D6.5 - Economic Evaluation (ECO-EVAL) for Solution 0520

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Abstract

This document describes the Economic Evaluation (ECO-EVAL) for SESAR Solution 0520, regarding U-Space Air and Ground Risk Models Enhancement at Technology Readiness Level (TRL) 2. It presents the benefits provided by the solution and assesses at a high level their economic impact on the main stakeholders involved in its deployment and operation. The aim is to determine whether the solution is worth deploying in European Civil Aviation Conference (ECAC) airspace from an economic standpoint.

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[U-AGREE]

U-SPACE AIR AND GROUND RISK MODELS ENHANCEMENT

U-AGREE

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1 Executive summary

This document provides the economic evaluation (ECO-EVAL) related to the European Civil Aviation Conference (ECAC) level deployment of *SESAR Solution 0520 – Integrated Risk Models for Unmanned Aerial Systems (UAS) in the U-space* that has been matured through validation activities to TRL2.

The solution 0520 delivers Integrated risk models for Unmanned Aerial Systems (UAS) as an extension of the Specific Operations Safety Assessment (SORA) model in U-space airspaces, which allow to more accurately link UAS operations with their multidimensional harmful effects on safety (i.e., Mid-Air Collisions 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). The integrated risk models for Unmanned Aerial Systems (UAS) in the U-space developed by SESAR Solution 0520 will provide benefits in terms of increased capacity, access and equity, while having a positive impact on safety and security.

This solution is mainly intended for Very-Low-Level (VLL), Low-Level (LL), U-space and Class-C airspaces. The key stakeholders relevant to the solution mainly include Air Navigation Service Providers (ANSPs), UAS operators, U-space Service Providers (USSPs), Common Information Service Providers (CISPs), Insurance companies, Authorities, and Research companies. This ECO-EVAL evaluates the solution in the economic context in accordance with the SESAR program, to help analyse and determine whether the solution is worth deploying in European airspace. Being a TRL2 solution, the assessment presented in this document is mostly qualitative.

The core of the U-AGREE value proposition lies in the deployment of integrated risk engines that process safety, security, privacy, environmental and fairness & equity factors simultaneously. By quantifying the mitigating effects of digital U-space services, such as strategic deconfliction and conformance monitoring, the solution allows for a potential reduction in the required assurance levels for UAS operators. This creates a regulatory environment where flight authorizations can be processed with minimal to zero manual intervention, significantly lowering the administrative burden and legal costs for both service providers and national authorities, fostering the Return of Investment (ROI) for UAS operations.

From an investment perspective, the main expenses are primarily software and knowledge-intensive. USSPs, CISPs, and Authorities must invest in API-based architectures and cloud infrastructure capable of handling high-resolution data, such as real-time population density and "digital twin" city mapping. Additionally, a critical portion of the investment is allocated to upskilling technical staff and inspectors, ensuring that the human-in-the-loop can effectively oversee and audit automated risk outputs. This transition from manual checklists to algorithmic oversight is essential for managing the projected growth of the UAS market.

The long-term operational benefits are realized through increased airspace capacity and improved social acceptance. By providing a *"Comprehensive Airspace Picture"* that risks impacts, U-AGREE helps authorities secure the social license to operate complex missions in sensitive areas. Furthermore, the use of a project-validated, standardized methodology provides a robust legal shield for all stakeholders. This standardization reduces the risk of litigation and serves as a catalyst for a harmonized European drone economy, ultimately facilitating the seamless integration of unmanned and manned aviation by the final operating capability in 2035.

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2 Introduction

2.1 Purpose of the document

This document defines the economic evaluation (ECO-EVAL) *for SESAR Solution 0520 – Integrated Risk Models for Unmanned Aerial Systems (UAS) in the U-space*, at Technology Readiness Level (TRL) 2. ECO-EVAL places the problem and the solution it hopes to solve within the economic context of ECAC Airspace.

The document provides a qualitative analysis of the costs and benefits of the solution. Particularly, its emphasis is placed on the economic implications and the impact that its deployment will have to the stakeholders as defined in the SESAR architecture.

2.2 Scope

As **Unmanned Aerial Systems** (UAS) and Innovative Air Mobility (IAM) operations increase, encompassing the majority of the expected operations over sparsely populated and urban areas in specific category according to EASA Reg **2019/947, sets forth the requirement to develop a risk assessment using Specific Operations Risk Assessment (SORA).** In this process, risk models are crucial to determine the initial (unmitigated) ground risk classes (GRC) and air risk classes (ARC) and apply mitigation measures to get residual air and ground risk classes, which are then combined in a specific assurance and integrity level (SAIL).

On the other hand, EASA Reg **2019/947** introduces the concept of U-space airspace, that can be designated by competent authorities for safety, security, privacy or environmental protection reasons. In a U-space airspace almost all UAS operations will have to make use of a set of U-space services set out in EU Reg 2021/664.

However, **the SORA risk models do not account for the mitigation effect of U-space services on the ground or air risk. Therefore, the cost of mitigating those risks entirely rests on UAS operators' shoulders.**

SESAR Solution 0520 targets the development of **integrated risk models** for **UAS** in the **U-space**, as an extension of the **SORA** model, which will allow to more accurately link UAS operations with their **multidimensional harmful effects on safety, security, privacy and the environment,** in special for the **VLL**, taking into account the **mitigating effect of U-space services**.

The **ECO-EVAL of U-AGREE project (SESAR Solution 0520)** aims to assess the impacts in terms of costs and benefits of the solution by placing it in the **economic context defined in the SESAR architecture.**

This analysis is carried out between **Q3 2025 and Q2 2026**, using the latest resources made available.

2.3 Intended readership

This document is intended for a broad range of stakeholders involved in the development, implementation, and oversight of U-space operations and airspace risk assessment, ranging from U-

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AGREE project partners and SESAR JU community to stakeholders involved in regulating and developing ECAC Airspace. The target audience includes, but is not limited to:

- **Regulatory Authorities (e.g., Civil Aviation Authorities, SESAR 3 JU, EASA, AESA)**: To assess the alignment of the U-AGREE solution with regulatory frameworks and its impact on U-space airspace designation and operations.
- **Standardisation bodies**: Establish new standards adapted to the new use of Airspace and U-space, that can enable the interoperability of these systems and foster the U-space ecosystem.
- **Air Navigation Service Providers (ANSPs):** To understand how the U-AGREE solution can help to quantify and mitigate the risk of UAS operations in controlled airspace.
- **Common Information Service Providers (CISPs)**: To understand the integration of risk models as part of authorisation processes within U-space airspaces, and the role of the centralized actors in this process, and U-space services into existing air traffic management structures.
- **U-space Service Providers (USSPs)**: To explore the application of the U-AGREE solution for enhancing safety, security, and compliance of U-space operations, and how U-space services provided by USSPs are mitigating the risks for UAS operations in U-space airspace. How the USSP can serve of this solution from the economic standpoint.
- **Airspace users**: Understand how the UAS operations will be integrated in the current airspace and what are the mitigations in place, and the risks quantifications.
- **Airport/Airfield/Vertiport providers/owners**: To understand how the U-AGREE solution can help to quantify and mitigate the risk of UAS operations in Airport/Airfield/Vertiport.
- **UAS Operators**: To evaluate the potential impact of U-AGREE's risk assessment framework on operational efficiency and regulatory compliance, understanding the economic value.
- **Aerospace Industry Stakeholders**: To get insights of the concept developed in U-space and UAS operations as a mitigation of the risks, to understand how to contribute to its enhancement or serve of it, supporting strategic investment, technology development, and contribution to scalable UAS solutions.
- **Research and Academic Institutions**: To contribute to the advancement of risk assessment methodologies and integration of these models into U-space safety mechanisms.
- **Insurance Companies**: Collaboration with insurances companies aims to improve risk assessment and mitigation strategies in the UAS/IAM domain and the development of suitable insurance policies.

2.4 Background

U-AGREE builds upon a substantial body of prior SESAR and European research addressing UAS integration, U-space service provision, and the management of **safety and societal risks associated with low-altitude operations**. In particular, the project capitalises on previous work on U-space concepts, Integrated CNS, separation management, and risk assessment methodologies, while extending these results towards a harmonised assessment of **risk and their mitigation through U-space services.**

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U-AGREE focuses on the characterisation and mitigation of potentially negative effects of UAS operations through the provision and use of U-space services. From a safety perspective, the project addresses the hazards posed by UAS to people on the ground and to other airspace users (manned and unmanned) operating within U-space airspace, with particular emphasis on **mid-air collision** (MAC) risk. To this end, U-AGREE leverages established **SORA by JARUS [24]** ground and air risk models, while adopting the collision risk modelling approach developed by the **BUBBLES [21]** project as a basis for estimating the likelihood of MAC events. The severity of consequences is derived using recognised ground and air impact models, ensuring methodological consistency with existing regulatory and operational practices.

In addition to safety, U-AGREE considers environmental and societal effects of UAS operations, such as noise and visual pollution. For these aspects, the project builds upon modelling approaches previously developed in the **DACUS [20]** project, further refining them to reflect different U-space service levels and traffic densities.

The regulatory framework for U-AGREE is provided by Commission Implementing Regulation (EU) **2021/664 [15]**, which establishes requirements for the provision and use of U-space services. Within this framework, the regulation mandates the definition of U-space service performance and UAS capability requirements to ensure that operational risks are reduced to an acceptable level based on the outcomes of an **Airspace Risk Assessment (ARA) [23].** U-AGREE applies the ARA methodology developed by **EUROCONTROL** to identify the required performance levels for U-space services and UAS capabilities.

In a first step, the assessment is based on the U-space services defined in Regulation (EU) 2021/664, together with the associated Acceptable Means of Compliance and Guidance Material and relevant state-of-the-art standards. In a second step, U-AGREE evaluates the effectiveness of more advanced U-space services (U3) as defined in the U-space Concept of Operations developed under the CORUS V and **CORUS-XUAM[18] projects**. The project further establishes coordination mechanisms with its sibling project **CORUS FIVE [19]** to ensure alignment with the latest developments in U-space and IAM integration.

Finally, U-AGREE leverages **separation management and conflict detection** and resolution concepts developed in earlier and ongoing projects, including **BUBBLES and SPATIO[22]**, to assess how advanced U-space services can reduce collision risk and associated externalities. By consolidating and extending these results, U-AGREE provides a coherent analytical foundation for assessing the safety, environmental, and economic impacts of U-space service deployment within the **SESAR** framework.

2.5 Structure of the document

The present document is divided into 10 chapters following this structure:

- Chapter 1 – Executive Summary: Summarizes the key elements and concepts of the SESAR solution ECO-EVAL,
- Chapter 2 – Introduction: presents the purpose and scope of the document. It also introduces the document's target audience and the background on which the project is based. A glossary of terms and a list of acronyms are provided for ease reading,

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- Chapter 3 – Objectives and scope of the ECO-EVAL: describes the purpose of the ECO-EVAL as well as the problem that the solution intends to solve, while presenting its main characteristics,
- Chapter 4 – Benefits: Presents the benefits of the solution and how they are achieved, as well as their overall impact,
- Chapter 5 – Cost assessment: Describes the high-level costs involved in implementing the solution and how they relate to the stakeholders,
- Chapter 6 to 8 – Not applicable for U-AGREE at solution is TRL2 level.
- Chapter 9 – Next steps and recommendations
- Chapter 10 – References

This document also includes one appendix:

- Appendix A – Maturity criteria (self-assessment): provides a self-assessment of this ECO-EVAL based on the maturity criteria applicable to TRL2.

