U-space Airspace Risk Assessment

Method and Guidelines - Volume 1

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European Organisation for the Safety of the Air Navigation (EUROCONTROL)
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EXECUTIVE SUMMARY

There may be many reasons for a state's authorities to consider designating part of their airspace as a U-space airspace, capable of safely managing the flights of many unmanned aircraft (UAS – drones), especially where manned aircraft may fly, and over urban areas. The foreseen increase in UAS operations enabled by the implementation of U-space will also increase hazards to the other airspace users, people, and property if not addressed through appropriate mitigating measures. Whatever the reason, the European Commission's Implementing Regulation (EU) 2021/664 [EU, 2021/664] states that an airspace risk assessment (ARA) is required to support the decision to designate a U-space airspace.

This risk assessment evaluates the risks related to UAS operations in the assessed airspace. It is the basis for the definition of UAS capabilities and performance requirements, U-space service performance requirements, and the operational conditions, airspace constraints and other measures necessary for mitigating the risks related to the planned U-space airspace to an acceptable level. The requirement for evaluating and so mitigating safety risks, such as the air and ground risks, is a major driver of these assessments. However, aspects related to security, privacy, and environmental issues may also require the implementation of appropriate risk mitigation measures.

An ARA is performed by, or on behalf of, an entity having the required competence, tasked by the state, and managed by a project manager. The project manager should be empowered to ensure the proper execution of the assessment. This will enable the collection of relevant data.

The project manager will be assisted by a "core team", generally be composed of people from the civil aviation administration and the local ANSP, and responsible for the execution of the assessment. The core team must include experts in safety. The core team should not be too large, or coordination becomes unwieldy. The core team should be supplemented by a support team that will include a wide range of representatives from both aviation and non-aviation (political, military, ports, etc.) stakeholders concerned by the area under assessment, who will be called upon for data collection, clarification, advice, and review.

There are three main phases to an ARA: preparation, reference scenario, and assessment.

The Preparation phase lays out the scope of the assessment to be performed, brings the core and support teams together, and gathers preliminary information, including regulation, that will form the basis for the data collection in the reference scenario phase.

The Reference Scenario phase gives the context of the change (in this case, the designation of U-space airspace), and will later be used as a basis for the assessment of safety, security, privacy, and environmental concerns. This phase aims to provide a complete description of the airspace under study at the time the assessment is performed. This includes how UAS operations are managed before the implementation of U-space airspace, the different sources of risk to be considered - air risk, risk to people, property and infrastructure on the ground, risk from interference - the different players affected by the change, and the applicable regulation. It is important that the reference scenario phase be complete, and it therefore includes interviewing many stakeholders - often members of the "support team" - to not only validate and complete information found through document study, but to obtain insight into proposed future use of the airspace under assessment.

The output of the Reference Scenario phase will be a report fully detailing the airspace and its use, the ground and population below it, and the electromagnetic environment, together with current and future UAS use. This report will be the subject of coordination with stakeholders concerned (especially authorities), to produce a ConOps, complemented by a series of design documents, that will define the changes to be addressed during the Assessment phase.

The Assessment phase analyses the safety, security, privacy, and environmental risks to aircraft, people, and infrastructure from the change to the functional environment that the designation of U-space implies. Security, privacy, and environmental risks should be evaluated before the safety risks to refine the initial potential U-space airspace design and geographical zones (e.g. where UAS operations may not be allowed or be subject to restrictions) provided by the ConOps and related design documents. The assessment of safety risk described in this document follows the Expanded Safety Reference Material (E-SRM) method developed by EUROCONTROL that extends the standard SRM to include UAS. This requires the definition of safety criteria, produces a safety specification that will satisfy these criteria, and draws up a set of safety requirement that will implement this specification. However, any other approved safety assessment method may be used in an ARA.

The Safety Assessment Report produced at the end of the assessment, along with the parallel updates to the ConOps and design documents, will be used to support the decision to designate the U-space airspace. It must be complete enough to provide evidence that the ARA has fully identified safety risks and their mitigations, and ultimately provides the required assurance that the proposed U-space airspace will be acceptably safe.

DEFINITIONS, ACRONYMS AND ABBREVIATIONS

Term	Definition
ADS-B	Automatic dependent surveillance-broadcast
AEC	Airspace encounter category
AGL	Above ground level
AIP	Aeronautical information publication
AMC/GM	Acceptable means of compliance and guidance material
ANS	Air navigation services
ANSP	Air navigation service provider
ARA	Airspace risk assessment
ARC	Air risk class
ATC	Air traffic control
ATM	Air traffic management
ATM/ANS	Air traffic management and air navigation services
ATSP	Air traffic services provider
ATZ	Aerodrome traffic zone
BRLOS	Beyond radio line of sight
BVLOS	Beyond visual line of sight
C2	Command and control link
CA	Competent authority
CAA	Civil aviation authority
CBA	Cross-border area
CIS	Common information services
CISP	Common information services provider
CNS	Communications, navigation, surveillance
COM	Communications
COMSEC	Communications security
CONOPS	Concept of operations
CSIRT	Computer security incident response team
CTR	Control zone
C-UAS	Counter UAS
DAA	Detect and avoid
DAR	Dynamic airspace reconfiguration
DPIA	Data protection impact assessment
EASA	European aviation safety agency
EGNOS	European geostationary navigation overlay service
EMI	Electromagnetic interference
EPA	Environmental Protection Agency
E-SRM	Expanded Safety Reference Material (EUROCONTROL)
EU	European union
EVLOS	Extended visual line of sight
FHA	Functional hazard assessment
GA	General aviation
GBAS	Ground-based augmentation system
GDPR	General data protection regulation
GIS	Geographic information system
GNSS	Global navigation satellite system
GRC	Ground risk class
HEMS	Helicopter emergency medical services
HPX	Hazard-related proxy
ICAO	International civil aviation organisation
IFR	Instrument flight rules

ILS	Instrument landing system
IRM	Integrated risk model
JARUS	Joint authorities on rulemaking for unmanned systems
KOM	Kick-off meeting
LOA	Letter of agreement
LTE	Long term evolution
NAVAID	Navigational aid
NDB	Non-directional beacon
NSA	National supervisory authority
NOTAM	Notice to airmen
OHA	Operational hazard assessment
OSO	Operational safety objective
PDRA	Pre-defined risk assessment
PSSA	Preliminary system safety assessment
RCS	Risk classification scheme
RLOS	Radio line-of-sight
RMZ	Radio mandatory zone
RP	Remote pilot
SAC	Safety criteria
SAR	Search and rescue
SBAS	Satellite-based augmentation system
SCS	Severity classification scheme
SID	Standard instrument departure
SJU	SESAR joint undertaking
SORA	Specific operations risk assessment (by JARUS)
SR	Safety requirement
SRM	Safety reference material
SSI	Safety specification item
STAR	Standard terminal arrival route
STS	Standard scenario
TET	Transaction expiration time
TMA	Terminal area
TMPR	Tactical mitigations performance requirements (see SORA)
TMZ	Transponder mandatory zone
TRA	Temporary reserved area
TSA	Temporary segregated airspace
UA	Unmanned aircraft
UAM	Urban air mobility
UAS	Unmanned aircraft system
UHF	Ultra-high frequency
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

1 INTRODUCTION

Unmanned aircraft systems (UAS or drones) are now a part of our daily lives. Their benefit to society is being increasingly recognised in their use for state (military, border surveillance, policing, environmental protection and detection, search and rescue (SAR), etc.), commercial (agriculture, infrastructure inspection, cargo delivery, photography and cinema, etc.) or leisure activities. In future, however, there will be many drone operations over an urban environment where a collision - between drones or with manned aircraft - or simply a loss of control can have serious consequences for people and property on the ground below. These operations can also be linked to security, privacy and/or environmental concerns that affect the ground environment (populated areas, critical infrastructure, environmentally protected areas, etc.). An assessment of the risks and their mitigation is, therefore, essential.

Many of these risks can be mitigated through the definition by the state authorities of UAS geographical zones - portions of airspace in which specific conditions are applied to UAS operations performed inside them (the prohibition or restriction of certain operations, the establishment of specific requirements, or the provision of services that ensure that UAS trajectories do not conflict with others, etc.).

Other mitigations come from a closer management of the operations through the provision of services. “U-space airspace” is the name given in Europe to a particular subtype of UAS geographical zone in which a specific set of services (“U-space services”) are provided to UAS operations. U-space services are highly automated digital services designed to support large numbers of safe, secure, and efficient UAS operations.

The European Commission’s Implementing Regulation (EU) 2021/664 [EU, 2021/664] states that an airspace risk assessment (ARA) is required to support the designation of U-space airspace by an EU member state. This risk assessment evaluates the risks related to UAS operations in the assessed airspace. It is the basis for the definition of UAS capabilities and performance requirements, U-space service performance requirements, and the operational conditions, airspace constraints and other measures necessary for mitigating the risks related to the planned U-space airspace to an acceptable level.

The methodology presented here builds upon experience in safety assurance and the assessment of change to the functional system, as followed by air traffic service providers (ANSPs), according to Commission Implementing Regulation (EU) 2017/373 [EU, 2017/373], modified to consider the specificities of U-space airspace. It has also been extended to include considerations of security, privacy, and environmental aspects, in line with the Acceptable Means of Compliance and Guidance Material (AMC/GM) to Regulation 2021/664 [EASA, 2023].

1.1 OBJECTIVE AND SCOPE

The aim of the present document is to describe a methodology for the execution of an ARA in support of the designation of U-space airspace(s) by states.

The ARA method presented here examines the risk of change to the management and use of an airspace – in this case an airspace in which it is intended to offer U-space services – and is thus completely different from an operational risk assessment that may be required of UAS operators before performing operations. For the time being it is focused on very low-level (VLL) airspace, generally that below 500ft/150m. The Methodology may require additional amendment for it to be applicable for airspace above 500ft/150m.

The methodology covers the essential processes that support the designation of new U-space airspaces. The general aspects of the methodology are described in the present document, while further guidance will be developed in separate volumes.

This document is intended to be used in conjunction with the AMC/GM to Regulation 2 21/664, providing additional guidance to aid states in performing an ARA in accordance with the applicable AMC/GM, which takes precedence over the contents of this document.

1.2 INTENDED AUDIENCE

This document is mainly intended for use by stakeholders involved in the designation of U-space airspace. These include Civil Aviation Authorities (CAAs), National Supervisory Authorities (NSA), Air Navigation Service Providers (ANSPs), etc. as well as any other entity designated to participate in the ARA process by the entity tasked by the state, including non-aviation stakeholders - municipalities, law-enforcement, etc. The content of Section 5.2 is aimed at aviation safety experts.

The information contained in this document should also provide useful reference for others involved in U-space operations - Common Information Service Provides (CISPs), U-Space Service Providers (USSPs), UAS operators, UAS manufacturers, etc. - as well as traditional airspace users that will be affected by the designation of U-space airspace (airlines, general aviation, etc.), airport operators, and ATSPs.

1.3 DOCUMENT STRUCTURE

This document is divided into the following sections:

- **Section 2** provides background information based on applicable regulation, regarding what a U-space airspace is, and why an ARA is required for the designation of U-space airspaces. It also explains the overall scope and methodology of an ARA as proposed by the present document.
- **Section 3** details the Preparatory phase of the ARA, including the definition of the scope of the assessment and the preparation of the required resources.
- **Section 4** describes the Reference Scenario phase, in which data collection and verification lead to the definition of the reference scenario.
- **Section 5** explains the Assessment phase, in which hazards are identified, and the risks related to these hazards are analysed.
- **Section 6** describes the final report collecting the outputs from the assessment.
- **Section 7** gives an overview of further activities outside the scope of an ARA, that are necessary for the designation of a U-space airspace.
- **Section 8** gives a brief conclusion on the ARA methodology.
- **Section 9** lists the references used in the present document.

Finally, the appendices provide standard forms and checklists designed to assist stakeholders in ensuring that all elements of an assessment have been fully included, and an example of the execution of the Reference Scenario phase.

2 U-SPACE AIRSPACE RISK ASSESSMENT

The ARA methodology described in the present document assesses the risks of an airspace in which a U-space airspace is proposed and defines requirements for the mitigation of such risks prior to the designation and implementation of this U-space airspace. These risks are mostly concerned with the safety of other airspace users, and people and property on the ground; however, security, environment, and privacy risks are also considered. To clarify the context of an ARA, this section begins with an introduction to U-space airspace from a technical and regulatory point of view.

2.1 THE U-SPACE AIRSPACE

A U-space airspace is a particular type of UAS geographical zone, defined by [EU, 2021/664] as “a UAS geographical zone designated by [EU] member states, where UAS operations are only allowed to take place with the support of U-space services”.

A UAS geographical zone is, in turn, formally defined by Commission Implementing Regulation (EU) 2019/947 [EU, 2019/947] as “a portion of airspace established by the competent authority that facilitates, restricts or excludes UAS operations in order to address risks pertaining to safety, privacy, protection of personal data, security or the environment, arising from UAS operations”. Article 15 of [EU, 2019/947] lays down the capabilities and obligations of EU member states related to the use of UAS geographical zones. These include:

- The reasons why UAS geographical zones are defined: safety, security, privacy, and/or environmental concerns.
- The possible restrictions that can be issued: such as prohibition, request of particular operational conditions, compliance with environmental standards or technical features, etc.
- The possible exemptions that can be issued, related to ‘open’ category limitations.
- The obligations of states to make information on the UAS geographical zones publicly available.

The implementation of U-space airspaces aims to enable large numbers of safe UAS operations, and to allow complex drone operations, such as BVLOS operations. The mitigations, strategic or tactical, offered by U-space airspace (i.e. provision of U-space services, dynamic airspace reconfiguration (DAR)) are meant to ensure a safety continuum of manned aircraft operations in the vicinity, in limiting the risk of UAS encounters with manned aircraft (e.g. in ensuring separation).

It is important to note that U-space airspace builds on the definition of geographical zones for UAS given by [EU, 2019/947], which remains applicable in U-space airspace. Therefore, any operation in U-space airspace is subject to the requirements applicable to the relevant operational category (Open, Specific, Certified), in addition to any UAS capability or performance requirements established for that U-space airspace.

During the process of obtaining an operational authorisation (SORA), UAS operators can apply for and obtain credit for the mitigations provided by U-space, whether they are strategic or tactical. UAS operators may first benefit from strategic mitigation to reduce an operation’s air risk class (ARC) and may also be able to justify meeting Tactical Mitigation Performance Requirements (TMPR) through using U-space services (e.g. traffic information), instead of requiring large investments in Detect and Avoid (DAA) equipment.

U-space airspaces are not expected to be homogenous blocks, but instead to contain internal arrangements related to different applicable local requirements and/or the definition of airspace structures, such as a grid distribution, corridors, or layers.

U-space services are in turn defined as “services 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”. A noticeable difference between U-space services and Air Traffic Services is that there is no designation of an entity for the provision of U-space services in a U-space airspace. This means that any certified USSP that wishes to operate in a given U-space airspace may provide U-space services, given that the certified capabilities and performances of the USSP are appropriate to ensuring the safe provision of services in that U-space airspace.

According to [EU, 2021/664], four mandatory services must be provided to UAS in any U-space airspace:

1) The network identification service, which allows the continuous processing of the remote identification of UAS and the provision of this information to relevant stakeholders.
2) The geo-awareness service, which provides the UAS operator with information relative to applicable operational conditions and airspace constraints, UAS geographical zones, and temporary restrictions that are applicable to the U-space airspace.
3) The UAS flight authorisation service, which guarantees that planned individual UAS flights are strategically de-conflicted and comply with applicable airspace restrictions and temporary airspace limitations.
4) The traffic information service, which provides UAS operators with information on any other conspicuous air traffic that may be near the position or intended route of the UAS flight.

In addition, based on the outputs of the ARA performed before the designation of the U-space airspace, states may require one or both of the following optional U-space services:

5) The weather information service, that provides USSPs and UAS operators with reliable up-to-date weather information and forecasts.
6) The conformance monitoring service, which alerts UAS operators if they, or another nearby UAS operations, deviate from the assigned flight authorisation thresholds.

In addition to the U-space services mentioned above, common information services (CIS) must be provided in any U-space airspace. The aim of these services is to make all common information of interest related to the U-space airspace, such as its geographical limits, the applicable operational requirements, or the list of certified U-space service providers offering U-space services in the airspace, available to the relevant stakeholders.

When U-space airspace is defined within controlled airspace, DAR must be applied by the ATC when necessary to ensure that manned aircraft that are provided with an air traffic control service remain segregated from UAS. DAR is defined in Commission Implementing Regulation (EU) 2021/665 [EU, 2021/665] as “the temporary modification of the U-space airspace in order to accommodate short-term changes in manned traffic demand, by adjusting the geographical limits of that U-space airspace”. This concept is further described in [EU, 2021/665].

