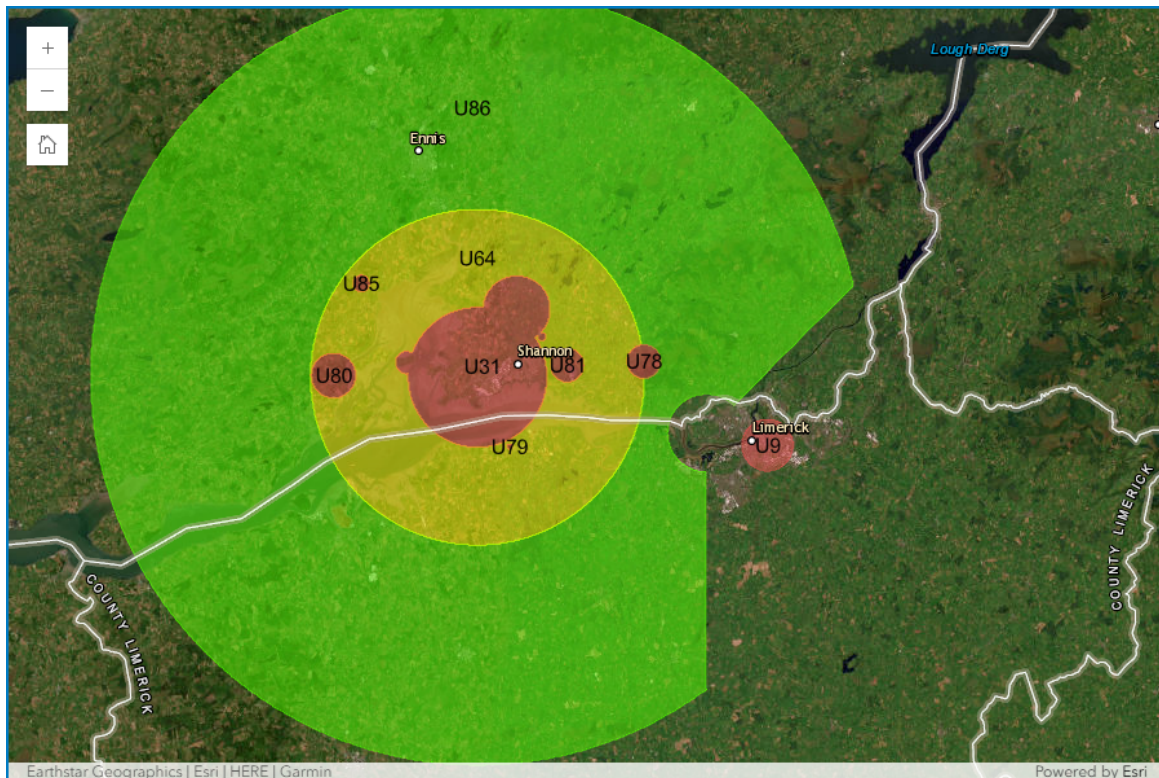


Figure 9. European color code used in Ireland for UAS Geographical Zones in class C airspace [41].

- Red (U31) – Shannon Control Zone (CTR) – Red Zone: Only allows for UAS operations in Specific category, under coordination with the Zone authority (in this case, AirNavIE), and there is an email for contact.
- Amber (U64) – Shannon Control Zone (CTR) – Amber Zone: Height restriction of 30 m, extendable to 15 m over obstacles within 50 m radius, applies. Above this, only specific category operations allowed with prior approval of zone authority (in this case, AirNavIE), and there is an email for contact. In this case, UAS operations in Open Category under 30 m are allowed, and extendable with the mentioned special case.
- Green (U31) – Shannon Control Zone (CTR) – Green Zone: Height restriction of 90 m applies. Above this, only specific category operations allowed with prior approval of zone authority (in this case, AirNavIE), and there is an email for contact. In this case, UAS operations in Open Category under 90 m are allowed.

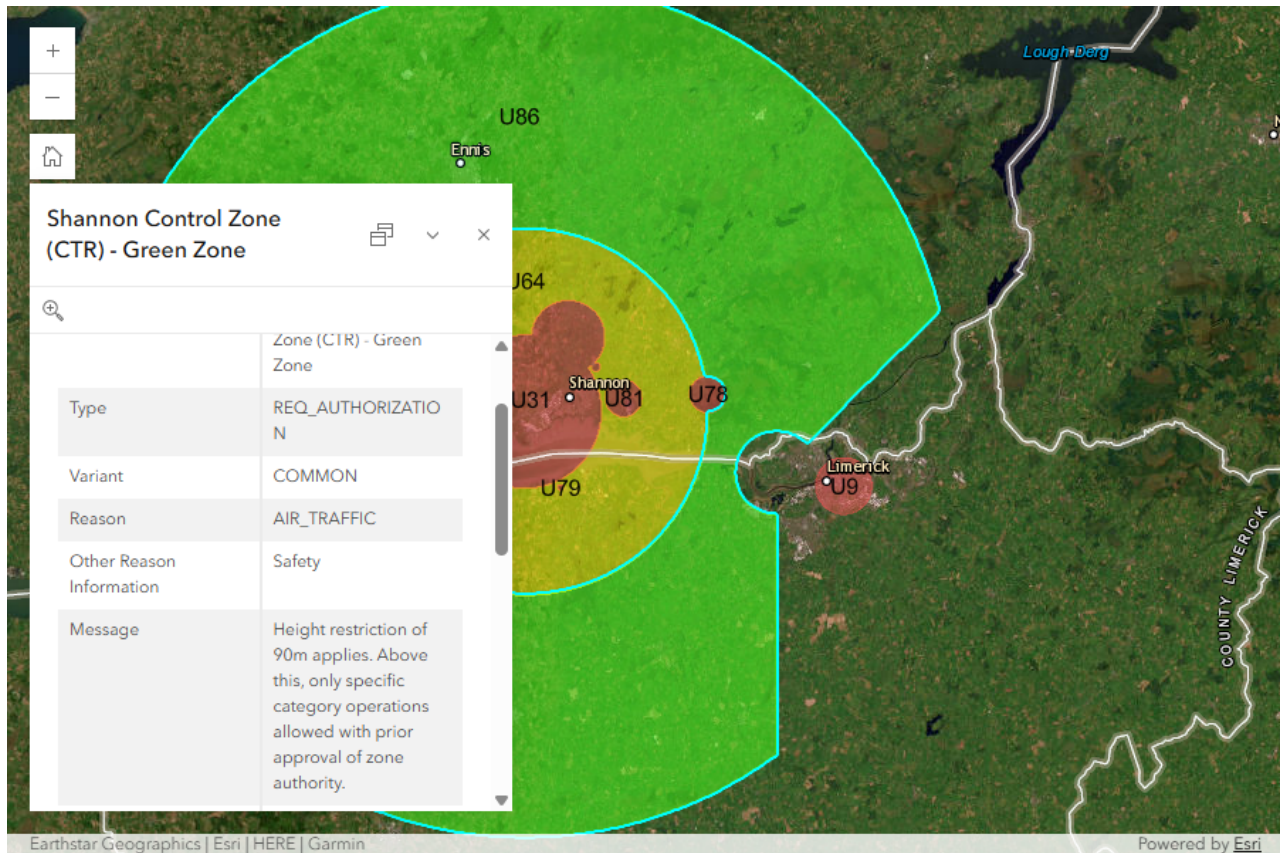


Figure 10. Example of Information available in [41] about UAS Geographical Zones.

The coordination with AirNavIE (ATC Unit) is performed:

- Strategically with U.F.101 (with a minimum of approximately 7 working days depending of ATC tower)
- Tactically: Communications via telephone only (therefore, no specific phraseology or training is required for the UAS operator).

3.3.1.3 National Non-SORA Authorisation and Airspace Access Procedures in Italy

Within the Italian regulatory framework, the authorisation of UAS operations is not limited to the application of operational risk assessment methodologies such as SORA. In parallel with the EU operational categories, Italy applies a set of national airspace-management and access procedures that regulate how activities, including civil UAS operations, may be conducted in portions of airspace that are restricted, sensitive or potentially hazardous for other airspace users. These procedures are primarily airspace-driven and institutional in nature and apply independently from the safety assessment of the operation, constituting a mandatory layer of authorisation and coordination whenever UAS operations interact with controlled, restricted or protected airspace volumes.

A fundamental role in this framework is played by ENAC Circulars ATM-03C and ATM-05B, which, although not specifically developed for unmanned aviation, explicitly include civil specialised operations and UAS activities among those that may justify the establishment of reserved or segregated airspace. Circular ATM-03C regulates the establishment, review and revocation of permanent or long-term reserved areas, typically exceeding 90 days in duration. From a UAS

perspective, this mechanism becomes relevant when operations are recurrent, continuous or structurally linked to long-term activities requiring stable airspace protection, such as infrastructure monitoring, critical site protection or permanent experimentation areas. When active, the reserved airspace is unclassified and not provided with air traffic services, and its approval follows an institutional evaluation conducted by ENAC in coordination with the competent civil and military ANSPs, primarily ENAV and ITAF, with formal publication in the Italian AIP.

For operations of limited duration, Circular ATM-05B establishes the national framework for temporary airspace reservation, applicable to time windows not exceeding 90 days. This circular is of particular operational relevance to UAS operators, as it represents the primary mechanism to enable temporary or project-based operations that require protection of a defined airspace volume to safely conduct activities considered hazardous for other airspace users. In addition to defining the process for creating temporary reserved or segregated areas, ATM-05B also clarifies the procedural pathways through which operators may request access to restricted or sensitive airspace, notably in cases where restrictions are linked to public security, institutional infrastructures or protected sites. In such circumstances, the process entails coordination not only with ENAC and the competent ANSPs, but also with other State authorities responsible for the restricted areas, such as Prefetture or Ministries with jurisdiction over public order or institutional assets. For UAS operations, ATM-05B therefore functions both as an airspace reservation instrument and as a reference framework for navigating the institutional authorisation processes required to lawfully access restricted airspace.

Beyond airspace reservation mechanisms, ENAC Circular ATM-09A introduces the Italian implementation of UAS geographical zones pursuant to Article 15 of Regulation (EU) 2019/947 and constitutes a further non-SORA regulatory layer with direct operational impact. The circular establishes portions of airspace where UAS operations are prohibited or subject to conditions for reasons of safety, security or environmental protection, with particular emphasis on aerodrome and heliport environments. Within these environments, ATM-09A clearly provides that Open category operations are not permitted, while Specific and Certified category operations may be authorised under defined conditions. The circular details the geometric configuration of restricted volumes based on distance from the Aerodrome Reference Point and aerodrome characteristics, and defines the conditions under which UAS operations may be conducted through case-by-case authorisation, generally supported by NOTAM publication and explicit coordination with the competent ATS units. ATM-09A also introduces narrowly framed derogations for operations conducted in close proximity to artificial structures and defines specific cases in which operations above airport areas may be authorised for purposes directly related to airport infrastructure, subject to formal coordination, submission of a risk assessment and continuous tactical communications with ATS. These provisions regulate access to predefined airspace volumes and apply regardless of whether SORA is used as the underlying safety assessment methodology.

Finally, the ENAC Regulation UAS-IT complements the above framework by introducing additional national procedural and administrative requirements, particularly relevant for BVLOS operations. The regulation establishes obligations linked to national airspace awareness and coordination, including, where applicable, the activation of the Declaration of Operation (DOP) through the **D-Flight platform**. These requirements are not risk-assessment tools but national operational measures intended to ensure visibility, coordination and deconfliction within Italian airspace, and they apply independently from the categorisation of the operation or the methodology used to demonstrate safety.

3.3.2 New SESAR operating method

U-AGREE risk models and mitigation barriers' models enable new operating methods in different stages of the UAS operations illustrated in Figure 4.

New operating methods in the long-term strategic phase

In the strategic, long-term phase, competent authorities apply U-AGREE risk methods to estimate the unmitigated risk posed by UAS operations in a given environment and determine whether it is acceptable or it needs to be mitigated. In case the risk exceeds acceptance thresholds, competent authorities utilise the U-AGREE mitigation barrier models to determine the U-space services that need to be rolled out in a particular airspace volume, as well as their performance requirements and the capabilities and required performance of the UAS that will operate therein.

U-AGREE defines two new operating methods for the airspace design with different time horizons:

- In the short-term, risk will be estimated using SORA 2.5 risk models and risk mitigation will be based on the U-space services defined by the Commission Implementing Regulation (EU) 2021/664.
- In the mid-term, risk will be estimated using the U-AGREE risk models and risk mitigation will be based on the U3 services envisaged by the CORUS five project in the medium time horizon (MTH).

New operating methods in the strategic phase

In the strategic phase, UAS operators that intend to conduct a BVLOS operation will have to operate under the Specific category and will need to apply for an operational authorisation based on the outcomes of a SORA, unless they operation is classified as certified. As part of the SORA, the operator must estimate the intrinsic (i.e., unmitigated) ground risk and the residual risk after the application of mitigation measures.

U-AGREE defines two new operating methods based on the SORA process with different time horizons:

- In the short-term, operators will estimate the risk of their operations using SORA 2.5 models and will use U-space services in accordance to Commission Implementing Regulation (EU) 2021/664 to mitigate them.
- In the mid-term, operators will estimate the risk of their operations using SORA 3.0 models in a streamlined process integrated in the U-space workflow in which U-AGREE risk models will enable more accurate risk and risk-mitigation with (near)real-time evidence of both.

U-AGREE new operating methods will occur under the following Operating Scenarios:

- OS-1 Airspace design considering SORA 2.5 risk models and U-space services according to Regulation 664.
- OS-2 Airspace design considering U-AGREE risk models and advanced U-space services according to the CORUS ConOps Ed. 4.0.
- OS-3 Pre-flight risk assessment using SORA 2.5 risk models and U-space enabled data exchange.

- OS-4 Pre-flight risk assessment using U-AGREE risk models and an approval process embedded in the U-space workflow.

U-AGREE Operational Scenarios

OS-1 Airspace design considering SORA 2.5 risk models and U-space services according to Regulation 664.

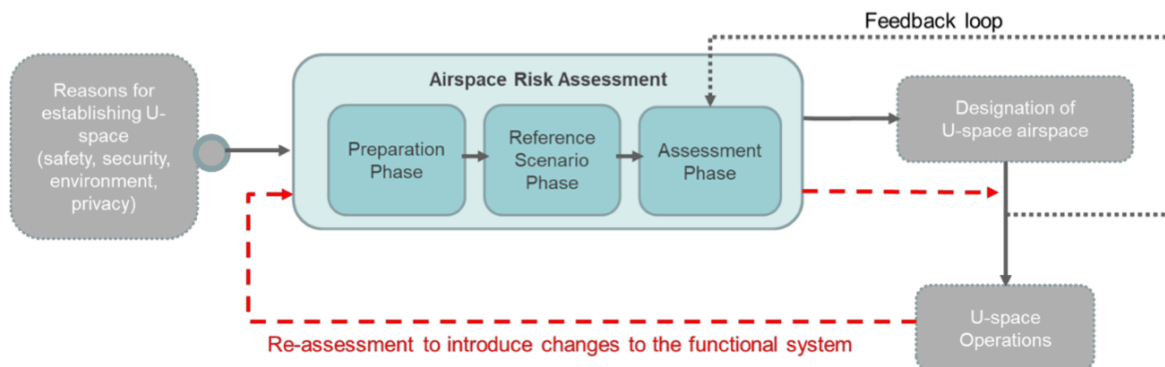


Figure 11. Graphical view of the ARA process [16].

Figure 12 provides a graphical overview of this Operational Scenario 1. This operational scenario applies in the short-term, once the authority competent for the designation of the U-space airspace has completed the preparation phase and defined the reference scenario (see Figure 11 for reference). During these phases, the competent authority collects the inputs necessary to conduct the assessment phase:

Aeronautical data

- Ground facilities, encompassing locations and detailed description of airports, heliports and vertiports, as well as location and characteristics of NAVAIDs and aeronautical surveillance systems.
- Airspace structures, including the airspace limits, layers or corridors defined for UAS operations, routes regularly used by manned aviation (either VFR or IFR), airspace classification, airspace encounter category (AEC) and location and description of UAS geographical zones.
- Air traffic description providing details on the characteristics and volume of all types of manned operations, encompassing commercial and general aviation operations in the airspace of interest, as well as any recreational activities.
- Air traffic description providing detail of the characteristics and volume of all types of unmanned operations expected in the considered airspace volume. The description will include relative number and the physical characteristics, performances, and capabilities of each type of UAS expected to operate in the airspace of interest and may account for temporal and spatial variations due to variable demand or any other reason. In addition to the traffic mix, the description will include expected unmanned traffic patterns linked, for instance, to logistics hubs, hospitals, etc.

Ground features

- Population density maps in digital format. The map shall also include information about the distribution of shelters and obstacles that could be used to mitigate the risk people on the ground are exposed to.
- A digital elevation model (DEM) of the terrain in the area of interest.
- Location of critical infrastructures, such as energy plants, critical services, transport networks, security critical facilities and hazardous industries. Although they are not critical infrastructures in the strict sense, the location of singular cultural heritage elements shall be also included.
- Description of natural features of the terrain such as waterbodies or forests, as well as areas of special environmental protection.

Environmental conditions

- Meteorological conditions (including local conditions in urban environments) encompassing precipitations (type, intensity and frequency), wind (predominant directions and average intensity and wind gust intensity), temperature (maximum and minimum), humidity and visibility.
- Solar radiation and solar storms.
- The location and characteristics of manmade sources of radiofrequency emissions that could affect UAS electronic systems.

Communication, Navigation and Surveillance infrastructure

- Coverage and other quality of service (QoS) parameters of public telecommunication networks in the UAS operational volume (e.g., mobile 4G/5G).
- Coverage and other QoS parameters of global navigation satellite systems (GNSS) in the UAS operational volume.