2.6 Glossary of terms

Term	Definition	Source of the definition
ECO-EVAL reference scenario	The scenario against which the solution is compared, i.e. the situation without the proposed SESAR solution (but including other improvements which have been implemented in the meantime).	DES transversal CBA team
ECO-EVAL solution scenario	The scenario with the proposed SESAR solution and other improvements which have been implemented in the meantime.	DES transversal CBA team
Economic evaluation (ECO-EVAL)	The economic evaluation assesses the potential benefits that an innovative idea or application under analysis by an exploratory research project could provide against an initial high-level estimation of the costs that it may imply.	SESAR 3 JU Project Handbook – Programme Execution Framework, edition 01.00, 11 April 2022
Implementation cost	All costs related to the acquisition and implementation of the SESAR solution.	SESAR 16.06.06_D26_03 Methods to Assess Cost and Benefits for CBAs, ed. 00.02.02
Investment cost	The investment cost covers the pre-implementation costs (e.g., feasibility studies) and the implementation costs (e.g., system integration). Note that the pre-implementation costs shall not consider the SESAR R&I costs.	DES transversal CBA team

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Term	Definition	Source of the definition
Operating cost	All costs related to the change in daily operations that is brought about by the SESAR solution.	SESAR 16.06.06_D26_03 Methods to Assess Cost and Benefits for CBAs, ed. 00.02.02
Pre-implementation cost	All costs that need to be used up to define the needs, to develop solutions, and to decide which solution best serves the needs. Note that the SESAR R&I costs shall not be included as costs in any DES CBA/ECO-EVAL.	SESAR 16.06.06_D26_03 Methods to Assess Cost and Benefits for CBAs, ed. 00.02.02
Air Traffic Management	The dynamic, integrated management of air traffic and airspace including air traffic services, airspace management and air traffic flow management – safely, economically and efficiently – through the provision of facilities and seamless services in collaboration with all parties and involving airborne and ground-based functions.	ICAO 4444 62[9]
Exploratory Research	Explores new concepts beyond those identified in the European ATM Master Plan or emerging technologies and methods. The knowledge acquired can be transferred into the SESAR industrial and demonstration activities.	European ATM Master Plan [10]
Mid-air Collision	A MAC is defined as *an accident where two aircraft come into contact with each other while both are airborne*.	ICAO Common taxonomy team, Aviation occurrence categories, definitions and usage notes IACO 4.2, 2011. [26]
Near Mid-air Collision	An NMAC is a situation in which *two aircraft come within 100 ft vertically and 500 ft horizontally of each other while in flight*.	ASTM, Standard Specification for Detect and Avoid System Performance Requirements, 2023. [25]
Very Low-Level Altitude	Altitude below 150 meters or 500 feet AGL	ICAO UTM Framework Edition 4 [11]
Unmanned Aerial System	Unmanned aerial system (UAS) means an unmanned aircraft and the equipment to control it remotely	Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 on unmanned aircraft systems and on third-country operators of

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Term	Definition	Source of the definition
		unmanned aircraft systems, European Commission, 2019, C/2019/1821 [12][14]
U-space	U-space airspace means a UAS geographical zone designated by Member States, where UAS operations are only allowed to take place with the support of U-space services U-space service means a service relying on digital services and automation of functions designed to support safe, secure and efficient access to U-space airspace for a large number of UAS	Commission Implementing Regulation (EU) 2021/664 of 22 April 2021 on a regulatory framework for the U-space (C/2021/2671) [15] SESAR Smart ATM U-space and urban air mobility [17]

Table 1: glossary of terms

2.7 List of acronyms

Term	Definition
AB	Advisory Board
a/c	Aircraft
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-L	Automatic Dependent Surveillance – Light
AEC	Airspace Encounter Category
AIM	Accident-Incident Model
AOM	Airspace Organisation and Management
AMC	Acceptable Means of Compliance
AMC&GM	Acceptable Means of Compliance and Guidance Material
AMSL	Above Mean Sea Level
ANSP	Air Navigation Service Provider
ARA	Airspace Risk Assessment
ARC	Air Risk Class

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Term	Definition
ASTM	American Society for Testing and Materials
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
ATS	Air Traffic Services
ATSP	Air Traffic Service Provider
ATZ	Aerodrome Traffic Zone
AUC	Airspace user costs
BIM	Benefit Impact Mechanism
CA	Collision Avoidance
CAA	Civil Aviation Authority
CAP	Capacity
CAPEX	Capital Expenditure
CBA	Cost benefit analysis
CEF	Cost efficiency
CIS	Common Information Services
CISP	Common Information Services Provider
CMS	Conformance Monitoring Service
CNS	Communication, Navigation and Surveillance
ConOps	Concept of Operations
CTA	Controlled Area
CTR	Controlled Region
DAR	Dynamic Airspace Reconfiguration
DCB	Demand and Capacity Balancing
DEM	Digital Elevation Model

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Term	Definition
DRID	Direct Remote Identification
DSD	Digital Sky Demonstrator
EASA	European Union Aviation Safety Agency
ECAC	European Civil Aviation Conference
ECO-EVAL	Economic Evaluation
EDA	European Defence Agency
EGNOS	European Geostationary Navigation Overlay Service
ENUS	European Network of U-space Stakeholders
ENV	Environment
EAR	Easy Access Rules
E-SRM	Expanded Safety Reference Material
EU	European Union
EUROCAE	European Organisation for Civil Aviation Equipment.
EUROCONTROL	European Organisation for the Safety of Air Navigation
FAS	Flight Authorisation Service
FAX	Flight Authorisation Exchange
FH	Flight hour
GATMOC	Global ATM Operational Concept
GNSS	Global Navigation Satellite Systems
GRC	Ground Risk Class
GM	Guidance Material
HAZID	Hazard Identification
IAM	Innovative Air Mobility
IFR	Instrumental Flight Rules
IR	Implementing Regulation

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Term	Definition
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
KoM	Kick-off Meeting
KPA	Key Performance Area
KPI	Key Performance Indicator
LL	Low Level
MAC	Mid-air collision
MEDUSA	MEthoDology for the USpace Safety Assessment
MOPS	Minimum Operational Performance Standards
MTOW	Maximum Take-Off Mass
NIS	Network Identification Service
NW	Network Manager
OPEX	Operational Expenditure
OSED	Operational Services and Environment Description
PBN	Performance-based Navigation
PDRA	Pre-defined Risk Assessment
RN	Research Need
RR	Risk ratio
RTCA	Radio-technical Commission for Aeronautics
RTK	Real Time Kinematics
SAC	Safety Criteria
SAIL	Specific Integrity and Assurance Level
SEC	Security
SESAR	Single European Sky ATM Research
SESAR 3 JU	SESAR 3 Joint Undertaking
SID	Standard Instrumental Departure

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Term	Definition
SIL	Software-in-the-Loop
SOP	Standard Operating Procedure
SORA	Specific Operations Risk Assessment
SRD	Short Range Device
SPR/INTEROP	Safety, performance and interoperability requirements
SRIA	Strategic Research and Innovation Agenda
SSI	Safety Specification Items
STAR	Standard Arrival
TIS	Traffic Information Service
TLS	Target Level of Safety
TMA	Terminal Manoeuvring Area
TMPR	Tactical Mitigation Performance Requirement
TRL	Technology Readiness Level
UA	Unmanned Aircraft
UAM	Urban Air Mobility
UAS	Unmanned Aerial System
USSP	U-space Service Provider
VFR	Visual Flight Rules
VLL	Very Low-Level airspace
VLOS	Visual line of sight
VTOL	Vertical Take-Off and Landing

Table 2: list of acronyms

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3 Objectives and scope of the ECO-EVAL

3.1 Problem addressed by the SESAR solution

EU Reg. 2019/947 defines three categories of operations: open, specific and certified [13]. **For operations in the specific category** (which encompass the majority of the expected operations over urban areas), **Reg. 2019/947 sets forth the requirement to develop a risk assessment using SORA.** In this process, risk models are crucial to determine the initial (unmitigated) ground risk classes (GRC) and air risk classes (ARC) and apply mitigation measures to get residual air and ground risk classes, which are then combined in a specific assurance and integrity level (SAIL). Afterwards, UAS operators must go through 24 operational safety objectives (OSOs) demonstrating to show compliance with the required level of robustness depending on the SAIL. On the other hand, Reg. 2021/664 [15] introduces the concept of U-space airspace, that can be designated by competent authorities for safety, security, privacy or environmental protection reasons. In a U-space airspace almost all UAS operations will have to make use of a set of U-space services set out in Reg 2021/664. However, **the SORA risk models do not account for the mitigation effect of U-space** services on the ground or air risk. Therefore, **the cost of mitigating those risks entirely rests on UAS operators' shoulders**, being a manual process nowadays.

3.2 SESAR solution description

This solution delivers advanced Integrated risk models for Unmanned Aerial Systems (UAS) that enhance capacity, safety, access & equity and security for UAS operations in 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 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).

Current risk models, such as Specific Operations Safety Assessment (SORA), are essential to aviation safety but have limitations in addressing the complexities and risks posed by unmanned aerial systems (UAS), in special those operating at very low levels (VLL) in urban areas. These limitations make it challenging to ensure both safety and regulatory compliance, potentially slowing down the growth of UAS use in urban areas.

The enhanced risk models tailored to UAS, in special in urban VLL environments, address these gaps, by including mid-air collisions (both UAS-to-UAS and UAS-to-manned aircraft), impacts on critical infrastructure, privacy concerns, and environmental effects, as well as the mitigating effect of U-space services.
Fast time simulations will be conducted in realistic environments to showcase the operational benefits enabled by the proposed solution in terms of capacity, safety, and security improvement. The European Union Aviation Agency (EASA) will support the development of the solution with a view to aligning the solution with the envisaged evolution of the regulatory framework on the U-space.

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Furthermore, the solution will support EUROCAE WG-105 in the development of new standards for U-space services and the systems they rely on.

Key Benefits:

- Increased capacity, safety, and security for UAS operations in urban areas.
- 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

3.2.1 SESAR solution interdependencies

U-AGREE has developed the solution 0520 – Integrated risk models for Unmanned Aerial Systems (UAS) in the U-space. This solution is not mutually exclusive with any other SESAR solution. The solution has been aligned with the 0512 – Development of an integrated U-space/ATM CONOPS and shares the vision and timeline for the U-space implementation. Nevertheless, solution 0520 is not tied to solution 0512 and the risk models could be still applied if the evolution of the U-space diverges from what that solution envisages.

At a different level, there are solutions whose deployment might amplify the impact of U-AGREE on the targeted KPAs. They are solutions that would have a mitigation effect in the U-AGREE risk-based framework:

- 0394 – ATM-U-space interface & services.
- 0395 – Dynamic Airspace Reconfiguration.
- 0458 – Strategic Conflict Resolution and Separation Management Service.
- 0460 – Tactical Conflict Prediction, Resolution and Implementation.
- 0449 – AirSpace Design Service.
- 0450 – Autonomous Flight Plan Approval Service.

Finally, there are solutions that provide wider reference frameworks for the assessment the impact of UAS accidents beyond safety:

- 0403 – U-space Environmental and Social Impact Assessment Framework.
- 0463 – IAM impact assessment framework and toolset for improved trade-off between societal acceptance and airspace capacity levels of IAM.

3.3 Objectives of the ECO-EVAL

The objective of this TRL2 ECO-EVAL is to help build an assessment of whether SESAR Solution 0520 is worth deploying, across ECAC, from an economic perspective for the involved stakeholders. This ECO-

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EVAL provides a consolidated assessment of the costs and benefits of deploying SESAR Solution 0520 in U-space, Controlled, Very-low level (VLL) and Low-Level (LL) airspaces, included in the ECO-EVAL solution scenario (see section 3.5.2).

This ECO-EVAL includes the evidence gathered to estimate the benefits and costs of the solution. The output is an overview of the high-level impact of costs and benefits per stakeholder group, recommendations and next steps.

3.4 Stakeholder identification

Stakeholder	Deployment locations (or operating environments)	Cost drivers	Benefits in operations	Involved – Provided inputs and reviewed this document.
ANSP	U-space / VLL / Controlled and LL Airspaces	System integration costs. ATCO and Airspace planners training costs. SOP updates.	Improved airspace capacity. Enhanced safety oversight – reduced risks of collisions. Operational efficiency.	Involved – Provided inputs and reviewed this document.
Scheduled airlines (mainline and regional), Business aviation, IFR General aviation	U-space / VLL / Controlled and LL Airspaces	Not applicable	Reduced Mid-Air Collision (MAC) Risk. Predictability & time savings. Reduced Insurance Liability.	Not involved
Rotorcraft, VFR General aviation	U-space / VLL / Controlled and LL Airspaces	Not applicable	Operational Safety (MAC Mitigation).	Not involved

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Stakeholder	Deployment locations (or operating environments)	Cost drivers	Benefits in operations	Involved – Provided inputs and reviewed this document.
			Reduced Insurance Liability. **Airspace preservation – safe integration with UAS** **Improved safe flight planning, serving to identify the areas where risks are higher.**	
UAS operators	**U-space / VLL /Controlled Airspaces**	**U-space service fees for U-AGREE model.**	**Increase Robustness and facilitate SORA compliance.** **Faster authorisations approvals by Civil Aviation Authority.** **Accelerated ROI.** **Increased U-space capacity.** **Reduced insurance premiums.**	Involved – Provided inputs and reviewed this document.
Military	**U-space /Controlled/ VLL and LL airspaces**	-	**Dynamic airspace reconfiguration (DAR) precision.**	**Not involved.**

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Stakeholder	Deployment locations (or operating environments)	Cost drivers	Benefits in operations	Involved – Provided inputs and reviewed this document.
			Dual-Use Technology – assess risks of military aircraft interventions. **Reduced operational risk for UAS-Manned aircraft collision.**	
Common information service provider (CISP)	**U-space /VLL and Controlled Airspaces**	**High-fidelity data infrastructure (e.g: upgrade serves).** **Cost to ensure systems interoperability.** **Adapt certification costs.** **Cyber resilience costs.** **Legal and liability costs.**	**Operational consistency – reduced liability issues.** **Scalable service model.** **Market centrality - CISP as indispensable hub for U-space.** **Streamlined airspace reconfiguration.**	Involved – Provided inputs and reviewed this document.
U-space service provider (USSP)	**U-space /VLL and Controlled Airspaces**	**Algorithm development & integration.** **Advanced high-fidelity dynamic data acquisition.**	**New revenue streams, supporting UAS Operational Authorisation process (e.g.SORA).**	Involved – Provided inputs and reviewed this document.