When U-space airspace is defined in uncontrolled airspace, manned aircraft can enter U-space airspace without DAR since they are not subject to provision of ATC service. In these cases, manned aircraft must continuously make themselves electronically conspicuous to the U-space service providers, so that UAS operators are aware of their presence near UAS operations and can therefore perform any actions necessary to prevent collision with their UAS. The electronic conspicuity requirement is further described in Commission Implementing Regulation (EU) 2021/666 [EU, 2021/666] and now included in the consolidated Commission Implementing Regulation (EU) 2017/923 [EU, 2017/923].

It is important to note that it is not intended to provide manned aircraft with U-space services when operating within a U-space airspace.

UAS flying under IFR are subject to the same rules as manned IFR aircraft, and treated in the same manner as regards DAR, electronic conspicuousness, and service provision.

In terms of airspace classification, a U-space airspace is regarded as a restricted area, in which specific access conditions apply, both for manned and unmanned aircraft.

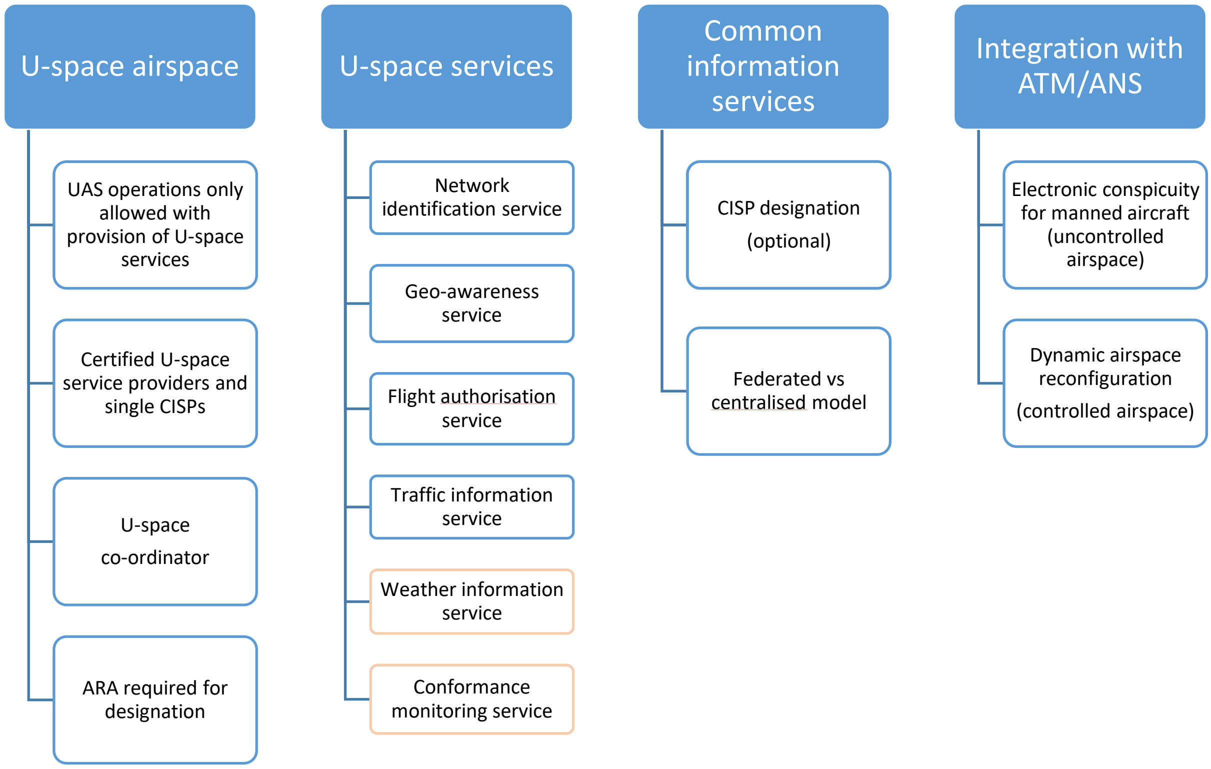

Figure 1 - The main elements of U-space airspace

2.2 SOURCES OF RISK IN U-SPACE OPERATIONS

As described in section 2.1, the main reasons driving the need to define any UAS geographical zone are safety, security, privacy, and environmental concerns. As U-space airspaces are a particular type of UAS geographical zones, these reasons are also applicable to U-space airspaces and hence, subject to analysis during the ARA, the different risks related to these concerns must be identified and, when necessary, properly mitigated.

This subsection briefly describes the main threats and risk factors applicable to U-space airspaces (e.g. considering VLL airspace or operations in urban environments), to aid successful information gathering during the initial steps of the ARA.

Among these concerns, safety risks are considered the major driver of the ARA. These safety-related issues are further detailed in Subsection 2.2.1. Nonetheless, aspects related to security, privacy, and environmental issues may also require the implementation of appropriate risk mitigation measures.

2.2.1 SAFETY RISKS

The aviation industry prioritizes safety above all else, and hazard and risk concepts play a crucial role in ensuring safe operations. The definitions of hazard and risk have been established by the European Commission's Implementing Regulation (EU) 2017/373 [EU, 2017/373], which aims to establish a common set of safety standards for all airspace users and service providers. Common terminology has been adopted to maintain homogeneity across the industry, and the air traffic management/air navigation services (ATM/ANS). These definitions are maintained in the scope of ARA to ensure consistency across the industry.

Within the scope of aviation safety, a hazard is defined by [EU, 2017/373] as ‘any condition, event, or circumstance which could induce a harmful effect’, while risk is defined as ‘the combination of the overall probability or frequency of occurrence of a harmful effect induced by a hazard and the severity of that effect’.

The harmful effects to be considered during an ARA should be tailored to the specificities of the assessed airspace. For example, during the initial implementation of U-space, the U-space airspaces are expected to be defined close to the ground, and UAS are not expected to carry people-on board. During ARA, the two following categories of harmful effects should be considered:

- **Harmful effects caused to people on-board an aircraft in flight.** Risks associated with this harmful effect are commonly referred to as “air risks” and are mainly related to mid-air-collisions involving UAS and manned aircraft. In most cases this will be applicable to manned aircraft, but ultimately may also encompass UAS operations performed in the Certified category that carry people. Nonetheless, at the initial stage of the implementation, U-space is not foreseen to support passenger operations.
- **Harmful effects caused to people on the ground.** Risks associated with this harmful effect are commonly referred to as “ground risks”. These risks could happen either as a collateral effect of a mid-air collision or a ground impact caused by other reasons.

While an ARA is mainly focused on the air risks and ground risks due to mid-air collisions, there are many other hazards that the assessment will bring to light – infrastructure, densely populated areas, etc. – that will provide data to enable the analysis of other relevant risks (e.g. loss of control, as defined by SORA) to be properly addressed later by UAS operators, such as during the SORA undertaken to obtain operational authorisations to perform operations in Specific category.

Air risk is mainly influenced by the following risk factors (non-exhaustive list):

- **Density of air traffic**. Areas with a high density of air traffic are of special concern. Some examples of these are: areas in the vicinity of airports and aerodromes, and along recognised flight paths into and out of them; areas near hospitals with HEMS traffic; areas with seasonal or permanent recreational activities (paragliders, base jump, flying suits, kite surf, etc.).

- **Type of aircraft.** All kinds of manned aircraft from large airliners, through helicopters and general aviation, to balloons and even paragliders might be encountered during UAS operations. The probability and consequences of a mid-air collision will depend upon the type of aircraft encountered, the aircraft size, the number of crew and passengers onboard, the performance of the aircraft, etc.

Ground risk is mainly influenced by the following risk factors (non-exhaustive list):

- **Population density.** Population-related risks are obviously greater over permanently populated residential areas, but due to the expected movement of people during the working days, these may become less populated, while other areas such as business districts or city centre shopping zones, more composed of shops, offices, etc. may become more densely populated. This cyclic nature must be considered. UAS flights are typically concentrated in specific areas, often with a primary focus on providing services to the local population. Sensitive areas such as schools and hospitals need special attention. Finally, areas where recreational, occasional, or seasonal events bring a large number of people together (e.g. festivals, concerts, stadiums, beaches) are also related to higher ground risks.
- **Sheltering and obstacles.** Not all the people near UAS operations are directly exposed to risk. Shelter and obstacles can prevent, to a certain degree, a person being impacted by a falling aircraft or projected debris. The presence of sheltering and obstacles varies depending on the local scenario (e.g.: a high shelter/obstacle factor in a heavily built-up area versus low shelter/obstacle factor in beach).
- **Type of aircraft.** In case of an accident, the sizes and expected kinetic energy of the aircraft will affect both severity and probability of the harmful effects on people on the ground.

It is important to note that ground risk and air risk are coupled to a certain extent in U-space airspaces, especially in densely populated areas, since areas with a higher frequency of mid-air collisions will also pose a higher ground risk, as aircraft will generally fall to the ground after a mid-air collision.
In addition, serious damage to critical infrastructure due to UAS operations should also be considered**.** Critical infrastructure includes, but is not limited to, aeronautical infrastructures, bridges, railways, hospitals, power stations and substations, cell-phone towers, government buildings, etc. Even though damage to critical infrastructure may not be directly related to injuries or death to humans, it can be a cause of numerous effects that could result in undesired harmful effects. Damage to critical aviation infrastructure, for example, may cause disruption to the provision of safety-critical services to manned aircraft operating in the vicinity.

Major transport-related infrastructure to be considered include airports and aerodromes (including all equipment required for their proper functioning), harbours, roads and motorways, and railway stations and lines. Any office-block or factory could suffer major consequences as a result of a drone accident, but increased attention should be paid to chemical and nuclear sites, power stations, and laboratories, where the consequences could be much greater.

In the case of VLL airspaces, the threat that ground infrastructure poses to drones themselves should not be forgotten when assessing safety risks. Cranes, windfarms, and electro-magnetic wave emitting sites such as radars, high-voltage lines, or solar farms could cause dangerous situations, as could areas used by model-flying clubs. Other threats could come from geysers or artificial water jets in parks or hotel grounds, etc. Finally, areas where a GNSS outage could occur are also a concern.

2.2.2 SECURITY RISKS

The main difference between safety and security risks is intention. Security-related threats are linked to a willingness to cause harm, as opposed to safety threats, in which damage caused is unintentional.

Security-related risks are linked to (non-exhaustive list):

- Critical infrastructure (power stations, chemical plants, government buildings, hospitals, etc.) and military installations, as well as any other facilities (such as schools) that could be targeted by unlawful attacks.
- Places where VIPs, individually or collectively may gather, such as the conference centres where summits may take place, the hotels that VIPs may stay in, and the routes taken between the two, are of security concern.

The ever-growing risks of cyber-attack are a major factor in this category. U-space is a highly automated and interconnected system, so special care must be taken to reduce its exposure while ensuring its resilience with regard to cyber threats, and so minimise the level of cyber-security risk.

2.2.3 PRIVACY RISKS

The visualisation (whether intentional or accidental), capture and/or retention of personal or industrial information by drones that may fly over or near certain areas (e.g. people, property, industrial sites) can have implications for the privacy of citizens and the confidentiality of data.

In Europe, the General Data Protection Regulations (GDPR) are the guiding principle, and privacy risk assessments should be carried out depending on the privacy risk assessment process adopted. Sensitive sites should be appropriately considered in an airspace assessment.

2.2.4 ENVIRONMENTAL RISKS

While the environmental risks related to U-space operations are similar to those of traditional aviation, where climate change, noise, and pollutants are major problems, the exposure of people of people and wildlife to nuisance may significantly increase. The main environmental hazards related to UAS operations are noise and visual pollution, as well as leakage of dangerous substances.

Noise and visual pollution are physical threats that directly affect the people (or fauna) in the area where operations take place. Hence, the ambient noise level and the presence of sensitive fauna are the main related risk factors, along with the characteristics of air traffic (the noise produced by each individual aircraft, aircraft sizes, traffic density, etc.).

The leakage of dangerous substances is a major source of environmental risk. It is important to consider both goods carried by aircraft for their operations (e.g., delivery of blood samples, a biological risk) and the equipment required by the aircraft to operate (e.g., lithium-based batteries, a chemical risk). The consequences of a drone accident contaminating a populated area or other sites such as water bodies, especially those containing water that could be used for human or animal consumption, are major environmental concern related to U-space operations. Furthermore, certain critical infrastructure (e.g. power stations, chemical plants) mentioned for their safety and security risk, could also pose environmental risks if they are damaged by UAS.

The negative impact on air quality from UAS that generate gaseous emissions (e.g., through using combustion engines), can be a concern, especially in densely populated areas, where local pollution levels may already be high.

2.3 THE REQUIREMENT FOR A U-SPACE AIRSPACE RISK ASSESSMENT METHOD

The arrival of new airspace users, and new types of operation, brings new risks. UAS can pose a safety and security threat because the absence of a pilot on board changes the concept of flying, the perception of and exposure to the risk. As well as the ATM perspective. The integration of UAS into the airspace must ensure that safety, security, privacy, and environmental protection are guaranteed to the utmost. A fundamental, and well known, process for accomplishing this in aviation, and any other activity where hazards must be minimised, is risk assessment, and the implementation of mitigation measures identified by such an assessment.

A risk assessment is a thorough look at the complete system to identify those elements, situations, processes, etc. that may cause, or allow, harm, particularly to people. It first involves identifying hazards and risk factors that may cause harm (hazard identification). Once the hazards have been identified, the likelihood and severity of the associated risk are analysed and evaluated (risk analysis, and risk evaluation). It is then possible to determine which measures should be taken to effectively mitigate risks to an acceptable level (risk mitigation).

An ARA to support the decision to designate a U-space airspace takes a reference scenario as a baseline against which functional changes such as the introduction of U-space services, possible airspace re-design, CNS requirements, geo-fencing requirements, and the assignment of different airspace classifications, will be applied in later processes. The planning methodology used in this process needs to be constructed through a clear set of objectives and a realistic view of airspace operations.

Airspace assessments are common for the airspace used by manned aviation and controlled by air traffic controllers, and the method of performing these is proven. However, this is not the case for the new environment enabled by U-space, where unmanned aircraft with a wide variety of sizes, shapes, and performance characteristics will use the same airspace as manned aircraft.

In addition, new types of hazard and risk are to be considered, since the UAS may be flown at low levels, close to sensitive infrastructure or over populated areas, by remote pilots who have not undergone the same training as those of manned aircraft. These UAS will also mostly be reliant on a new set of U-space services for their authorisation, separation, and surveillance. These new operational environments and the proximity of UAS flights to the ground mean that an ARA needs to be conducted in collaboration with non-aviation entities.

Therefore, an ARA to support the designation of U-space airspace in VLL airspace, where most UAS operations are expected to take place, requires a different approach and method from a traditional airspace.

2.4 THE U-SPACE AIRSPACE RISK ASSESSMENT METHOD

The method consists of three main phases that are performed in sequence:

1) During the Preparation phase, the scope of the assessment is defined (i.e.: the airspace volume under assessment), the assessment team is created, and the resources required for

the assessment are gathered and prepared. The primary output of this phase is the Scoping Document, which aims to provide a complete description of the ARA project to be executed. This phase is further explained in Section 3.

2) The Reference Scenario phase follows the Preparation phase. This phase is focused on creating a thorough understanding of the context of the assessment, including both the ground and air aspects. The core steps of the Reference Scenario Phase are data collection, interviews, data verification, and the establishment of the reference scenario. The primary output of this phase is the Reference Scenario document, which aims to provide a complete insight regarding the airspace volume under assessment, before any changes are introduced. This phase is further explained in Section 4.

3) During the Assessment phase, safety, security, privacy, and environmental risks are assessed to derive the main outputs of the ARA: UAS capabilities and performance requirements, U-space service performance requirements, and airspace limitations and operational constraints. The airspace is assessed on the basis of the concept of operations (ConOps) and the Reference Scenario. In these assessments, the different hazards are identified, along with the risks associated with these hazards. Appropriate mitigation measures are then identified with the goal that the designated U-space airspace will be acceptably safe, and any security, privacy, and environmental concerns will have been properly addressed. The assessment of safety risks, which is expected to be the main reason for deciding to implement U-space airspaces, is based on safety assessment and assurance of changes to the functional system, as described in [EU, 2017/373]. The change associated with the ARA is, in this case, the designation of a new U-space airspace. The Assessment phase is further explained in Section 5.