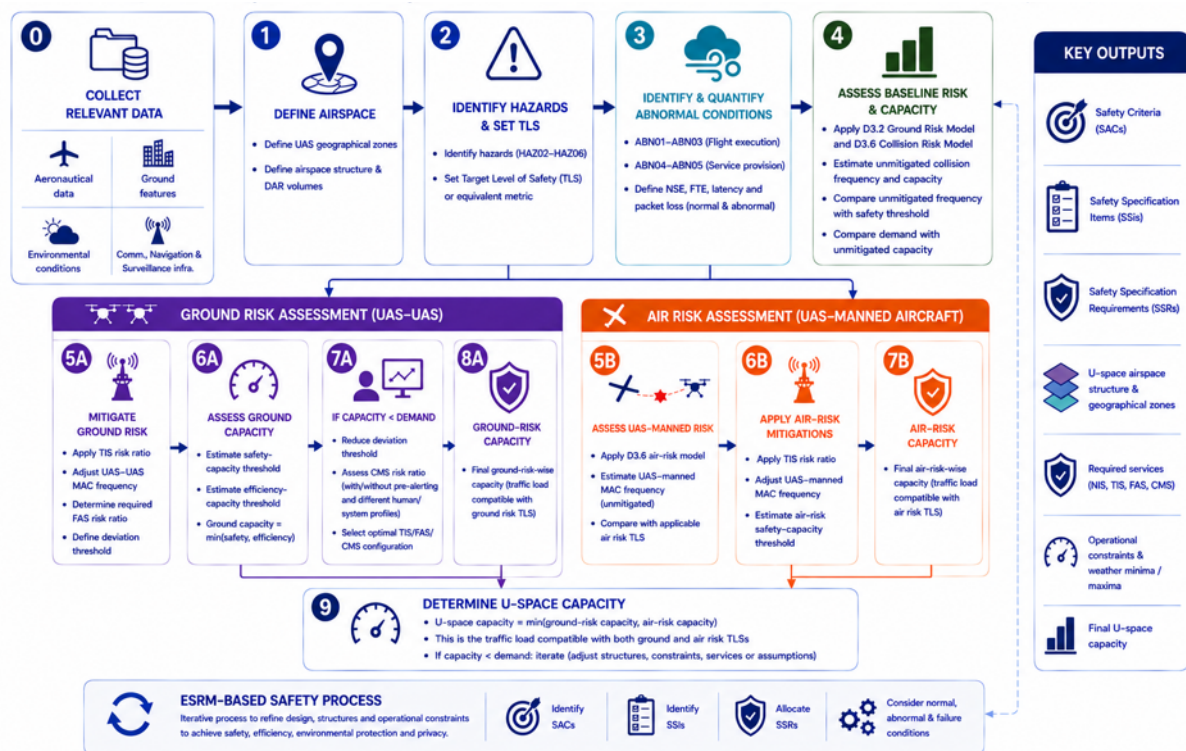


Figure 12. Overview of U-AGREE Operational Scenario 1.

Based on the information collected during the preparation and reference scenario phase, the competent authority shall first:

- Identify and define the necessary UAS geographical zones that are needed for safety, security, privacy or environmental reasons.
- In case the U-space airspace is to be designated in controlled airspace, define the structure of volumes to apply the DAR effectively, where necessary, taking into account the specific airspace structure identified in the previous phases of the ARA.
- Identify the hazards that U-space services will have to tackle from those listed in Table 4: Hazards inherent to aviation identified by U-AGREE according to the GATMOC and identify the TLS or equivalent metric.
 - For HAZ02 (UAS conflicting trajectories resulting in a Mid-Air Collision (MAC) and a subsequent crash into the ground), the TLS will be defined by apportioning the 10% of the SORA ground risk TLS (10^{-7} FAT/F-H) to accidents on the ground provoked by a MAC between UAS.
 - For HAZ03 (UAS and manned aircraft conflicting trajectories resulting in a MAC in uncontrolled airspace) the SORA air risk TLS (10^{-7} MAC/F-H) in uncontrolled airspace will be directly applied.
 - For HAZ04 (UAS and manned aircraft conflicting trajectories resulting in a MAC in controlled airspace) the SORA air risk TLS (10^{-9} MAC/F-H) in controlled airspace will be directly applied.

- For HAZ05 (UAS infringement of airspace-wide or geographical zone-specific constraints), specific acceptable limits to infringements to UAS geographical zones need to be agreed with the affected stakeholders (police, health or education authorities, infrastructure managers, etc.).
 - For HAZ06 (Wildlife strike on an airborne UAS), the risk will be mitigated by defining UAS geographical zones with specific access conditions. Therefore, the risk will be bounded, as for HAZ05, by limiting the frequency of infringement to those UAS geographical zones.
- Identify and quantify the expected abnormal conditions that might impact the flight execution from those listed in Table 5 (namely, ABN01, ABN02 and ABN03) and define the expected navigation performance in terms of Navigation System Error (NSE) and Flight Technical Error (FTE) in normal and abnormal conditions.
 - Identify and quantify the risk due to the expected abnormal conditions that might impact the provision of U-space services from those listed in Table 5 (namely, ABN04 and ABN05) and define the associated system latencies and packet loss rates in normal and abnormal conditions.

Subsequently, the competent authority will perform a bifurcated safety assessment based on the E-SRM methodology, comprising two parallel assessment threads: one focused on ground risk and the other on air risk. For the ground risk assessment, the competent authority shall:

- Apply the U-AGREE initial ground risk model described in deliverable D3.2 to determine the maximum UAS-UAS MAC frequency compatible with the applicable ground risk TLS.
- Apply the U-AGREE collision risk model described in deliverable D3.6 to determine the unmitigated UAS-UAS collision frequency and the associated unmitigated safety-capacity threshold (i.e., the traffic load compatible with the ground risk TLS) considering the forecasted UAS traffic mix and traffic patterns accounting for the NSE and FTE in nominal and abnormal conditions.
- Determine whether the maximum UAS-UAS MAC frequency is breached, or the projected demand exceeds the estimated capacity. If this is not the case, no U-space airspace would be needed from the ground-risk point of view.
- If the UAS-UAS MAC frequency exceeds the acceptable ground-risk threshold and/or the unmitigated safety-capacity cannot accommodate the expected demand, estimate the risk reduction provided by the Traffic Information Service (TIS) for UAS-UAS encounters. This risk reduction shall be expressed through a TIS risk ratio, defined as the ratio between the probability of an NMAC with the TIS in place and the corresponding probability without the TIS. The maximum UAS-UAS MAC frequency compatible with the ground-risk TLS shall then be adjusted accordingly by dividing the safety-capacity threshold by the TIS risk ratio.
- Determine the required risk ratio of the FAS needed to reduce the UAS-UAS MAC frequency to the acceptable limit and the associated protection buffer (i.e., the deviation threshold).
- Estimate the ground-risk efficiency-capacity threshold (which is driven by the size of the deviation threshold and the strategic deconfliction criteria) and the resulting ground risk-wise capacity, that will be the minimum between the safety-capacity threshold and the efficiency-capacity threshold.
- If the resulting ground risk-wise capacity after the combined application of the FAS and the TIS is lower than the expected demand, reduce the deviation thresholds and determine the CMS

risk ratio under different configuration combinations (with or without pre-alerting, and considering different human/system response profiles), both in normal and abnormal conditions. Select the configuration that best satisfies the required capacity from a ground-risk perspective.

NOTE: This should be an iterative process through which the competent authority could define additional structures within the U-space airspace. For example, the use of layers to accommodate aircraft with similar performance characteristics could reduce collision risk and consequently increase capacity. Similarly, operational constraints applicable to UAS operations could also be defined. For instance, reducing UAS speed could decrease collision risk and therefore increase capacity, while limiting the minimum cruise altitude or restricting take-off and landing locations could reduce visual and acoustic nuisance, mitigate the impact on wildlife, and reduce the risks posed by different species, as discussed in Deliverable D3.4. This process should also support the competent authority in defining weather minima and maxima, as well as the deviation thresholds, the “geometrical proximity” criteria for the provision of NIS, and the “proximity” criteria for the provision of TIS.

On the air-risk side, the competent authority shall:

- Apply the U-AGREE collision risk model described in Deliverable D3.6 to determine the unmitigated UAS-manned collision frequency and the associated safety-capacity threshold considering the forecasted UAS traffic mix and traffic pattern accounting for the NSE and FTE in nominal and abnormal conditions.
- Estimate the risk ratio of the Traffic Information Service for UAS-manned encounters in normal and abnormal conditions (including ABN06) and considering a range of human performance profiles, adjust the UAS-manned MAC frequency accordingly and estimate the associated capacity (air-risk-wise safety-capacity).

Finally, the competent authority shall determine the U-space capacity as the minimum of the ground-risk and air-risk-wise capacities.

The common thread underlying this entire process, which connects the different stages into a comprehensive safety-driven approach, is the EUROCONTROL Expanded Safety Reference Material (ESRM). The ESRM enables the identification of Safety Criteria (SAC) and Safety Specification Items (SSIs), as well as the allocation of Safety Specification Requirements (SSRs) in normal, abnormal and failure conditions in a systematic manner. The use cases described in Section 3.3.2 under this operational scenario illustrate how the U-AGREE risk and mitigation barriers models can support this process by underpinning a quantitative approach.

OS-2 Airspace design considering U-AGREE risk models and advanced U-space services according to the CORUS ConOps Ed. 5.0.

In the mid-term, as U-space evolves into a mature framework and the demand for new operations increases, particularly for higher-risk SAIL V and VI operations in the Specific category, type #2 cargo operations, and type #3 certified operations for IAM, new services and operational procedures are expected to be developed and adopted through new or amended regulations. More accurate risk models, such as those proposed by U-AGREE in its Deliverables D3.4, D3.5 and D3.6, are also expected to be integrated into the UAS regulatory framework, enabling less conservative yet more realistic risk estimations. This evolution will trigger a major reassessment of existing U-space airspaces and support

the establishment of new, ubiquitous U-space airspaces across a broad range of operational contexts, as addressed in this operational scenario and graphically illustrated in Figure 13.

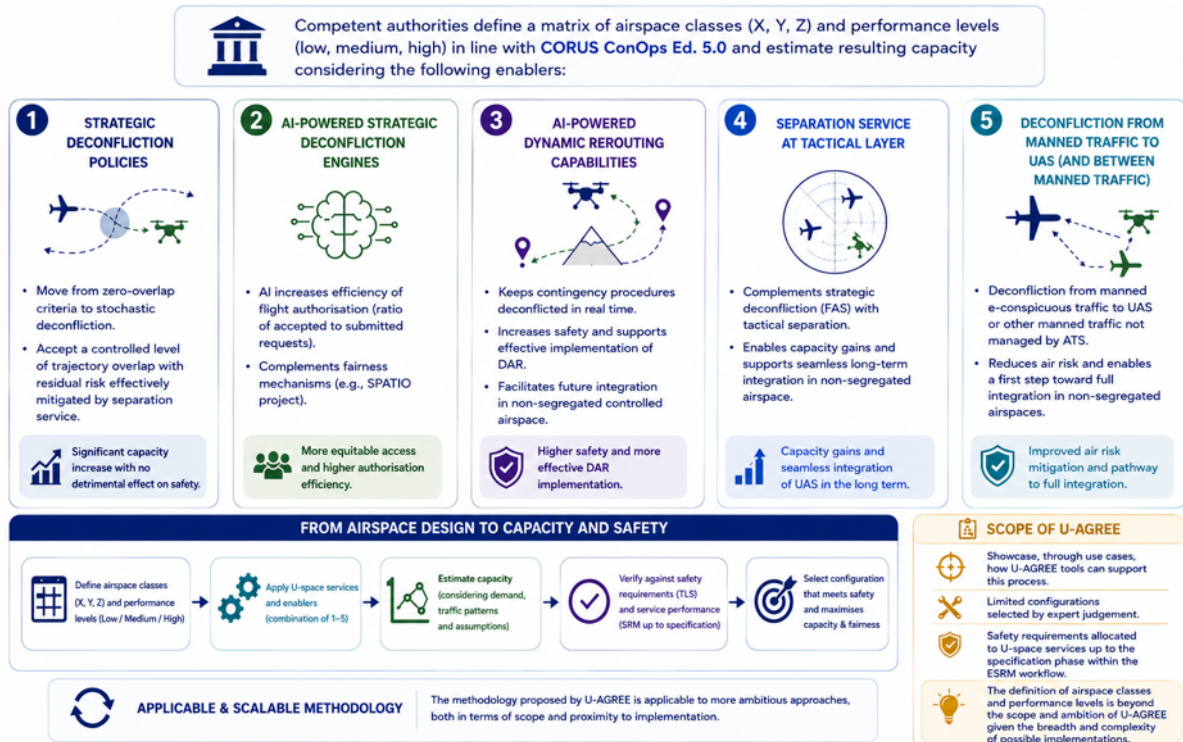


Figure 13. Overview of U-AGREE Operational Scenario 2

Competent authorities responsible for the oversight and redesign of the airspace structure will define a matrix of airspace classes (X, Y, Z) and performance levels (e.g., low, medium, and high performance), in accordance with the CORUS ConOps Ed. 5.0, and will estimate the resulting capacity while taking into consideration:

- More flexible yet effective strategic deconfliction policies. The zero-overlap criteria applied in the short term clearly prioritises safety over capacity. Stochastic deconfliction approaches that accept a controlled level of trajectories overlap resulting in a residual risk that can be still effectively mitigated by a separation service would notably increase capacity with no detrimental effect on safety.
- The use of AI-powered strategic deconfliction engines will contribute to a more equitable access to the airspace since the efficiency of the flight authorisation (measured as the ratio between submitted and accepted flight authorisation request) will increase. This will complement specific fairness mechanism that are also envisaged (for instance, in the SPATIO project).
- The development of AI-powered dynamic rerouting capabilities would help keep the contingency procedures deconflicted in real time, notably increasing safety. These capabilities would also contribute to a safer and more effective implementation of the DAR, also contributing to the future integration of UAS operations in non-segregated controlled airspace.

- The provision of a separation service complementing at tactical layer the mitigation achieved through the strategic deconfliction mechanism implemented within the FAS will complete the picture, enabling the gain in capacity and contributing to the seamless integration of UAS into non-segregated airspace in the long-term.
- The provision of deconfliction from manned e-conspicuous traffic to UAS or even other manned traffic not managed by an ATS unit would have a beneficial impact on the mitigation of air risk and might constitute a first step towards the full integration of UAS in non-segregated airspaces in the long-term horizon.

The definition of the different airspace classes and their associated performance levels falls beyond the scope and ambition of U-AGREE. The breadth and complexity of the possible implementations would require resources far exceeding the timeframe and manpower available within a non-application-oriented exploratory research project.

Instead, U-AGREE will showcase, through the use cases described in Section 3.3.2 under this operational scenario, how the tools developed within the project could support such a process. Only a limited number of configurations, identified by the consortium as particularly relevant based on expert judgement, are presented. Safety requirements will also be allocated to the involved U-space services, although only up to the specification phase within the ESRM workflow.

Nevertheless, the methodology proposed by U-AGREE remains applicable to more ambitious approaches, both in terms of scope and proximity to implementation.

OS-3 Pre-flight risk assessment using SORA 2.5 risk models and U-space enabled data exchange

Nowadays, the Operational Authorisation process by the NSA (for operations in the Specific category) demands a risk assessment of the proposed operation using the SORA 2.5 methodology. EASA accepts U-space as a tactical mitigation to the Air Risk, recommending classifying as ARC-b those UAS operations within a U-space airspace. Once the Operator receives the Operational Authorisation, it can start to plan and execute its flight in the U-space volume by means of a U-space Service Provider (USSP). But there is not any liaison among both processes.

The Operational Scenario 3 proposes an initial integration among both processes, SORA Operational Authorisation and U-space service provision. In this OS, the operator will still need an Operational Authorisation from the NSA, but to develop the SORA study, the Operator will take advantage of a SORA Tool provided by U-space (the tool can be considered a Safety Service as per JARUS SORA 2.5 Annex H, being provided by the USSP or another entity); in this Tool the operator will define the trajectory or area demanded for the operation and the Tool will help them to calculate the 10 steps of the SORA process and, moreover, the Tool will become the evidence to be provided to the NSA to justify the Tactical Mitigation Performance Requirements (TMPR) and also the fulfilment of:

- OSO #06 “C3 link characteristics are appropriate for the operation”, with regard to the real performance of the C3 link before and during the execution of the flights, through an assessment of R/C link coverage or cellular network performances (depending on the type of C3 link).
- OSO #13 “External services supporting UAS operations are adequate to the operation”, ensuring the GNSS coverage performances availability for each intended operation.

- OSO #23 “Environmental conditions for safe operations defined, measurable and adhered to”, verifying that the weather forecast for the expected flight is within the limits approved for the operation.

The Tool will provide the NSA with evidence derived from real operational data, supporting its adoption as an approved Means of Compliance for these OSOs and TMPR. The Tool will guarantee to the NSA that these checks are developed, prior to each operation, to confirm that the requested U-space Flight Authorisation for each individual operation is within the boundary of the approved Operational Authorisation and that the C3 link coverage, GNSS performance and weather conditions are adequate for the operation. This way the SORA Tool defined in OS3 will provide an initial integration between the SORA and U-space processes.

The Tool will also help gather the data to regularly verify that the assumptions of the U-space Airspace Risk Assessment (ARA) developed to deploy the U-space airspace remain valid and identify when a reassessment is needed.