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Stakeholder	Deployment locations (or operating environments)	Cost drivers	Benefits in operations	Involved – Provided inputs and reviewed this document.
		Cybersecurity & data integrity. Certification adjustments. Legal and Liability costs.	Scalability through automation. Market differentiation. Liability reduction. Simulation environments.	
Insurance Companies	U-space /Controlled/ VLL and LL airspaces	Costs to integrate U-AGREE's risk models into underwriting algorithms. Verified flight/risk data Integration. Specialist training.	Reduced loss ratio – less "unforeseen" accidents. Market expansion. Dynamic pricing. Improved claims handling.	Not involved
Citizens/ City Hall / Local Government	U-space /Controlled/ VLL and LL airspaces	Data digitization & maintenance costs. Staff Resourcing and training. Public consultation costs.	Streamlined ARA Process. Social acceptance improvement. Economic development – in special for UAS industry.	Not involved

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Stakeholder	Deployment locations (or operating environments)	Cost drivers	Benefits in operations	Involved – Provided inputs and reviewed this document.
			Urban management efficiency.	
Regulatory Authorities	U-space /Controlled/ VLL and LL airspaces	Training costs on new model. Data digitization costs.	Streamlined ARA Process. Operational Efficiency. Improvement on safety.	Not involved
Researchers / R&D organizations	U-space /Controlled/ VLL and LL airspaces	Computational infrastructure. Data acquisition. Specialized talent.	Industry partnerships. Open data & methodology. IP and knowledge creation.	Involved
Standardisation bodies	U-space /Controlled/ VLL and LL airspaces	Standards creation.	Market harmonization Accelerated standard publication.	Partially involved

Table 3: SESAR Solution 0520 ECO-EVAL stakeholders and impacts

3.5 ECO-EVAL scenarios and assumptions

This section describes the scenarios that are compared in the ECO-EVAL. The aim is to reflect the delta (difference) between the ECO-EVAL reference scenario (where the SESAR solution is not deployed, bottom boxes in Figure 1) and the ECO-EVAL solution scenario (reflecting the proposed deployment of the SESAR solution across ECAC, upper boxes in Figure 1). The comparison between the ECO-EVAL

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scenarios considers the point in time when the solution is available to be deployed and hence differs for each solution.

The delta approach means that the focus is on identifying the impact of the changes between the ECO-EVAL reference and ECO-EVAL solution scenarios. For example, new systems to be deployed, training requirements or changes in operating costs.

Defining the ECO-EVAL reference scenario has proven to be challenging because of the assumptions that need to be made regarding the 'ongoing deployments' that are relevant for the solution and their impacts.

To avoid being blocked by this issue, some elements of this TRL2 ECO-EVAL focus on the difference between the current situation and the ECO-EVAL solution scenario. This is reflected in the following scenario descriptions.

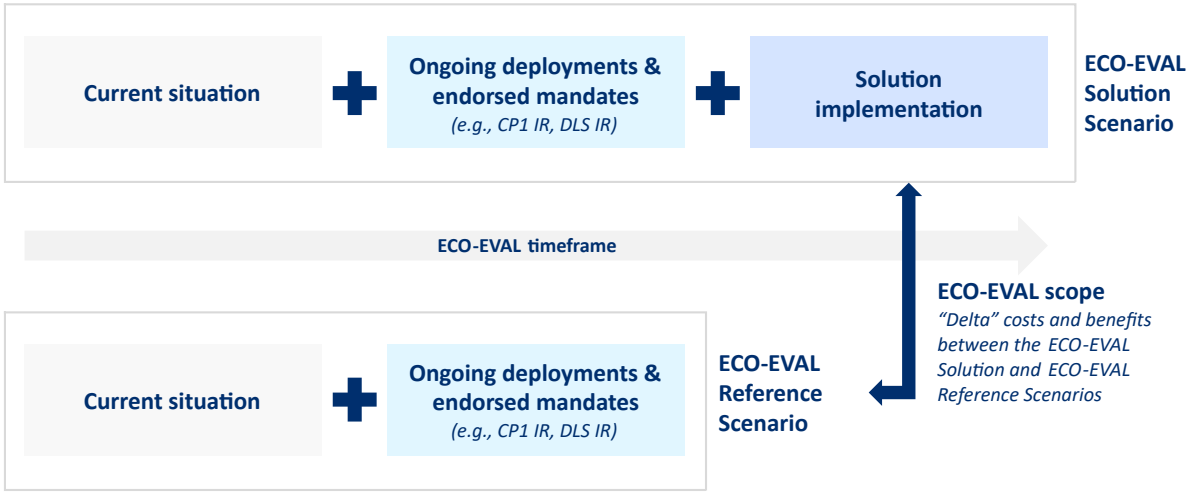

Figure 1: ECO-EVAL scenario overview

3.5.1 ECO-EVAL reference scenario

The U-AGREE project (SESAR Solution 0520) focuses on providing an integrated risk model in U-space and UAS operations and addressing the mitigation effects of applying U-space services. As solution 0520 falls within the domain U-space and UAS operations, its reference scenario is based on the current state of EASA UAS operations, in particular addressing mainly operations that are covered by Specific Operations Risks Assessment (SORA), and U-space services provision.

3.5.1.1 EASA UAS Operations and SORA

Currently EU Reg. 2019/947 defines three categories of operations: open, specific and certified [13]. **For operations in the specific category** (which encompass the majority of the expected operations over urban areas), **Reg. 2019/947 sets forth the requirement to develop a risk assessment using SORA.** In this process, risk models are crucial to determine the initial (unmitigated) ground risk classes (GRC) and air risk classes (ARC) and apply mitigation measures to get residual air and ground risk classes, which are then combined in a specific assurance and integrity level (SAIL). Afterwards, UAS operators must go through 24 operational safety objectives (OSOs) demonstrating to show compliance with the required level of robustness depending on the SAIL.

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The Specific Operations Risk Assessment (SORA) developed within JARUS has progressively evolved from a methodology largely driven by qualitative expert judgement toward an approach that can be supported by measurable data, repeatable calculations, and ultimately digital tools. This evolution is not purely editorial: it reflects the increasing operational complexity of UAS missions (e.g., BVLOS, higher traffic densities, proximity to urban areas) and the parallel regulatory push for scalable, harmonised authorisations that can be processed efficiently by both operators and authorities.

In Europe, SORA 2.0 was implemented in 2019 and used extensively since then. Over the years some key limitations have emerged based on its use and the lessons learnt. The main limitation is that key inputs and mitigations are largely qualitative. Ground risk assessments rely on broad descriptors such as “sparsely populated” or “gathering of people,” without incorporating explicit population data, resulting in subjective decisions and inconsistencies across authorities. Tactical ground mitigations are limited, and containment and adjacent-area parameters are also qualitative, hindering repeatability and complicating standardisation. The Air Risk model in SORA 2.0 is also largely qualitative and is often overly conservative, not accounting for critical factors like UAS size and Maximum Take-Off Mass (MTOM). Furthermore, mitigations arising from the provision of U-space services are not clearly integrated, which has contributed to restricting access to non-segregated airspace for many operations.

SORA 2.5 represents an intermediate step towards a more quantitative approach to risk assessment. Qualitative ground-area descriptors are now replaced by population density bands (from very low densities to >50,000 people/km²) associated with descriptive categories, enabling the intrinsic GRC to be derived from data rather than interpretation. In parallel, ground mitigations are expanded (e.g., sheltering and time-based restrictions) and complemented by tactical mitigations that credit the operator’s ability to maintain visual control over most of the overflown area and respond to unexpected incursions by uninvolved persons. Containment also becomes more quantitative: SORA 2.5 introduces a more rational way to define adjacent areas based on speed and time, and then links containment performance expectations to parameters such as SAIL, maximum characteristic dimension and speed, average population density, and proximity to outdoor assemblies.

Once the methodology is expressed in measurable inputs, it becomes suitable for digitalisation. Operators can replace narrative justifications with reproducible calculations, supported by geospatial layers (e.g., population density datasets, geozones) and flight-geometry data. Authorities, in turn, can review results faster because the underlying assumptions are transparent and machine-checkable. This enables partial automation of the “front end” of the SORA: pre-filling intrinsic GRC from GIS data, computing containment/adjacent-area buffers from UA performance parameters, and standardising the mapping between risk classes, mitigations, and required assurance. The same digital building blocks also support continuous improvement: as better datasets or operational evidence become available, parameters can be updated without changing the overall process structure, improving both consistency and regulatory confidence.

The next major evolution (i.e SORA 3.0) is expected to concentrate on the air risk side, where today’s process still contains significant qualitative judgement. A more standardised and quantitative definition of aerodrome environments, together with revised AEC/ARC determination rules that reflect airspace organisation and the level of Air Traffic Service provision, would reduce national variability and improve cross-border harmonisation. This direction aligns with the broader European trajectory toward U-space, where safe integration of increasing numbers of UAS operations is explicitly linked to a “high degree of automation and digitalisation” through U-space services (Commission Implementing

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Regulation (EU) 2021/664). As U-space services mature (e.g., authorisation, traffic information, conformance monitoring), they can provide objective inputs to air risk mitigations and enable new mitigation concepts that are quantitative by design (for example, explicit separation/containment performance and validated risk-reduction credits). In the longer term, such quantification is a prerequisite for routine, semi-automated authorisation workflows and for enabling highly automated or autonomous UAS operations while maintaining a clear, auditable safety case.

3.5.1.2 U-space services provision

Currently, Reg. 2021/664 [15] introduces the concept of U-space airspace, that can be designated by competent authorities for safety, security, privacy or environmental protection reasons. In a U-space airspace almost all UAS operations will have to make use of a set of U-space services set out in Reg 2021/664. However, there haven't been contemplated yet in U-space, how the provision of these U-space services can justify the reduction the risk level for a given UAS operation, as proof of mitigation of the risks detected during the process of SORA. This mitigation justification is provided by U-AGREE Project, and further information can be found in U-AGREE D4.2 [29].

3.5.2 ECO-EVAL solution scenario

How will Solution 0520 work:

The **U-AGREE Project (SESAR Solution 0520)** envisions a shift from the current qualitative and often conservative risk assessment methodologies within current UAS and U-space operations toward a high-fidelity, quantitative, and integrated risk modeling framework. As current standards like SORA are evolving towards quantitative analysis, U-AGREE is proposing to include models of these risks in the assessment for each operation, and introducing in the U-space operations workflow, particularly regarding the mitigating effects of digital U-space services.

1. **Operational mechanism of the solution:** Solution 0520 works by replacing "static" risk assumptions with advanced integrated risk models. These models ingest high-resolution data to assess not only air risks, such as UAS-to-UAS and UAS-to-manned aircraft collisions, but also the broader societal and security implications, including impacts on critical infrastructure, privacy infringements, and environmental effects. Crucially, the solution incorporates the mitigating effect of U-space services directly into the risk calculation. By quantifying how services like Strategic Deconfliction, Conformance Monitoring and Tactical Conflict Resolution among others, lower the residual risk of a UAS mission, the solution allows for a potential reduction in the required Specific Assurance and Integrity Level (SAIL) and the associated Operational Safety Objectives (OSOs).

2. **Economic and regulatory integration** From an Economic Evaluation perspective, Solution 0520 operates as a digital enabler for scalability. By automating the risk assessment process and aligning it with the evolving EASA regulatory framework and EUROCAE WG-105 standards, the solution facilitates:

    a. **Accelerated market access:** It enables fully automated flight authorizations with minimal to zero manual intervention, significantly reducing the administrative lead time and legal costs for both UAS Operators and Competent Authorities.

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b. **Optimized airspace capacity:** Through Fast Time Simulations (FTS) in different airspace environments, the solution demonstrates how more precise risk modeling and U-space based mitigation barriers removes the need for excessive safety buffers, thereby increasing the volume of simultaneous operations possible in a given airspace, maximizing the number of operations and efficiency of the airspace. Indeed, the solution will facilitate the deployment of U-space airspaces by facilitating the risk calculations process on the assessment phase of the Airspace Risk Assessment (ARA) [23].

c. **Stakeholder cost-sharing:** By recognizing U-space services as valid safety mitigations, the economic burden of risk management is shared between the UAS operator's on-board equipment and the ground-based service infrastructure, lowering the barrier to entry for complex urban missions.