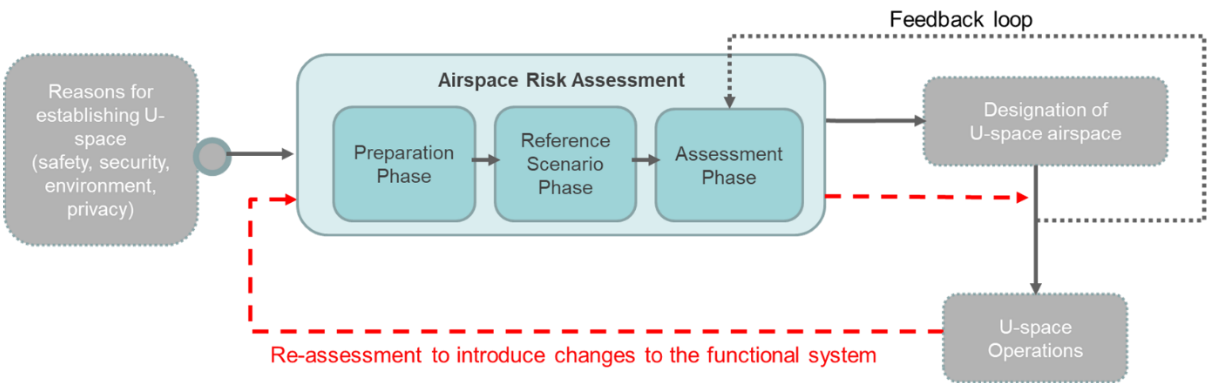

Figure 2: The phases of a U-space Airspace Risk Assessment

Two inputs are necessary before starting the Assessment Phase. The first is the context, which describes the environment before changes are introduced and is provided by the Reference Scenario included in the ARA methodology. The second is the ConOps, supplemented by a series of design documents, that describe the change to be introduced. In the case of an ARA conducted to support the designation of a U-space airspace, the ConOps should describe how operations will be conducted in that U-space airspace. The development of a ConOps requires the involvement and necessitates decision-making of the relevant authorities (e.g. at a national level); as such, it is outside the scope of the ARA. Therefore, the ConOps should preferably be provided as an input to the ARA project and updated in parallel to ARA.

The ConOps should consider the outputs from the Reference Scenario phase, to ensure that the data collected (e.g.: description of additional use-cases based on stakeholders' interests) are considered.

The ConOps and related design documents should be updated during the Assessment phase, according to the findings of the conducted assessments. 0 Appendix 5 provides additional guidance regarding the content of the ConOps and related design documents.

Finally, it is important to emphasise that the methodology discussed in this document does not cover all the steps towards the successful implementation of a functional U-space airspace. The interactions between the ARA and other activities necessary to start UAS operations in U-space airspace are described in Section 7. This methodology is tailored to cover the initial steps of the process, leading to the designation of U-space airspace, and the definition of safety, security, privacy, and environmental requirements related to it. Before implementation, the airspace will need to be designed to take these requirements into account and fully validated through simulation, or other means.

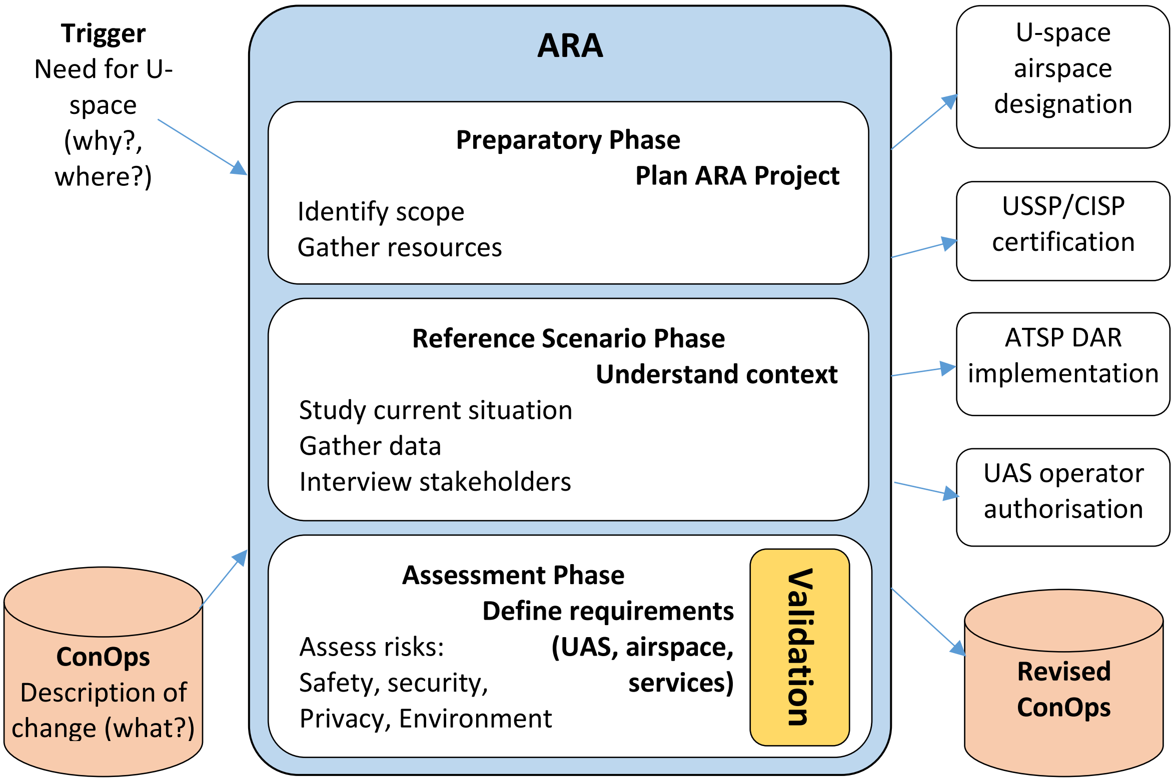

Figure 3 - Inputs to and results from ARA

3 PREPARATION PHASE

An ARA is performed by, or on behalf of, an entity tasked by the state.

3.1 CREATING AN ASSESSMENT TEAM

The first step in the execution of an ARA is the identification of the people in charge of such task, i.e., the assessment team.

The assessment team is comprised of:

i. the Core Team that will carry out the main tasks of the assessment, and
ii. the Support Team that will play an auxiliary role through supplying/collecting data and undergoing interviews.

Splitting stakeholders into these two separate teams facilitates the management of the project and delegation of work. Another list of other involved stakeholders who could have minor participation may be drawn up if necessary.

The composition of the assessment team should be reviewed as the scope of the assessment is defined in more detail (see section 3.3.3).

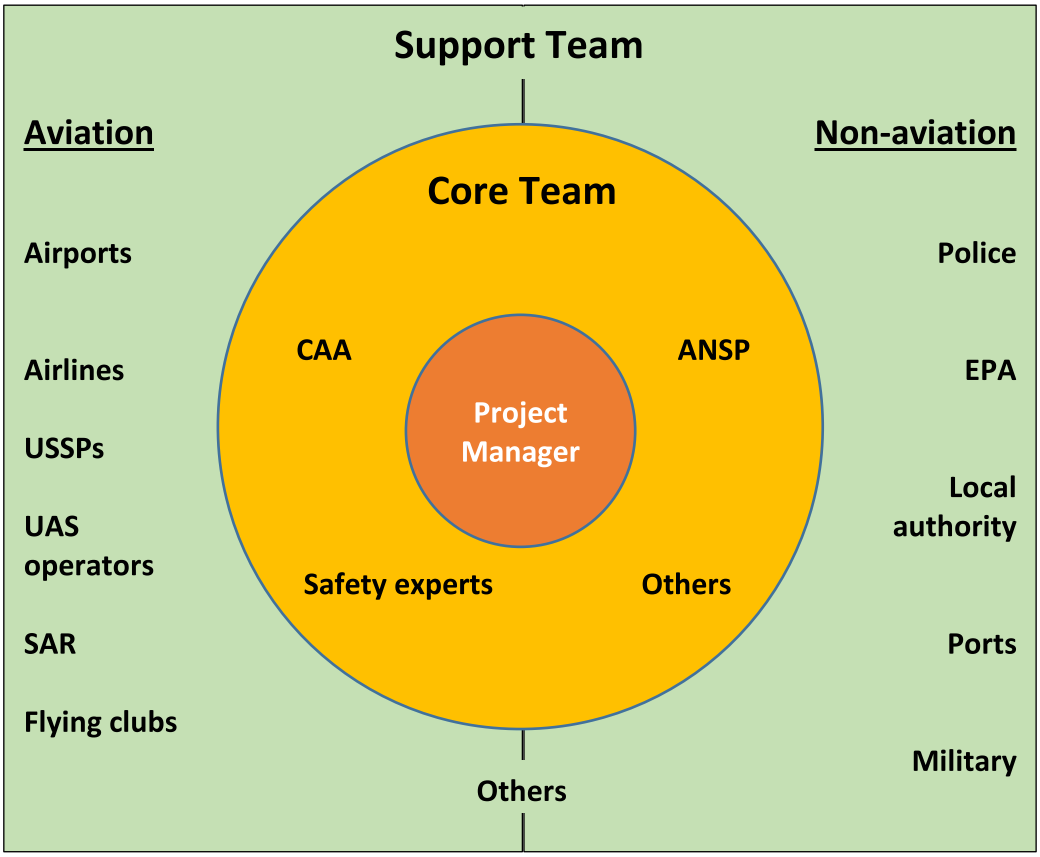

Figure 4 - Managing an ARA

3.1.1 THE PROJECT MANAGER

The project manager is responsible for the correct and timely execution of the ARA. The project manager should be a member of, or work under the supervision of, the tasking entity and should be empowered to ensure the proper execution of the assessment. This will enable the collection of relevant data.

The ARA has its own coordination process, with input obtained from a diverse set of stakeholders and its main goal being the collection of data for the Reference Scenario, including the operational use cases to be assessed. This process should not be mistaken for the wider coordination mechanism laid down in Article 18(f) of Regulation (EU) 2021/664, which can be established in parallel to an ARA process. Throughout the life cycle (planning, execution, review etc.) of the coordination mechanism, the ARA project manager should liaise with the U-space coordinator to ensure that all necessary stakeholders (e.g. institutions, organisations) have the necessary level of awareness, in particular, at a later stage in the process that will include the public affected by the introduction of the U-space airspace to ensure social acceptance. The decision to designate U-space based on the results of an ARA must be completed by a hearing process, which would nevertheless be a different type of process in each state, and thus outside the scope of an ARA.

The project manager decides which stakeholders to invite to join the project and which teams they will be integrated into. Which organisations and institutions need to be involved in each team will be refined along the assessment and when the scope gains in maturity and clarity.

The project manager leads the core team.

3.1.2 THE CORE TEAM

Creating a strong core team is important for the successful execution of an assessment. The Core Team will generally be composed of people from the civil aviation administration and the local ANSP and will be responsible for the execution of the assessment. The core team must include experts in safety. The core team should not be too large, to not impair the efficiency of internal coordination.

3.1.3 THE SUPPORT TEAM

The core team should be supplemented by a support team that will include representatives from stakeholders (both aviation and non-aviation) with a concern in the area under assessment. The support team can be called upon collectively, but most likely individually for data collection, clarification, advice, and review.

The support team will include aviation stakeholders such as airports, UAS operators, and general aviation representatives. However, it is important to involve non-aviation entities which can also provide insight into ground/air risks and, if possible, in the other areas of risk to be addressed (security, privacy, the environment), as well as aspects related to industry, transport, etc. This could include organisations responsible for critical infrastructure, state defence, the military, state security, customs, local governance, hospitals, the maritime sector, ports, electro-magnetic wave-emitting sites, telecommunications, forestry, flight schools etc. When involving a new sector - railway, maritime, military, etc. – it is important to work at the level where decisions can be made, and data quality ensured. The aviation sector and ground-related sectors are not necessarily interoperable at present and good communication is essential.

3.2 DRAFTING THE RISK ASSESSMENT ACTION PLAN

Preparation for an ARA begins with planning. This planning should include the time required to set up working arrangements; to identify relevant policy and regulatory material, the risks to be assessed and other relevant aspects; to assess environmental constraints; as well as the time needed for performing a regulatory assessment, if necessary; producing the reference scenario and the risk assessment; and writing the assessment report. This plan should be kept to as much as possible during the assessment, though modifications may be found to be necessary at a later stage.

The timing of these activities will depend on the resources available, the size of the airspace volume, and its complexity. A1.5 is a detailed action plan template containing all the major steps of the ARA. Additional checklists and planning models for the preparation phase can be found in Appendix 1.

3.3 PRODUCING THE SCOPING DOCUMENT

Once initial planning is complete, a scoping document describing the parameters of the assessment should be produced by the project manager. The scoping document should provide a reference for the assessment teams and outside interested parties such as decision makers or stakeholders involved.

Table 1 provides a summary of the content of the scoping document.

Table 1. Scoping document content

Scoping Document Content	
1	A general introduction, including the reasons for performing an assessment, and the general scope of the assessment
2	How the assessment will be managed and undertaken: members of the core team, members of the support team, and other stakeholders involved
3	What will be assessed: the airspace volume under assessment, major elements that could present ground risks or air risks, etc.
4	A summary of the applicable regulatory framework, not only for drones and aviation, but including environmental, privacy, security regulations
5	Assumptions and constraints, including any aspects that could play a role in determining the safety of the airspace under assessment

These sections are further described below. A suggested template for a scoping document that contains all the information in the table above is provided in A1.5.

3.3.1 SCOPING DOCUMENT INTRODUCTION

The introduction should provide the following information:

- Objectives of the document, including a brief description of the location and characteristics of the airspace under assessment;
- Entities driving the ARA, including who the Competent Authority is;
- Description of the intended audience;

- The needs/motivations driving the implementation of one or more U-spaces and thus the need for an ARA;
- A description of the assessment method copied from section 2.4 of the present document.

3.3.2 MANAGEMENT OF THE ASSESSMENT

This section describes how the assessment will be undertaken and managed. It includes details of the members of the core team and support team, as described in section 3.1, and other stakeholders involved. These teams may need to be updated as the scope of the project becomes better defined.

3.3.3 SCOPE OF THE ASSESSMENT

The first step in the definition of the scope is to identify the geographic limits of the airspace under assessment, preferably relative to the WGS84 ellipsoid for the horizontal boundary, and both relative to barometric AMSL and WGS84 ellipsoid for the vertical limits. The airspace under assessment should be a single, continuous volume that encompasses the airspace volume(s) expected to be designated as U-space airspace(s), together with a buffer of adjacent airspace. Both horizontal and vertical bounds should be identified at this stage. The lower limit of the vertical dimension is expected to be surface level in most situations, while the upper limit should be established with a reasonable margin considering the expected height limit of the planned U-space airspace. It is recommended that any nearby aviation infrastructure (e.g., airports, aerodromes) be included as part of the adjacent airspace, unless these are already located within the expected U-space airspace.

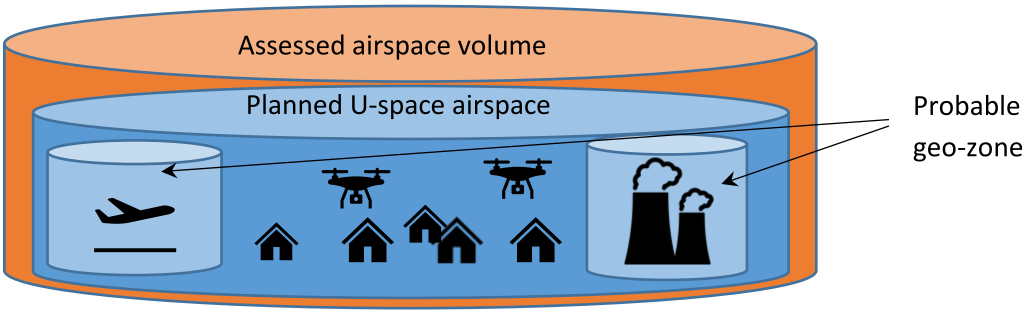

Figure 5 - The assessed airspace volume

It is important to note that one of the aims of the ARA is the identification of which portions of the airspace assessed should be designated as U-space airspace, either as a single block or as a combination of sectors/structures. Therefore, the final proposal for U-space airspace designation might differ from the volume initially considered. It is recommended that a dedicated project be created in a computer-based geographic information system (GIS), in which all geographic information of interest can be stored. This will allow data to be arranged in layers so that selections can be visualised when necessary. The geographic bounds of the airspace under assessment should be the base layer of the GIS project.

At this stage of the assessment, an initial inventory of infrastructure and operational aspects of the current airspace that need to be taken into account should be produced. This inventory will be the reference for future work and should therefore contain all the critical elements, to ensure that no important aspect remains unassessed. The inventory should contain references to the major sources of the different kinds of risk to be assessed, as explained in section 2.2 above.

The following is a non-exhaustive list of elements to be considered as part of the inventory:

- Aerodromes and heliports
- Airspace classification and delineation, horizontally and vertically
- Populated areas
- Critical infrastructure (power stations, bridges/dams, harbours, NAVAIDs, etc.)
- Environmentally protected areas

It is recommended that this inventory, describing the location and/or boundaries of its elements, be included as a dedicated layer in the GIS project.

3.3.4 SUMMARY OF APPLICABLE REGULATORY FRAMEWORK

It is important to identify regulations, both national and European, in force or in development, that are related to the scope of the assessment.

The following is a non-exhaustive list of the different fields that should be covered:

I. Aviation, including manned and unmanned aircraft. Special focus on safety policy, and safety assessment requirements and guidelines.
II. State security legislation, including the security of sensitive sites and cyber-security.
III. Environmental policy and guidelines.
IV. Privacy and data protection.
V. Any other applicable regulation.