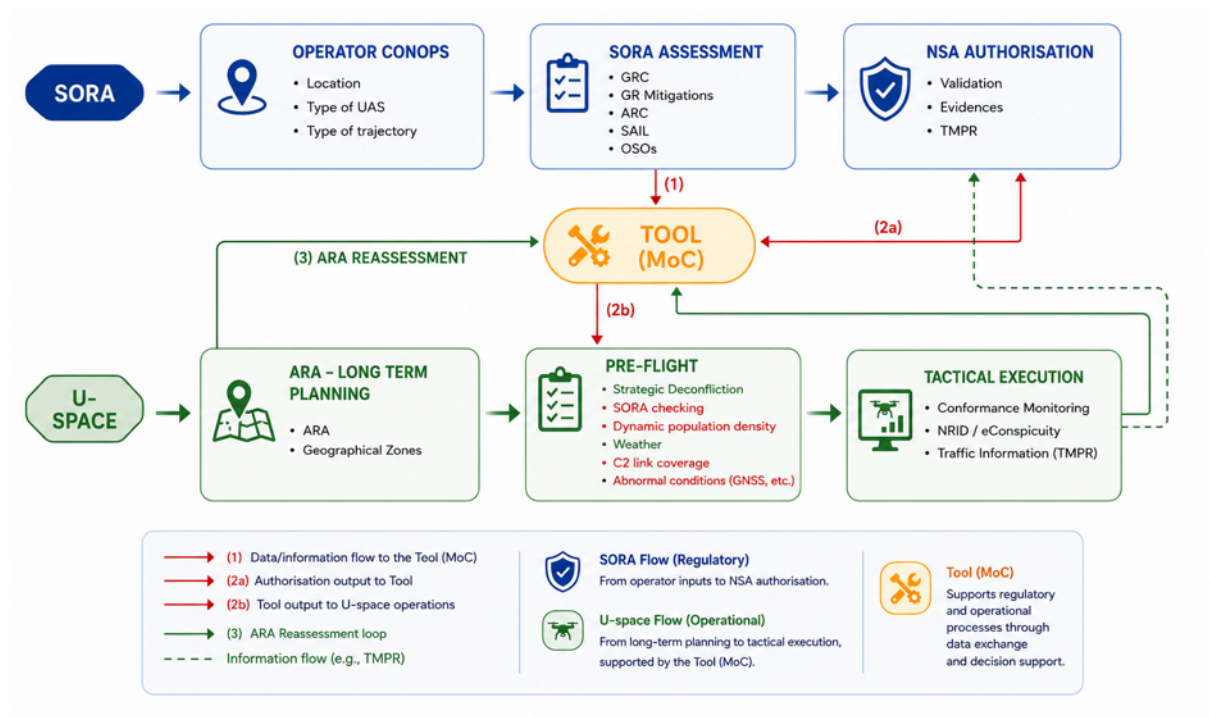


Figure 14: Overview of U-AGREE Operational Scenario 3.

OS-4 Pre-flight risk assessment using U-AGREE risk models and an approval process embedded in the U-space workflow.

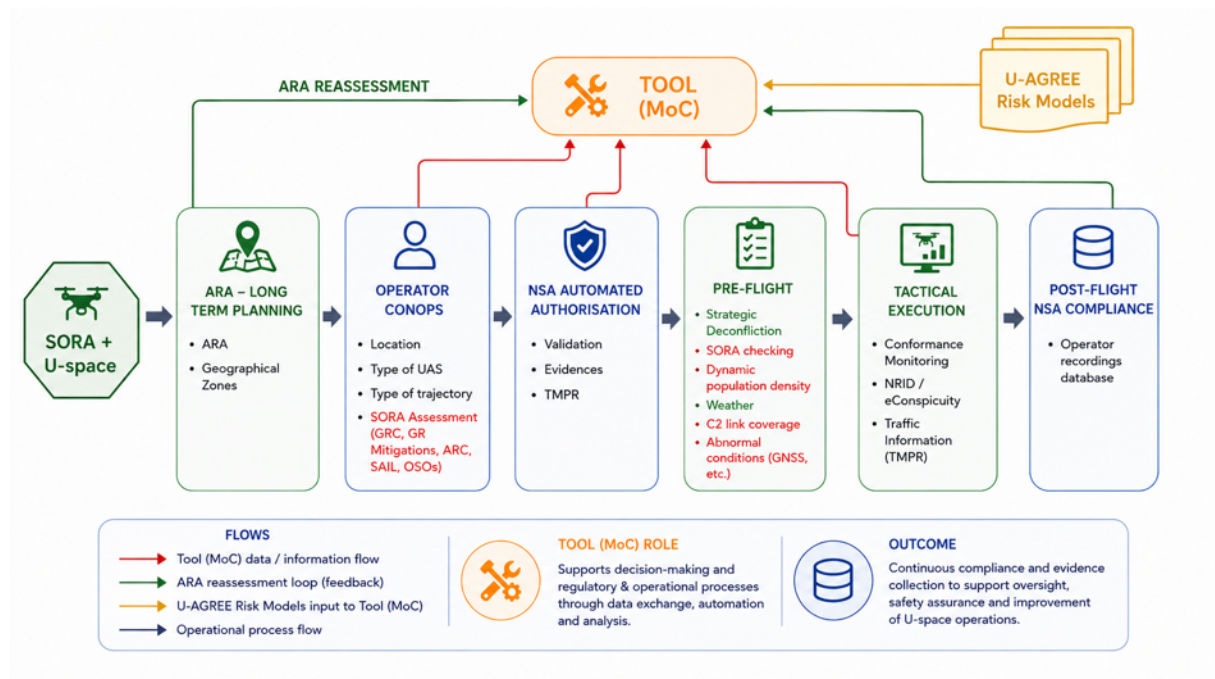


Figure 15: Overview of Operational Scenario 4

OS-4 presents a long-term scenario in which the initial integration proposed in OS-3 is completed, becoming SORA and U-space a unitary process. The operator will still demand an Operational Authorisation but it will be granted automatically if it is developed within the U-space ecosystem, approved by the NSA to ensure the robustness of the SORA assessment and that the Tool provides or is able to verify all the demanded evidence for the operational authorisation; this included checking in the EASA database that the demanded UAS model has been approved for the demanded M2 mitigations and SAIL Level, and also with NSAs database that the operator is competent and proven for the type of Operational Authorisation demanded.

The rest of the process will be identical than the one described in OS-3.

3.3.2.1 Use cases

OS-1 Airspace design considering SORA 2.5 risk models and U-space services according to Regulation 664

UC1.1 Reference airspace: no U-space

This use case describes how the competent authority applies U-AGREE initial risk models to estimate the maximum traffic density that can be safely accommodated in the Class G and Terminal Airspace

operating environments without the support of U-space mitigation services. This assessment constitutes the baseline against which the benefits of additional mitigation mechanisms described in U-AGREE deliverable D4.1 will later be evaluated. The assessment considers the hazards identified in U-AGREE deliverable D2.3 and summarised in Table 4.

The main stakeholder for this use case is the competent authority responsible for assessing the designation of a U-space airspace, although other stakeholders providing relevant information will also be involved to some extent. Additional stakeholders impacted by this use case include UAS operators, insofar as their activity may be constrained by the outcomes of the use case, as well as other authorities responsible for defining UAS geographical zones, whose effectiveness could be affected by the increase in UAS operations.

NOV-5 - UC1.1 Reference airspace no U-space

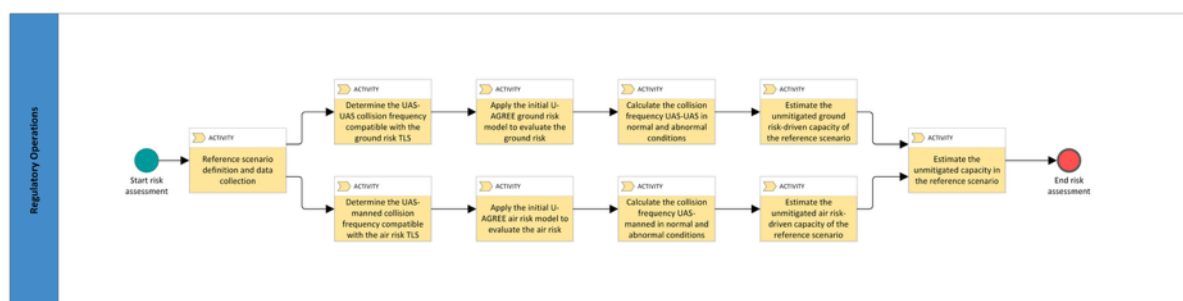


Figure 16. Overview of U-AGREE Use Case 1.1

This use case comprises three stages, as illustrated in Figure 16:

1. Estimation of the maximum traffic density that can be accommodated without any risk mitigation measures while satisfying the acceptable unmitigated ground-risk criteria associated with UAS-UAS MACs under normal and abnormal conditions.
2. Estimation of the maximum traffic density that can be accommodated without any risk mitigation measures while satisfying the acceptable unmitigated air-risk criteria associated with UAS-manned aircraft MACs, considering operations in controlled and uncontrolled airspace and, for Class G airspace, both operations confined to the VLL and operations extending above it.
3. Determination of the overall unmitigated airspace capacity, defined as the most restrictive capacity resulting from the unmitigated ground-risk and air-risk assessments.

Although the Easy Access Rules for U-space indicate that, in the short term, the designation of U-space airspace is expected to focus on the VLL airspace, this use case extends the assessment to operations above that limit, since there is no regulatory constraint precluding such operations and national authorities may consider this option in specific cases.

Stage #1: Estimation of the unmitigated ground risk capacity

In this stage the competent authority will:

1. Determine the target level of safety for the ground risk derived from mid-air collisions.

2. Apply SORA 2.5 ground risk model to determine the average number of fatalities due to a UAS impact on the ground.
3. Apply the U-AGREE initial risk model (D3.2) to derive the maximum UAS-UAS MAC frequency compatible with the TLS.
4. Apply the U-AGREE collision risk model described in deliverable D3.6 to estimate the unmitigated UAS-UAS MAC frequency considering operations up to the VLL under:
 - a. Normal conditions: NSE and FTE from [44].
 - b. Abnormal weather conditions: degraded flight performance, modelled through a twofold increase in FTE relative to nominal conditions.
 - c. Abnormal GNSS conditions: degraded navigation performance, modelled through a twofold increase in NSE relative to nominal conditions.
 - d. Abnormal communication conditions: degraded flight performance, modelled through a twofold increase in FTE relative to nominal conditions.
5. Apply the U-AGREE collision risk model described in deliverable D3.6 to estimate the unmitigated UAS-UAS MAC frequency for operations extending from ground level up to 500 ft below any vertically adjacent controlled airspace. This scope covers operations both below and above the VLL. The assessment shall be conducted under:
 - a. Normal conditions: NSE and FTE from [44].
 - b. Abnormal weather conditions: degraded flight performance, modelled through a twofold increase in FTE relative to nominal conditions.
 - c. Abnormal GNSS conditions: degraded navigation performance, modelled through a twofold increase in NSE relative to nominal conditions.
 - d. Abnormal communication conditions: degraded flight performance, modelled through a twofold increase in FTE relative to nominal conditions.
6. Compare the unmitigated UAS-UAS MAC frequencies to the threshold compatible with the ground-risk TLS to derive the unmitigated ground-risk-wise safety-capacity thresholds in normal and abnormal conditions corresponding to 5(a) to 5(d), and 6(a) to 6(d).

Stage #2: Estimation of the unmitigated air risk capacity

For uncontrolled class G airspace, the competent authority will:

1. Apply the U-AGREE collision risk model described in deliverable D3.6 to estimate the unmitigated UAS-manned MAC frequency considering operations up to the VLL under:
 - a. Normal conditions: NSE and FTE from [44] (general aviation – GA – aircraft are assumed to have the same navigation performance as large UAS, fixed wing or rotorcraft).
 - b. Abnormal weather conditions: degraded flight performance, modelled through a twofold increase in FTE relative to nominal conditions.
 - c. Abnormal GNSS conditions: degraded navigation performance, modelled through a twofold increase in NSE relative to nominal conditions.
 - d. Abnormal communication conditions: degraded flight performance, modelled through a twofold increase in FTE relative to nominal conditions.
2. Apply the U-AGREE collision risk model described in deliverable D3.6 to estimate the unmitigated UAS-manned MAC frequency for operations extending from ground level up to 500 ft below any vertically adjacent controlled airspace. This scope covers operations both below and above the VLL. The assessment shall be conducted under:

- a. Normal conditions: NSE and FTE from [44].
 - b. Abnormal weather conditions: degraded flight performance, modelled through a twofold increase in FTE relative to nominal conditions.
 - c. Abnormal GNSS conditions: degraded navigation performance, modelled through a twofold increase in NSE relative to nominal conditions.
 - d. Abnormal communication conditions: degraded flight performance, modelled through a twofold increase in FTE relative to nominal conditions.
3. Compare the unmitigated UAS-manned MAC frequency to the air-risk TLS to derive the unmitigated air-risk-wise safety-capacity thresholds in normal and abnormal conditions corresponding to 1(a) to 1(d), and 2(a) to 2(d).

Note: Where the upper limit of the U-space airspace exceeds the VLL, different traffic mixes may need to be considered depending on the expected manned traffic patterns.

For controlled terminal airspace the competent authority will:

1. Apply the U-AGREE collision risk model described in deliverable D3.6 to estimate the unmitigated UAS-manned MAC frequency considering operations up to the assessed airspace ceiling under:
 1. Normal conditions: NSE and FTE from [44].
 2. Abnormal weather conditions: degraded flight performance, modelled through a twofold increase in FTE relative to nominal conditions.
 3. Abnormal GNSS conditions: degraded navigation performance, modelled through a twofold increase in NSE relative to nominal conditions.
 4. Abnormal communication conditions: degraded flight performance, modelled through a twofold increase in FTE relative to nominal conditions.
2. Compare the unmitigated UAS-manned MAC frequency to the air-risk TLS to derive the unmitigated air-risk-wise safety-capacity thresholds in normal and abnormal conditions corresponding to 1(a) to 1(d).

Stage #3: Estimation of the unmitigated capacity

The competent authority will determine the resulting unmitigated capacity in normal and abnormal conditions as the minimum between the unmitigated ground-risk-wise and air-risk-wise capacities. The competent authority will use those unmitigated capacities as the baseline for determining the required performance of the U-space services subsequently deployed to mitigate the identified risks, as well as the required UAS capabilities and performance, the airspace structure, and any additional airspace limitations or operational constraints.

UC1.2 Risk mitigation through Flight Authorisation Service and Traffic Information Service

This use case describes how competent authorities apply the minimum bundle of U-space services laid down in Commission Implementing Regulation (EU) 2021/664 to mitigate the risk posed by UAS both on the ground and on the air, thereby increasing the airspace capacity compared to the unmitigated capacity while still meeting the applicable TLS.

The main stakeholder in this use case is the competent authority charged with the responsibility for designating the U-space airspace and defining the required performance of the involved U-space services and aircraft therein, as well as any additional airspace limitation or constraint.

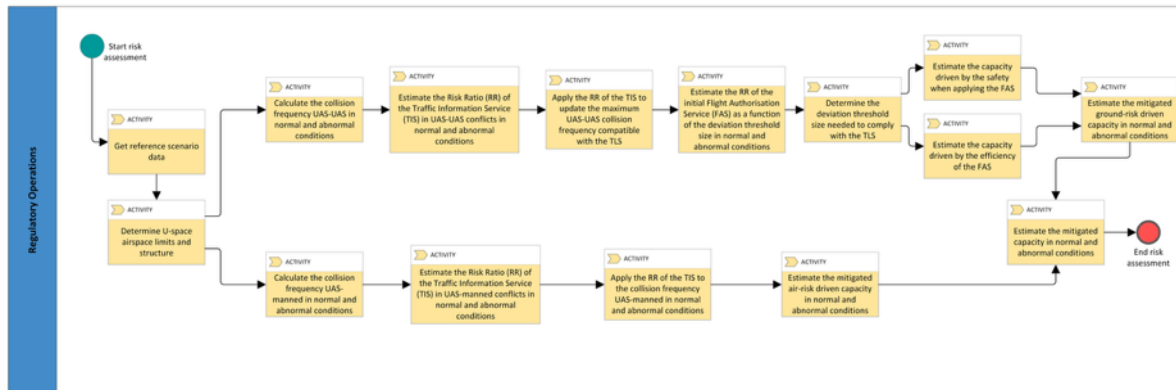


Figure 17. Overview of U-AGREE Use Case 1.2

As in the case of UC1.1, this use case also comprises the three stages illustrated in Figure 17:

1. Estimation of the capacity associated with ground risk due to UAS-UAS MACs, considering the mitigation provided by the TIS and the FAS under both normal and abnormal conditions. This capacity will largely depend on the type of overflowed area (urban, suburban, or rural).
2. Estimation of the capacity associated with air risk due to UAS-manned aircraft MACs, considering the mitigation provided by the TIS. This capacity will depend on whether operations take place in controlled or uncontrolled airspace and, for operations conducted in uncontrolled Class G airspace, on whether they are confined to the VLL volume or extend above it.
3. Estimation of the mitigated airspace capacity, defined as the minimum of the mitigated capacities resulting from the ground-risk and air-risk assessments described in Items 1 and 2.

Although the Easy Access Rules for U-space indicate that, in the short term, the designation of U-space airspace is expected to focus on the VLL airspace, this use case also extends the assessment to operations above that limit, since there is no regulatory constraint precluding such operations and national authorities may consider this option in specific cases.

Stage #1: Estimation of the mitigated ground risk capacity

In this stage the competent authority will:

1. Determine the lateral and vertical limits of the U-space airspace, together with any internal airspace structures, such as layers and corridors.
2. Apply the U-AGREE collision risk model described in Deliverable D3.6 to estimate the unmitigated UAS-UAS MAC frequency within the limits of the U-space airspace defined in Step 1, taking into consideration any internal airspace structures, the expected traffic mix and the projected traffic pattern. The assessment shall account for the same normal and abnormal conditions affecting the flight execution considered in UC1.1.
3. Apply the U-AGREE encounter model described in deliverable D3.6 to determine the risk ratio representing the mitigation effectiveness provided by the TIS for UAS-UAS MACs, considering

the expected traffic mix. The assessment shall be conducted under both normal and abnormal conditions and for different remote pilot performance profiles. In addition to abnormal conditions affecting the flight execution (as in Step 2), abnormal CNS conditions affecting the provision of U-space services execution need also to be considered. Potential operational fault conditions that may affect safety shall be identified together with the corresponding mitigation measures.

4. Determine the risk ratio representing the mitigation effectiveness provided by the FAS for UAS-UAS MACs as a function of the protection buffer (i.e., the deviation threshold). The assessment shall be conducted under applicable normal and abnormal conditions. Potential operational fault conditions that may affect safety shall be identified together with the corresponding mitigation measures.
5. Apply the combined mitigation effect represented by the risk ratios estimated in Steps 3 and 4 to the unmitigated UAS-UAS MAC frequency computed in Step 2 to obtain the mitigated UAS-UAS MAC frequency under normal and abnormal conditions.
6. Estimate the ground-risk safety capacity under normal and abnormal conditions by comparing the mitigated UAS-UAS MAC frequency obtained in Step 5 with the maximum UAS-UAS MAC frequency compatible with the applicable TLS, as determined in UC1.1.
7. Estimate the ground-risk efficiency capacity, considering the protection buffer and the zero-overlap conflict resolution policy.
8. Determine the ground-risk capacity as the minimum of the safety capacity and efficiency capacities estimated in Steps 6 and 7.
9. Consolidate the performance requirements for the U-space services and UAS involved, together with the required aircraft capabilities. Identify any applicable airspace constraints and operational limitations, including the selected deviation thresholds, the UAS-UAS encounter distance for the provision of TIS, the proximity distance for the provision of NIS, and any airspace structures (e.g., layers or corridors) considered in the assessment.