3. **Scope beyond VLL**: While urban Very Low Level (VLL) environments remain a primary focus due to their high density and risk complexity, U-AGREE is designed to be environmentally agnostic where relevant. The integrated risk models are scalable to encompass operations that interface with traditional ATM (Air Traffic Management) above VLL, ensuring a seamless "Comprehensive Airspace Picture " and consistent safety levels throughout the mission trajectory, regardless of altitude. FlightAware® support with their data to this comprehensive picture.

What is to be deployed:

The U-AGREE project (SESAR Solution 0520) aims to deploy an advanced, integrated risk-modelling framework that serves as the quantitative foundation for U-space safety and airspace designation. The first step towards U-AGREE deployment is the establishment of a standardized digital risk-assessment methodology that is interoperable across the various U-space and ATM stakeholders. This requires a cost-efficient business model that incentivizes U-space Service Providers (USSPs) and Common Information Service Providers (CISPs) to integrate these high-fidelity models into their core service offerings.

In terms of infrastructure, the deployment of the U-AGREE solution relies on the evolution of digital platforms rather than physical CNS hardware. Initially, the solution targets the Specific category of UAS operations in urban environments, where the current SORA limitations are most restrictive. Subsequently, the framework is expected to scale, reaching General Aviation (GA) and Rotorcraft stakeholders by providing a "Comprehensive Airspace Picture " that manages the interface between manned and unmanned traffic.

Therefore, the solution requires the deployment of API-based data exchange layers between U-space entities (USSPs, CISPs) and traditional ATM entities (ANSP, Network Manager). This includes the deployment of cloud-based data processing and storage infrastructure capable of handling dynamic ground-risk variables (such as real-time population density), dynamic air traffic and environmental data. Where applicable, staff including ANSP, Civil Aviation Authority (CAA) inspectors, and USSP operators, must receive specialized training to interpret the quantitative risk outputs and apply the new "U-space mitigations " enabled by the U-AGREE models.

Finally, UAS software developers and avionics manufacturers will be advised to design and test flight-planning tools that natively ingest U-AGREE risk scores to optimize mission trajectories. This can be

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either covered within USSPs already (through an enhancement of the "Flight Authorization service"), or by UAS fleet management tools. Simultaneously, National and Civil Aviation Authorities will need to deploy updated regulatory inspection routines and Airspace Risk Assessment (ARA) protocols. This deployment ensures that the legal transition from qualitative safety cases to automated, model-driven approvals is both safe and compliant with the envisaged evolution of the U-space regulatory framework.

Interdependencies:

See section 3.2.1 of this document.

ECO-EVAL timeline

The ECO-EVAL covers the period from 2026 to 2050 as defined in the common assumptions [4]. This mean that the net present value is calculated by discounting the cash-flows back to 2026 (the end of DES wave 1).

Table 4 lists the key dates used in the ECO-EVAL and Figure 2 shows them over a timeline.

Dates	SESAR Solution 0520
Start of deployment date (SOD): the start of investments for the first deployment location.	**2028**
End of deployment date: the end of the investments for the final deployment location, same as FOC.	**2035**
Initial operating capability (IOC): the time when the first benefits occur following the *minimum deployment* necessary to provide them. Costs continue after this date as further deployment occurs at other locations.	**2030**
Final operating capability (FOC): maximum benefits from the *full deployment*[2] of the SESAR solution at applicable locations. Investment costs are considered to end[3] here although any operating cost impacts would continue.	**2035**

Table 4: ECO-EVAL investment and benefit dates

[2] Where ***full deployment*** means deploying the SESAR solution in all the locations where it makes sense to deploy it (i.e. it does not mean it has to be deployed everywhere)

[3] The basic assumption is that infrastructure does not need to be replaced during the ECO-EVAL period.

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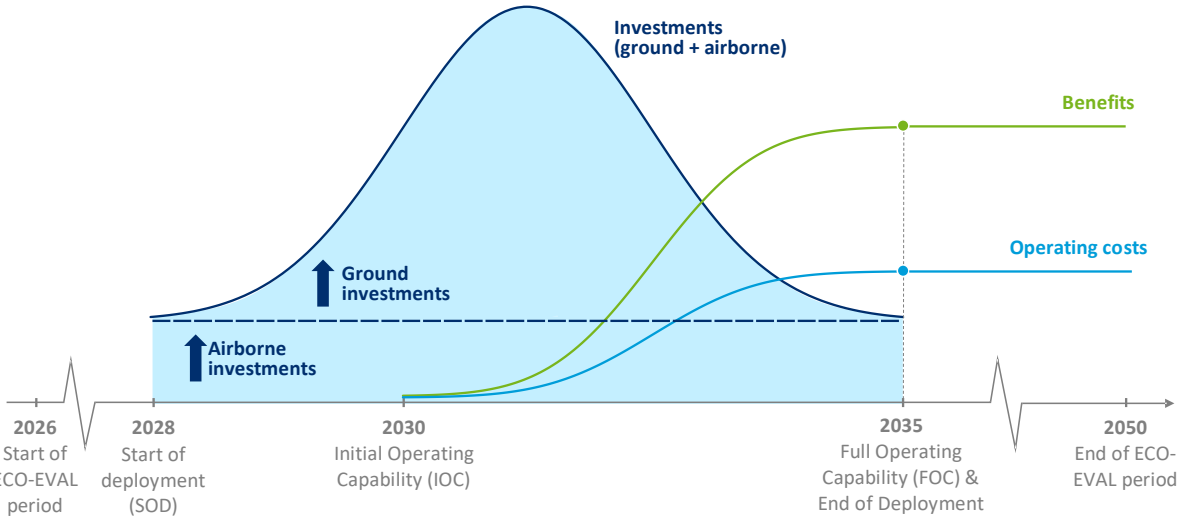

Figure 2: overview of ECO-EVAL dates

Figure 2 shows that:

- Investment costs are the addition of the (i) ground investment costs (spread following a bell curve[4] between the start and end of deployment dates), and (ii) airborne investment costs (spread linearly between the start and end of deployment dates);
- Benefits ramp-up following an 'S' adoption curve[4] between IOC and FOC and then continue up to the end of the ECO-EVAL period;
- Operating cost impacts (increases or decreases) would also start at IOC and ramp-up following an 'S' adoption curve to FOC before continuing for the rest of the ECO-EVAL duration.

3.5.3 Assumptions

This section describes the assumptions considered during the development of solution 0520. There are two main categories, divided into two different sub-sections:

- **Common assumptions**, related to the global nature of the evolution of European airspace and the associated costs,
- The **assumptions solution-specific** to the 0520 solution, which as their name suggests, are specifically induced by the deployment of the solution.

3.5.3.1 Common assumptions

These are the global propositions taken from the **SESAR Programme Library** that apply to all solutions within the Digital European Sky (DES) framework.

[4] The bell curve is based on the diffusion of innovation theory (see Investopedia for further reference).

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- **ECAC traffic forecast:** The evaluation uses the STATFOR long-term forecast [27] based on an unconstrained scenario.
    - **2030:** 12,073,641 IFR Movements.
    - **2035:** 12,668,365 IFR Movements.
- **Economic parameters:**
    - **Average Fuel Burn:** 5,279 kg per flight (based on the ECAC Performance Model 1.0).
    - **ATCO employment costs:** ATCOs in operations contribute to 26.5% of the ANSP costs.
    - **Number of ATCOs:** 17 885
    - **Core air traffic operating hours:** 16 hours per day.
- **Standard fuel burn rates (for conversion of time savings):**
    - **Taxiing (In/Out):** 9.7 kg/min.
    - **TMA Arrival:** 42.8 kg/min.
    - **TMA Departure:** 59.6 kg/min.

3.5.3.2 Solution-specific (local) assumptions for U-AGREE

These following assumptions below are tailored to the unique operational environment of **SESAR Solution 0520.**

- **Regulatory & Standardization framework:**
    - Publications of EUROCAE WG-105 standards and update of EU Reg 2021/664 EASA Acceptable Means of Compliance (AMC) [16] based on the project's results by 2028.
- **Impacted traffic & Market penetration:**
    - **Initial Scope:** Deployment focuses on mainly "Specific Category" UAS operations in different environments for UAS operations.
    - **Scaling:** After IOC (2030), the solution impacts General Aviation (GA) and Rotorcraft operating in VLL, Controlled, U-space and LL airspaces.
- **Equipage & technology adoption:**
    - **USSP Integration:** It is assumed that 100% of USSPs in designated U-space airspaces will have integrated the U-AGREE risk-modeling APIs by FOC (2035).
    - **Electronic conspicuity:** Following the EU Reg 2021/664 [15] and 2021/666 [28] 2, it is assumed that all manned aircrafts will be electronic conspicuous when U-space is deployed, supporting the integration of manned-unmanned traffic data.

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- **U-space airspace deployment:** by 2028, it is assumed U-space airspaces will be deployed within Europe, and by 2035 each EASA member country will have at least one.

- **Operational efficiency assumptions:**
  - **Administrative lead time:** The transition to automated risk assessments is assumed to reduce manual intervention by minimal to zero for standard flight authorizations.
  - **Human performance:** The different stakeholders involved in U-space operations processes will reduce their workload, increasing operating efficiency, and hence, human performance.
  - **U-space mitigations justifications:** It is assumed that the presence of certified U-space services (e.g., strategic deconfliction) provides a quantifiable reduction in the ground and air risk class, effectively lowering the SAIL requirements for operators.

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4 Benefits

This chapter describes the benefits provided by the U-AGREE Project (SESAR Solution 0520) following the scenario described in Section 3.5.2. This section gives a brief overview of these areas before going into more detail, particularly with regard to the associated Performance Indicators (PIs) and Key Performance Indicators (KPIs).

4.1 Benefits overview

The benefits identified within the Operational Service and Environment Description (OSED) [1] and Exploratory Research Plan (ERP) [2] of Solution 0520 cover Kery Performance Areas (KPAs) and PI related to U-space. They highlight the impact of U-AGREE on areas such as Capacity (CAP), Safety (SAF), Security (SEC), Environment (ENV) and Access & Equity (A&E). The primary benefits of the solution are:

1. Regulatory agility and accelerated market access

- **Digitalizing SORA:** By supporting transforming qualitative, manual Specific Operations Risk Assessments (SORA) into quantitative, automated digital tools, the solution drastically reduces the administrative lead time for flight approvals. This fosters a scalable business environment for UAS operators by accelerating time-to-market.
- **Streamlining Airspace Risk Assessments (ARA):** U-AGREE facilitates the rapid and cost-effective deployment of U-space airspaces. It provides competent Authorities with a standardized, data-driven process for the ARA phase, removing the bottleneck of manual, subjective risk calculations.

2. Economic viability and airspace optimization

- **Maximizing airspace capacity:** Improving the precision of risk models removes the need for overly conservative, static safety buffers. This unlocks high-density operations in complex urban Very Low Level (VLL) and trans-VLL environments, directly boosting the revenue potential for U-space and ATM industries.
- **Quantifying U-space mitigations:** Through high-fidelity Fast Time Simulations (FTS), the solution mathematically justifies and quantifies how specific U-space services (e.g., Strategic Deconfliction) mitigate operational risk. This allows operators to safely lower their Specific Assurance and Integrity Levels (SAIL), reducing onboard equipage costs, and easing the SORA or Operational Authorization grants, facilitating the increment on UAS operations.

3. Enhanced safety and legal robustness

- **Holistic safety:** The solution elevates safety from a generic objective to a precise metric. It delivers a comprehensive "Comprehensive Airspace Picture" that rigorously calculates the probability of mid-air collisions (manned and unmanned) and ground impacts under highly dynamic conditions.
- **Standardization and liability shield:** By establishing a validated, standardised (e.g.: EUROCAE) and regulated (e.g.: EASA) methodology, U-AGREE provides a standardized "legal shield" for key stakeholders including but not limited to USSPs, CISPs, and Authorities. This lowers the risk of systemic litigation and helps stabilize insurance premiums for the U-space and UAS industry.

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4. Social impact and public trust

- **Securing the social license to operate:** Unlike traditional models, U-AGREE integrates environmental impacts (noise) and privacy concerns directly into the risk calculation. This provides City Halls and regulators with the transparent data needed to foster public acceptance and integrate drone operations harmoniously into urban life

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4.2 Benefit summary

Table 5 summarises the solution benefits showing the benefit impact mechanisms (BIMs) impact (positive, negative or neutral). It explains how the solution provides estimates.