At this stage of the assessment, simply identifying the list of applicable regulation will suffice. A full regulatory gap analysis may be performed later in the Reference Scenario phase and again after the full ARA.

3.3.5 ASSUMPTIONS, CONSTRAINTS AND OTHER ASPECTS

This section should contain the assumptions, constraints, and any other aspects that could play a role in the execution of the ARA that might not have been covered in previous sections of the Scoping Document. For example, it might be assumed that the regular cultural or sporting events will continue to be held on the same basis.

3.4 KICK-OFF MEETING

Once the teams have been constituted, a kick-off meeting (KoM), which should involve as many members as possible of both the core and support teams, is essential for ensuring that all the players understand the reasons for the airspace assessment, how it will be undertaken and what their roles in it are. This KoM should preferably include the following points:

1. Achievements and expectations - from the project leader;
2. A presentation on the airspace assessment methodology
    - Objective & Scope; Project Team; Project Plan;
3. The main concerns/challenges in an urban environment - from the urban authority;
4. A roundtable where participants have a chance to express their vision and expected role, and ask any questions they may have;
5. Agreement on the way forward: timeline, list of deliverables with expected completion date.

4 REFERENCE SCENARIO PHASE

The Reference Scenario phase aims to provide a complete description of the relevant airspace when the assessment is performed. This includes how UAS operations are managed in the absence of U-space airspace, the different sources of risk to be considered, the different stakeholders affected by the change, and the applicable regulation. In summary, the Reference Scenario represents the context of the change, which will later be used to support the assessment of safety, security, privacy, and environmental concerns.

For this purpose, this phase is divided into four steps, executed in the following order:

1. Overview of applicable regulation: a thorough analysis of national and EU regulations that affect, or could be affected by UAS operations;
2. Data collection: gathering all relevant information;
3. Cross-checking: to validate previously collected data;
4. Producing the reference scenario: consolidate the validated data to create the scenario.

The data collection and cross-checking steps may include interviews with relevant stakeholders.

The reference scenario will be the basis of the risk analysis described in section 5.

4.1 OVERVIEW OF APPLICABLE REGULATION

It is essential to have a complete knowledge of the applicable regulatory framework when performing an ARA. This should therefore be the first information collected. The summary of applicable regulation collected for the Scoping Document should be used as a basis for this.

The overview of applicable regulation should provide the following information:

- A list of the applicable regulation, both at EU and national levels;
- A summary of the primary impacts these regulations have on UAS operations;
- (Optional) An assessment of the possible gaps in compliance between applicable regulation and integration of drones into a volume of airspace.

Requirements directly applicable to UAS operations by means of dedicated regulations, both at European and National levels, should be studied.

At the European level, there are two main sets of UAS regulation:

- General UAS regulation
  - Commission Implementing Regulation (EU) 2019/947 on the rules and procedures for operating unmanned aircraft that sets up a risk-based and operation-centred approach [EU, 2019/947];
  - Commission Delegated Regulation (EU) 2019/945 on UAS and third-country operators of UAS that, as well as defining performance requirements for certain types of drone, regulates their operation by operators based in third (i.e., non-EU) countries [EU, 2019/945];

  together with all related regulations that amend them, and their applicable AMC/ GM.

- The U-space regulatory framework:

- Commission Implementing Regulation (EU) 2021/664, defining the U-space airspace and the applicable services and general requirements related to the U-space, including the obligation to perform an ARA to support the designation of U-space airspace [EU, 2021/664].
- Commission Implementing Regulation (EU) 2021/665 amending Regulation (EU) 2017/373, with the requirement to apply dynamic airspace reconfiguration when controlled manned aircraft are required to enter U-space airspace [EU, 2021/665].
- Commission Implementing Regulation (EU) 2021/666 amending Regulation (EU) 923/2012, with the electronic conspicuity requirement for uncontrolled manned aircraft operating within U-space airspace [EU,2021/666].

In addition, each state may have developed its own UAS-related regulations that precede or complement the applicable European framework for various purposes, such as (non-exhaustive list):

- To establish limitations on operations performed in specific environments (e.g., urban areas, controlled airspace), including the need for coordinating operations with affected entities (e.g., ANSPs).
- To require additional technical equipment or capabilities for certain operations (e.g., BVLOS).
- To regulate state operations (police, search and rescue, border patrol, customs, etc.), that lie out of the scope of the European framework.

It is important to consider other applicable aviation regulations that, even if they do not specifically target UAS operations, might contain provisions directly applicable to UAS operations or, at the very minimum, establish requirements on other airspace users, or because of the impact of UAS operations on entities acting under such regulations. For example, local ATSPs under the scope of [EU, 2017/373] will be affected by the designation of U-space airspace within the controlled airspace they manage.

Other non-aviation regulations, such as data protection regulation or environmental regulation might also affect U-space operations and should therefore be identified.

4.1.1 OPTIONAL REGULATORY GAP ANALYSIS

An optional regulatory gap analysis might be performed after the regulatory overview. The goal of the gap analysis is to detect areas where there may be gaps in compliance between different regulatory requirements and national rules in relation to the integration of drones into a volume of airspace.

4.2 DATA COLLECTION

The core activity of the Reference Scenario phase is collecting the data necessary to feed the assessment phase. A good data collection process is essential for a complete airspace assessment. To ensure data quality and validity, it is crucial that data be collected from reliable sources. Entities working within the Single European Sky framework generally have the means and culture required for the provision of high-quality information, but this might not be applicable to entities outside the aviation sector. The establishment of effective common data formats and data quality requirements may be necessary for ensuring interoperability between the aviation sector and ground-related sectors.

The ARA will generally use static data for its analysis. Dynamic data can also be used, however; for example, mobile phone operators can provide dynamic population density indications based on the number of mobile phones in a certain area. There is an important trade-off between static data and dynamic data: while dynamic data may seem to better represent the current situation, in many cases it is difficult or too expensive to obtain, and hardly processable (e.g. requires important resources). Dynamic data may also result in an incorrect picture of the true situation if the sample is not acquired over a representative and long enough period. The relation between the cost of acquiring data and the benefits those data bring to the airspace assessment should be considered, to guarantee a proper allocation of resources.

It is important to define the format of the different kinds of data to be collected, and the level of detail that will be required. All geographic information should preferably be collected in the GIS project associated with the ARA, arranged in layers according to the nature of this information. A non-exhaustive checklist of information that should be obtained and verified is given in [EASA, 2022] and included for reference in Appendix 2 of the present document.

The following subsections describe the recommended data related to a variety of fields that should be collected to ensure a complete assessment.

4.2.1 AERONAUTICAL DATA

It is recommended to collect, at least, information related to:

- Ground facilities: airports, heliports, runways, taxiways, terminals, etc.; NAVAIDs (ILS, NDB, VOR, etc.); surveillance (radar, etc.);
- Airspace structures and standard procedures: Obstacle protection surfaces; Corridors; VFR routes; SIDs and STARs; Airspace classification (including P, D, and R areas); the corresponding AEC according to the SORA method; existing UAS geo-zones (if any); drone no-fly zones;
- Air traffic (characteristics and volume of traffic): commercial operations in the vicinity of airports; general aviation, including the identification of areas where recreational activities are performed (e.g. paragliders).

A considerable part of the team's work consists of collecting large amounts of information relevant to the airspace volume being assessed from aeronautical sources such as the AIP. However, in general AIPs etc. are not always fully up to date and could provide incorrect data for the assessment. The findings will need to be validated through interviews with relevant parties. For example, if the airspace volume includes SIDs and STARs, it is essential that these be validated to obtain the actual routes/levels flown by aircraft using these SID/STARS. This is normally done using records from tracking/radar systems. The protection areas and surfaces defined for IFR procedures should also be taken into account as appropriate.

In addition, data regarding accidents and incidents involving manned aircraft within the assessed airspace should be gathered. This information provides a valuable safety reference for later stages of the assessment.

4.2.2 URBAN ENVIRONMENT

The urban environment is a key aspect to be considered in the case of operations in the VLL, which is expected to be the large majority of cases.

4.2.2.1 POPULATION

Population is the main component of the ground risk from UAS operations. It is therefore crucial to have a complete and accurate view of the population distribution in the area under the assessed airspace, so that the risks to this population can be correctly evaluated.

The main indicator to be used for this purpose is population density. A population density map that covers the assessed areas should be included within the GIS project. This map should include a classification based on the population density thresholds described by Annex F of the SORA methodology, which were included in version 2.5 [1] [JARUS, 2022]. Alternatively, the classification used by previous SORA versions ('sparsely populated' or 'populated'), could be used.

This reference to the SORA method is relevant to the ARA, since this information is critical for describing and assessing existing operations and future use cases. It should be noted that, while the qualitative implications of the legacy SORA classification are generally well understood, there is no specific quantitative metric at the European level that sets a threshold between 'sparsely populated' and 'populated'. Independent of the SORA version used as reference, areas in which 'assemblies of people'[2] are regularly formed (stadiums, schools, etc.) should similarly be included. Information about the presence of obstacles or shelter that can be used to mitigate these ground risks should also be recorded.

In addition, data regarding past incidents and accidents related to means of ground transport (e.g., car accidents) should be gathered if deemed appropriate. This information provides a valuable safety reference for later stages of the assessment.

4.2.2.2 OBSTACLES IN THE URBAN ENVIRONMENT

The urban environment is not only of concern because of risk to population on the ground, but also because of the risks that man-made structures can pose to UAS flights at low level, and vice-versa. A digital elevation model that includes fixed man-made structures is a great asset for the identification of these risks. However, they are relatively costly to produce. If there is no readily available model for the area under assessment, an ad-hoc digital model may be created. Alternatively, geographical information regarding the most representative fixed obstacles in the assessed area should be collected. Such information may be obtained from the national AIP, if needed.

Temporary structures, such as cranes, are also a source of risk for UAS operations. However, there is little purpose in mapping temporary objects in the reference scenario, as the value of this data is quite low for the ARA. Instead, it is recommended to simply identify any locations of interest in which regular deployment of cranes or other temporary obstacles is expected (e.g., harbours, industrial areas under construction).

Both fixed and mobile obstacles can cause other problems than direct collision, such as the obstruction of field of view, the shielding of electromagnetic waves (possibly affecting command and control of drones), or the induction of a multipath effect in GNSS signals. Therefore, not only is the exact location of obstacles of interest, but also their surroundings and their effects.

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[1] SORA V2.5 is, at the time of writing this document, open for public consultation. Note that the content of the SORA method might vary after the public consultation.

[2] [EU, 2019/947] defines 'assemblies of people' as "gatherings where persons are unable to move away due to the density of the people present".

4.2.3 CRITICAL INFRASTRUCTURE

The location of critical infrastructure is an important part of a reference scenario. Apart from aeronautical infrastructure, covered in previous sections, the following non-exhaustive list of facilities should be considered:

- Energy plants: power plants, solar farms, dams, etc.
- Critical services: water treatment plants, energy distribution facilities, hospitals, etc.
- Transport networks: harbours, train stations, railways, main roads, etc.
- Security critical facilities: prisons, police or military facilities, banks, etc.
- Hazardous industries: with chemical, nuclear, or biological hazards, etc.

In some cases, such as nuclear stations or military facilities, airspace restrictions may already have been defined in previous steps, due to the presence of such infrastructure.

Data regarding past incidents and accidents related to critical infrastructures should be gathered, if available. This information provides a valuable safety reference for later stages of the assessment.

4.2.4 TERRAIN AND NATURAL FEATURES

In addition to the man-made obstacles described above, information should be gathered regarding the terrain elevation and any relevant natural feature. Subtle changes in terrain slope, as well as natural features such as canyons, rivers, or forests, may have an important impact on UAS operations conducted close to the ground.

4.2.5 ENVIRONMENTAL PROTECTION

The location and extension of environmentally protected areas within the assessed airspace volume should be identified, together with any applicable restriction to UAS operations. Areas with regular presence of birds (e.g. due to migration, nesting) are especially relevant when considering UAS operations in the VLL.

4.2.6 METEOROLOGICAL CONDITIONS

UAS operations are subject to appropriate weather conditions, hence their availability is limited depending on the meteorology characteristic to the assessed airspace. It is strongly recommended that data regarding at least the following meteorological parameters be gathered:

- Intensity and frequency of precipitation, including rain, hail, snow, etc.;
- Wind, including predominant directions, average intensity, and wind gust intensity;
- Temperature, including maximum and minimum. Special attention should be paid to icing conditions.

Other parameters of interest are humidity, solar storms (KP-index), electromagnetic storms, and visibility.

In urban environments, it is important to consider local meteorological conditions caused by human activity and man-made obstacles, such as wind shear or convective flows (“urban canyons”).

4.2.7 COMMUNICATION, NAVIGATION AND SURVEILLANCE (CNS)

U-space airspace operations need CNS support for their proper execution, and it is important to collect information regarding the status of existing CNS systems that could support these operations. For cost efficiency, some of the functions used by manned aviation or other human activities could be also applied to the U-space airspace. These functions could also, however, be negatively affected by the designation of U-space airspace, and the execution of regular UAS operations in it. Information regarding CNS systems used in manned aviation is therefore an important asset for the ARA.

When evaluating the performance of CNS in the surrounding of obstacles or within the urban environment, the possible impacts due to the environment should be considered (e.g. multipath effect, loss of RLOS, EMI), as well as the sources of these impacts.

4.2.7.1 COMMUNICATION

Mobile network coverage (e.g., 4G/5G networks) in the assessed airspace should be mapped since communication between UAS operators and the U-space system is expected to rely on these networks. The pilot-to-UAS communication link, commonly referred to as the command & control (C2) link is usually based on a direct radio link via UHF, limited to RLOS conditions. However, there is increasing interest in replacing this method with mobile networks to allow operations to be performed in BRLOS conditions. However, existing mobile network coverage is generally based on antennas at height, on towers, hills, tall buildings etc., near where telephone users are located, and antenna beams are orientated towards the ground. It is important to consider that in the case of U-space, users are expected to operate in the air, where coverage could be significantly less than the coverage measured at ground level.

In addition, it is recommended that information regarding the location of aeronautical radio stations, and the identifications of the radio frequencies used by them, be collected. VHF communications are a possible solution for communication between U-space users and ATM, but measures may be needed to avoid interference in ATM communication caused by U-space operations, depending on the frequency ranges used and the locations where operations take place.

4.2.7.2 NAVIGATION

GNSS data are expected to be the primary source for navigation in U-space airspace and geospatial information regarding the performance of GNSS constellations of interest in the assessed airspace should therefore be obtained from the corresponding periodical performance reports issued by the entities managing GNSS. In the case of EGNOS information regarding service availability and accuracy are provided for the Open Service, while continuity and integrity performance is additionally provided for the Safety of Life service. EGNOS reports can be downloaded from https://egnos-user-support.essp-sas.eu/documents/field_gc_document_type/84. Alternatively, live tests may be conducted to measure the local coverage and GNSS performance.

The location of NAVAIDs and their radiation beams should be obtained, if applicable, because these could be used both to support U-space operations and to prevent any interference caused by U-space operations in sensitive ATM navigation systems such as ILS.

4.2.7.3 SURVEILLANCE

Surveillance in U-space airspaces is expected to rely on collaborative means via the network identification service and the data transmitted by the UAS through its remote identification.

Therefore, only in rare occasions will appropriate UAS surveillance systems be available before the introduction of U-space. If these systems are available, their specifications and coverage should be collected.

Surveillance systems used for manned aviation are generally not well suited to support U-space operations - aviation radars are not designed to detect small aircraft at low heights, for example. However, they should also be considered, as they can be a source of electromagnetic interference for U-space operations.

In addition, C-UAS systems could be deployed in specific locations, such as military facilities, in which case, it is recommended to identify all C-UAS systems and to coordinate with the entities in charge of such systems.

4.2.8 UAS FLIGHT-DATA COLLECTION

Flight-data on the use of UAS in the assessed airspace is a key input for the definition of the reference scenario. Two different methods are recommended for collecting such data.

The first approach consists of directly consulting records regarding the use of UAS. Article. 14 of [EU, 2019/947] requires EU member states to maintain updated registration systems for UAS whose design is subject to certification and for UAS operators whose operations may present a risk to safety, security, privacy, and protection of personal data or the environment. Although this information is generally quite generic, it might provide insight regarding the overall status of unmanned aviation in a given state, by means of checking the total number of registered UAS operators, the number of operational declarations received, the number of operational authorisations issued, or the number of certified UAS registered. This information can be complemented with additional data regarding UAS operations that has been collected by other means and that provide more specific information regarding specific flights, such as the actual location of the operations. This kind of data can be found from:

- Records from operational authorisations (SORA) processed by the relevant CA.
- Flight planning apps;
- Model aircraft clubs and associations;
- Flight plans in the case of UAS flights performed within controlled airspace, if requested for such operations;
- Existing coordination and communication procedures with ATC/ANSPs, and/or infrastructure managers (e.g. airports, airfields, critical infrastructure), if any.