Note: Where the upper limit of the U-space airspace exceeds the VLL, different traffic mixes may need to be considered for the assessments performed in Steps 2 to 6, depending on the airspace structure, allocation policies, and expected manned traffic patterns. For example, high-performance aircraft may be allocated to airspace volumes above the VLL, while low-performance aircraft may be restricted to operations below the VLL.

Stage #2: Estimation of the mitigated air risk capacity

In this stage, the competent authority will:

1. Apply the U-AGREE collision risk model described in Deliverable D3.6 to estimate the unmitigated UAS-manned MAC frequency within the limits of the U-space airspace, taking into consideration any internal airspace structures. The assessment shall consider both normal and abnormal conditions.
2. Apply the U-AGREE encounter model described in deliverable D3.6 to determine the risk ratio representing the mitigation effectiveness provided by the TIS for UAS-manned MACs, considering the applicable traffic mix. The assessment shall be conducted under the applicable normal and abnormal conditions and for different remote pilot performance profiles. Potential

operational fault conditions that may affect safety shall be identified together with the corresponding mitigation measures.

3. Apply the mitigation effect represented by the risk ratio estimated in Step 2 to the unmitigated UAS-manned MAC frequency computed in Step 1 to obtain the mitigated UAS-manned MAC frequency under normal and abnormal conditions.
4. Estimate the air-risk safety capacity under normal and abnormal conditions by comparing the mitigated UAS-manned MAC frequency obtained in Step 3 with the maximum UAS-manned MAC frequency compatible with the applicable TLS for controlled or uncontrolled airspace.
5. Consolidate the performance requirements for the U-space services and UAS involved, together with the required aircraft capabilities. Identify any applicable airspace constraints and operational limitations, including the UAS-manned encounter distance for the provision of TIS, the proximity distance for the provision of NIS, and any airspace structures (e.g., layers or corridors) considered in the assessment.

Note: Where the upper limit of the U-space airspace exceeds the VLL, different traffic mixes may need to be considered for the assessments performed in Steps 1 and 2, depending on the airspace structure, allocation policies, and expected manned traffic patterns. For example, high-performance aircraft may be allocated to airspace volumes above the VLL, while low-performance aircraft may be restricted to operations below the VLL.

Stage #3: Estimation of the mitigated capacity

The competent authority will determine the resulting unmitigated airspace capacity under normal and abnormal conditions as the minimum of the unmitigated ground-risk and air-risk capacities. The resulting capacity shall serve as the baseline for determining whether additional U-space services, enhanced UAS performance and capabilities, or airspace limitations and operational constraints are required to safely accommodate the expected demand.

UC 1.3 – Risk mitigation through Flight Authorisation Service, Conformance Monitoring without pre-alert and Traffic Information Service

This use case, illustrated in Figure 18, only applies when the resulting capacity at the end of UC1.2 is constrained by the ground-risk assessment and is insufficient to accommodate the envisaged demand. In such cases, the provision of the CMS can increase capacity by enhancing UAS containment performance, thereby allowing a reduction in the protection buffer required by the FAS. The resulting improvement in FAS effectiveness reduces the mitigated UAS-UAS MAC frequency, increasing the ground-risk safety capacity, while the smaller protection buffers increase the ground-risk efficiency capacity. Consequently, the overall achievable airspace capacity is increased.

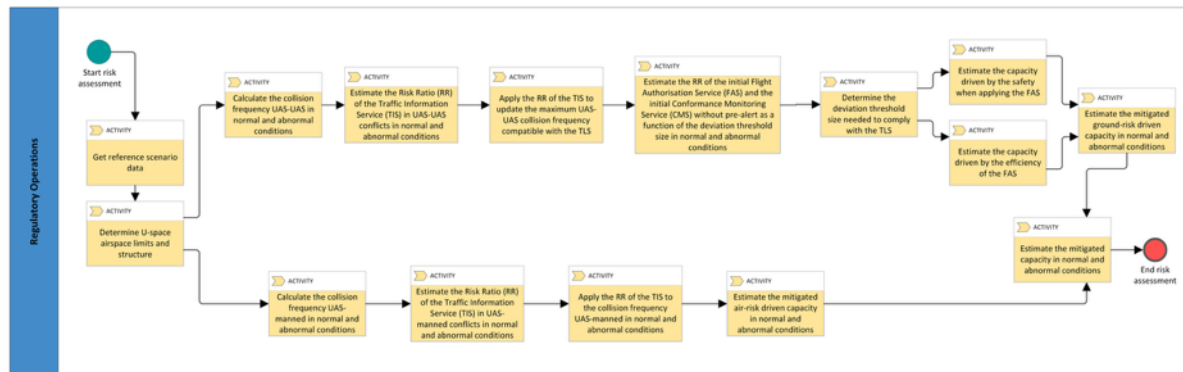


Figure 18. Overview of U-AGREE Use Case 1.3

In this case, the competent authority shall:

1. Apply the U-AGREE collision risk model described in Deliverable D3.6 to estimate the mitigated UAS-UAS MAC frequency as a function of the protection buffer, considering the combined effect of the FAS and CMS without the optional pre-alerting capability. The assessment shall be conducted within the limits of the U-space airspace defined in UC1.2, taking into account any internal airspace structures. It shall also account for abnormal conditions affecting both flight execution and the provision of the CMS, as well as different CMS automation levels. The traffic-mix caveat defined in UC1.1 and UC1.2 also applies to this use case.
2. Apply the TIS risk ratio obtained in UC1.2 to further mitigate collision risk and obtain the final mitigated UAS-UAS MAC frequency.
3. Estimate the ground-risk safety capacity under normal and abnormal conditions by comparing the mitigated UAS-UAS MAC frequency obtained in Step 2 with the maximum UAS-UAS MAC frequency compatible with the applicable ground-risk TLS, as determined in UC1.1.
4. Estimate the ground-risk efficiency capacity, considering the updated protection buffer and the zero-overlap conflict resolution policy.
5. Determine the ground-risk capacity as the minimum of the safety capacity and efficiency capacity estimated in Steps 3 and 4.
6. Identify any additional airspace constraints and operational limitations beyond those defined in UC1.2, including the selected protection buffers.

UC 1.4 Risk mitigation through Flight Authorisation Service, Conformance Monitoring with pre-alert and Traffic Information Service

This use case, represented in Figure 19, is equivalent to UC1.3, but considers an enhanced Conformance Monitoring Service (CMS) capable of issuing pre-alerts to remote pilots before the UA exits the 4D operational volume specified in the flight authorisation. The additional warning time provided by the pre-alerting capability enables earlier corrective actions, thereby improving UAS containment performance.

The improved containment performance shall be reflected in the joint assessment of the mitigation effectiveness provided by the CMS and the Flight Authorisation Service (FAS). As a result, smaller

protection buffers may be achieved while maintaining the same level of safety, leading to an increase in both the ground-risk safety capacity and the ground-risk efficiency capacity.

The assessment methodology, assumptions, performance metrics, and capacity determination process remain unchanged with respect to UC1.3. Only the CMS containment performance parameters are updated to account for the pre-alerting capability.

The competent authority shall use the resulting capacity estimates to determine any additional performance requirements for the CMS, FAS, and UAS involved, as well as any associated airspace constraints or operational limitations.

NOV-5 - UC1.4 Risk mitigation through Flight Authorisation Service, Conformance Monitoring Service with pre-alert and Traffic Information Service

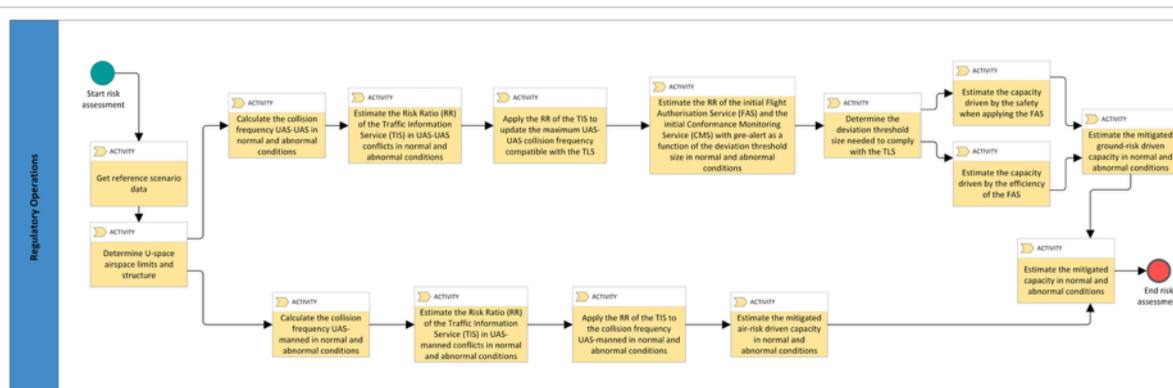


Figure 19. Overview of U-AGREE Use Case 1.4

OS-2 Airspace design considering U-AGREE risk models and advanced U-space services according to the CORUS ConOps Ed. 5.0

UC2.1 – Reference: No U-space

NOV-5 - UC2.1 Reference airspace no U-space

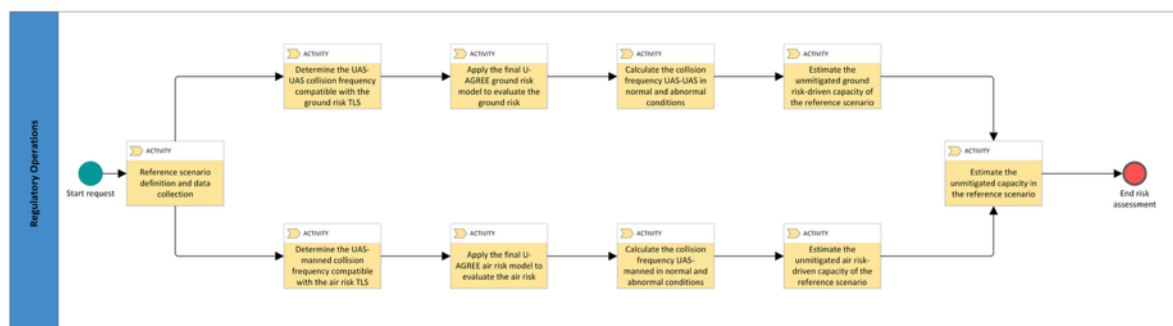


Figure 20. Overview of U-AGREE Use Case 2.1

This use case describes how the competent authority applies the final U-AGREE risk models to reassess the maximum traffic density that can be safely accommodated in the Class G and Terminal Airspace operating environments without the support of U-space mitigation services. This assessment establishes the baseline against which the benefits of the advanced mitigation mechanisms described in U-AGREE Deliverable D4.2 will subsequently be evaluated. The assessment considers the hazards identified in U-AGREE Deliverable D2.3 and summarised in Table 4.

The main stakeholder for this use case is the competent authority responsible for assessing the designation of a U-space airspace, although other stakeholders providing relevant information will also be involved to some extent. Additional stakeholders impacted by this use case include UAS operators, insofar as their activity may be constrained by the outcomes of the use case, as well as other authorities responsible for defining UAS geographical zones, whose effectiveness could be affected by the increase in UAS operations.

This use case mirrors the three stages already defined for UC1.1, as illustrated in Figure 20, where the points at which UC2.1 diverges from UC1.1 are emphasised in red:

1. Estimation of the maximum traffic density that can be accommodated without any risk mitigation measures while satisfying the acceptable unmitigated ground-risk criteria associated with UAS-UAS MACs under normal and abnormal conditions.
2. Estimation of the maximum traffic density that can be accommodated without any risk mitigation measures while satisfying the acceptable unmitigated air-risk criteria associated with UAS-manned aircraft MACs, considering operations in controlled and uncontrolled airspace and, for Class G airspace, both operations confined to the VLL and operations extending above it.
3. Determination of the overall unmitigated airspace capacity, defined as the minimum capacity value resulting from the unmitigated ground-risk and air-risk assessments.

In line with the CORUS five approach, this use case extends the assessment to operations above the VLL limit, since U-space deployments in the mid-term are not expected to be constrained by that limit.

Stage #1: Estimation of the unmitigated ground risk capacity

In this stage the competent authority will:

1. Determine the target level of safety for the ground risk derived from mid-air collisions.
2. Apply U-AGREE ground risk models (D3.2 and D3.5) to determine the average number of fatalities due to a UAS impact on the ground.
3. Apply the U-AGREE initial risk model (D3.2) to derive the maximum UAS-UAS MAC frequency compatible with the TLS.
4. Apply the U-AGREE collision risk model described in deliverable D3.6 to estimate the unmitigated UAS-UAS MAC frequency considering operations up to the VLL under the same normal and abnormal conditions as in UC1.1.
5. Apply the U-AGREE collision risk model described in deliverable D3.6 to estimate the unmitigated UAS-UAS MAC frequency for operations extending from ground level up to 500 ft below any vertically adjacent controlled airspace. This scope covers operations both below and above the VLL. The assessment shall be conducted under the same normal and abnormal conditions as those defined in UC1.1.

6. Compare the unmitigated UAS-UAS MAC frequencies to the threshold compatible with the ground-risk TLS obtained in step 3 to derive the unmitigated ground-risk-wise safety-capacity thresholds in normal and abnormal conditions.

Stage #2: Estimation of the unmitigated air risk capacity

For uncontrolled class G airspace the competent authority will:

1. Determine the target level of safety for the air risk derived from mid-air collisions.
2. Apply U-AGREE final air risk model (D3.4, D5.2) to determine the average number of fatalities in the air due to a UAS-manned MAC.
3. Apply the U-AGREE final air risk model (D3.4, D5.2) to derive the maximum UAS-manned MAC frequency compatible with the TLS.
4. Apply the U-AGREE collision risk model described in deliverable D3.6 to estimate the unmitigated UAS-manned MAC frequency considering operations up to the VLL under the same normal and abnormal conditions used in UC1.1.
5. Apply the U-AGREE collision risk model described in deliverable D3.6 to estimate the unmitigated UAS-manned MAC frequency for operations extending from ground level up to 500 ft below any vertically adjacent controlled airspace, assuming the safety buffer defined in U-AGREE assumption OA-3. This scope covers operations both below and above the VLL. The assessment shall be conducted under the same normal and abnormal conditions as those defined in UC1.1.
6. Compare the unmitigated UAS-manned MAC frequency to the maximum UAS-manned MAC frequency compatible with the TLS to derive the unmitigated air-risk-wise safety-capacity thresholds in normal and abnormal conditions).

Note: Where the upper limit of the U-space airspace exceeds the VLL, different traffic mixes may need to be considered depending on the expected manned traffic patterns.

For controlled terminal airspace the competent authority will:

1. Apply the U-AGREE collision risk model described in deliverable D3.6 to estimate the unmitigated UAS-manned MAC frequency considering operations up to the assessed airspace ceiling under the same normal and abnormal conditions used in UC1.1.
2. Compare the unmitigated UAS-manned MAC frequency to the air-risk TLS to derive the unmitigated air-risk-wise safety-capacity thresholds in normal and abnormal conditions corresponding to 1(a) to 1(d).

Stage #3: Estimation of the unmitigated capacity

The competent authority will determine the resulting unmitigated capacity in normal and abnormal conditions as the minimum between the unmitigated ground-risk-wise and air-risk-wise capacities. The competent authority will use those unmitigated capacities as the baseline for determining the required performance of the U-space services subsequently deployed to mitigate the identified risks, as well as the required UAS capabilities and performance, the airspace structure, and any additional airspace limitations or operational constraints.

UC2.2 Risk mitigation through advanced U-space services according to the CORUS ConOps Ed. 5.0

The main stakeholder in this use case is the competent authority responsible for designating the U-space airspace and defining the required performance of the U-space services and aircraft operating therein, as well as any additional airspace limitations or operational constraints.

This use case describes how competent authorities may apply advanced U-space services to mitigate the risks associated with UAS operations in the mid-term, thereby increasing the capacity that can be safely accommodated, supporting the projected growth in demand, and enabling more equitable access to the airspace for different categories of operators while remaining compliant with the applicable TLS. Nevertheless, the wide range of advanced mitigation features expected to become available in the mid-term gives rise to an impractically large number of possible combinations for assessment.

NOV-5 - UC2.2 Risk mitigation through advanced U-space services according to the CORUS ConOps Ed. 5.0

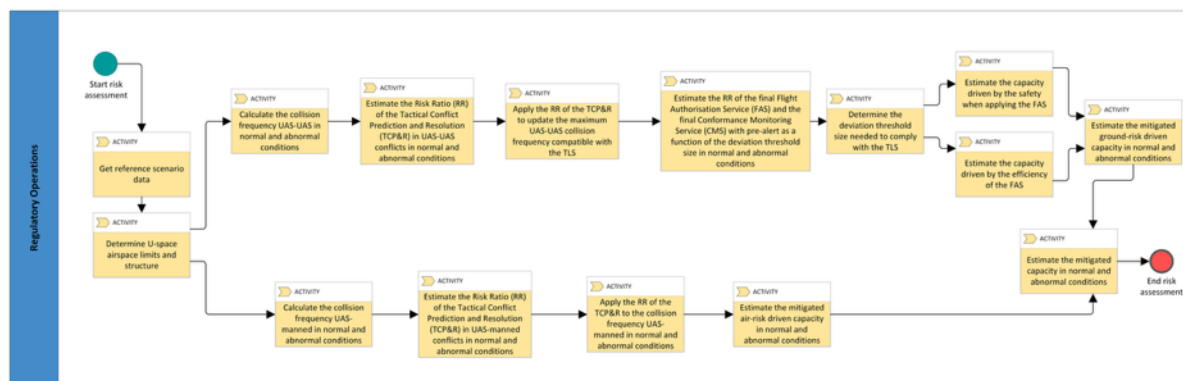


Figure 21. Overview of U-AGREE Use Case 2.2

Therefore, this use case focuses on evaluating the safety and efficiency benefits provided by the Flight Authorisation Service (FAS) and the Tactical Conflict Prediction and Resolution (TCP&R) service under different configurations. The objective is to support the competent authority in selecting the most appropriate combination of mitigation mechanisms for different airspace environments and in deriving the corresponding performance requirements.