KPI / PI	BIM impact	How the solution provides the benefit and evaluation (low, medium, high impact)
SAFETY **U-AGREE-KPI-01** Number of NMAC/FH	Reduced number of NMAC/FH **(Positive Impact)**	**How:** U-AGREE refinement of risk models and simulation environments support better assessment on defining and ensuring separation minima between UAS and UAS, and UAS and manned aviation. **Contribution:** High **Evaluation:** Through simulation exercises.
SAFETY **U-AGREE-KPI-02** Number of Non-conformance events/FH	Reduced number of Non-conformance/FH **(Positive Impact)**	**How:** U-AGREE refinement of risk models and simulation environments support better assessment on defining UAS operation 4D volumes, ensuring less non-conformance events. **Contribution:** Medium **Evaluation:** Through simulation exercises.
U-AGREE-KPI-03 **Derived from U.CAP1** Area drone density (derived from *U-*	Increased number of drones per U-space **(Positive Impact)**	**How:** U-AGREE refinement of risk models and simulation environments support better assessment on defining UAS operation 4D volumes, and separation minima, increasing the capacity. **Contribution:** High **Evaluation:** Through simulation exercises.

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KPI / PI	BIM impact	How the solution provides the benefit and evaluation (low, medium, high impact)
space maximum number of drones)		
CAPACITY U-AGREE-KPI-04 Average number of authorised U-plans	Increased average number of authorised U-plans **(Positive Impact)**	**How:** U-AGREE refinement of risk models and simulation environments support better assessment on defining UAS operation 4D volumes, and separation minima, increasing the average number of U-plans that can be authorised. Supports SORA OSOs mitigation as well. **Contribution:** Medium **Evaluation:** Through simulation exercises.
CAPACITY U-AGREE-KPI-05 Maximum number of authorised U-plans	Increased number of authorised U-plans **(Positive Impact)**	**How:** U-AGREE refinement of risk models and simulation environments support better assessment on defining UAS operation 4D volumes, and separation minima, increasing the average number of U-plans that can be authorised. Supports SORA OSOs mitigation as well. **Contribution:** Medium **Evaluation:** Through simulation exercises.
SEC & ENV U-AGREE-KPI-06 Number of geo-zones infringement/FH	Reduced number of geo-zones infringement/FH **(Positive Impact)**	**How:** U-AGREE refinement of risk models and simulation environments support better assessment on defining geo-zones and UAS routes, to prevent unvoluntary infringement of these geo-zones. **Contribution:** Medium **Evaluation:** Through simulation exercises.

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KPI / PI	BIM impact	How the solution provides the benefit and evaluation (low, medium, high impact)
U.ACCESS1 U-AGREE-KPI-07 Authorization approval rate	Higher number of Authorization approval rate **(Positive Impact)**	**How:** U-AGREE refinement of risk models and simulation environments enables an infrastructure with mathematical certainty rather than manual negotiation. This results in high Authorisation Approval Rate that fosters the industry growth while maintaining the safety. **Contribution:** High **Evaluation:** Through simulation exercises.

Table 5: solution performance benefits

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4.3 SAFETY U-AGREE-KPI-01 - Number of NMAC/FH

U-AGREE refinement of risk models and simulation environments support better assessment on defining and ensuring separation minima between UAS and UAS, and UAS and manned aviation.

Contribution: High

Impact: Reduced number of NMAC/FH **(Positive Impact)**

Evaluation: Through simulation exercises.

4.4 SAFETY U-AGREE-KPI-02 Number of Non-conformance events/FH

U-AGREE refinement of risk models and simulation environments support better assessment on defining UAS operation 4D volumes, ensuring less non-conformance events.

Contribution: Medium

Impact: Reduced number of Non-conformance/FH **(Positive Impact)**

Evaluation: Through simulation exercises.

4.5 U-AGREE-KPI-03 (Derived from U.CAP1) - Area drone density (derived from U-space maximum number of drones)

U-AGREE refinement of risk models and simulation environments support better assessment on defining UAS operation 4D volumes, and separation minima, increasing the capacity.

Contribution: High

Impact: Increased number of drones per U-space **(Positive Impact)**

Evaluation: Through simulation exercises.

4.6 CAPACITY U-AGREE-KPI-04 - Average number of authorised U-plans

U-AGREE refinement of risk models and simulation environments support better assessment on defining UAS operation 4D volumes, and separation minima, increasing the average number of U-plans that can be authorised. Supports SORA OSOs mitigation as well.

Contribution: Medium

Impact: Increased average number of authorised U-plans **(Positive Impact)**

Evaluation: Through simulation exercises.

4.7 CAPACITY U-AGREE-KPI-05 - Maximum number of authorised U-plans

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U-AGREE refinement of risk models and simulation environments support better assessment on defining UAS operation 4D volumes, and separation minima, increasing the maximum number of U-plans that can be authorised. Supports SORA OSOs mitigation as well.

Contribution: Medium

Impact: Increased number of authorised U-plans **(Positive Impact)**

Evaluation: Through simulation exercises.

4.8 SEC & ENV U-AGREE-KPI-06 - Number of geo-zones infringement/FH

U-AGREE refinement of risk models and simulation environments support better assessment on defining geo-zones and UAS routes, to prevent unvoluntary infringement of these geo-zones.

Contribution: Medium

Impact: Reduced number of geo-zones infringement/FH **(Positive Impact)**

Evaluation: Through simulation exercises.

4.9 U.ACCESS1 U-AGREE-KPI-07 - Authorization approval rate

U-AGREE refinement of risk models and simulation environments enables an infrastructure with mathematical certainty rather than manual negotiation. This results in high Authorisation Approval Rate that fosters the industry growth while maintaining the safety.

Impact: Higher number of Authorization approval rate **(Positive Impact)**

Contribution: High

Evaluation: Through simulation exercises.

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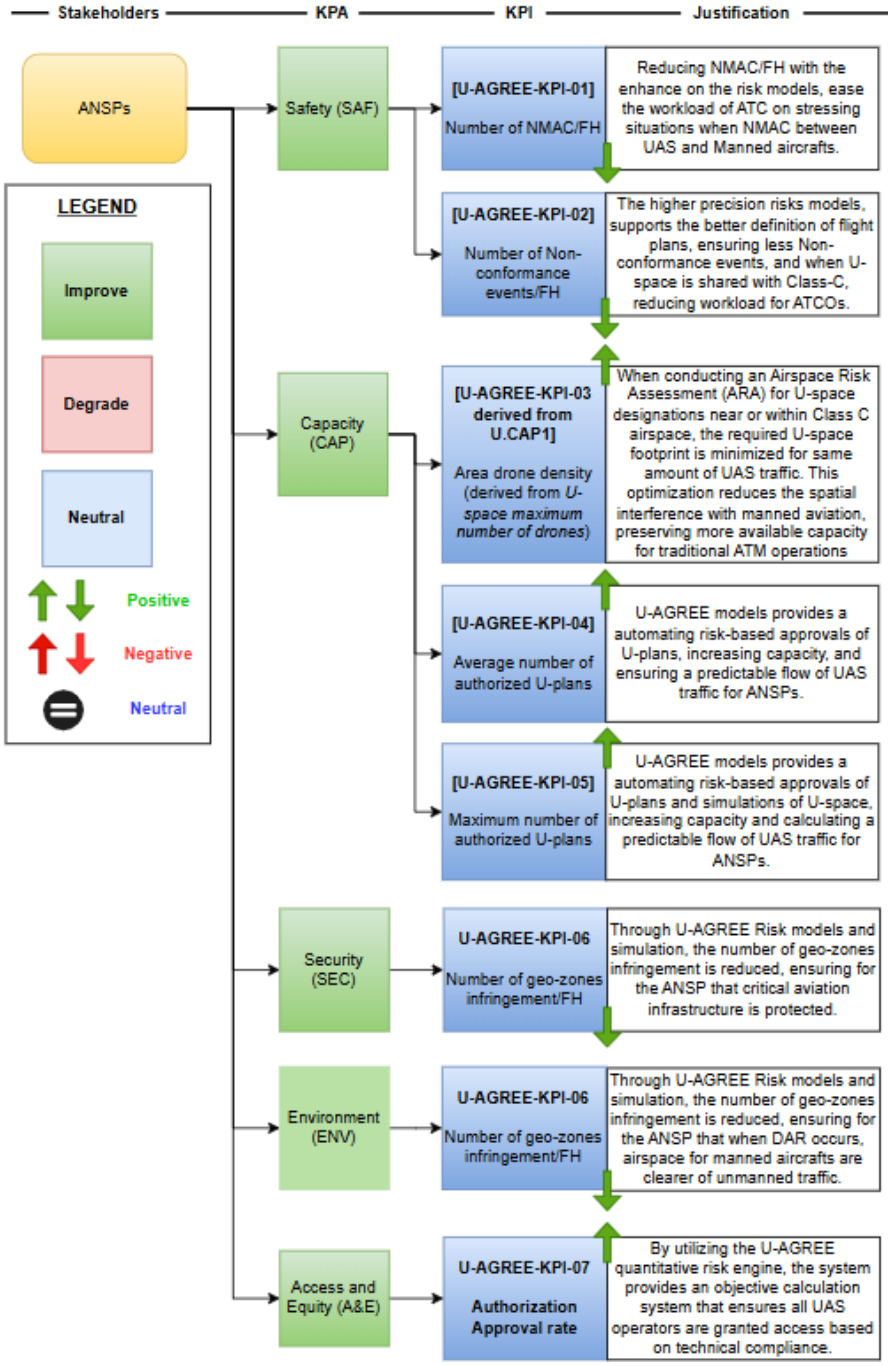

Figure 3 - ANSP KPIs benefits impact

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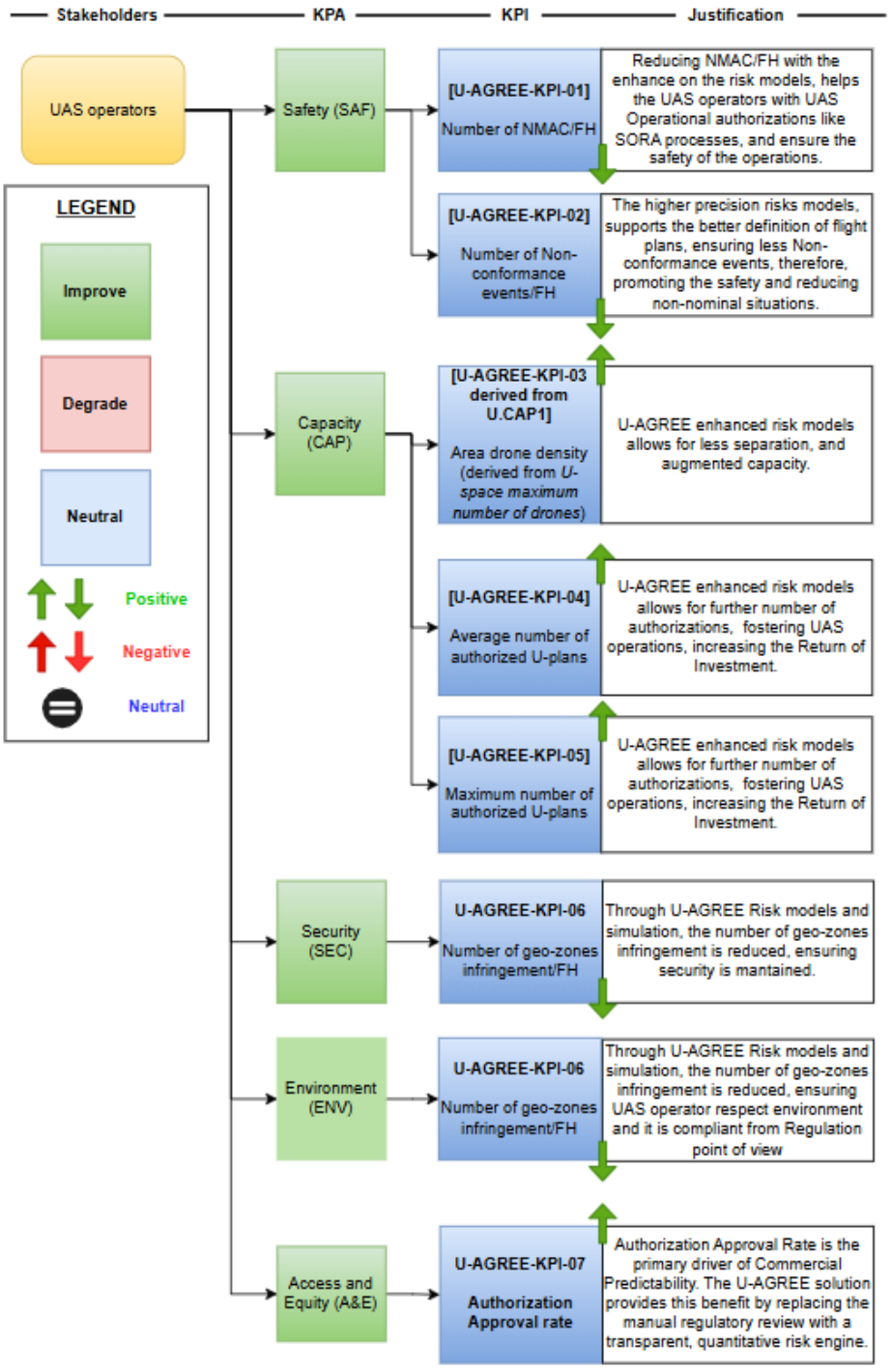