A brief catalogue with examples of different kinds of UAS operation (if any) already performed in the airspace should be compiled. If accurate descriptions are not possible, generic information is an acceptable alternative. It is recommended that at a minimum a variety of operations in the Open and Specific categories be assessed, if possible. For each different operation in the catalogue, the following information should be recorded:

- Area where the operations take place.
- Most frequent flight height.
- Whether operations are performed VLOS, BVLOS, or EVLOS conditions.
- UAS model used, if available. Alternatively, a simple classification (e.g., small < 5kg, medium < 25kg, large > 25 kg) might provide enough information.
- Whether the operation is performed in sparsely populated areas or populated areas, or a mix of both.

- In addition, if the operation is usually conducted over a controlled ground area or an assembly of people, this should be noted.
- The AEC of the airspace in which the operations take place.
- The operational category (i.e., Open, Specific, or Certified), with further detail, if possible (e.g., Subcategory A1, Standard Scenario (STS), Pre-defined risk assessment (PDRA), etc.).

The main issue with this approach is that it only considers legal flights that have been duly authorised and coordinated. However, data collected so far suggest that there are a relatively large number of UAS flights that do not comply with the applicable regulations. For this reason, a second approach consists of monitoring UAS flights with surveillance tools that directly detect UAS operations, whether they are legal or not. Monitoring for this should last a period of several weeks and be performed at different times of the day and at different locations. This process will give a better picture of UAS operations in the airspace under analysis and provide experience in the detection and prevention of illegal UAS operations. The limitations of the surveillance systems and the constraints imposed by the physical environment in which the measures are taken (e.g., obstacles, EMI) should be considered. The data collected will require post-processing to filter out errors and repeated information, and to set the tolerances for different geographical locations.

In addition, this information should be complemented with past reports of issues related to UAS operations, such as accidents, incidents, complaints made by citizens, effects to manned aviation, etc., if any.

After the identification of existing UAS operations, these should be assessed to identify the applicable requirements for them to be conducted, considering the relevant national and European regulatory frameworks. The requirements applicable to the operational categories can be directly obtained from [EU, 2019/947] and its associated AMC/GM [EASA, 2022], for Open category operations and Specific category operations performed under STS or PDRA. In the case of Specific category operations with an operational authorisation based on a dedicated SORA, the corresponding UAS operators might provide a list of the applicable requirements established by the CA in the authorisation process.

Requirements due to other applicable European regulations (e.g. regarding privacy and data protection) might also be considered. Any additional requirements due to national regulation, especially those imposed on state UAS operations and on other operations flying over populated areas, in BVLOS conditions and/or within controlled airspace (e.g. additional equipment, coordination processes) should also be identified. If no previous UAS operations have been recorded inside the assessed airspace, this step may be limited to identifying applicable generic requirements in line with EU and national regulations.

Overall, the assessment of existing operations is meant to accurately represent how UAS operations are managed before any changes are introduced. The requirements applicable to existing operations should be used as reference when defining UAS capabilities and performance requirements during the assessment phase, to ensure a proportional approach whenever it is feasible. In addition, the previous process will help in the identification of any gaps between the requirements applicable to the conduct of UAS operations before U-space airspace designation, and the established UAS capabilities and performance requirements for operating in the designated U-space airspace.

4.2.9 INTERVIEWS, CROSS-CHECKING AND VALIDATION

Relevant data may not be immediately available from documented sources; dedicated interviews can be arranged with the stakeholders in the assessment team to obtain the data related to their fields of expertise. Such interviews should be undertaken after as much document-based data as possible has been collected. In this way, the completeness and correctness of the data collected can be verified through cross-checking with the interviewees. It is especially important to ensure that data provided by different sources on the same matter is consistent, and that all data of a specific type are expressed in the appropriate format, so that they can be properly processed.

It is important that stakeholders provide insight regarding their concerns, as well as facts or assumptions that could lead to constraints that require consideration during the assessment phase.

These interviews are also useful to detect flaws in the collected data, such as:

- Outdated or even erroneous data;
- Missing key information;
- Data classified using erroneous criteria;
- Data that do not represent the interests or concerns of stakeholders.

The opportunity should be taken during these interviews to discuss the future expectations of UAS operators or other relevant stakeholders with an interest in UAS operations, so that a catalogue of future use cases may be drawn up. This list might reflect stakeholders' interest in performing UAS operations that would be enabled by U-space airspace (e.g. large-scale BVLOS commercial delivery operations in urban areas). The use-case catalogue will be used to support the Assessment phase.

These use cases should also form one of the items presented to political stakeholders during any consultations that should take place before the Assessment phase begins.

4.3 PRODUCING THE REFERENCE SCENARIO DOCUMENT

Once the data have been obtained and verified, the Reference Scenario document, which is a major deliverable of the ARA project, should be produced. This provides the context necessary to support the assessment of the proposed U-space airspace. This document should be as complete as possible, including all the information obtained during the data collection phase.

A template for the Reference Scenario document is provided in Appendix 3.

This written document is a companion to the datasets gathered during the Reference Scenario phase. It is recommended that all geospatial information be included in the GIS project associated with the ARA. Large datasets that cannot be included in the written document should be stored in accessible formats (e.g., tabular) and referred to, when applicable, in the written document and the datasets.

5 ASSESSMENT PHASE

The assessment phase consists of the coordinated assessment of safety, security, privacy, and environmental risks related to the designation of the U-space airspace. This assessment will be used to derive the final outputs of the ARA, which include UAS capabilities and performance requirements, U-space service performance requirements, as well as airspace limitations and operational constraints.

Before beginning the assessment phase, two essential inputs are required:

- The context, which refers to the environment before the change is introduced.
- The ConOps, which specifies what change is being introduced.

The Reference Scenario Phase of ARA is designed to cover any aspect related to the context, by means of analysing the local scenario where U-space airspace designation is planned. As such, this information should be already known upon finishing the Reference Scenario Phase. However, the definition of the ConOps has a wider scope than what is covered by ARA, in some cases requiring decision-making at a national level. Therefore, a ConOps, complemented by a series of design documents as necessary, should be provided as an input to the Assessment phase. These documents will be refined during the Assessment phase following an iterative process, by which the original ConOps will be modified according to the findings of the different assessments.

Once the context and the initial ConOps are clearly defined, the assessment of safety, security, privacy, and environmental risks can begin. These assessments should be conducted according to methodologies appropriate to each of these fields, as determined by the assessment team. These methodologies should include hazard identification, risk analysis, and risk mitigation. When possible, the security, privacy, and environmental assessments should be conducted before the safety assessment, so that the outputs derived from these assessments can be used to refine the ConOps before conducting the safety assessment. The iterative nature of the process might require revisiting previously concluded assessments if new changes are found to be needed (e.g. new mitigations or restrictions). The following sections define the actions to be performed during the assessment phase.

5.1 SECURITY, PRIVACY, AND ENVIRONMENTAL ASSESSMENTS

The assessment phase must examine four aspects of the change to the functional system due to designating U-space: safety, security, privacy, and the environment. While the major part of the assessment will focus on safety (see section 5.2), the other three aspects should not be ignored. GM8 to Article 3(1) of [EASA, 2022] provides guidance on these. This section summarises and complements this guidance material. The results of these assessments will very likely be requested during any following public consultation. A report of the results of the security, privacy, and environmental assessments should be created.

5.1.1 SECURITY

Security and safety are strongly related. In some cases, the assessment of security concerns may be included within the safety assessment.

On 14th December 2022, the European Union published directives (EU) 2022/2555 [EU, 2022/2555] on measures for a high common level of cybersecurity across the Union and (EU) 2022/2557 [EU, 2022/2557] on the resilience of critical entities.

Regulation 2555 requires EU member states to adopt national cybersecurity strategies, designate competent authorities and cyber crisis management authorities, computer security incident response teams (CSIRTs), etc. and defines rules and obligations for cybersecurity risk-management measures and reporting, cybersecurity information sharing, and supervision and enforcement.

Regulation 2557 requires EU member states to identify, support, and supervise entities critical to society or economic activities, and to take specific measures to ensure that their essential services are not obstructed. It lays down obligations on these critical entities to enhance their resilience and ability to provide services. States must produce a strategy and a risk assessment for this by January 2026.

The annexes to these regulations list critical sectors to be considered, including air transport players. It is clear that these regulations have major implications on drone use. A security risk assessment must ensure that the security risks to critical infrastructure from intentional, unauthorised actions are understood and mitigated. Such actions could be from the operators themselves or the result of cyber-attacks on the drones.
The EUROCAE ED-201A method for assessing and sharing of information on security risks is illustrated in [EASA, 2022]. This is repeated here together with the guidelines that accompany it.

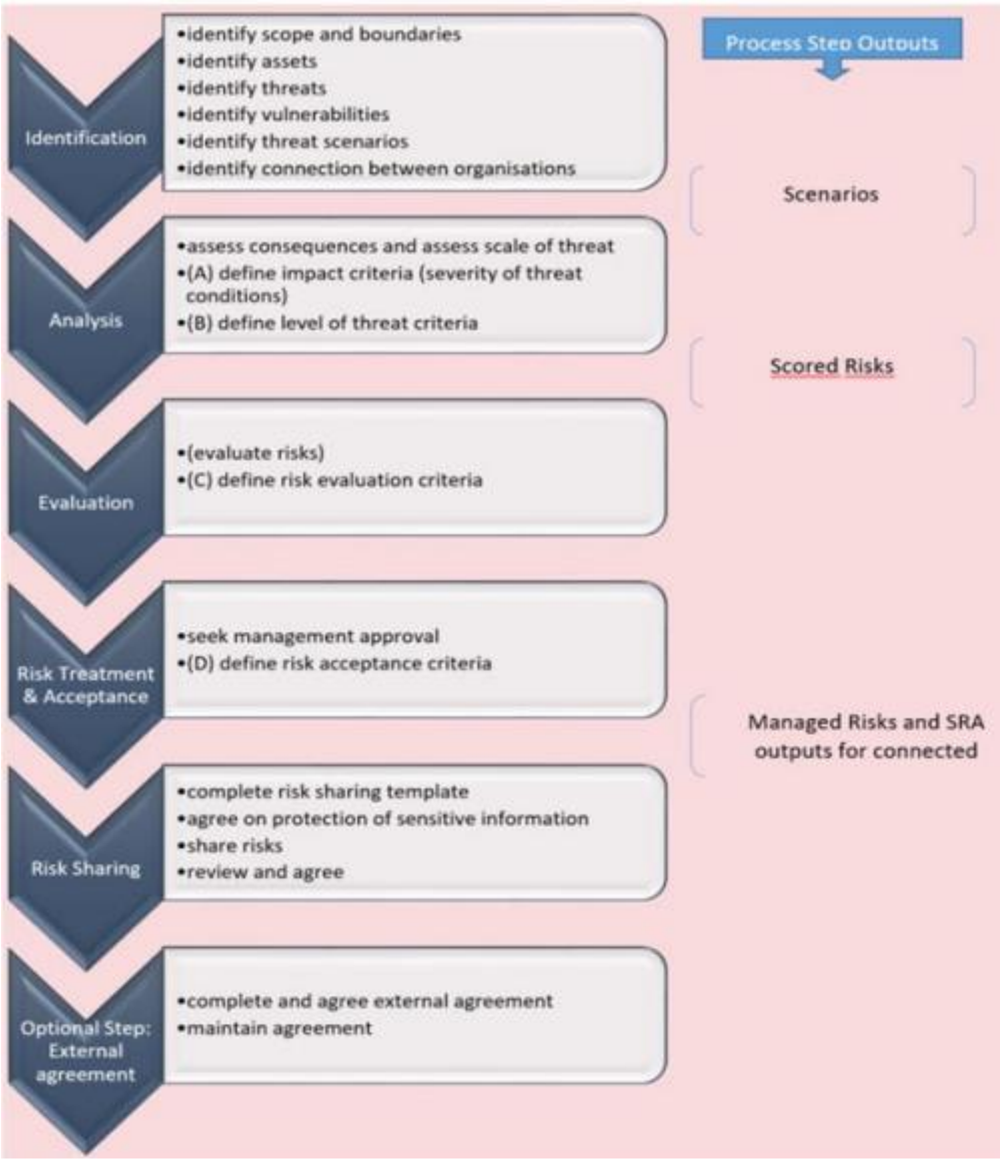

Figure 6: Risk assessment and sharing of information

"There are fixed inputs (marked with the letters A, B, C, D) that should be common to all risk assessments conducted by an organisation. These would be established as part of the overall corporate risk management process. The activities described may be conducted in a different order depending on the particular methodology used, and the activities and fixed inputs may have different names as well. Risk sharing can happen at any life cycle stage and should be dependent on agreed thresholds for reporting."

The assessment should take the caveat in GM8.e on ensuring comparability and compatibility between the different security assessment methodologies and definitions of risk into account and adhere to the principles for risk sharing outputs given in GM8.f.

5.1.2 PRIVACY

There are two aspects to privacy - personal private data (identity, private life, etc.), and commercial data (intellectual property, espionage, etc). The EU General Data protection Regulation (GDPR) [EU, 2016/6799] only covers personal data side of these aspects, through requiring a data protection impact assessment (DPIA). This is mostly concerned with the processing of any personal data collected. In the case of drones, this concerns "the privacy risks to third parties emerging from intentional or accidental visualisation, capture and/or retention of personal images or information through (close) overflight or hovering" ([EASA, 2022]) - and its impact on the rights and freedoms of the subjects of that data. This can be a broad scope - images, where and when photos were taken, who was in an image, etc. A DPIA may be used to support the ARA.

The commercial side needs to be addressed at national level as national regulation may apply. If so, a privacy assessment may be required for these as well. In both cases, the method used for conducting a privacy risk assessment will depend on national regulation.

5.1.3 ENVIRONMENT

[EASA, 2022] describes three areas where environmental impact needs to be assessed: noise, local air quality, and the protection of wildlife and the natural environment. It defines these as being especially important "near built-up areas, especially schools and hospitals, protected landscape, natural reserves, along known wildlife migratory routes, or over lakes, rivers, and other bodies of water." In most cases, environmental impact assessments and impact management plans and programmes will already have been carried out or put in place in the areas under study. The assessments carried out in the context of designating U-space should comply with these existing plans and programmes and follow any processes and procedures mandated by them.

If these assessments bring to light any environmentally sensitive areas not already protected by flight limitations, new limitations (e.g. geo-zones) could be proposed, if necessary. Again, this is most likely subject to national regulation.

Noise

The EU Environmental Noise Directive (END) 2002/49/EC10 [EU, 2002] is applicable to UAS as much as to anything else and the noise action plans it requires must be updated to include noise from UAS. The environmental risk assessments must ensure that UAS operations comply with these action plans. Furthermore, [EU, 2019/945] and [EU, 2019/947] require operators to follow guidelines for reducing noise during operations.

The assessment of noise has been well defined for manned aircraft for many years:

- Identify possible health problems caused by different exposure levels through a dose-response assessment;
- Determine the level of population exposure to the noise - "how many people and for how long";
- Determine the resulting risks in terms of health problems suffered by the exposed population;
- Evaluate the risk and propose mitigations if necessary.

Such an approach can be used for assessing the noise from drones. A major problem here, however, is that noise assessments for manned aircraft rely on noise certification data from aircraft manufacturers. This data does not exist for the great majority of UAS available.

Air quality

In most cases, drones will not have any impact on local air quality since their propulsion and lift come from electrical batteries. However, if it is possible that drones may be operated in the proposed U-space airspace using motors that produce chemical emissions, an assessment of the impact of such emissions on local air quality should be made in accordance with EU Directive 2008/50/EC12 [EU, 2008] and with local air-quality action plans, if any.

Protection of wildlife and the natural environment

While bird strikes on manned aircraft can cause problems of control of these aircraft, and this is also the case for drones, drones can cause major problems for bird populations. An environmental assessment of proposed U-space airspace should, therefore, include the paths of known bird migration routes, with the season concerned, to ensure that such migration is not disrupted. As stated in [EASA, 2022], these assessments should also ensure that laws on the protection of wild birds (EU Directive 2009/147/EC13 [EU, 2009]) and the conservation of natural habitats and of wild fauna and flora, areas of special scientific interest, and areas of outstanding natural beauty (EU Directive 92/43/EEC14 [EU, 1992]) are respected.

5.2 SAFETY ASSESSMENT

For the assessment of safety-related aspects within the ARA, it is recommended to use, as far as applicable, existing methods for safety assessment and assurance of changes to functional systems of ATS providers based on Annex IV to [EU, 2017/373]. NSA and ATS providers typically possess prior expertise in reviewing and implementing safety assessments, which can prove advantageous in alleviating the workload associated with conducting an ARA. The safety assessment procedure covers the bare minimum requirements outlined in AMC1 to Article 3(1) of [EU, 2021/664] for the safety component, including hazard identification, risk analysis, and risk mitigation.