The use case spans through the three stages illustrated in Figure 21:

1. Mitigation of the ground risk due to UAS-UAS MACs, considering the mitigation provided by the FAS applying a soft strategic deconfliction policy and the TCD&R service with different configurations and levels of automation, under both normal and abnormal conditions.
2. Mitigation of the air risk due to UAS-manned aircraft MACs, considering the mitigation provided by the FAS and the TCD&R service with different configurations and levels of automation, under both normal and abnormal conditions.
3. Estimation of the mitigated airspace capacity and the required level of performance, in the light of the results of stages 1 and 2.

In line with the CORUS five ConOps, the assessment will consider both controlled and uncontrolled airspace, as well as operations extending above the VLL.

Stage #1: Ground risk mitigation.

In this stage, the competent authority will:

1. Determine the lateral and vertical limits of the U-space airspace, together with any internal airspace structures, such as layers and corridors.
2. Apply the U-AGREE collision risk model described in Deliverable D3.6 to estimate the unmitigated UAS-UAS MAC frequency within the limits of the U-space airspace defined in Step 1, considering any internal airspace structures, the expected traffic mix and the projected traffic pattern. The assessment shall account for the same normal and abnormal conditions affecting the flight execution considered in UC1.1.
3. Apply the U-AGREE encounter model described in deliverable D3.6 to determine the risk ratio representing the mitigation effectiveness provided by the TCD&R for UAS-UAS MACs, considering the expected traffic mix. The assessment shall be conducted under both normal and abnormal conditions and for different configurations (e.g., levels of automation or conflict detection and resolution algorithms' parameters). In addition to abnormal conditions affecting the flight execution (as in Step 2), abnormal CNS conditions affecting the provision of U-space services execution need also to be considered. Potential operational fault conditions that may affect safety shall be identified together with the corresponding mitigation measures.
4. Determine the risk ratio representing the mitigation effectiveness provided by the FAS and the CMS for UAS-UAS MACs for different configurations (e.g., protection buffers' size or conflict resolution policies). The assessment shall be conducted under applicable normal and abnormal conditions. Potential operational fault conditions that may affect safety shall be identified together with the corresponding mitigation measures.
5. Consolidate the performance requirements for the U-space services and involved aircraft, together with the required aircraft capabilities taking into consideration the different configurations considered in the risk assessment. Identify any applicable airspace constraints and operational limitations, as well as any airspace structures (e.g., layers or corridors) considered in the assessment.

Note: Where the upper limit of the U-space airspace exceeds the VLL, different traffic mixes may need to be considered for the assessments performed in Steps 2 to 4, depending on the airspace structure, allocation policies, and expected manned traffic patterns. For example, high-performance aircraft may be allocated to airspace volumes above the VLL, while low-performance aircraft may be restricted to operations below the VLL.

Stage #2: Air risk mitigation

In this stage, the competent authority will:

1. Apply the U-AGREE collision risk model described in Deliverable D3.6 to estimate the unmitigated UAS-manned MAC frequency within the limits of the U-space airspace, considering any internal airspace structures. The assessment shall consider both normal and abnormal conditions.

2. Apply the U-AGREE encounter model described in deliverable D3.6 to determine the risk ratio representing the mitigation effectiveness provided by the TCD&R for UAS-manned MACs, considering the expected traffic mix. The assessment shall be conducted under both normal and abnormal conditions and for different configurations (e.g., levels of automation or conflict detection and resolution algorithms' parameters). In addition to abnormal conditions affecting the flight execution (as in Step 2), abnormal CNS conditions affecting the provision of U-space services execution need also to be considered. Potential operational fault conditions that may affect safety shall be identified together with the corresponding mitigation measures.
3. Determine the risk ratio representing the mitigation effectiveness provided by the FAS and the CMS for UAS-manned MACs for different configurations (e.g., protection buffers' size or conflict resolution policies). The assessment shall be conducted under applicable normal and abnormal conditions. Potential operational fault conditions that may affect safety shall be identified together with the corresponding mitigation measures.
4. Consolidate the performance requirements for the U-space services and involved aircraft, together with the required aircraft capabilities taking into consideration the different configurations considered in the risk assessment. Identify any applicable airspace constraints and operational limitations, as well as any airspace structures (e.g., layers or corridors) considered in the assessment.

Note: Where the upper limit of the U-space airspace exceeds the VLL, different traffic mixes may need to be considered for the assessments performed in Steps 1 and 2, depending on the airspace structure, allocation policies, and expected manned traffic patterns. For example, high-performance aircraft may be allocated to airspace volumes above the VLL, while low-performance aircraft may be restricted to operations below the VLL.

Stage #3: Estimation of the mitigated capacity and the corresponding performance requirements

In this stage, the competent authority will:

1. Identity the U-space configurations that lead to a mitigated UAS-UAS MAC frequency below the threshold compatible with the ground risk TLS determined in UC2.1 under normal and abnormal conditions.
2. Estimate the ground-risk-wise safety capacity under normal and abnormal conditions by comparing the mitigated UAS-UAS MAC frequencies obtained in Step 1 for any feasible combination of mitigations with the maximum UAS-UAS MAC frequency compatible with the applicable TLS, as determined in UC2.1.
3. Estimate the ground-risk-wise efficiency capacity, considering the U-space configurations considered in step 2.
4. Determine the ground-risk-wise capacity as the minimum of the safety capacity and efficiency capacities estimated in Steps 2 and 3.
5. Identity the U-space configurations that lead to a mitigated UAS-manned MAC frequency below the threshold compatible with the air risk TLS determined in UC2.1 under normal and abnormal conditions.
6. Estimate the air-risk-wise safety capacity under normal and abnormal conditions by comparing the mitigated UAS-manned MAC frequencies obtained in Step 5 for any feasible combination of mitigations with the maximum UAS-manned MAC frequency compatible with the applicable TLS, as determined in UC2.1.

7. Estimate the air-risk-wise efficiency capacity, considering the U-space configurations considered in step 5.
8. Determine the air-risk-wise capacity as the minimum of the safety capacity and efficiency capacities estimated in Steps 6 and 7.
9. Determine the resulting unmitigated capacity in normal and abnormal conditions as the minimum between the unmitigated ground-risk-wise and air-risk-wise capacities.

It falls out of U-AGREE whether the competent authorities apply steps 1 to 9 any particular candidate U-space on a case-by-case basis or use this approach to define a set of standard U-space airspaces with different baseline risk and capacity targets, along with the associated performance levels.

OS-3 Pre-flight risk assessment using SORA 2.5 risk models and U-space enabled data exchange

UC3.1 – Reference: Operations in U-space with a previous and independent Operational Authorisation process

NOV-5 - UC3.1 Reference Operations in U-space with a previous and independent Operational Authorisation process

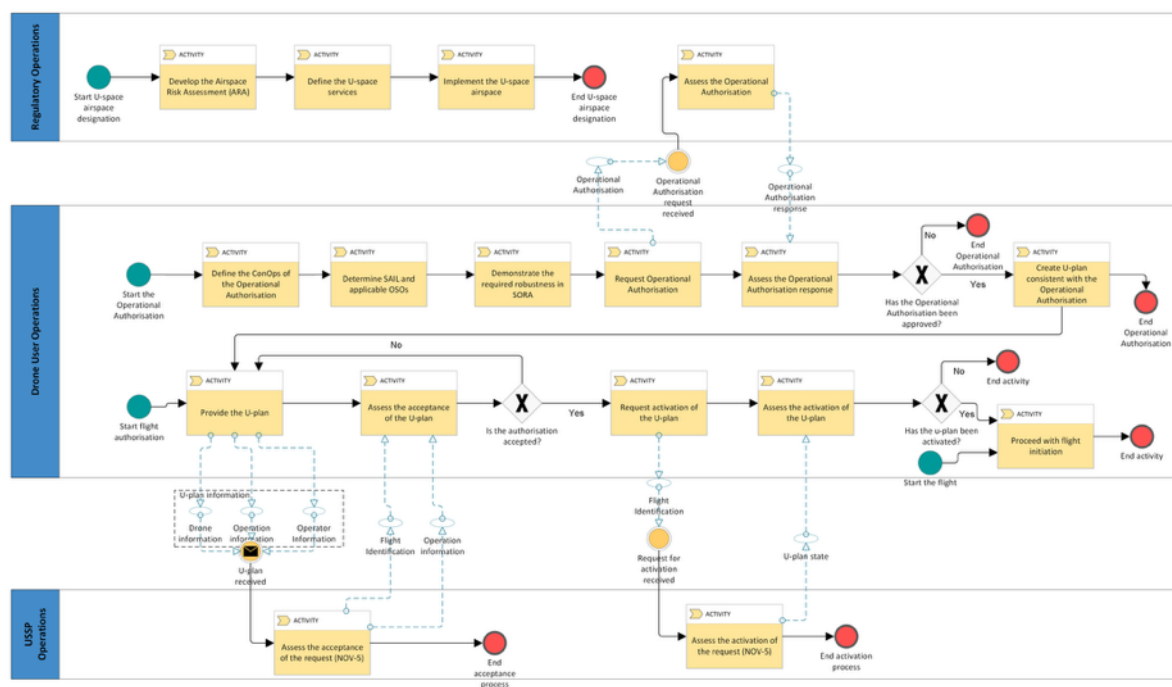


Figure 22. Overview of U-AGREE Use Case 3.1

This use case, graphically illustrated in Figure 22, describes the current process followed by UAS operators in the Specific category, willing to fly in a U-space airspace. Nowadays, the Operational Authorisation process by the NSA (for operations in the Specific category) demands a risk assessment of the proposed operation using the SORA 2.5 methodology. EASA accepts U-space as a tactical mitigation to the Air Risk, recommending classifying as ARC-b those UAS operations within a U-space airspace. Once the Operator receives the Operational Authorisation, it can start to plan and execute

its flight in the U-space volume by means of a U-space Service Provider (USSP). But there is not any liaison among both processes.

The main stakeholder in this use case is the UAS operator, but the NSA, the U-space coordinator and the U-space Service Provider (USSP) are also involved.

This use case consists of four stages:

1. Once a U-space volume is designated, the U-space Coordinator leads the development of the Airspace Risk Assessment, necessary to safely implement the U-space airspace.
2. A UAS operator, willing to fly in the Specific Category, develops a SORA study to request to the NSA an Operational Authorisation for the intended operation. To be granted and Operational Authorisation, the UAS operator has to provide to the NSA supporting evidence of the fulfilment of the robustness required for each OSO, according to the SAIL level of the operation.
3. In the Pre-tactical phase, the UAS Operator creates a flight plan coherent with the Operational Authorisation received and submits a Flight Authorisation request to the USSP to fly in the U-space volume.
4. The operator activates the Flight Authorisation received and executes the flight.

There is no liaison among the Operational Authorisation process with the NSA and the Flight Authorisation request to the USSP.

UC3.2 SORA 2.5 Operational Authorisation supported on evidence provided by the U-space SW Tool

The sequence of steps in this Use Case, as illustrated in Figure 23, is the same than in the Reference Case, but presenting an initial integration among both processes, SORA Operational Authorisation and U-space service provision. In this OS, the operator will still need an Operational Authorisation from the NSA, but to develop the SORA study, the Operator will take advantage of a SORA Tool provided by U-space.

The use case considers the same four stages plus an additional one at the end:

1. To deploy a U-space airspace, the U-space coordinator will lead the development of an Airspace Risk Assessment. At this stage, baseline assumptions are established regarding operational risk, traffic characteristics, and performance of supporting services (e.g. C2 link, GNSS, weather conditions); The future availability of operational data (to be gathered via the SORA Tool) is anticipated as a mechanism to validate and periodically update these assumptions.
2. In the strategic phase, months before the operation, the UAS operator will develop a SORA study by means of the U-space SORA Tool, through which the operator:
 - a. Defines the intended trajectory or operational volume.
 - b. Performs the 10 steps of the SORA methodology with automated support.
 - c. The Tool provides a Means of Compliance for the NSA to generate evidence based on real data to demonstrate compliance with required robustness levels (according to the SAIL), to justify the Tactical Mitigation Performance Requirements (TMPR) and also the fulfilment of OSOs related to C3 link coverage, GNSS performances and weather (OSO #06, #13 and #23).

The UAS operator submits the Operational Authorisation request to the NSA, which will evaluate the study and provide the Authorisation accepting the SORA Tool as MoC for the evidence with regard to these OSOs.

NOV-5 - UC3.2 SORA 2.5 Operational Authorisation supported on evidence provided by the U-space SW Tool

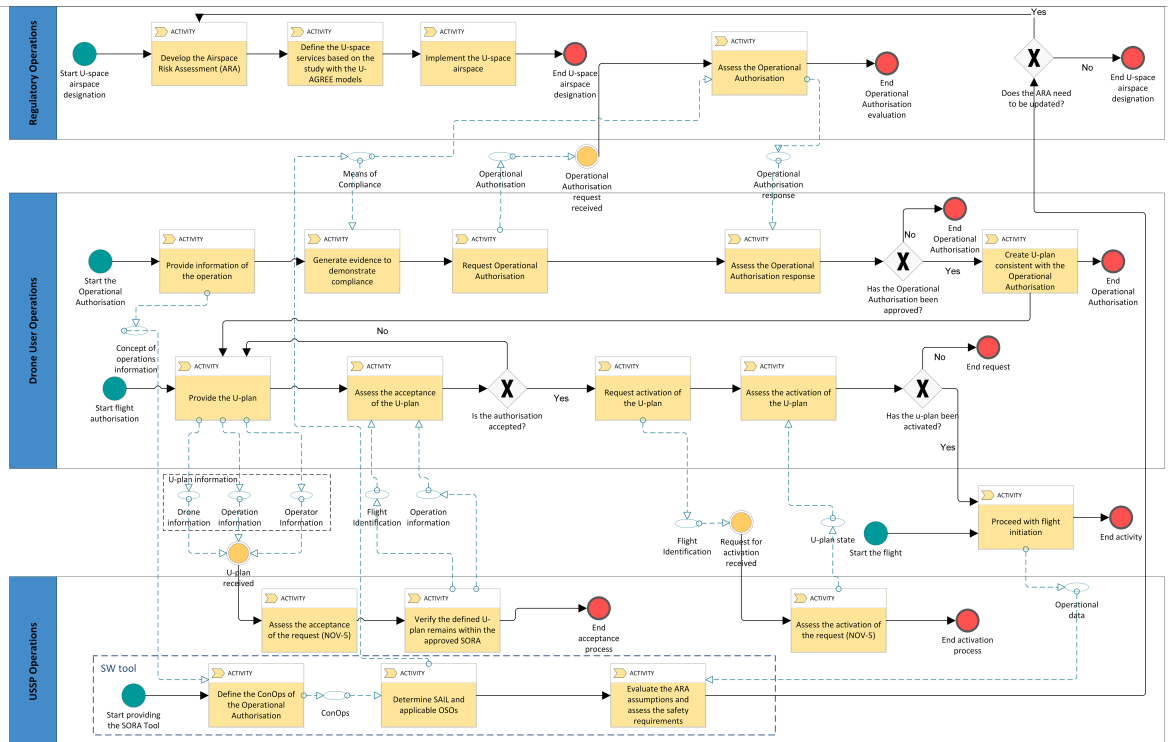


Figure 23. Overview of U-AGREE Use Case 3.2

3. In the pre-tactical phase, the operator prepares a flight plan consistent with the approved Operational Authorisation and submits a Flight Authorisation request to the U-space Service Provider (USSP). At this stage, the SORA Tool is used again prior to each operation to:
 - a. Verify that the requested operation remains within the boundaries of the approved SORA.
 - b. Check, using up-to-date data, that C2 link performance is adequate, GNSS performance is available and sufficient, Weather conditions are within approved limits.

The Tool provides operational evidence supporting the USSP decision-making process and ensuring consistency between strategic approval (SORA) and the specific operation.

4. Once the Flight Authorisation is granted the operator activates the authorisation and executes the flight. During and after the operation the SORA Tool collects real operational data, including: C3 link performance, GNSS performance, actual environmental conditions.

These data serve two purposes:

- a. Operational compliance evidence for the executed flight.

- b. Feedback into the U-space system, supporting the periodic verification and refinement of the ARA assumptions.
5. ARA Safety Requirements are checked and updated considering the data gathered by the SORA Tool for every UAS operation.

The main change introduced by OS3 is the transition from a static SORA process to a data-driven, continuously validated framework integrated with U-space operations.

OS-4 Pre-flight risk assessment using U-AGREE risk models and an approval process embedded in the U-space workflow

UC4.1 – SORA 2.5 Operational Authorisation integrated in the U-space framework

In this OS-4, the Reference use case is the UC3.2, i.e., the use case for OS-3 with an initial integration of the SORA Tool.