Figure 4 UAS operators KPIs benefits impact

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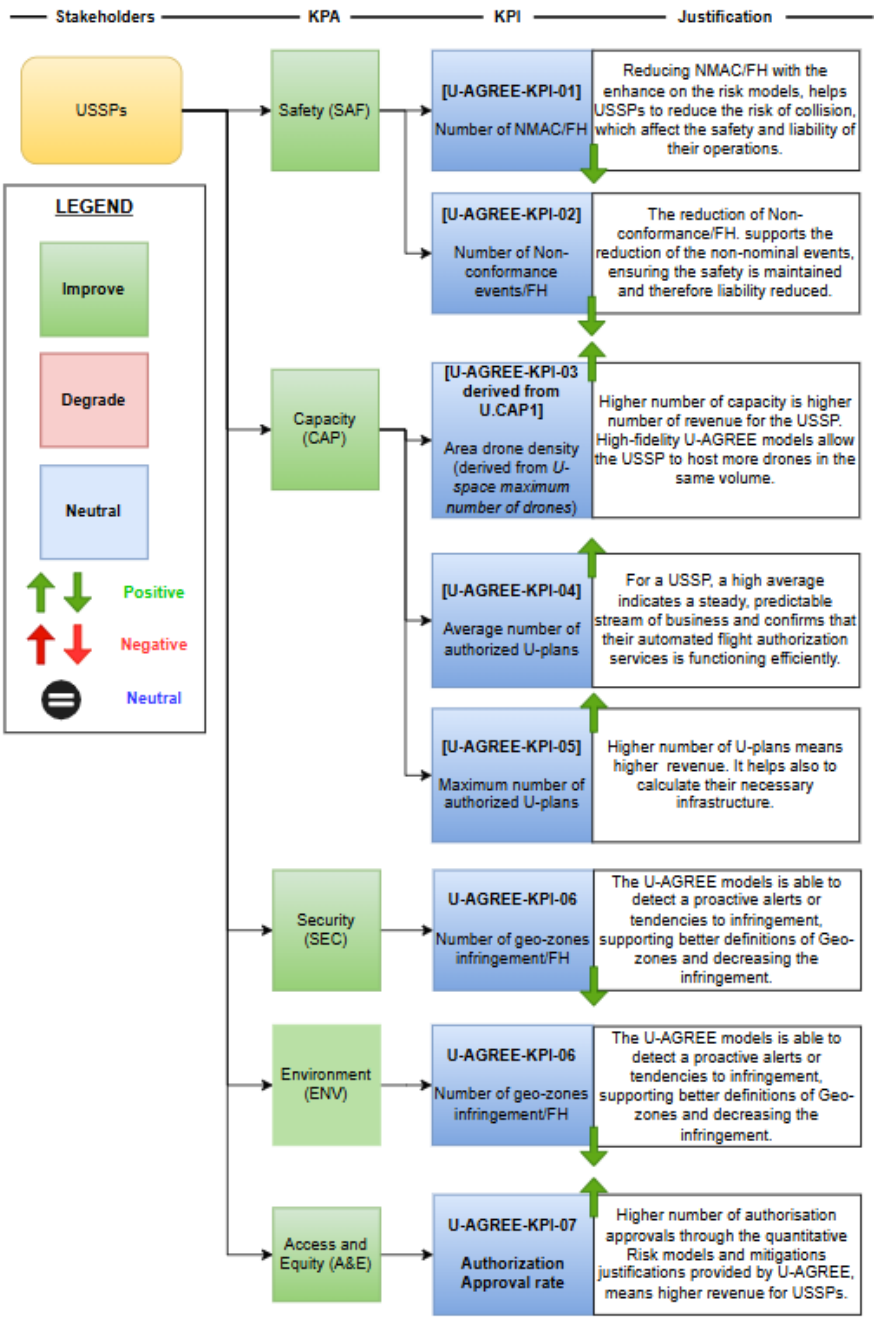

Figure 5 USSPs KPIs benefits impact

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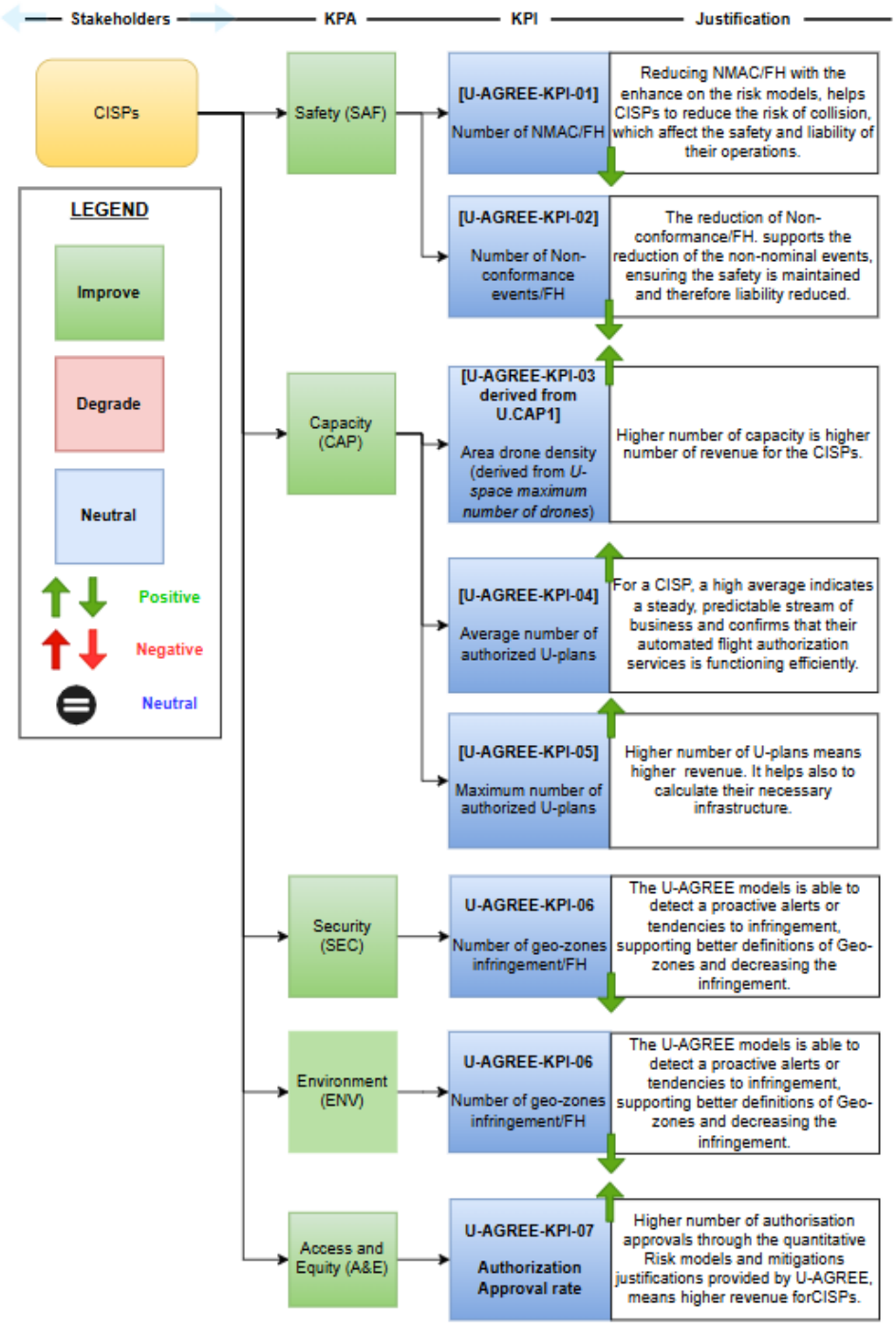

Figure 6 CISPs KPIS Benefits impact

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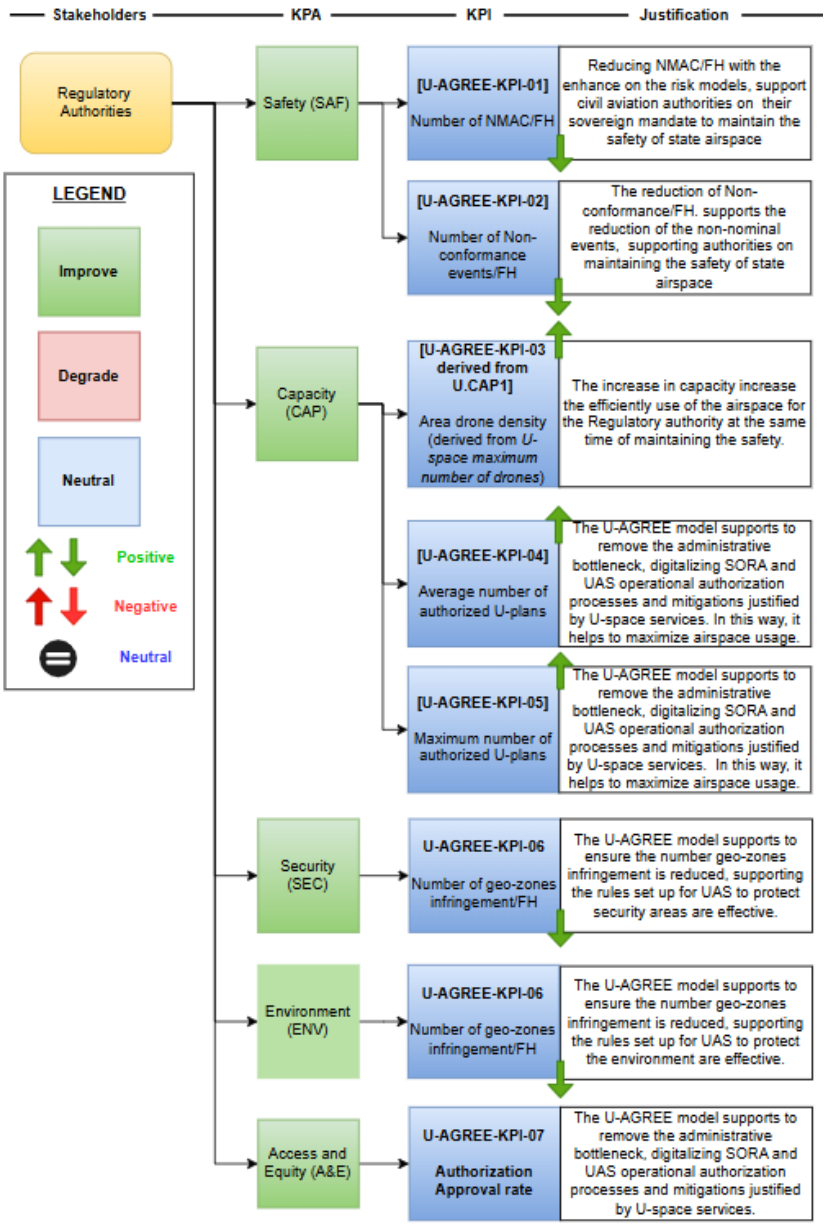