Compared with safety assessments under [EU, 2017/373], the safety assessment conducted in the context of ARA features an additional element: the introduction of the airspace safety specification at operational level, as specified in GM6.f to Article 3(1) of [EU,2021/664]. The safety specification describes what must happen at the operational level within the airspace to satisfy the specified safety criteria. Section 5.2.1 provides a detailed account of the process for defining these criteria, while Section 5.2.2 describes the process for defining the safety specification at an operational level.

During the definition of the airspace safety specification in the safety assessment, it is recommended to assess both the success approach, which evaluates the safety contribution of the change when functioning as intended; and the failure approach, which assesses the negative impact on safety resulting from failures in the functional system.

When conducting an ARA to support the designation of U-space airspace(s), the change to the functional system under consideration is the actual designation of the U-space airspace(s). For the initial ARA conducted in a given state, this typically entails the introduction of a new type of functional system at a national level.

To define a functional system for U-space airspace, the methodology set forth in [EU, 2017/373] is used and applied to the U-space context (as detailed in GM4 to Article 15(1) of [EU, 2021/664]). In line with point GM2.f to Article 3(1) of [EU, 2021/664], the recommended approach for the overarching safety argument underpinning the safety assessment is to demonstrate, with a given level of confidence, that operations carried out within the proposed U-space airspace will be acceptably safe. Accordingly, a safety assessment report should be produced to support the decision made by the state regarding the designation of the U-space airspace following completion of the ARA. The safety assessment report must detail the processes undertaken during the safety assessment, along with the resulting outputs.

It is worth mentioning that this safety assessment does not necessarily cover the phases of transition into service and operation of a functional U-space airspace. Additionally, when performing the ARA, there might be a lack of information regarding the service providers who will operate within the proposed U-space airspace, and/or about their functional systems. Therefore, the scope of the safety assessment should remain general and focused on the airspace level.

The volume of airspace to be considered within the scope should correspond to the airspace volume assessed, as previously described in the Reference Scenario. This volume should adequately cover the volume(s) to be designated as U-space airspace(s) and their adjacent airspace.

The change is expected to have a significant impact on the context, particularly when U-space airspace is planned to be designated in controlled airspace. The relevant actors involved should have previously been identified during the Reference Scenario phase. Even if an ARA is not performed under the scope of [EU, 2017/373], the safety assessment conducted within the context of an ARA might be considered a multi-actor safety assessment, as the designation of U-space airspace in controlled airspace will affect any ATSPs operating in that airspace. Therefore, any affected ATSPs will likely need to conduct their own safety assessment under the scope of [EU, 2017/373] for any changes to their functional systems related to the implementation of DAR. This assessment should be coordinated with the ARA project, as outlined in Section 7.3.

There are three major milestones when conducting a safety assessment in the context of an ARA:

- Setting the safety criteria
- Defining the safety specification at operational level
- Deriving the safety requirements

In addition to achieving these three major milestones of the safety assessment, other activities, including validation and verification, as well as the identification of monitoring criteria, should be conducted to ensure a thorough evaluation. It is crucial to understand that the safety assessment process is not a linear one, and that revisiting steps that have been performed previously may be necessary to address any additional gaps, refine assumptions, or address any other concerns that may arise during the process. Therefore, it is essential to maintain flexibility and adaptability throughout the safety assessment process. A safety assessment report should be produced, describing the process followed during the safety assessment and the related outputs and findings.

The following sections describe the methods used to achieve these milestones, as well as to perform the other activities required to complete the safety assessment.

Finally, EUROCONTROL has developed the Expanded Safety Reference Material (E-SRM), which is a comprehensive methodology for conducting safety assessments and safety support assessments in ATM/ANS and UAS/U-space operations. The following sections describe general principles that can be applied with the E-SRM method or any other suitable safety assessment methodology. If a state desires to apply E-SRM, additional guidance on this topic can be found in the E-SRM core document and related documents on the E-SRM developed by EUROCONTROL.

5.2.1 SAFETY CRITERIA

Safety criteria (SAC) describe the safety acceptability of the change (i.e. the designation of U-space airspace). To define the SAC, the following steps should be taken:

Identify hazards inherent to aviation.

By definition, hazards inherent to aviation are those that exist in the operational environment before any form of planning, de-confliction or other form of mitigation have taken place. The primary purpose of the change is to contribute to mitigating them.

These hazards are the basis for the definition of safety criteria. The identified hazards should cover the whole scope of the change, including both ground and air risks. Only the hazards inherent to aviation (and associated risks) that fall within the scope of the safety assessment, i.e. which are relevant to the change, need to be identified.

An ARA should be primarily focused on hazards inherent to aviation that are related to mid-air collisions (e.g. conflicting trajectories of aircraft), although other types of accidents might also be considered (e.g. wake-induced accidents, CFIT).

When assessing hazards inherent to aviation, it is important to consider all different types of encounter between types of airspace user (e.g. UAS, manned aircraft subject to ATC provision, manned aircraft not subject to ATC provision), since accidents involving different combinations of airspace user will require different mitigation barriers.

Impact analysis of the change

The safety implication of the change can be analysed using integrated risk models (IRMs), by identifying where the change will impact the risk models. An IRM shows the risks of aviation accidents and provides a structured breakdown of their causes with a level of detail sufficient for supporting the SAC definition. These IRMs are not intended to replace a suitable hazard identification and risk analysis but to complement these processes.

IRMs have traditionally been used to analyse the safety of changes to the ATM/ANS functional system. However, for the initial implementation stages of U-space airspace, the availability of IRMs applicable to the context of the operational environment of this U-space airspace may be limited. When necessary, states should develop their own IRMs as part of this assessment.

In cases where IRMs are not available, they should be developed in the ARA project and include U-space services and other possible mitigations for the risks of UAS operations. Model development should be based on the ConOps provided by the state. In each model, the precursors to the accident are either the immediate outcome of the failure of the safety barriers or events induced at the level of the operational activities and/or services provided to the airspace users.

The impact analysis of the change must be performed by safety experts together with operational and technical experts who have a good understanding of the change. In this process, the potential events that might be precursors to the accident associated with the hazard inherent to aviation and which are relevant to the change should be identified. Each incident should be assigned a well-defined probability distance to the corresponding accident category.

Building the event sequences that link these accident precursors, and accounting for the potential risk mitigations available in the operational environment under assessment, allows the identification of certain countable events that might lead to the definition of relevant proxy-based SACs (i.e. expressed in terms of a measure that relates to the safety risk) to be determined.

Setting the Safety Criteria

Once the impact analysis has been done, the SACs that describe the tolerable safety level following the change are defined. These should be set at the level of the corresponding precursors in the models, if possible, or at the accident or harmful effect level. These SACs should consider the singularities and specificities of U-space airspaces, compared with the ATM/ANS framework, including any possible impact on critical infrastructure, if applicable.

These elements should be taken into account when defining the SACs:

- defining them at a harmful effect, accident or precursor level (proxy-based safety criteria)
- showing that a safety benefit is achieved through the provision of U-space services.
- considering the traffic evolution allowed by the change, if it is considered necessary.

SACs can be expressed relatively or absolutely. In both cases the potential traffic increase enabled by the corresponding change, U-space airspace designation, must be taken into account. In some cases, the impact of a change in the functional system could be estimated to be neutral with respect to a specific hazard. This could occur if the volume of UAS traffic is maintained with respect to a previous situation in which the state had a process of approving operations and mitigating risks alternative to U-space and considering certain traffic demand. In any case, it is worth noting that one or more SACs should be defined even if the estimated impact is safety-neutral.

The following are examples of relative and absolute safety criteria, respectively:

- The frequency of UAS-to-UAS mid-air collisions should not be increased by the designation of U-space airspace.
- The frequency of UAS-to-UAS mid-air collisions should not be higher than [X] per flight hour.

The safety targets expressed in each safety criteria must be determined by each state since they depend on the particular conditions of their operational context.

As previously mentioned, the IRMs can support the definition of proxies between the hazard and the harmful effect. Consequently, the SACs set with the support of IRMs can be defined in terms of proxies. Proxies are defined as measurable elements in terms of the acceptable frequency of the accident precursors affected by the change, either in relative or absolute terms.

The following are examples of proxies:

- Related to UAS-UAS mid-air collision: excursions from approved 4D flight authorisations.

  Since UAS flight plans are meant to be de-conflicted, leaving the deconflicted volume is a precursor to the collision.

- Related to mid-air collision between UAS and manned aircraft subject to ATC provision: infringements of the dynamic airspace reconfiguration volume.

  In this case, the precursor to the accident is the infringement of the airspace volume that has been reconfigured to allow manned traffic operations.

- Related to mid-air collision between UAS and manned aircraft not subject to ATC provision: losses of separation.

  In this case, there is a requirement in AMC1 to Art. 3(4)(e) regarding the definition of a minimum safety distance. Therefore, the infringement of this distance (loss of separation) could be expressed as a proxy.

5.2.2 SAFETY SPECIFICATION

To meet the SACs defined in the previous step, it is necessary to develop the Safety Specification at operational level. This means the functional, performance and integrity/reliability safety properties of the change to the functional system. This specifies the desired safety behaviour of the change at its interface with the operational environment and describes what the change to the functional system should deliver to satisfy the SACs.

The Safety Specification provides mitigation of the risks inherent to aviation (by means of Safety Specification Items - SSI) and limits the risks arising from functional system failures (by means of hazard-related proxies – HPX, also complemented by SSI). They consider normal and abnormal conditions (success approach) and the failures of the functional system (failure approach).

The safety specification for a change should be determined at the level of the operational activities/service and should include:

- Normal conditions:
  - SSIs to mitigate the relevant risks inherent to aviation in normal conditions of operation.
- Abnormal conditions:
  - SSIs to work through (robustness), or at least recover from (resilience) any abnormal condition.
- Failure conditions:
  - HPX: a qualitative or quantitative statement that defines the maximum tolerable frequency or probability of operational hazards caused by failures internal to the functional system.
  - Additional SSIs to mitigate against the adverse effects due to failures internal to the functional system.

Safety specification - Normal conditions

The Safety Specification should specify the desired safety behaviour of the change at its interface with the operational context considering normal conditions - those conditions of the operational environment that the functional systems are expected to encounter in day-to-day operations and for which the system must always deliver full functionality and performance.

The definition of a set of SSIs establishes the Safety Specification in normal conditions. The SSIs are derived using the description of the operational activities associated with the change.

The operational activities are performed by the main operational entities involved in the functional system (USSPs, CIS, ATC, UAS operator, remote pilot, pilot/airborne system, etc.)

The functional system contributes to the mitigation of the risks associated with hazards inherent to aviation (and associated risks) through the delivery of operational activities/services to the aircraft. For this reason, the SSIs need to be defined at a level as close as possible to the operational activities/services.

The operational activities associated with the change can be defined by:

- the description (by steps) of each use case (the operational activities) and/or
- a formal operational representation (e.g. diagrams where each functional process/use case is described through a process model made up of operational activities interacting through information flows).

A complete set of SSIs should be identified based on the operational activities (use cases, etc.) to describe the safety-relevant changes. The traceability of these SSIs to the SACs will ensure that they are satisfied in normal conditions of operation.

Safety specification - Abnormal conditions

The safety specification in abnormal conditions is intended to specify the desired safety behaviour of the change when there are abnormalities in the context in which the functional system is intended to operate.

Therefore, a new set of SSIs are needed to address to the ability of the changed functional system to work through (“robustness”), or at least recover from (“resilience”), any abnormal conditions, external to the functional system, that might be encountered relatively infrequently.

‘Abnormal conditions’ mean those external changes in the operational environment that the functional systems may exceptionally encounter and under which the system may be allowed to enter a degraded state, provided that it can easily recover when the abnormal condition passes and the risk during the period of the degraded state is shown to be tolerable.

The abnormal conditions relevant to the change should be listed and described, e.g. UAS emergency, U-space service unavailability, unplanned vertiport closure/change, sudden change in weather conditions, electromagnetic interference, degraded UAS performance, failure in external systems such as GNSS, etc.

A complete set of SSIs should be identified based on the use-case description associated with these abnormal conditions or any other form of operational representation that will ensure the mitigation of the consequences of failure resulting from the identified abnormal conditions. The SSI should be traceable to the applicable SACs.

Safety specification - Failure conditions

To complete the Safety Specification, which already considers normal and abnormal conditions, it is necessary to include the Safety Specification for failure conditions. The Safety Specification in failure conditions is intended to specify the desired safety behaviour of the change in failure conditions - situations triggered by failures generated/modified by the functional system itself, at the interface within the context in which is intended to operate. In this case, the assessment focuses on identifying how to limit the possible negative contribution to safety that the modified functional system could make in case of failure(s).

For the failure case, it is important to consider the definitions of integrity and reliability of the systems. Integrity means the ability of a system, under all defined circumstances, to provide all the services (or functions) required by the users, with no unintended or un-requested services (or functions). Reliability, on the other hand, is understood to be the ability of a system / element to perform a given function within a certain period without failure.

Two types of safety specification element must be defined for this:

- Additional SSIs to those already identified in the safety specification relative to normal and abnormal conditions, which are intended to mitigate against the consequences of failure due to operational hazards generated or modified by the change (protective mitigation). These SSIs address functionality and/or performance properties.
- HPXs that address integrity/reliability properties to limit the frequency with which the functional system-generated operational hazards (either generated or modified by change) could be allowed to occur while remaining tolerably safe.

To derive the SSIs in failure conditions, it is necessary to carry out an Operational Hazard Identification and the Risk Analysis.

Operational Hazard Identification

In the context of operational hazard identification, it is crucial to clarify that the hazards being referred to in this section are specifically those generated or modified by the change, and that result from the failure of the functional system that has been affected, modified, or introduced by the change. It is important to distinguish these hazards from those inherent to aviation, and therefore this section focuses solely on identifying and mitigating operational hazards that arise due to changes made to the system.

Operational hazard identification is generally conducted during a Functional Hazard Assessment (FHA), inferring the possible U-space services (or other) that could be implemented, or during an Operational Hazard Assessment (OHA) process.

There are various known approaches to conduct FHA and OHA, which need to be adapted to support their applicability the safety assessment of U-space airspaces.

The definition of operational hazards should be made at an operational level; that is, independently of the system design. These hazards specifically describe the failure of operational activities or services, as opposed to human errors or technical system failures.

The following are examples of situations related to operational hazards:

- The non-conformance of a UAS operation with its flight authorisation. This means the de-confliction undertaken by flight authorisation service is no longer effective and the UAS is at higher risk of conflict with other traffic.
- The failure in providing a service to a target user. It is recommended that the different services and the consumers of the services be considered separately, as the operational consequences depend both on the service and the user. One approach for identifying these operational hazards is through the analysis of the corresponding operational activities or services. Specifically, for each SSI derived from the success approach, it is possible to consider the potential consequences if these elements were not met or were

not met correctly due to failure modes. This analysis helps identify the operational hazards that need to be addressed to ensure that the system is safe for operation.

Risk Analysis

After identifying the operational hazards, their impact is evaluated by determining the consequences (effects) of each one. These consequences can become an accident if no safety barrier is left working nominally (therefore leading to harmful effects), or be an accident precursor, if there are barriers left between the direct consequences of the operational hazard and the accident. Accidents precursors are characterised by their distance to the accident.

The consequence of an operational hazard is determined by the effectiveness of the safety barriers in place (i.e. working nominally), specifically the last one that is able to prevent the progression towards an accident.

To determine the distance to the accident resulting from an operational hazard, the effectiveness of remaining safety barriers is analysed given the operational hazard occurrence, taking potential common causes into account. The analysis stops at the level of the accident precursor for which the subsequent barrier would remain working nominally, and the distance to the accident is measured accordingly.

IRMs facilitate the identification of consequences and associated distance to the accident for an operational hazard, thereby improving the consistency of the risk analysis. In addition to the use of IRMs, the involvement of operational experts remains crucial in this process. This includes their input in determining the effects and distance to the accident, as well as in the identification of operational hazards. As such, operational experts should be engaged in the assessment, preferably during hazard identification and risk analysis sessions.

Additional SSIs

After identifying operational hazards and conducting a risk analysis, the SSIs derived for normal and abnormal conditions now need to be reviewed to ensure they are complete. If necessary, the safety specification can be updated with additional mitigation measures to protect against the consequences of operational hazards.

This includes adding safety specification items for failure conditions to protect the system against possible failures, or to mitigate against potential system failures caused by the identified operational hazards resulting from the change. Once again, the involvement of operational experts during this process can help ensure that all relevant hazards are adequately addressed.

The following example illustrates how the decision to mandate the provision of optional U-space services can be part of this process:

- As defined in [EU, 2021/664], the conformance monitoring service is meant to raise an alert in a case of non-conformance, therefore potentially reducing the consequences of such an event. Operational experts might decide that to achieve the desired safety levels, the provision of the conformance monitoring service is required as a mitigation barrier against the consequences of non-conforming UAS operations.