NOV-5 - UC4.1 SORA 2.5 Operational Authorisation integrated in the U-space framework

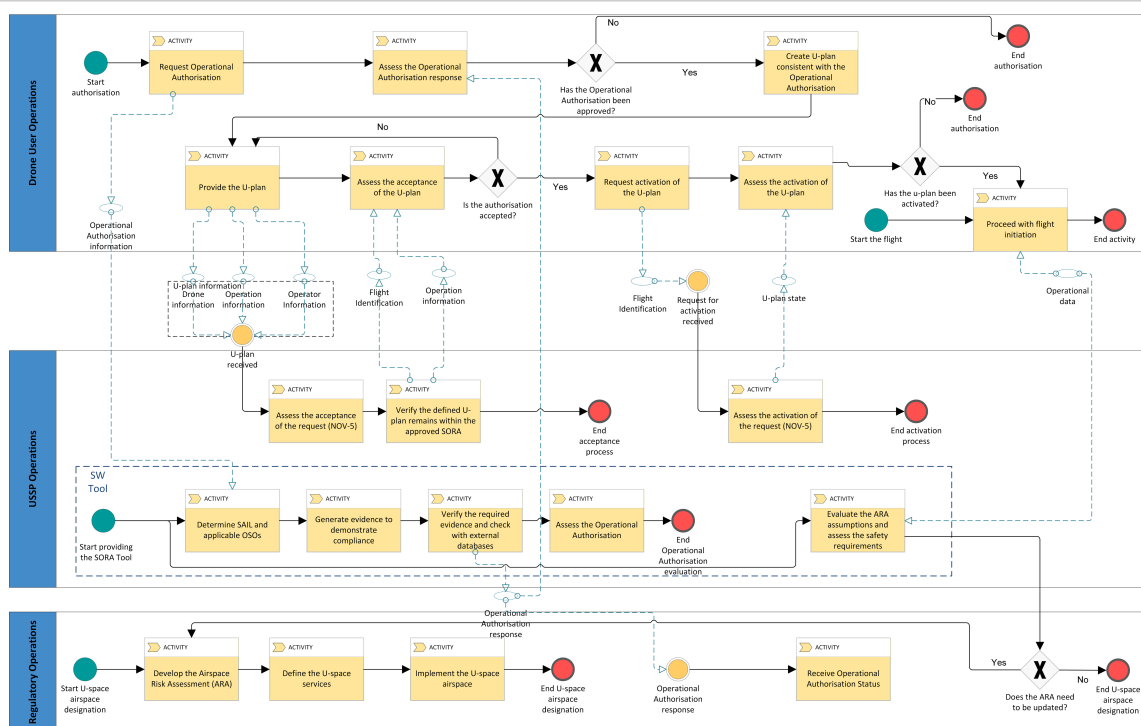


Figure 24. Overview of U-AGREE Use Case 4.1

The sequence of events illustrated in Figure 24 is as follows:

1. Once a U-space volume is designated, the U-space Coordinator develops the Airspace Risk Assessment (ARA) to enable safe deployment of the U-space airspace. As in OS-3, the ARA defines the baseline assumptions (traffic, risk levels, service performance). However, in OS-4 these assumptions are designed to be continuously validated through operational data fully integrated in the system.

2. Operational Authorisation (fully integrated and automated SORA process). A UAS operator intending to operate in the Specific Category initiates the SORA process within the U-space ecosystem using the enhanced SORA Tool, only a few days or hours before the intended operation. The SORA process and U-space services become a single, unified workflow, in which:
 - a. The SORA Tool Performs the full 10-step SORA assessment.
 - b. Automatically generates and verifies all required evidence.
 - c. Interfaces with external databases to validate:
 - i. UAS approval status (EASA database), including suitability for the required M2 mitigations and SAIL level.
 - ii. Operator competency (NSA database) for the requested type of operation.

If all requirements are met the Operational Authorisation is granted automatically, without a separate manual assessment by the NSA. The Tool itself is pre-approved by the NSA as ensuring compliance and robustness.

3. The pre-tactical process remains functionally identical to OS-3, but fully embedded in the same ecosystem. The operator prepares a flight plan consistent with the approved Operational Authorisation and submits a Flight Authorisation request to the U-space Service Provider (USSP). At this stage, the SORA Tool is used again prior to each operation to:
 - a. Verify that the requested operation remains within the boundaries of the approved SORA.
 - b. Check, using up-to-date data, that C2 link performance is adequate, GNSS performance is available and sufficient, Weather conditions are within approved limits.

The Tool provides operational evidence supporting the USSP decision-making process and ensuring consistency between strategic approval (SORA) and the specific operation.

4. Once the Flight Authorisation is granted the operator activates the authorisation and executes the flight. During and after the operation the SORA Tool collects real operational data, including: C3 link performance, GNSS performance, actual environmental conditions.

These data serve two purposes:

- a. Operational compliance evidence for the executed flight.
 - b. Feedback into the U-space system, supporting the periodic verification and refinement of the ARA assumptions.
5. ARA Safety Requirements are checked and updated considering the data gathered by the SORA Tool for every UAS operation.

3.3.3 Differences between new and previous operating methods

U-AGREE proposes a new SESAR solution that enables new capabilities within the SESAR architecture. Therefore, the difference does not lie in how activities are performed, but in the introduction of new activities that were not previously possible.

Activities (in the SESAR architecture) that are impacted by the SESAR solution	Current operating method	New operating method
Determine the UAS-UAS collision frequency compatible with the ground risk TLS.	N/A	Regulatory Authority determines the UAS-UAS collision frequency compatible with the ground risk TLS.
Determine the UAS-manned aircraft collision frequency compatible with the air risk TLS	N/A	Regulatory Authority determines the UAS-manned aircraft collision frequency compatible with the air risk TLS
Calculate the unmitigated UAS-UAS collision frequency	N/A	Regulatory Authority calculates the unmitigated UAS-UAS collision frequency
Estimate the mitigation effectiveness (Risk Ratio) of U-space services	N/A	Regulatory Authority estimates the mitigation effectiveness (Risk Ratio) of U-space services
Estimate the ground-risk-wise safety-capacity	N/A	Regulatory Authority estimates the ground-risk-wise safety-capacity
Estimate the ground-risk-wise efficiency-capacity	N/A	Regulatory Authority estimates the ground-risk-wise efficiency-capacity
Estimate the ground-risk-wise capacity	N/A	Regulatory Authority estimates the ground-risk-wise capacity
Estimate the air-risk-wise safety-capacity	N/A	Regulatory Authority estimates the air-risk-wise safety-capacity
Estimate the air-risk-wise capacity	N/A	Regulatory Authority estimates the air-risk-wise capacity
Estimate the airspace capacity	N/A	Regulatory Authority estimates the airspace capacity
Define U-space services and enabling CNS required performance	N/A	Regulatory Authority determines the UAS-UAS collision frequency compatible with the ground risk TLS.
Get operational authorisation prior to the flight	UAS operators request the authorisation to the National	UAS operators conduct the SORA as part of the flight authorisation process.

	Aviation Authority supported by a SORA ²	
Obtain relevant risk-driving data prior to the flight (dynamic population density, C2 link coverage, GNSS status, other abnormal conditions)	UAS operators get relevant risk-driving data at the time the SORA is conducted (usually static)	UAS operators get relevant, real-time risk-driving data at the time of the flight authorisation request
Check compliance with SORA authorisation prior to the flight	UAS operators check the compliance with the SORA on their own before requesting a flight authorisation	UAS operators check the compliance with the SORA as part of the flight authorisation request.

Table 10: differences between the new and the previous operating method

² These activities are currently executed by UAS operators, but they are no part of the SESAR architecture.

4 Key assumptions

The following assumptions underpin the operational concept and the analyses presented in this document.

Operational Assumptions

- **OA-1 – Progressive deployment of U-space:** The implementation of U-space is assumed to follow a progressive deployment path consistent with the European regulatory framework and the CORUS five Concept of Operations, encompassing both short-term and mid-term implementation horizons.
- **OA-2 – Availability of U-space services:** The U-space services considered in this document are assumed to be available according to the deployment horizon and operating environment under consideration. In particular, advanced strategic services and tactical conflict detection and resolution capabilities are assumed to become available in the mid-term horizon.
- **OA-3 – Representative operating environments:** The operational environments considered by the solution are assumed to be represented by the Class G and Terminal U-space sub-operating environments defined by the PEARL project, including both baseline and U-space-enabled scenarios. A buffer of 500 ft is assumed between the closest controlled airspace in the vertical dimension. Lateral buffers should also be defined to facilitate the activation of mitigation measures (e.g., DAR or TCD&R).
- **OA-4 – Progressive integration of manned aviation:** The progressive integration of electronically conspicuous manned aircraft into the U-space ecosystem is assumed, particularly in the mid-term horizon, enabling the provision of strategic and tactical services to both manned and unmanned traffic.
- **OA-5 – Collaborative nature of U-space operations:** The solution assumes a collaborative operational environment in which participating airspace users provide the information required for the provision of U-space services. Aircraft that are not electronically conspicuous or otherwise unable to participate in the U-space ecosystem are outside the scope of the solution, except where their presence is considered through operational constraints, airspace design measures or background traffic assumptions.
- **OA-6 – Normal and abnormal operating conditions:** The operational scenarios considered by the solution include both normal and abnormal operating conditions, recognising that the occurrence of hazards and the effectiveness of mitigation measures may differ between them. In the absence of more detailed information, the FTE and NSE values for normal operating conditions have been taken from Appendix III of [44]. Under abnormal operating conditions, both FTE and NSE are conservatively assumed to be twice their corresponding normal-condition values.

Safety Assumptions

- **SA-1 – Ground risk in MACs involving aircraft carrying people is considered negligible:** Although a MAC with a UAS may cause an aircraft carrying people to crash, potentially resulting in fatalities on the ground, the number of ground fatalities is expected to be several orders of magnitude lower than the number of fatalities among the aircraft occupants.

- **SA-2 – U-space services provide measurable risk mitigation:** U-space services are assumed to provide measurable risk reduction that can be quantified and incorporated into risk assessments addressing mid-air collision hazards.
- **SA-3 – Risk-based decision making:** Decisions related to airspace designation, operational constraints and service performance requirements are assumed to be based on quantified risk assessments and comparison against applicable TLS.
- **SA-4 – Continued applicability of SORA:** The SORA methodology is assumed to remain the primary framework supporting operational risk assessments for UAS operations in the Specific category, with the proposed risk models complementing and extending its capabilities.

Performance Assumptions

- **PA-1 – Availability of supporting data:** The accuracy of the proposed risk models is assumed to depend on the availability of sufficiently accurate, representative and timely risk-driving data, including traffic, operational, environmental and population-related information.
- **PA-2 – Derivation of risk-based performance requirements:** The proposed risk models are assumed to enable the derivation of quantitative performance requirements for U-space services and associated CNS enablers based on their contribution to risk reduction.
- **PA-3 – Relationship between service performance and risk:** A measurable relationship is assumed to exist between the performance delivered by U-space services and the resulting level of operational risk, enabling the assessment of alternative service configurations and mitigation strategies.
- **PA-4 – Capacity benefits of advanced services:** Advanced U-space services are assumed to enable the safe accommodation of higher traffic densities and more complex operations while maintaining compliance with the applicable Target Levels of Safety.

5 References

5.1 Applicable documents

This OSED complies with the requirements set out in the following documents:

- [1] AMPLE3 Consortium, ATM Master Plan Maintenance Method and Guidance 2023 – Annex 4: Content Integration Architecture, Deliverable D2.1, Grant Agreement No. 101114738, Edition 00.04, Draft (Public), 10 June 2025.

Content development

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System and service development

- [3] SESAR 3 Joint Undertaking, Release 16 Plan, Ed. 00.01.00, 05 December 2025.

Performance management

- [4] PJ19-W2 CI Consortium, DES Performance Framework – U-space Companion Document, Deliverable D4.7, GA No. 874473, Ed. 00.01.02, PU, 03 April 2023.

System engineering

- [5] PJ.19 W2 CI Consortium, Architecture Definition Document (ADD) (2023), Deliverable D2.12, GA No. 874473, Ed. 01.01.00, PU, 07 July 2023.

Validation

- [6] SESAR 3 Joint Undertaking, Digital European Sky (DES) Higher-Echelon Requirements and Validation/Demonstration Guidelines, Ed. 03.00, 15 September 2023.

Project and programme management

- [7] 101167187 U-AGREE Grant Agreement, [24/06/2024]
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5.2 Reference documents

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- [10] SESAR CORUS five Project, CORUS five ConOps v4.9 Ed 00.06, internal working draft, not publicly available, SESAR 3 Joint Undertaking, Nov 2025.

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Appendix A Stakeholder identification and benefit impact mechanisms (BIM)

A.1 Stakeholders identification and expectations

Stakeholder	Involvement	Why it matters to the stakeholder
Regulatory Authorities	Use the risk models to support U-space designation, oversight activities and regulatory decision-making.	Enables evidence-based regulation and verification that acceptable safety levels are achieved.
UAS operators	Use the risk models and associated tools to support SORA assessments and operational planning.	Facilitates access to airspace, supports regulatory compliance and enables more predictable and scalable UAS operations.
U-space service provider (USSP)	Uses the outputs of the risk models to support flight authorisation, tactical services and operational monitoring.	Supports safe service provision and helps demonstrate that U-space services achieve the required safety performance.
Common information service providers (CISP)	Provide information services supporting U-space operations and risk assessment activities.	Benefits from clearly defined information requirements and performance targets derived from the risk models.
ANSP	Provides traffic and operational data used in the risk assessment process and supports the implementation of airspace management measures.	Helps ensure that U-space airspaces and associated mitigations remain compatible with existing ATM operations and manned traffic flows.
Rotorcraft, VFR General aviation	Directly affected by the coexistence of UAS	Benefit from improved assessment of collision risks and the implementation of proportionate mitigations in shared airspace environments.

	and manned aircraft in low-level airspace.	
Scheduled airlines (mainline and regional), Business aviation, IFR General aviation	Impacted by the designation of U-space airspaces and associated operational constraints.	Benefit from ensuring that UAS operations do not introduce unacceptable risks to manned aviation operations.
Military	May operate in or near U-space airspaces and interact with civil UAS operations.	Ensures that military operations can coexist safely with U-space activities and that airspace constraints remain compatible with mission requirements.
Insurance Companies	May use the outputs of risk assessments to better understand operational risk exposure.	Supports risk-informed underwriting and the development of insurance products for UAS operations.
Citizens/City Hall /Local Government	Indirect stakeholders affected by the deployment of U-space services and UAS operations over populated areas.	Benefit from improved safety, transparency and public acceptance of UAS operations.

Table 11: stakeholders' expectations and involvement

A.2 Benefits impact mechanisms (BIM)

The proposed SESAR solution can enable regular UAS operations in airspaces where they are currently limited because of the safety concerns they arouse among authorities and public. The quantitative risk models developed by U-AGREE allow a quantitative estimation of the risk and the mitigation barriers' models facilitate the accurate computation of the residual risk, thereby allaying the concerns UAS operations over densely populated areas, as well as those close to airport, currently raise.

The new features that the SESAR solution is bringing to the UAS/IAM ecosystem include:

1. Introduction of a mathematical model enabling the accurate estimation of the multidimensional severity of UAS ground impacts.
2. Introduction of a mathematical model enabling the accurate estimation of the multidimensional severity of mid-air collisions involving UAS and manned aircraft.
3. Introduction of a mathematical model enabling the accurate estimation of the average collision likelihood over large periods of time.
4. Introduction of a mathematical model enabling the accurate estimation of the collision likelihood for a single operation prior to the flight.

- Introduction of a mathematical model enabling the estimation of the mitigation provided by different combinations of U-space services.

Figure 25 to Figure 33 illustrate how these features impact the different U-AGREE stakeholders.

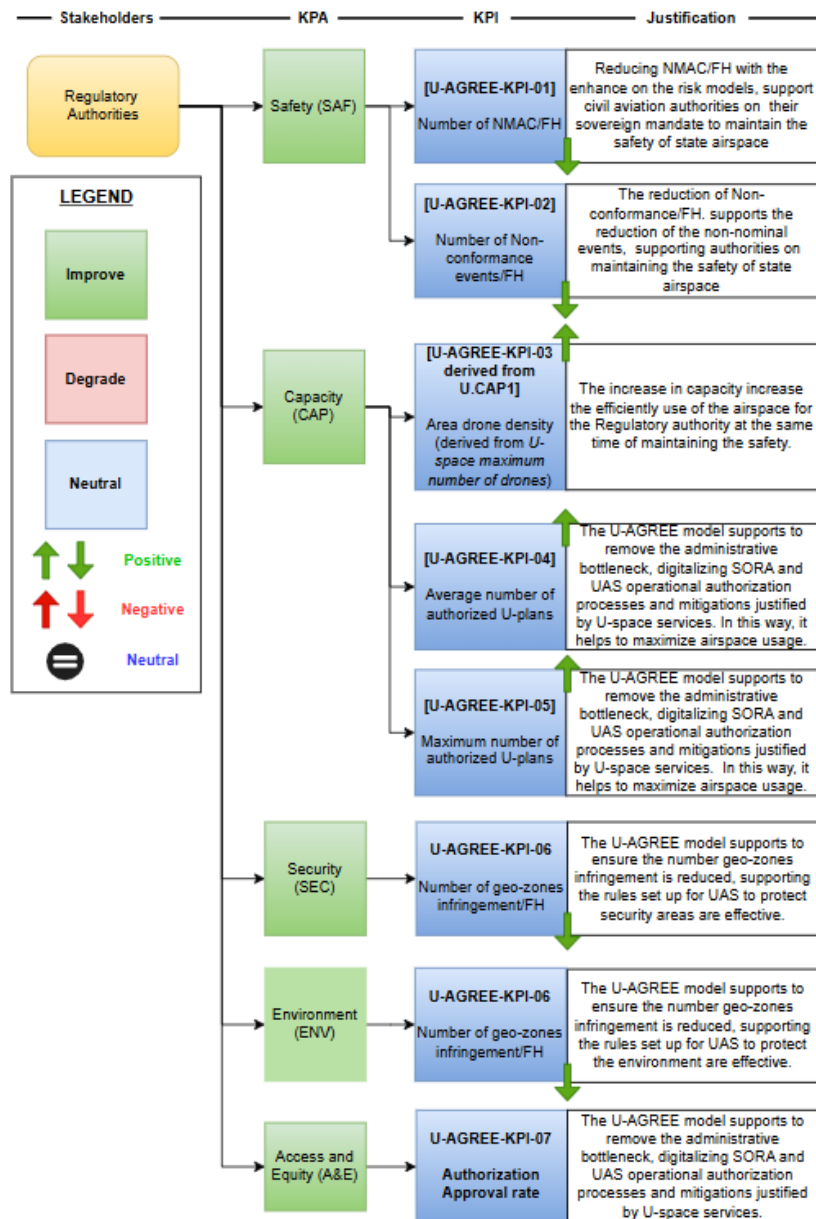


Figure 25. Benefits Mechanism (Regulatory Authorities)