Figure 7 Regulatory Authorities KPIS Benefits impact

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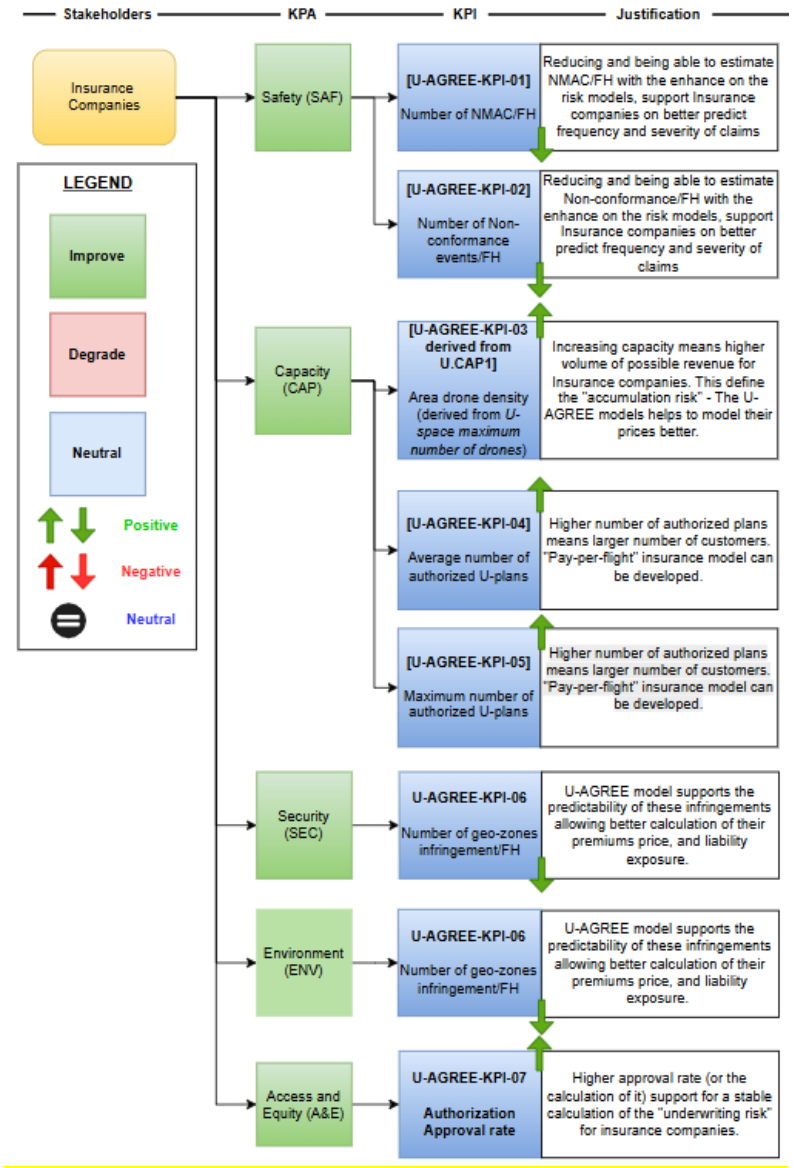

Figure 8 Insurance Companies KPIS Benefits impact

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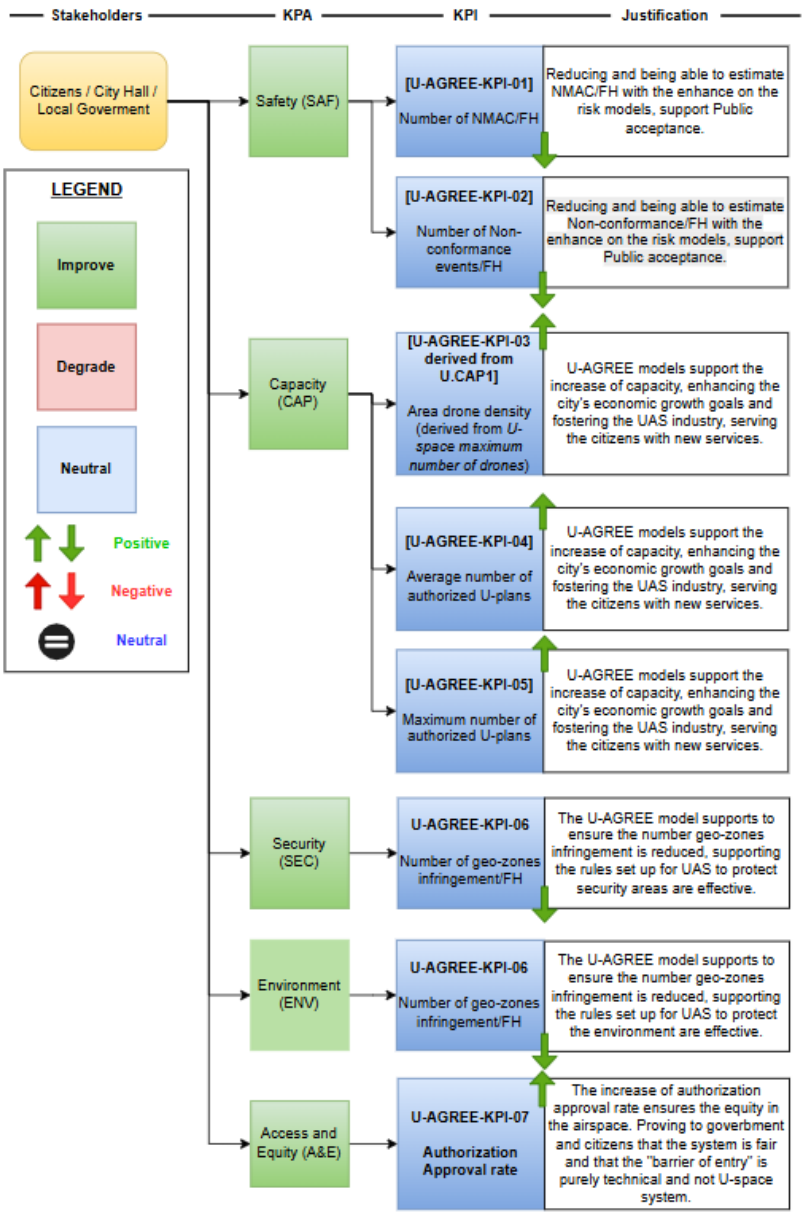

Figure 9 Citizens/City Hall / Local government KPIS Benefits impact

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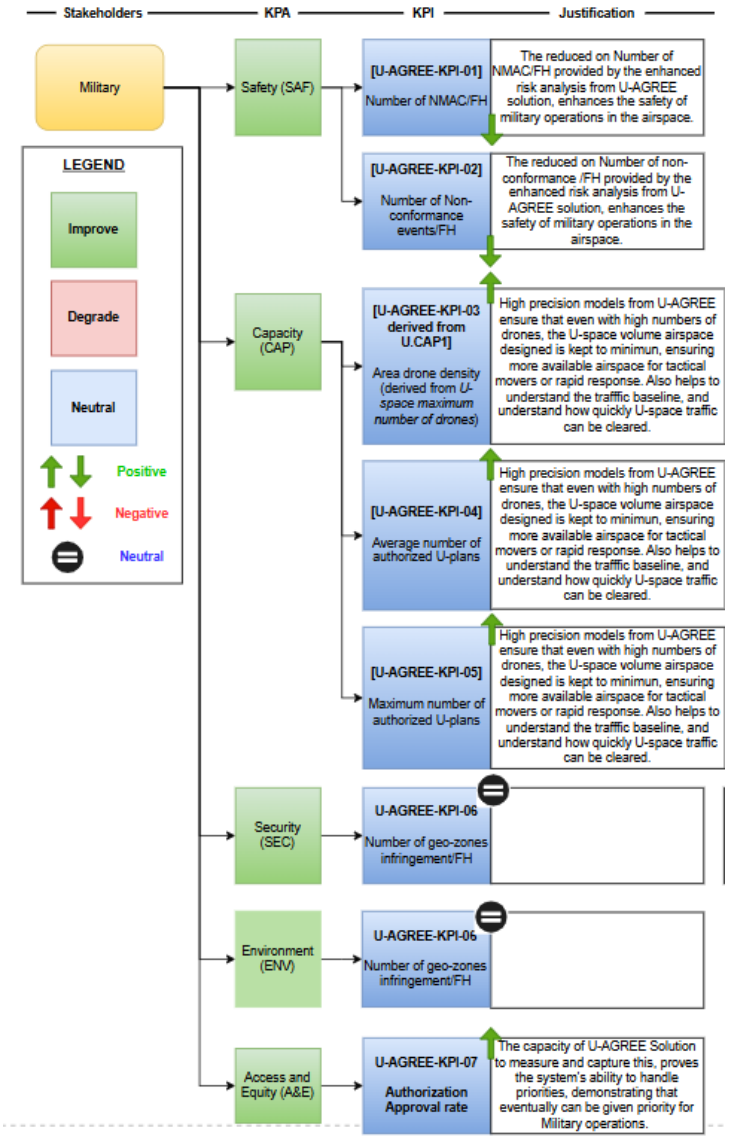

Figure 10 Military KPIS Benefits Impact

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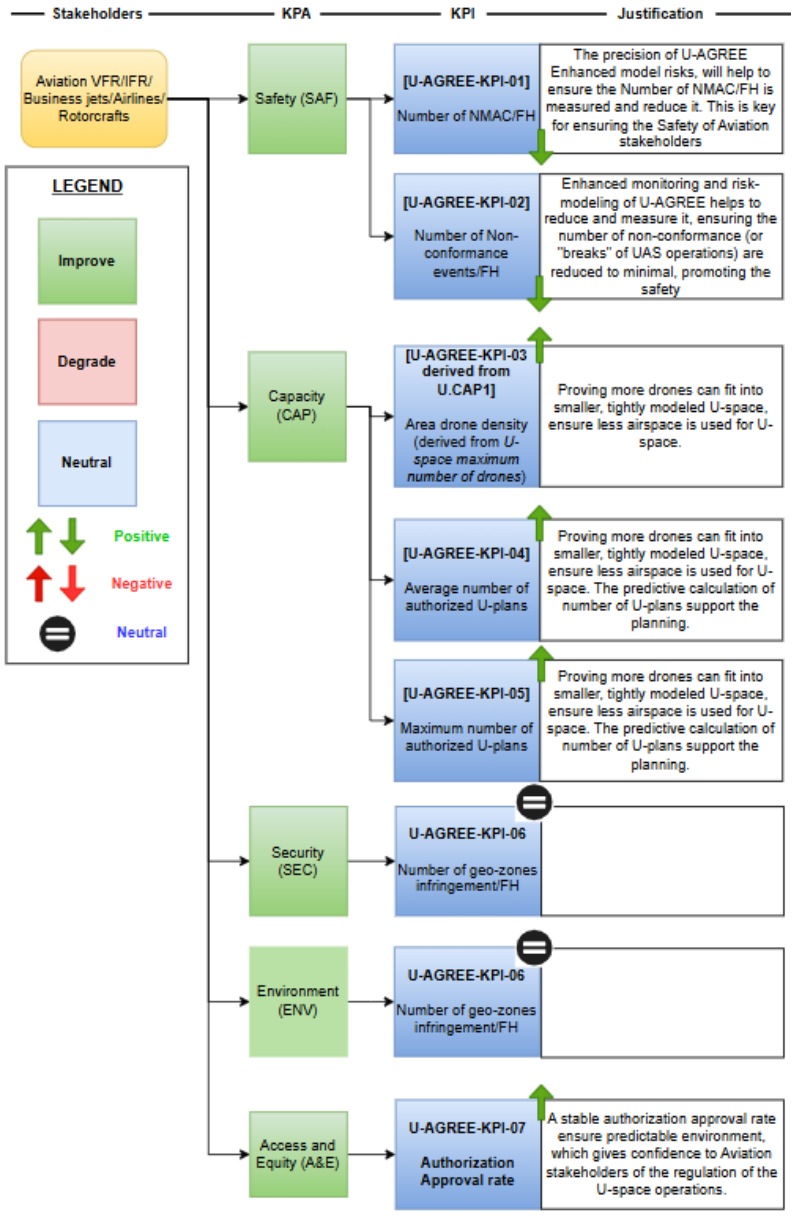

Figure 11 Aviation VFR/IFR/Airlines KPIS Benefits impact

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5 Cost assessment

Stakeholder	Cost category	Yes/No	Cost driver	Deployment locations (or operating environments)
ANSPs	Investment cost	YES	System integration costs. ATCO training. SOP updates.	Controlled/ U-space/ VLL/ LL Airspaces
	Operating cost	NO	-	
Airlines, Business Aviation, IFR General Aviation	Investment cost	NO	-	Controlled/ U-space/ VLL/ LL Airspaces
	Operating cost	NO	-	
Rotorcrafts, VFR General Aviation	Investment cost	NO	-	Controlled/ U-space/ VLL/ LL Airspaces
	Operating cost	NO	-	
Military	Investment cost	NO	-	Controlled/ U-space/ VLL/ LL Airspaces
	Operating cost	NO	-	
UAS Operators	Investment cost	NO	-	Controlled/ U-space/ VLL Airspaces
	Operating cost	YES	U-space service fees for U-AGREE model.	
USSPs	Investment cost	YES	Algorithm development & integration. Cybersecurity & data integrity. Certification adjustments. Advanced high-fidelity dynamic data integration models. Set up of Legal and Liability framework costs.	Controlled/ U-space/ VLL Airspaces

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Stakeholder	Cost category	Yes/No	Cost driver	Deployment locations (or operating environments)
	Operating cost	YES	Advanced high-fidelity dynamic data updated acquisition. Cybersecurity & data integrity. Legal and Liability costs.	
CISPs	Investment cost	YES	Integration of the model U-AGREE. High-fidelity data infrastructure (e.g: upgrade serves). Cost to ensure systems interoperability. Adapt certification costs. Cyber resilience costs. Legal and liability costs.	Controlled/ U-space/ VLL Airspaces
	Operating cost	YES	Advanced high-fidelity dynamic data updated acquisition. Cyber resilience costs. Legal and liability costs.	
Citizens/City Hall / Local Government	Investment cost	YES	Database collection digitization. Staff Resourcing and training. Public consultation costs.	Controlled/ U-space/ VLL/ LL Airspaces
	Operating cost	YES	Database update maintenance.	
Regulatory Authorities	Investment cost	YES	Training costs on new model.	Controlled/ U-space/ VLL/ LL Airspaces

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Stakeholder	Cost category	Yes/No	Cost driver	Deployment locations (or operating environments)
			Data digitization/adaptation costs for existing models.	
	Operating cost	NO	-	
Insurances companies	Investment cost	YES	Costs to integrate U-AGREE's risk models into underwriting algorithms. Verified flight/risk data Integration. Specialist training	Controlled/ U-space/ VLL/ LL Airspaces
	Operating cost	YES	Digital infrastructure to run the algorithms.	
Standardisation bodies	Investment cost	YES	Standards creation.	Controlled/ U-space/ VLL/ LL Airspaces
	Operating cost	NO	-	
Research/R&D organizations	Investment cost	YES	Computational infrastructure. Data acquisition. Specialized talent training.	Controlled/ U-space/ VLL/ LL Airspaces
	Operating cost	YES	Database update maintenance. Computational infrastructure maintenance. Specialized talent.	