HPX definition

As mentioned above, HPXs (failure approach) should be established to limit the frequency with which the functional system-generated operational hazards could be allowed to occur for the system to be tolerably safe.

These HPXs should therefore be defined in terms of maximum tolerable frequency of occurrence of an operational hazard. The severity classification schemes (SCSs) and risk classification schemes (RCS), and their associated accident distance-based classes may be used for this.

To develop the RCS, the following steps must be taken:

- Determine the distance of the hazard's effects to the accident. This distance is expressed as the probability of an accident occurring as a result of the hazard effect. This is achieved by identifying the precursor related to the hazard's effect in the IRM.
- Determine the maximum frequency of occurrence that is tolerable for the hazard's effect based on the probabilistic distance to the accident.

The IRMs must have pre-defined classes based on the distance to the accident for each precursor. Additionally, the distance-based classification should take the remaining safety barriers, which are specific to each type of accident, after the occurrence of the hazard, into account. Therefore, a dedicated accident distance-based classification should be proposed for each type of accident.

There is no need here to ensure the traceability of the HPXs (integrity/reliability) to the SACs, since this is implicitly achieved by using the RCS and its associated accident distance-based class derived from the IRMs.

The steps to be applied for establishing the HPXs for the failure approach given SCS and RCS and its associated classes based on accident distance are:

- Identify the operational hazards
- Determine, for each operational hazard, the relevant distance of the operational hazard's effect to the accident
- Calculate the corresponding HPX.

The distance to the accident for a given operational hazard should be determined during the risk analysis of this hazard.

If an operational hazard impacts several barriers or several IRMs, then HPXs should be calculated, and the most demanding proxy should be retained.

5.2.3 SAFETY REQUIREMENTS

The final milestone to be covered by the Safety Assessment is the derivation of Safety Requirements (SR), which are high-level design characteristics/items of the functional system that ensure that the system operates as specified and the means by which the safety specification is achieved.

In the specific context of ARA, the derived requirements should remain at a high-level and should focus on:

- UAS capabilities and performance requirements, which UAS operators will need to fulfil to operate in U-space airspace,

- U-space service performance requirements, which will apply to the certification processes for the designated CISP and USSP, and
- operational conditions and airspace constraints, which are a set rules related to the use of U-space airspace, including the airspace structure, to be respected by all airspace users when operating in U-space airspace.

The safety requirements are derived from the proper allocation of the safety specification to the elements of the high-level functional system design (people, procedure, and equipment). The safety requirements must be shown to fully satisfy the SACs.

Safety Requirements - Normal conditions

To be acceptably safe when the functional system is working as expected, the functionality and performance properties of the design elements impacted by the change need to be properly defined.

Ideally, most of this type of requirement should have already been defined, e.g. they might be included in the ConOps. In addition, a list of requirements that should be identified is given in the AMC/GM [EASA, 2022], mainly in AMC1 & AMC2 to Article 3(4). In these cases, the role of the safety assessment is to identify which requirements impact safety and to check the correctness and completeness of the set of safety requirements to ensure the achievement of the SSIs defined for normal operations.

If previous requirements are not available, it is necessary to derive a list of safety requirements based on a structural design description by mapping each safety specification item onto the corresponding design elements (human actors, machine-based elements, and their interactions).

Safety Requirements - Abnormal conditions

Similarly, the functionality and performance properties of the design elements impacted by the change when operating in abnormal conditions need to be properly defined. This is to ensure that the functional system continues to deliver the functional and performance safety properties under any foreseen external abnormal conditions that the functional system may exceptionally encounter.

For each abnormal condition, the degree and extent to which the design elements impacted by the change can continue to deliver the required performance must be assessed. Once the assessment is complete, the set of Safety Requirements will be enriched with new derived requirements that satisfy the SSIs related to abnormal conditions.

Safety Requirements - Failure conditions

Finally, Safety Requirements will need to be derived to ensure that the HPXs are satisfied, and that the additional safety mitigations identified as SSIs for failure conditions will be properly implemented.

To properly derive these Safety Requirements, it is recommended to carry out a Preliminary System Safety Assessment (PSSA), commonly used in the ATM/ANS domain. This is a mainly top-down iterative process, initiated at the beginning of a new design or modification to an existing design. In the context of ARA, the terms ‘system’ (or ‘functional system’) and ‘design’ refer to the design of the U-space airspace and its associated. The objective of performing a PSSA here is to demonstrate whether the assessed system architecture can reasonably be expected to achieve the SSIs and HPXs.

The major PSSA tasks are:

- Identification of the potential causes of each operational hazard through a deductive analysis. This assessment is limited to the information that is available when conducting the ARA, which may not include the description of the functional systems of USSPs that will provide U-space services in the proposed U-space airspace. Therefore, this assessment should not include causes of operational hazards that lie within the functional systems of USSPs or CISPs, thus remaining at the operational level. The causes internal to their functional systems should be addressed at a later stage outside the scope of the ARA, during the mandatory USSP/Single CISP certification processes.

- Specify Safety Requirements to mitigate the risk:
  - Functionality & performance Safety Requirements, to provide adequate mitigations to reduce the likelihood that specific failures would propagate up to the operational hazard.
  - Integrity & reliability Safety Requirements, to limit the frequency with which failure of modified/new equipment elements in the Solution Functional system (causes of operational hazard) could be allowed to occur.
  - If applicable, Functionality & performance Safety Requirements (new or already identified for Normal & Abnormal conditions) derived to provide mitigation against operational hazard effects.
- Show that all other possible failure modes associated with the design have been identified and mitigated such that the demonstration of the HPXs is complete and that any additional operational hazards are identified, and risks mitigated as appropriate.

5.2.4 OTHER ACTIVITIES

During the execution of the safety assessment, it is important to carry out additional complementary activities to ensure that the outputs produced by the assessment are adequate. These activities should be conducted in parallel to the safety assessment activities described above.

Validation activities

Validation is the process of ensuring that a system or product meets the intended targets (e.g. the set of safety criteria). This is usually done by testing or simulating the system under various conditions.

Simulation tools that represent U-space airspaces, if available, can be an excellent asset for verification purposes. These tools can be used to validate diverse assumptions taken during the assessment, depending on the complexity and capabilities of the simulation tool used. The tests can also confirm the effectiveness of the derived safety requirements in achieving their related safety goals.

Verification activities

It is recommended to verify that the safety assessment is performed adequately; this means, that the assessment has been conducted by personnel trained and competent for the tasks assigned to them, that the scope of the assessment has been appropriately covered, and that appropriate tools and methods have been used.

To ensure the verification that the whole scope of the change has been properly addressed, it is recommended to check the completeness of the safety argument, and to check the traceability of safety requirements, for example, by developing a structural hierarchy. For this purpose, the definition of safety requirements should include a reference to the related SSI and/or HPX, which should be referenced to the related SAC.

Specify monitoring criteria

A list of monitoring criteria describes the operational parameters that should be recorded and analysed after the start of operations in the proposed U-space airspaces.

Monitoring criteria are especially relevant for the initial designations of U-space airspaces, which will largely be supported by assumptions relying on expert judgement, and possibly operational data from environments other than U-space airspace, but with little directly applicable operational data from existing U-space airspaces.

The list of monitoring criteria should include, at least, the elements required to verify the continuous compliance of the defined safety criteria, complemented with as many parameters whose monitoring is considered necessary, such as those related to relevant assumptions used during the assessment.

If there is divergence between the collected data and the assumptions or safety targets defined during the ARA, a re-assessment could be triggered to re-evaluate the U-space airspace safety levels and refine/enhance the previously defined risk-mitigation barriers.

Develop the safety assessment report

The activities conducted during the safety assessment should be documented in a Safety Assessment report. This document will be used by the Coordination Mechanism, after the ARA is concluded, to support the decision to designate U-space airspace, by providing the evidence that the actions specified during the ARA have been adequately identified and will completely mitigate safety risks, ultimately providing the required assurance that the U-space airspace will be acceptably safe.

6 FINAL REPORT

The final report of an airspace assessment is targeted at those in the local CAA, the local ANSP, and others who will decide on the actions to take following this assessment. It should provide a clear, concise description of the activities undertaken, and the results obtained in terms of safety requirements, together with any proposals for mitigation measures that might seem apposite.

The intention of the report is to provide as much information as necessary to enable decision makers to understand the requirements for implementing U-space in the assessed airspace.

The report should contain a summary of the project plan, the stakeholders involved, the sources of data used, and interviews undertaken. A summary of regulatory gaps found, if any, should also be included. A description of the process of the reference scenario and highlights of the data found should be accompanied by visualisations of these data. The report should conclude with a summary of the safety assessment report.

A template for the final report is provided in Appendix 6.

7 OTHER ACTIVITIES RELATED TO ARA

This section describes a series of other activities necessary for the execution of UAS operations in the proposed U-space airspace, which are not part of the ARA, but which might be impacted by its outputs. Therefore, it is important to take these activities into consideration when performing an ARA, coordinating with the relevant stakeholders as necessary.

Table 2 -Activities related to ARA

Perspective	Activity	Purpose	Focus	Regulation
State	Airspace risk assessment	U-space airspace designation	Airspace level	CIR 664 Article 3
ATSP	Safety assessment	Implementation of DAR	ATSP functional system	CIR 373 ATS.OR.205
USSP/CISP	Safety support assessment	USSP/CISP certification	USSP/CISP functional system	CIR 664 Articles 14 & 15
UAS operator	Operational risk assessment	Specific category operations	ConOps of the operation Operations manual	CIR 947 Article 11

7.1 USSP AND SINGLE CISP CERTIFICATION

The requirements for the application for USSP certification, and the conditions for obtaining a certificate are described in Articles 14, 15, and 16 of [EU, 2021/664], and its AMC/GM [EASA, 2022]. While this process is separate from the ARA, USSPs and single CISPs will be required to demonstrate a level of performance established for the U-space in accordance with Article 3(4), which are to be determined based on the ARA outputs. Therefore, it is recommended this dependence be considered during the ARA project, to ensure a proper alignment between ARA and later USSP certification.

To facilitate harmonisation and interoperability, U-space service requirements defined during the ARA should be described in the form of functionality, performance, integrity, and/or reliability requirements, which should be technology-agnostic where possible. These requirements may also be based on recognised standards, where appropriate.

In addition, any possible safety gaps between the outputs of the ARA and the scope of the safety support assessment performed by a USSP and single CISPs to obtain its certificate to provide U-space services or common information services should be properly addressed.

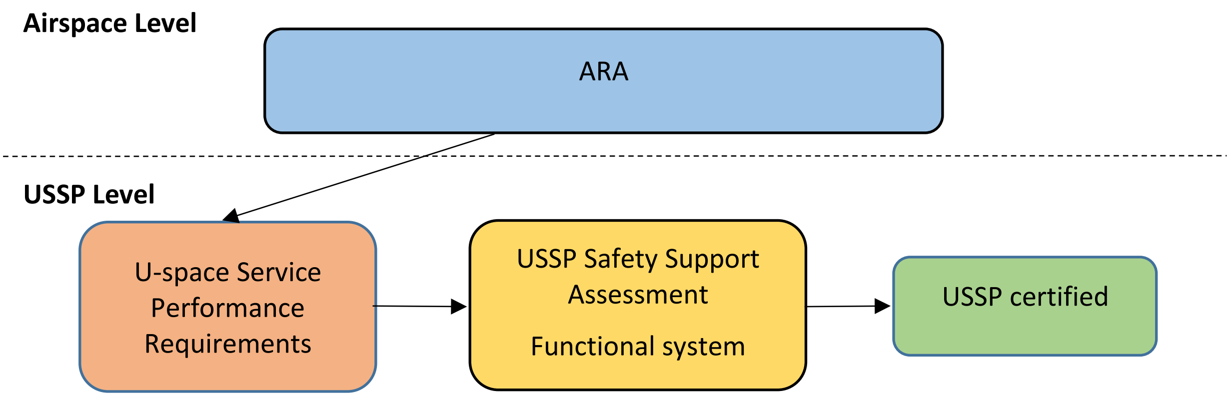

Figure 7 – Links between ARA and USSP Certification

7.2 SORA ALIGNMENT

UAS operators conducting operations in the Specific category within the proposed U-space airspace should be required to comply with [EU, 2019/947]. For operations performed in the Specific category, the applicable requirements may include the execution of risk assessments based on the SORA methodology, or the adoption of conditions and limitations given by STS or PDRA, which also consider the SORA methodology.

The SORA methodology Annex D up to version 2.5 describes UTM services as possible means of complying with the TMPR for the detect function for BVLOS operations. Future SORA versions are expected to include additional considerations of the UTM/U-space for the evaluation of the air risk and the definition of acceptable mitigations.

Therefore, the SORA process followed by UAS operators might be affected by the outputs of the ARA in the following aspects, which will vary according to the SORA methodology version followed:

- As part of the Reference Scenario phase, population density maps should be produced. It is recommended to align the data format used in these maps with the SORA method, helping UAS operators in identifying the appropriate intrinsic GRC to their operations. Note that while SORA version 2.0 uses a qualitative classification, SORA version 2.5 proposes a quantitative classification for the identification of intrinsic GRC.
- The airspace designated as U-space airspace might have an intrinsic ARC classification different from the classification prior to U-space airspace designation. It is recommended to determine the ARC classification applicable to the U-space airspace and make this information available to UAS operators. Guidance material is available in GM4 to Article 3(4) in [EASA, 2022]).

Additionally, states may create guidance for UAS operators on how to use the outputs of the ARA to justify different levels of compliance with the TMPR and OSOs required by the SORA methodology.

7.3 SAFETY ASSESSMENTS OF CHANGES OF AFFECTED ATSPS

As described in Section 5.2, the designation of U-space airspace in controlled airspace will affect the ATSPs that provide ATC service in that airspace. Therefore, the affected ATSPs should conduct a safety assessment of the changes in their functional systems. The changes that should be covered in the scope of this kind of assessments are:

- How the designation of U-space airspace affects the provision of ATC services to existing airspace users.
- The means (e.g. equipment, software) needed to activate and manage DAR.
- The procedures to activate and manage DAR.
- The training for the personnel in charge of activating and managing DAR.
- The interactions and interfaces with the relevant U-space actors (e.g. single CISP when designated, USSPs).
- Any other aspect as deemed necessary.

Although these aspects are exclusive to ATSPs (i.e. not covered by ARA), other aspects related to DAR are within the scope of the ARA and should be coordinated with the affected ATSPs during the ARA project. In this regard, ARA is expected to cover:

- The inner structure of the U-space airspace. This includes the creation of pre-defined volumes and/or other structures, such as a grid, to facilitate a smart application of DAR.
- The definition of the means and procedures for disseminating information regarding DAR (e.g. initial communication from CISP to USSPs and further acknowledgements), which should also consider the timeliness aspects related to information exchanges.

7.4 REVIEW REGULATORY GAP ASSESSMENT

The regulatory gap analysis should be reviewed in the light of the safety assessment.

8 CONCLUSIONS

An ARA related to drone use has many similarities with traditional airspace design. At its simplest, it involves taking a critical look at a certain airspace volume to identify the types of operation that will be conducted in that airspace and examining the associated air and ground risks. In addition, the safety assessment will provide the requirements on the change to the functional system that will ensure that risks in normal, abnormal, and failure conditions have been identified and can be mitigated.

The results of an ARA can lead to a possible redesign of the airspace, set CNS requirements, or identify requirements for restricting access to certain volumes. In addition, the outcome can be used to define and validate areas and levels of air and ground risk as mentioned in the SORA. Finally, an ARA will define the levels of performance necessary from U-space services, USSPs, an UAS that will be authorised to fly in the assessed U-space airspace.

ARAs provide the necessary groundwork, involving all the necessary stakeholders, for allowing the designation of a safe U-Space airspace.

From time to time, it will become necessary to re-assess existing U-space airspaces for which major changes are planned, to ensure that new situations are considered. This will be covered in a separate document.

This document provides an initial methodology for what is a new approach. A second volume will be published that provides more in-depth detail about the safety assessment than has been possible in this document.

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APPENDIX 1 CHECKLISTS AND PLANNING GUIDES FOR THE PREPARATION PHASE

The following checklists and guidelines are provided to assist teams when performing the Preparation phase of an ARA. They are not exhaustive, nor will all the elements given be necessary for every ARA performed.