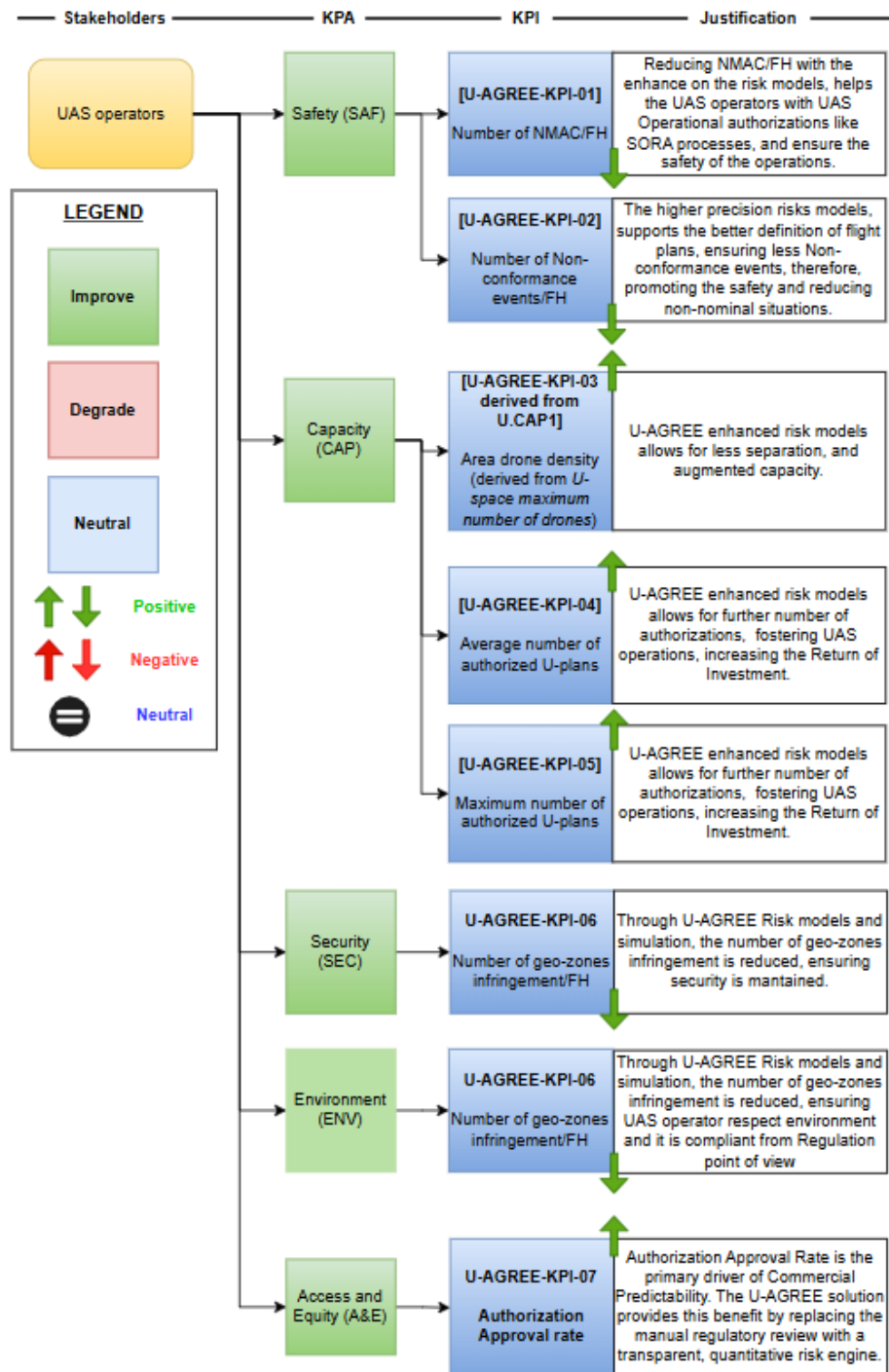


Figure 26. Benefits Mechanism (UAS operators)

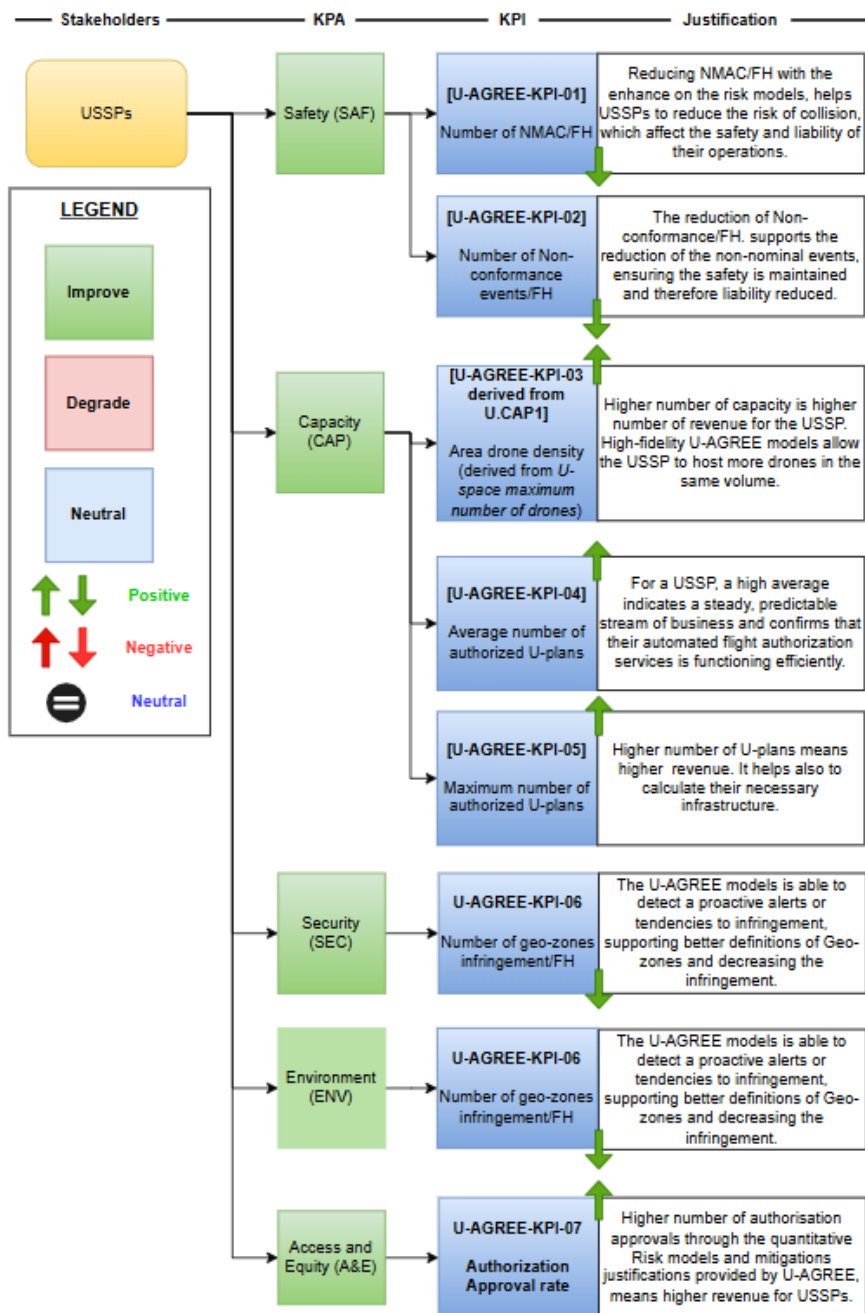


Figure 27. Benefits Mechanism (USSPs)

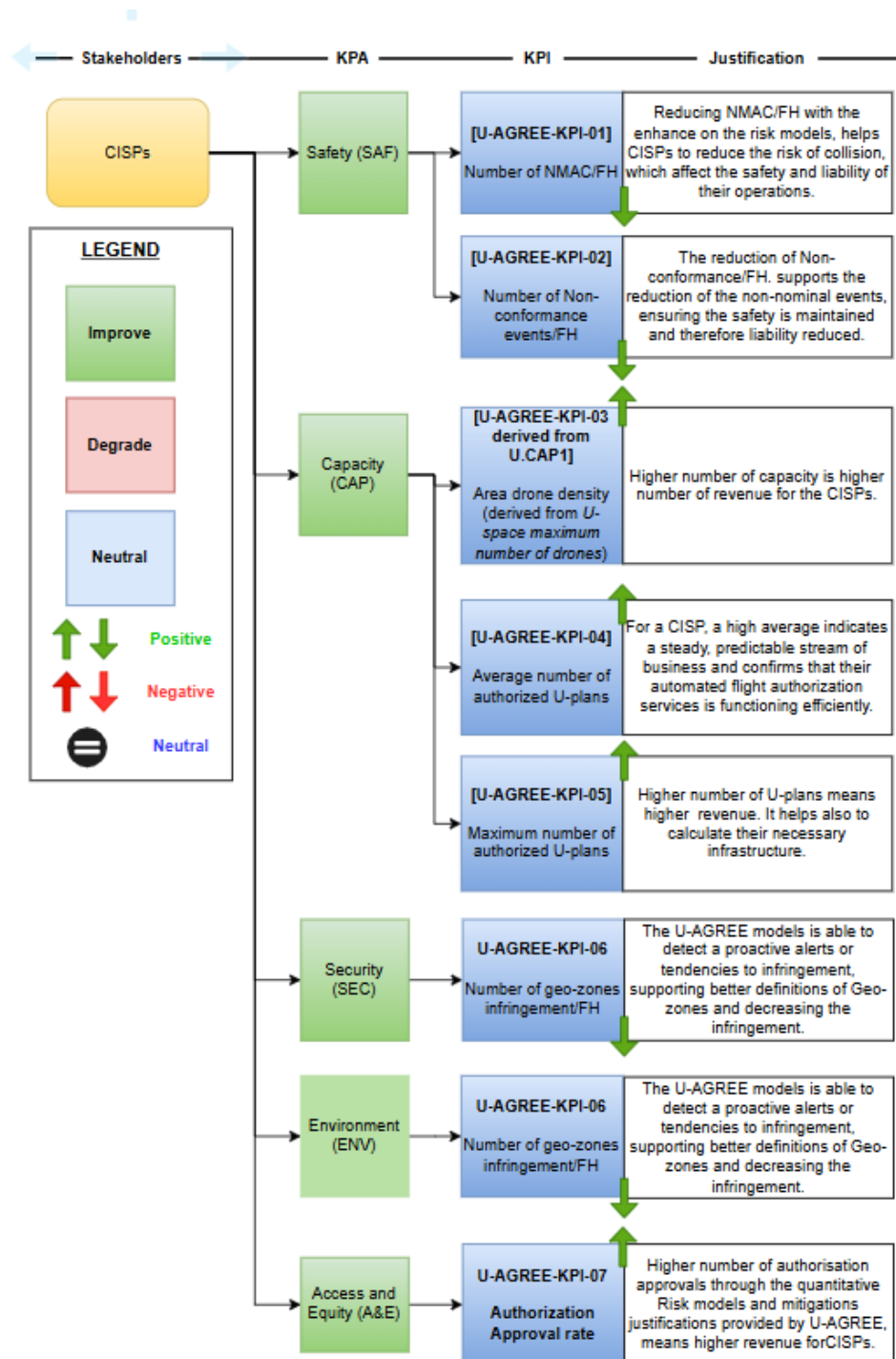


Figure 28. Benefits Mechanism (CISPs)

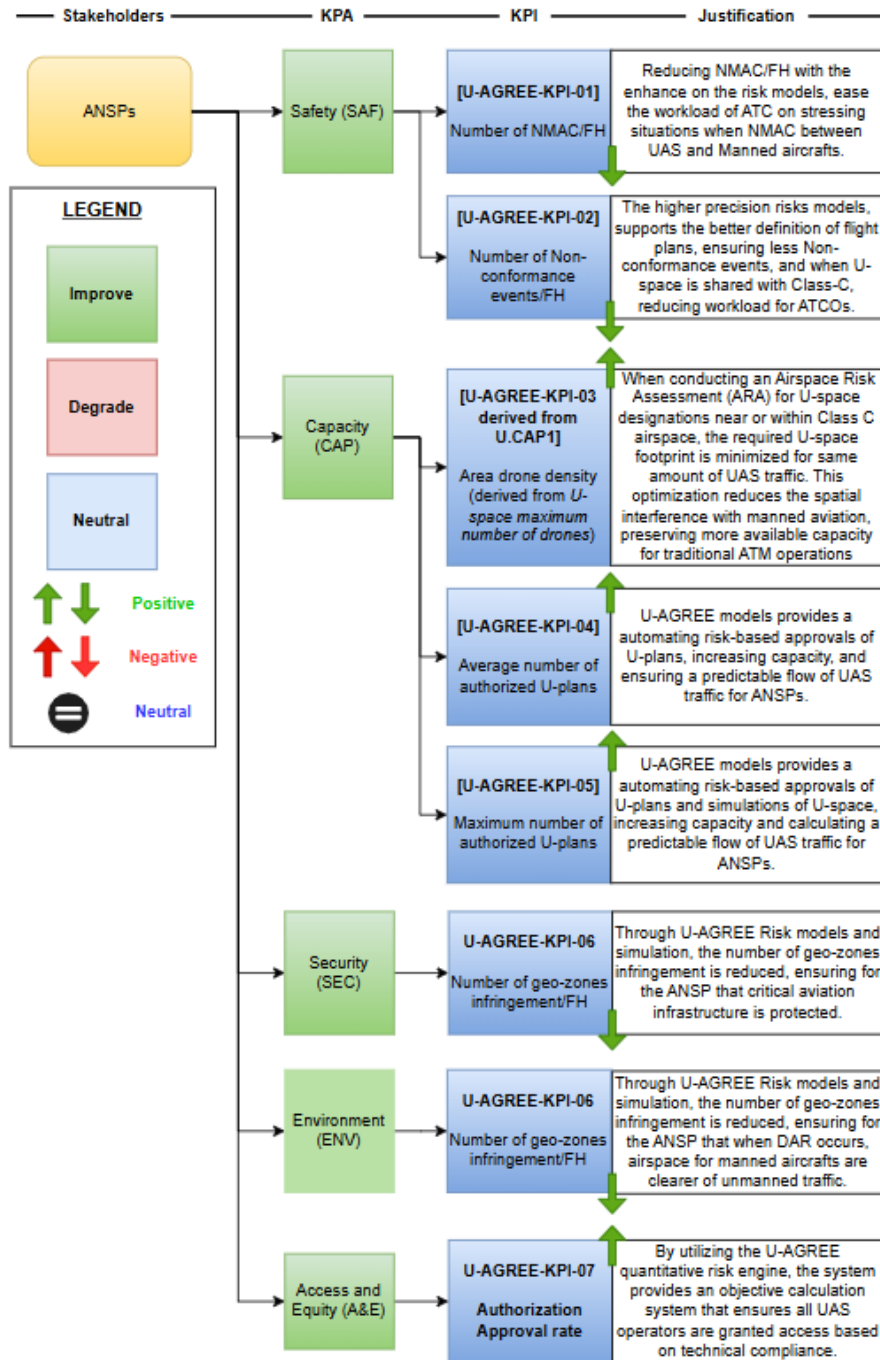


Figure 29. Benefits Mechanism (ANSPs)

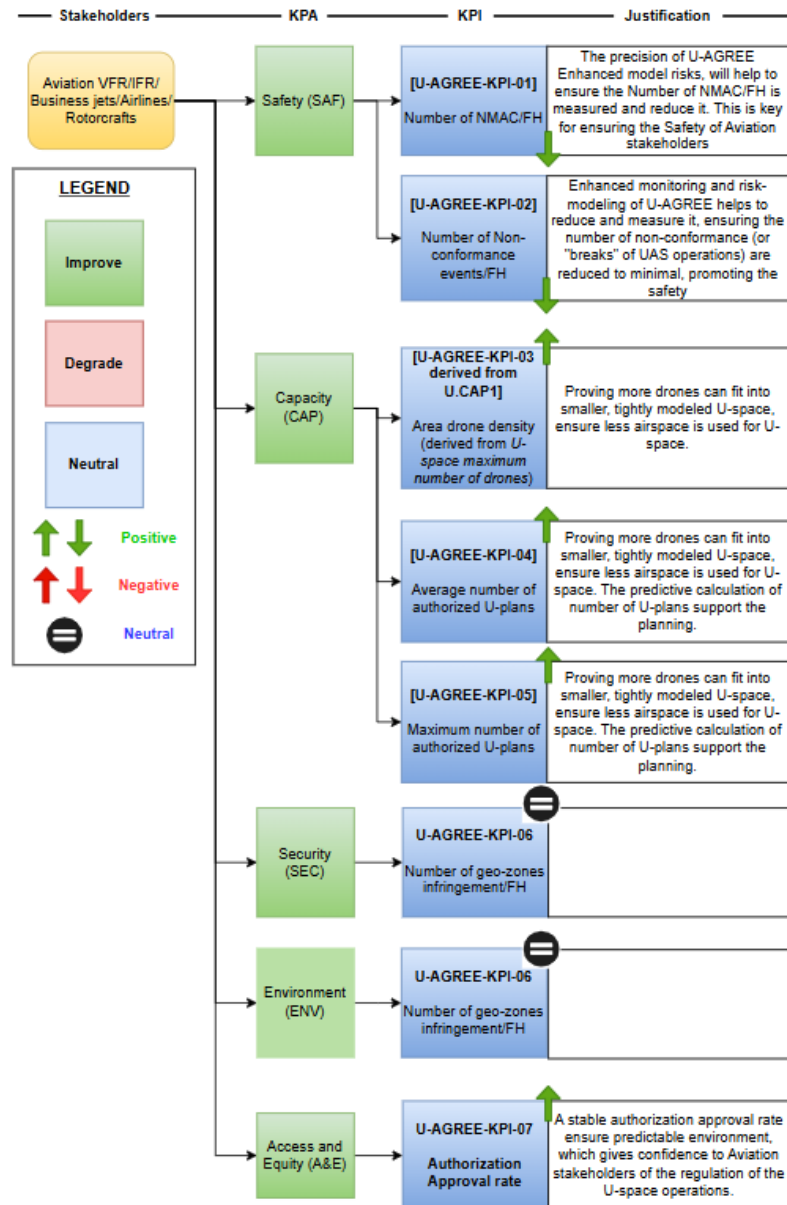


Figure 30. Benefits Mechanism (Aviation VFR/IFR/Business jets/Airlines/Rotorcrafts)