Table 6: identification of solution's cost drivers and deployment locations

5.1 ANSPs costs

Investment costs:

- **System integration:** Costs to integrate U-AGREE risk model outputs into existing ATM tools to provide a "Comprehensive Airspace Picture" that includes UAS risk levels.

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- **ATCO and Airspace planners training:** How to interpret new "residual risk" metrics when designating U-space volumes.
- **SOP (Standard Operating Procedures):** Safe modifications on SOP will have an investment cost.

5.2 Airlines, Business Aviation & IFR General aviation

Investment/operating costs: The implementation of U-AGREE solution does not impose any direct investment or operating costs on Airlines, Business Aviation & IFR General aviation. However, the solution enhances the predictability & time savings through the risks models and supports on the reduction of Mid-air collisions risks.

Therefore, **no cost drivers are identified for this stakeholder group**.

5.3 Rotorcrafts & VFR General aviation

Investment/operating costs: The implementation of U-AGREE solution does not impose any direct investment or operating costs on Rotorcrafts & VFR General aviation. However, the solution enhances supports on the reduction of Mid-air collisions risks.

Therefore, **no cost drivers are identified for this stakeholder group**.

5.4 Military costs

Investment/operating costs: The implementation of U-AGREE solution does not impose any direct investment or operating costs on Military. However, the solution enhances supports on the reduction of Mid-air collisions risks.

Therefore, **no cost drivers are identified for this stakeholder group**

5.5 UAS operators

Operating costs:

- **U-space service fees:** Subscriptions or "per-flight" costs paid to USSPs and CISPs to access the enhanced risk-mitigated environment provided by U-AGREE.

5.6 U-space Service Providers (USSPs)

Investment costs:

- **Algorithm development & integration:** Cost to implement the U-AGREE mathematical risk models into their cloud platforms to provide real-time risk scoring, and mitigation levels.
- **Advanced high-fidelity dynamic data integration models:** Costs to integrate source high-fidelity dynamic data needed for the model.
- **Cybersecurity & data integrity:** Investing in cybersecurity infrastructure.

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- **Certification adjustments:** Updating their USSP certificate with EASA/National Authorities to include these advanced "mitigating" service functionalities, that can be used in SORA.
- **Legal and Liability costs:** For drafting Service Level Agreements (SLAs) and contracts, ensuring the liability is clear in case wrong data or automation algorithm incorrectness can lead to an accident.

Operating costs:

- **Advanced high-fidelity dynamic data updated acquisition:** Costs to refresh and update the dynamic data from different sources (e.g: population density, bird behaviour, etc)
- **Cybersecurity & data integrity:** Ensuring the risk-model outputs are cyber-resilient, especially since these outputs will be used for safety validations. Cost on maintenance of servers.
- **Legal and Liability update and maintenance costs:** For updating Service Level Agreements (SLAs) and contracts, ensuring the liability is clear in case wrong data or automation algorithm incorrectness can lead to an accident.

5.7 Common Information Service Providers (CISPs)

Investment costs:

- **Integration of the model U-AGREE:** Invest in the technical capacity to distribute the dynamic risk data to USSPs.
- **High-Fidelity Data Infrastructure:** Costs to upgrade servers and APIs to handle the complex, multi-dimensional risk data generated by U-AGREE.
- **System Interoperability:** Implementation of standards to ensure seamless data exchange between systems.
- **Adapt certification:** Navigating the update on certification process to cover U-AGREE models.
- **Cyber resilience:** Significant investment in protecting the integrity of the risk data, as any corruption of the U-AGREE model outputs could lead to widespread operational safety risks.
- **Legal and liability costs:** Service Level Agreements (SLAs) and contracts, ensuring the liability is clear in case wrong data or automation algorithm incorrectness can lead to an accident.

Operating costs:

- **Cyber resilience costs:** Ensuring the risk-model and integrity of the risk data. Cost on maintenance of servers.
- **Legal and Liability update and maintenance costs:** For updating Service Level Agreements (SLAs) and contracts, ensuring the liability is clear in case wrong data or automation algorithm incorrectness can lead to an accident.

5.8 Citizens/City Hall / Local Government

Investment costs:

- **Database collection digitization:** Costs to convert city maps (ground risk data like hospital locations, schools, or heritage sites) into "digital twins" that the U-AGREE model can ingest.

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- **Staff Resourcing:** Dedicated "Smart City" with aviation expertise officers needed to participate in the Airspace Risk Assessment (ARA) and define local constraints.
- **Public consultation:** Organizing workshops and communication campaigns to explain the U-AGREE safety/noise/privacy mitigations to residents to gain acceptance.

Operating costs:

- **Database maintenance:** Costs to maintain sensors, servers and update database that the U-AGREE model can ingest.

5.9 Regulatory Authorities

Investment costs:

- **Training costs on new model:** Costs for training inspectors and technical staff to interpret U-AGREE's integrated risk outputs. Personnel must move beyond legal checklists to understand how the model calculates safety, privacy, and noise trade-offs.
- **Data digitization/adaptions costs for existing models:** Digitalization of existing authority tools to analyse risks, ARA, SORA processes…. To allow of the integration of U-AGREE risks models.

5.10 Insurance companies

Investment costs:

- **Costs to integrate U-AGREE's risk models into underwriting algorithm:** An investment in integrating the U-AGREE's risk models into the current algorithms that insurance companies have in place for calculating the premium and risks.
- **Verified flight/risk data Integration:** Investing in digital bridges to receive verified flight/risk data from USSPs or CISPs to automate "Pay-as-you-fly" insurance products
- **Specialist training:** Costs for training technical staff to interpret U-AGREE's integrated risk outputs.

Operating costs:

- **Digital infrastructure to run the algorithms:** Maintenance costs of digital infrastructure to run these algorithms.

5.11 Standardisation bodies

Investment costs:

- **Standards development to include U-AGREE Model:** The cost of technical experts who draft the Minimum Operational Performance Standards (MOPS) or MASPS. Consensus and approvals open consultations are included here.

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5.12 Research/R&D Companies

Investment costs:

- **Computational infrastructure investment:** Invest in the high-performance computing environments required for Fast Time Simulations (FTS) and risk-model training.
- **Data acquisition:** Costs (or legal effort) to acquire high-resolution urban "Digital Twin" data and population density metrics to feed the models.
- **Specialized talent training:** Training the staff in UAS safety and urban risk modelling.

Operating costs:

- **Database update maintenance:** Maintenance costs of digital infrastructure to run these algorithms.
- **Computational infrastructure maintenance:** Maintaining the high-performance computing environments required for Fast Time Simulations (FTS) and risk-model training.
- **Specialized talent:** Funding for PhDs, Post-Docs, Engineers and Data Scientists specializing in UAS safety and urban risk modelling.

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6 CBA model

This chapter shall be completed in the CBA deliverable that is expected for solutions aiming at a higher maturity level than TRL2.

Not applicable for U-AGREE.

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7 CBA results

This chapter shall be completed in the CBA deliverable that is expected for solutions aiming at a higher maturity level than TRL2.

Not applicable for U-AGREE.

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8 Sensitivity and risk analysis

This chapter shall be completed in the CBA deliverable that is expected for solutions aiming at a higher maturity level than TRL2.

Not applicable for U-AGREE.

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9 Recommendations and next steps

9.1 Solution summary and evaluation of ECO-EVAL results

The Economic Evaluation of U-AGREE (Solution 0520) demonstrates that transitioning from a qualitative, manual risk assessment process (such as SORA) to a highly automated, quantitative risk-modeling framework provides significant economic and operational value. While the initial deployment requires targeted Capital Expenditure (CAPEX) in data digitalization, API integration, and regulatory upskilling, the solution acts as a powerful catalyst for reducing Operating Expenditure (OPEX). By facilitating flight authorizations and Airspace Risk Assessments (ARA) with minimal to zero manual intervention, U-AGREE substantially lowers the administrative burden for U-space Service Providers (USSPs) and competent Authorities. Ultimately, the solution maximizes airspace capacity in dense urban environments and provides the robust legal and mathematical foundation necessary for the scalable integration of UAS operations.

9.2 Recommendations

- **Data Availability and Digitalization:** To fully realize the benefits of the U-AGREE risk models, key stakeholders, such as competent authorities and municipal entities must prioritize the digitalization of high-fidelity data. Information required for precise risk calculation (such as manned aviation traffic interfaces, environmental constraints and dynamic population density) must be made securely available to the U-space ecosystem.

- **Standardization of Data Ingestion:** It is highly recommended that standardization bodies (e.g., EUROCAE WG-105) establish clear protocols and data formats for the ingestion of the diverse sources mentioned above. Standardizing how USSPs and CISPs ingest ground and air risk data is critical to ensuring pan-European interoperability.

- **Industry prototyping and Software integration:** UAS and avionics manufacturers will need to initiate the design and testing of next-generation flight-planning tools. These systems must be engineered to natively ingest U-AGREE risk scores via standardized APIs, allowing UAS operators to automatically optimize mission trajectories based on the dynamic safety and environmental risk layers provided by the U-AGREE model, and being able to seamlessly integrate with USSPs and CISPs.

9.3 Next steps

- **Validation at Higher Technology Readiness Levels (TRL):** The immediate next step for the U-AGREE project is to transition the integrated risk models into higher TRL validation exercises. This will involve conducting FTS and practical validations with key operational stakeholders, including ANSPs, CAAs, UAS operators, USSPs, CISPs and local municipal representatives, to refine the models under realistic constraints.

- **Comprehensive Cost-Benefit Analysis (CBA):** As the solution matures and specific operational metrics are validated in higher TRL exercises, a full-scale Cost-Benefit Analysis must be

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developed. This CBA will transition the qualitative economic drivers identified in this report into more quantitative values.

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10 References

10.1 Applicable documents

This ECO-EVAL complies with the requirements set out in the following documents:

SESAR solution pack

[1] U-AGREE D2.6 Operational Service and Environment Description (OSED)

[2] U-AGREE D5.1 Exploratory Research Plan (ERP)

[3] U-AGREE D5.2 Exploratory Research Report (ERR)

Content development

[4] DES Common Assumptions, 00.02.01, 29 June 2023.

[5] DES SESAR solution ECO-EVAL quick start guide, 1.0, 2 February 2024.

[6] DES SESAR Maturity Criteria and sub-Criteria, 01.01, 15 February 2024.

Programme management

[7] 101167187 U-AGREE Grant Agreement.

[8] SESAR 3 JU Project Handbook – Programme Execution Framework, 11 April 2022, Ed. 1.0.

10.2 Reference documents

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[10] SESAR Joint Undertaking, European ATM Master Plan – Executive view, 2025.

[11] ICAO, “Unmanned Aircraft Systems Traffic Management (UTM) – A Common Framework with Core Principles for Global Harmonization Edition 4”, September 2023

[12] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, European Commission, 2019, C/2019/1821

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Appendix A Maturity criteria (self-assessment)

Sub-Criteria (As per TRL2)	Is the criteria covered?	Where	Justification (if not covered)
Scope of the solution and Enablers (if available)	Yes	Section 2.2, Section 3.1, Section 3.2	-
Interdependencies with other solutions	Yes	Section 3.2.1	-
Implementation/deployment options	Yes	Section 3.5	-
Identification of the impacted stakeholders	Yes	Section 3.4	-
Qualitative description of the benefits including the most impacted KPAs and KPIs	Yes	Chapter 4	-
Identification of cost drivers	Yes	Chapter 5	-

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