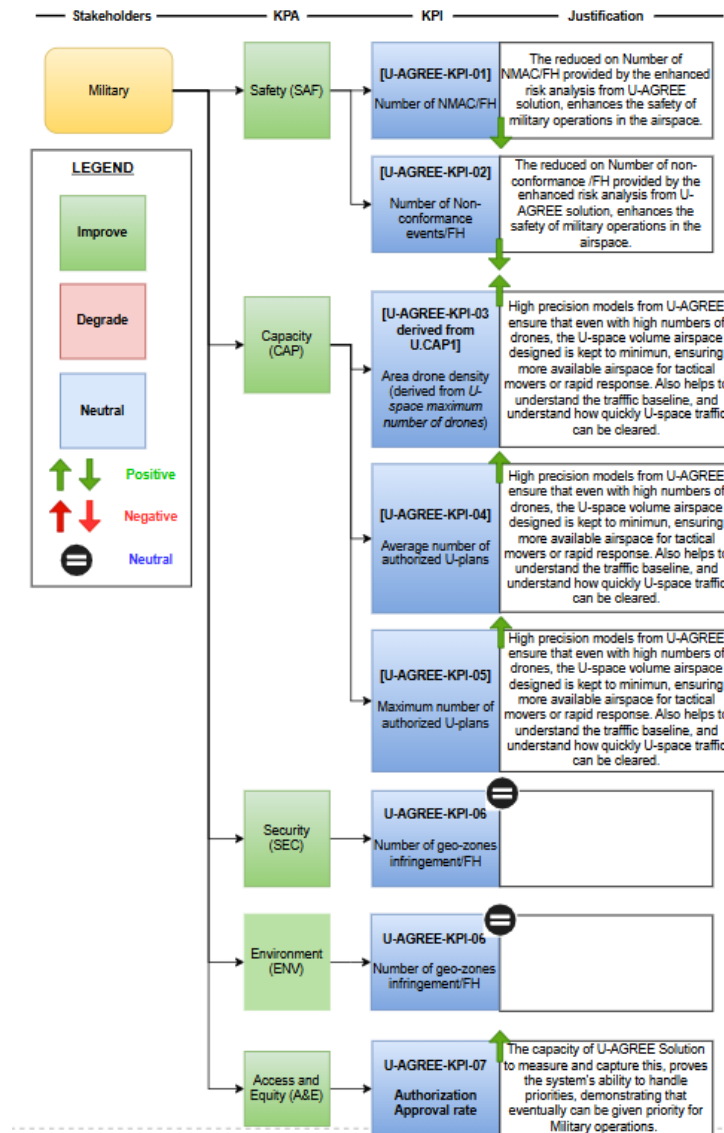


Figure 31. Benefits Mechanism (Military)

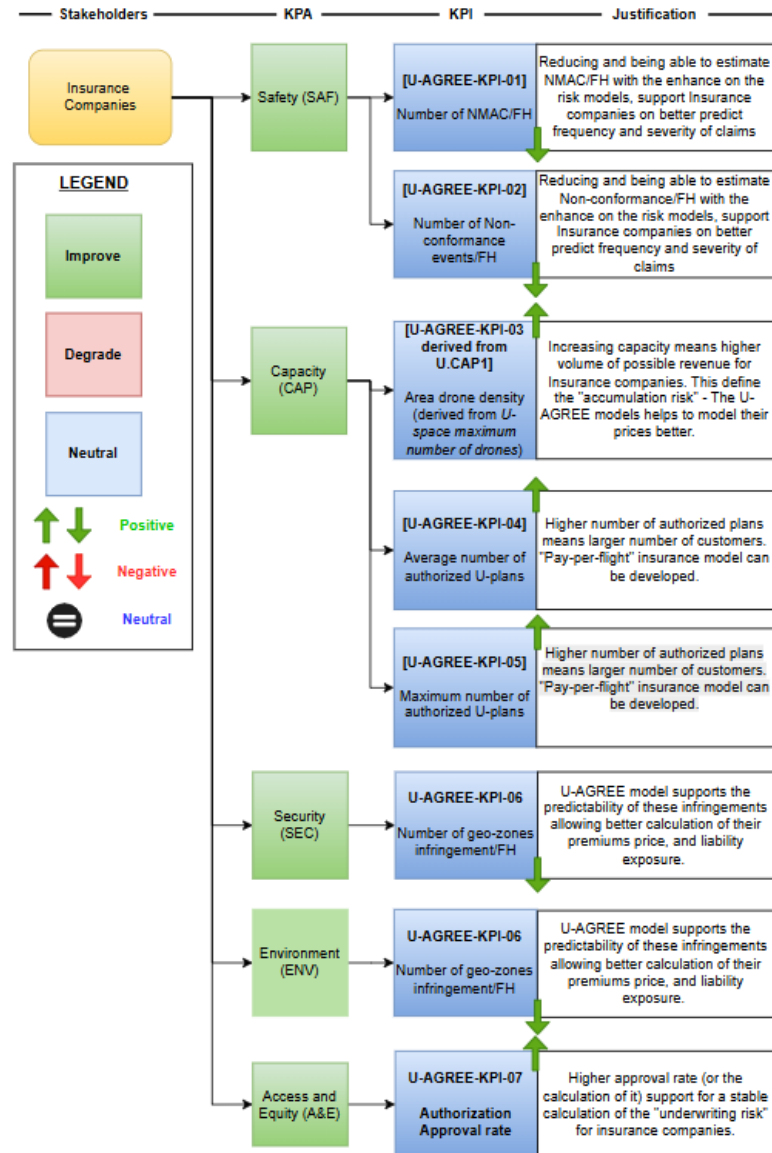


Figure 32. Benefits Mechanism (Insurance Companies)

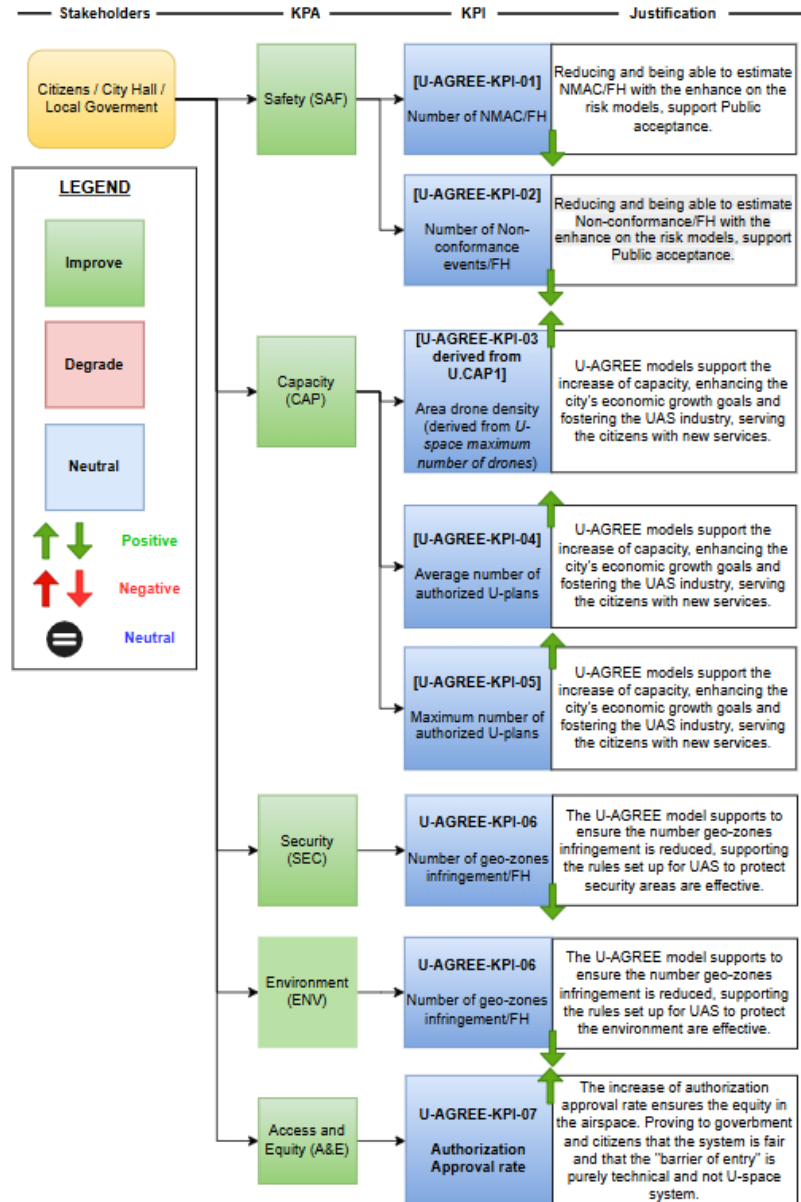


Figure 33. Benefits Mechanism (Citizens/City Hall/Local Government)

U-AGREE SOL 0520 Integrated risk models for Unmanned Aerial Systems (UAS) in the U-space
STAKEHOLDERS: USSPs, CISPs & UAS Operators

V2 01/09/2026

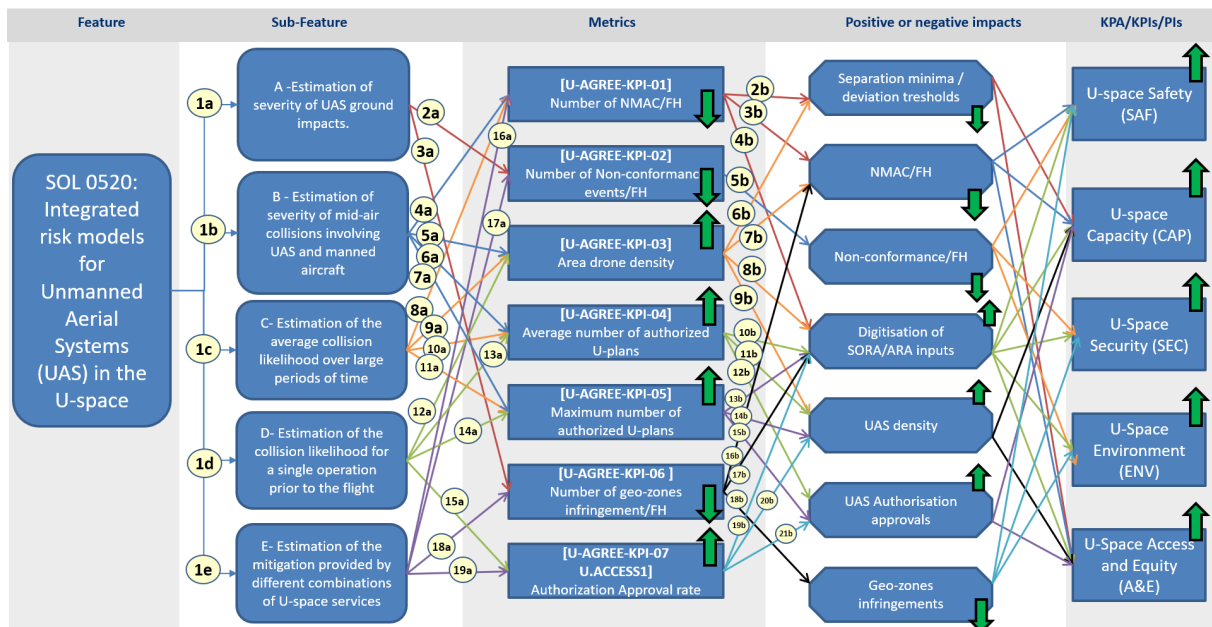


Figure 34. Benefits Impact Mechanisms (BIMs) SESAR Methodology

Table 12. Benefits Impact Mechanisms (BIMs) SESAR Methodology

Feature: Integrated risk models for Unmanned Aerial Systems (UAS) in the U-space	
Sub-Feature A: Mathematical model enabling the accurate estimation of the multidimensional severity of UAS ground impacts.	
Sub-Feature B: Mathematical model enabling the accurate estimation of the multidimensional severity of mid-air collisions involving UAS and manned aircraft	
Sub-Feature C: Mathematical model enabling the accurate estimation of the average collision likelihood over large periods of time	
Sub-Feature D: Mathematical model enabling the accurate estimation of the collision likelihood for a single operation prior to the flight	
Sub-Feature E: Mathematical model enabling the estimation of the mitigation provided by different combinations of U-space services	
1a	Incorporating integrated ground risk models into USSP & CISP services enables automated and accurate dynamic calculation of UAS ground impact severity

1b	Integrating air collision risk models into the USSP & CISP platform enables automated calculation of mid-air collision severity with other UAS and manned aircraft
1c	Utilizing long-term statistical risk assessments allows the USSP & CISP to evaluate average collision likelihood over extended operational timeframes
1d	Implementing tactical risk engines enables the USSP & CISP to calculate specific collision risks for individual flight intents during the pre-flight phase
1e	Integrating service evaluation algorithms allows the USSP & CISP to quantify risk reductions achieved by combining various active U-space services
2a	Dynamic ground impact severity assessment is quantitatively evaluated by monitoring the Number of Number of Non-conformance events/FH [U-AGREE-KPI-02], as this number indicates the prevention of an impact.
3a	Dynamic ground impact severity assessment is monitored by tracking the Number of geo-zones infringement/FH [U-AGREE-KPI-06], as this number help to understand the exposure to areas where consequences of an impact could be higher.
4a	Mid-air collision severity modeling is evaluated by monitoring the Number of NMAC per Flight Hour [U-AGREE-KPI-01], s it is the direct relationship between collision/proximity.
5a	Mid-air risk assessment capacity is measured against the Area drone density [U-AGREE-KPI-03] accommodated safely.
6a	Mid-air risk assessment capacity is measured against Average number of authorized U-plans [U-AGREE-KPI-04], as it provides the representation of the exposure to air traffic according to numbers of U-plan
7a	Mid-air risk assessment capacity is measured against Maximun number of authorized U-plans [U-AGREE-KPI-04], as it provides the representation of the exposure to air traffic according to numbers of U-plan
8a	Long-term collision likelihood analysis is evaluated against NMAC/FH [U-AGREE-KPI-01], as we relates the conflict events with exposure time.
9a	Long-term collision likelihood analysis is evaluated against Area drone density [U-AGREE-KPI-03] capacities.
10a	Long-term collision likelihood analysis is measured via the Average number of authorized U-plans [U-AGREE-KPI-04].
11a	Long-term collision risk modeling performance is measured through the Maximum number of authorized U-plans [U-AGREE-KPI-05].

12a	Pre-flight single operation risk estimation is evaluated by measuring Area drone density [U-AGREE-KPI-03], which provides support to the characterization of the expected traffic.
13a	Pre-flight single operation risk estimation is evaluated by measuring the Average number of authorized U-plans [U-AGREE-KPI-04], which provides support to the characterization of the expected traffic.
14a	Single operation risk calculation performance is measured against the Maximum number of authorized U-plans [U-AGREE-KPI-05], which provides support to the characterization of the expected traffic.
15a	Pre-flight risk estimation efficiency is measured using the Authorization Approval rate [U-AGREE-KPI-07], which can indicate the capacity of the system to approve/reject potential conflicting operations.
16a	Mitigation estimation provided by different combination of U-space services is evaluated by measuring the [U-AGREE-KPI-01] Number of NMAC/FH, as the purpose of the U-space services is to ensure the proper separation and effectiveness of unmanned traffic management.
17a	Mitigation estimation provided by different combinations of U-space services is evaluated by [U-AGREE-KPI-02] Number of Non-conformance events/FH, as Conformance Monitoring service effectiveness can be calculated with this.
18a	U-space service mitigation modeling is measured through the Number of geo-zones infringements per Flight Hour [U-AGREE-KPI-06], as Geo-Awareness service effectiveness can be calculated with this.
19a	U-space service mitigation efficiency is evaluated using the Authorization Approval rate [U-AGREE-KPI-07], as Flight Authorization effectiveness service can be calculated with this.
2b	A reduction in NMAC/FH [U-AGREE-KPI-01] directly refines and optimizes Separation minima / deviation thresholds for UAS operations, and this information will be used in the USSP & CISP.
3b	A reduction in NMAC/FH [U-AGREE-KPI-01] directly reduced the NMAC/FH for UAS operations.
4b	The NMAC/FH [U-AGREE-KPI-01] rate produces serves as an input for the Digitisation of SORA/ARA, increasing the digitalization process for UAS operators.
5b	Decreasing Non-conformance events/FH [U-AGREE-KPI-02] produces a beneficial reduction in operational Non-conformance/FH.
6b	Increasing safe Area drone density [U-AGREE-KPI-03] enables reduction in separation minima/deviation tresholds, increasing airspace capacity and access to airspaced.

7b	Increasing safe Area drone density [U-AGREE-KPI-03] is in base of NMAC/FH reduction.
8b	Increasing safe Area drone density [U-AGREE-KPI-03] enables faster Digitisation of SORA/ARA inputs and higher airspace capacity
9b	Safe Area drone density [U-AGREE-KPI-03] leads directly to an increase in UAS Density
10b	Increasing Average authorized U-plans [U-AGREE-KPI-04] serves as an input for air risk, increasing the automation of SORA/ARA input.
11b	Increasing Average authorized U-plans [U-AGREE-KPI-04] leads directly to an increase in UAS Density
12b	Increasing Maximun authorized U-plans [U-AGREE-KPI-05] leads directly to an increase in UAS Authorisation approvals
13b	Increasing the Maximum number of authorized U-plans leads to a beneficial increase in the Digisation of SORA/ARA inputs
14b	Increasing the Maximum number of authorized U-plans leads to a beneficial increase in the UAS Density
15b	Increasing the Maximum number of authorized U-plans leads to a beneficial increase in the UAS Auhtorisation approvals
16b	Reducing Geo-zones infringements/FH [U-AGREE-KPI-06] produces a beneficial reduction in NMAC/FH, as some Geo-zones are used to prevent air conflicts.
17b	Reducing Geo-zones infringements/FH [U-AGREE-KPI-06] produces a enables faster Digitisation of SORA/ARA inputs .
18b	Reducing Geo-zones infringements/FH [U-AGREE-KPI-06] produces a beneficial reduction in overall Geo-zones infringements.
19b	Increasing the Authorization Approval rate [U-AGREE-KPI-07] streamlining improves Digitisation of SORA/ARA inputs.
20b	A higher Authorization Approval rate [U-AGREE-KPI-07] directly increases UAS density.
21b	A higher Authorization Approval rate [U-AGREE-KPI-07] directly increases UAS Authorisation approvals