A1.1 U-SPACE AIRSPACE RISK ASSESSMENT PROJECT

<table>
<tr><td>Project Name</td><td colspan="5"></td></tr>
<tr><td>Start Date</td><td></td><td colspan="2">End Date</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Target Completion Date</td><td rowspan="2"></td><td colspan="4">Estimated Effort (see Preparatory Activities and Requirements)</td></tr>
<tr><td>Days</td><td></td><td>Total PM</td><td></td></tr>
<tr><td>Background & Context</td><td colspan="5"></td></tr>
<tr><td>Project Manager (National level)</td><td colspan="5"></td></tr>
<tr><td>Core Team Members</td><td colspan="5"></td></tr>
<tr><td>Support Team Members</td><td colspan="5"></td></tr>
<tr><td>Internal Reporting To</td><td colspan="5"></td></tr>
<tr><th colspan="6">Strategic Considerations</th></tr>
<tr><td colspan="6">Objectives</td></tr>
<tr><th colspan="6">Design Considerations</th></tr>
<tr><td colspan="6">Objectives</td></tr>
<tr><td colspan="6">Scope</td></tr>
<tr><td colspan="6">Dependencies</td></tr>
<tr><td colspan="6">Major concerns/risks to be addressed (if any)</td></tr>
</table>

A1.2 PREPARATORY ACTIVITIES AND REQUIREMENTS

Working arrangements	
• Appoint members of UAS airspace assessment team • Appoint project support team • Produce project management plan	
Number of working days required to set up working arrangements	
Identify policy and regulatory material	
• Identify regulations in force or in development • Gather safety policy, safety assessment requirements and guidelines • Gather environmental policy and guidelines • Other applicable regulation	
Number of working days required to identify relevant policy and regulatory material	
Assessment of environmental constraints	
• Review specific environmental aspects that need to be taken into account (that are not included in “ground risks” and the “regulatory framework”)	
Number of working days required to assess environmental constraints	
Produce initial inventory of elements to be taken into account in the risk assessment	
• Checklists to be completed by stakeholders o Urban risks o Other ground risks o Air risks o Communications, Navigation and Surveillance risks	
Number of working days required to identify the risks to be assessed	
Other aspects to be considered	
• Other elements could affect the smooth execution of the assessment, or need to be taken into account by it. These could include specific national values, habits, culture etc.	
Number of working days required to identify other relevant aspects	

A1.3 AIRSPACE ASSESSMENT ACTIVITIES

Assessment of the regulatory framework	
• Perform a gap analysis to understand what new regulations might be required and where there are regulatory conflicts, if any	
Number of working days required to perform a regulatory assessment	
Building the reference scenario	
• Define the airspace volume being assessed • Define ground infrastructure and non-aviation issues • Research relevant Aeronautical Information Publication (AIP) data • Interviews with stakeholders • Specify existing UAS traffic types and how they are currently managed • Describe the technical support infrastructure • Describe how weather and environmental constraints are currently considered • Other aspects to be considered • Produce written reference scenario	
Number of working days required to produce the reference scenario	
Assessment phase	
• Security risk assessment • Privacy risk assessment • Environmental risk assessment • Safety risk assessment • Define Safety Requirements based on the results of the safety assessment • Produce safety assessment report	
Number of working days required to produce the risk assessment	
Produce assessment report	
• Write a full assessment report based on the template provided	
Number of working days required to write the assessment report	

A1.4 ASSESSMENT STAKEHOLDERS

National/state entities	CT[3]	ST	Organisation	Point of Contact	Email
Competent authorities					
ATM/ANS service provision (ANSPs)					
Air traffic controllers (ATCOs)					
Police and state security					
State defence/Military					
Customs					
Aviation entities	CT	ST	Organisation	Point of Contact	Email
Flight information service					
Aerodrome operators					
Airlines					
Pilots (GA, IFR, emergency services)					
Flight schools					
UAS operators/pilots					
U-space service provider (USSP)					
UAS manufacturers					
Model aircraft clubs, air-sports associations, and aviation-related associations					
General aviation representatives (VFR)					
Non-aviation entities	CT	ST	Organisation	Point of Contact	Email
Critical infrastructure (nuclear facilities, etc.)					
Industry					
Local government					
Hospitals					
Education/schools					
Road and rail transport					
Ports and the maritime sector					
Telecommunications and others that emit electro-magnetic waves					
Telecommunications					
Forestry and environmental protection (including non-governmental organisations (NGOs))					
Others					

[3] CT = Core-team member; ST = Support-team member

A1.5 ACTION PLAN FOR AIRSPACE RISK ASSESSMENTS

	Action	Responsible/Resource	Target Date
Pre-preparatory phase			
0.	Description of Concept of Operations (ConOps): • Direct applicability from EU regulation • Operational architecture • Obligatory U-space services to be provided • State and military UAS operations		
Preparatory phase			
1.	Scope setting: • Creation of the assessment teams (core and support) • Definition of the objective of the assessment • Definition of airspace volume being assessed • Initial regulatory inventory (aviation, UAS, environment, privacy, security, other) • Initial infrastructure inventory • Definition of assumptions and constraints		
2.	Produce scoping document		
Reference Scenario Phase			
3.	Overview of applicable regulation • Complete list of applicable regulation • Impacts of applicable regulation • Optional regulatory gap assessment		
4.	Data collection: • Aeronautical ground facilities • Airspace structures and standard procedures • Air traffic characteristics and volume • Population density maps • Human-made obstacles • Natural obstacles • Environmentally protected areas • Historical weather • CNS infrastructure and performance		

	• Flight data regarding existing UAS operations		
5.	Interviews, cross-checking, and validation: • Interview stakeholders • Catalogue of use cases		
6.	Produce Reference Scenario document		
Assessment Phase			
7.	Conduct: • Security risk assessment • Privacy risk assessment • Environmental risk assessment		
8.	Produce a report with the findings of security, privacy, and environmental assessments		
Safety Assessment			
9.	Safety Criteria • Identify hazards inherent to aviation • Impact analysis of the change • Setting the Safety Criteria		
10.	Safety Specification • Normal conditions • Abnormal conditions • Failure conditions		
11.	Safety Requirements • Normal conditions • Abnormal conditions • Failure conditions		
12.	Other activities • Validation activities • Verification activities • Specify list of monitoring criteria		
13.	Produce the safety assessment report		
Finalisation			
14.	Consolidation, review Produce final ARA report		

A1.6 SCOPING DOCUMENT TEMPLATE

1. Introduction
   1.1. Objectives of this document
   1.2. Intended audience
   1.3. The need for an airspace assessment
   - Background including policy and regulations
   - Objectives
   - Scope of the assessment
   - Dependencies to be considered
   - Major concerns/risks to be addressed

   1.4. Elements of an airspace assessment
   - Inventory of risks and regulations
   - Building the reference scenario
   - Risk assessment

   1.5. Structure and contents of this document
2. Working arrangements and management
   - The core team and its members
   - The support team and its members
   - Other stakeholders involved
3. An inventory of the risks to be assessed
   - Urban perspective (population density; drone zones; environmental requirements).
   - Ground risks
   - Air risks
   - Communications, Navigation and Surveillance risks
4. An inventory of the regulatory framework
   - The regulations applicable to the airspace volume, including environmental and planning
5. Assumptions, constraints and other aspects
   - Any assumptions or constraints, if any, that could affect the validity of the assessment
   - Any other aspects that could have a bearing on the successful completion of the airspace assessment

Reports			
Report Type	Due Date	Person Responsible	Consultation Period
Draft Report			
Review			
Final Report			

Outstanding Actions/Issues		
Action	Due date	Person Responsible

APPENDIX 2 DATA COLLECTION CHECKLISTS

These non-exhaustive checklists should be used by all stakeholders for providing an initial understanding of potential risks they know of. This should then be elaborated through interviews.

Ground risks	
Airport/aerodrome ground operations	
• Critical aerodrome areas ○ ILS critical and sensitive areas, radar, etc.	
Populated areas	
• Boundaries of static population density areas ○ cities and suburbs	
• Boundaries of dynamic population density areas ○ Recurring or one-off events and gatherings (concerts, stadiums, beaches, etc.)	
• Schools, hospitals, and other public buildings	
Security and Critical infrastructure	
• Government/Military installations	
• Prisons	
• Bridges and dams	
• Telecommunication and data centres	
• High-tension power lines and substations	
• Nuclear and conventional power stations	
• Chemical industry sites	
• Laboratories	
• Main roads, railway lines	
• Ports, harbours, and waterways	
• Water treatment plants	
• Restricted, prohibited, and danger areas	
• Summits and VIP protection	

Air risks	
Generic airspace restrictions	
ATS routes • Airways • Conditional routes	
Aerodrome areas and zones • control zones (CTR) • terminal control areas (TMA) • aerodrome traffic zone (ATZ);	
Manned-aviation restricted areas • temporary reserved area (TRA) • temporary segregated airspace (TSA) • cross-border area (CBA) • radio mandatory zone (RMZ) • transponder mandatory zone (TMZ)	
Restricted airspace and no-drone zones	
Nature reserves and other noise-sensitive areas or environmentally sensitive areas	
Aerodrome operating hours, dimensions, and location	
Manned aircraft operations, locations, and most common routes	
Unmanned aircraft operations, locations, and most common routes	
Heliports and aerodromes	
Airport operating hours, dimensions and location	
IFR operations	
• Arrival and departure routes	
• Transit routes	
• Radar vectoring areas	
• Altitudes	
VFR operations	
• Common VFR routes and corridors	
• Operations below 150m (500ft)	
• Low-altitude military operations	
Generic operations	
• High probability of manned or unmanned traffic (HEMS, etc.)	
• Gliders, microlights	

• Balloons	
• Seasonal or permanent recreational activities	
• Base jump, wing suits, kite surfing, parachuting, parasailing, hang-gliders, paragliders, etc.	
State-specific operations	
• Police	
• Customs, border control	
• Firefighting	
• Military	
• Search and rescue	
• Maritime and fisheries surveillance	
• Operators of essential services	

Communication, Navigation and Surveillance (CNS)	
Communication	
• COM — VFR requirements, frequencies, radio, transaction expiration time (TET)	
• COMSEC — UAS COM interference, USSP–UAS link, USSP–RP, RP–USSP, e-conspicuity system	
• UAS COM and uncontrolled manned aircraft traffic (e-conspicuity) frequency availability, including coverage of 3/4/5G network	
Navigation	
• Navigation requirements and/or limitations (for U-space)	
• GNSS performance including outage reports and augmentation (GBAS, SBAS, etc.) availability	
Surveillance	
• Critical surveillance areas (coverage, etc.)	
• Available means of surveillance (ADS-B Out, SRD 860, mobile telephony (e.g. GNSS-LTE), etc.)	

APPENDIX 3 REFERENCE SCENARIO TEMPLATE

1. IntroductionObjectives of this document
   - Intended audience
   - Scope (vertical and horizontal limits of the assessed airspace volume)
   - Aviation regulation
   - Other regulation
   - Regulatory gap analysis (optional)

   3.1. Aeronautical data
   - Ground facilities
   - Airspace structures and standard procedures
   - Air traffic

   3.2. Urban environment
   - Population
   - Obstacles in the urban environment

   3.3. Critical infrastructure

   3.4. Terrain and natural features

   3.5. Meteorological conditions

   3.6. Communication, navigation, and surveillance (CNS)
   - Communication
   - Navigation
   - Surveillance

   3.7. UAS flight-data collection
   - UAS operations records
   - Monitoring of UAS flights (optional)
   - List of applicable requirements
4. Interviews, cross-checking, and validation

   4.1. Interview planning and preparation

   4.2. Outcomes of conducted interviews

   4.3. Catalogue of use cases
5. Other aspects to be considered[any other aspect of interest not covered by previous items]
6. Reference Scenario dataset[appendixes/links regarding the generated datasets, as necessary]

Reports			
Report Type	Due Date	Person Responsible	Consultation Period
Draft Report			
Review			
Final Report			

Outstanding Actions/Issues		
Action	Due date	Person Responsible

APPENDIX 4 EXAMPLE OF A REFERENCE SCENARIO PHASE

An ARA involves identifying stakeholders, decision-makers, regulatory aspects, and environmental considerations. A reference scenario is created of the current situation in the airspace volume assessed, using a list of data collected from aviation and non-aviation entities. The reference scenario building blocks and some of the results from several different ARAs are given below.

A4.1 AERONAUTICAL DATA

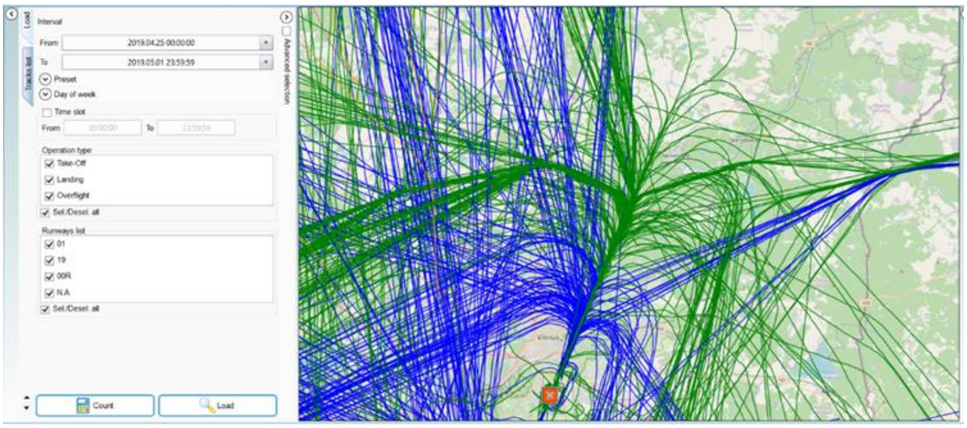

Figure 8: Take-off and landing from RWY01 and RWY19 at Vilnius

All available aeronautical data are collected from sources such as the AIP and the local ANSP – see Figure 8. This includes approved flight trajectories and special use areas such as:

- Geographical dimensions of airspace structures;
- IFR flight procedures;
- VFR routes;
- Drone tracking routes.

A4.2 AIRFIELDS, CRITICAL INFRASTRUCTURE AND OBJECTS RELATED TO NATIONAL SECURITY

UAS operations close to the airfields, critical infrastructure, and objects related to national security need to be analysed to determine where and when they should be restricted and require agreement from relevant authority.

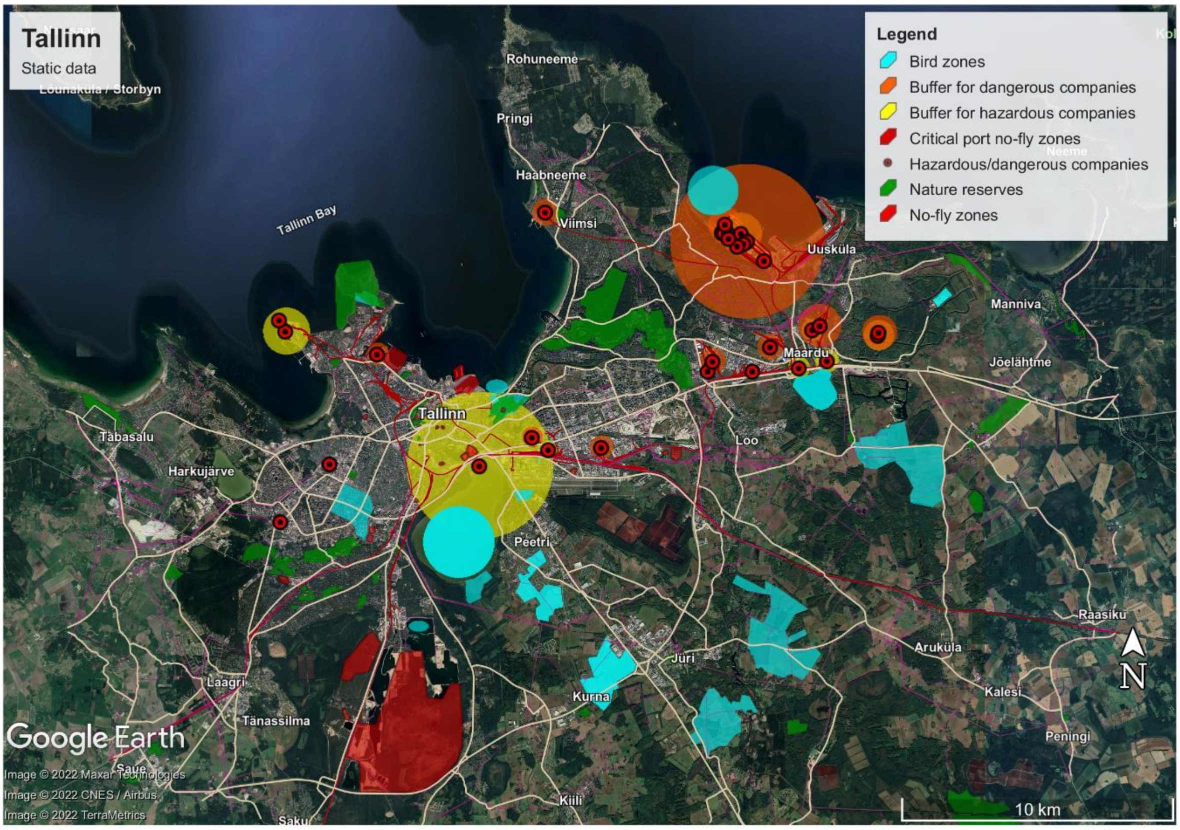

Figure 9: Critical and hazardous areas and sites in Tallinn

Three categories of critical infrastructure and other security-related zones can be defined:

- Zones requiring operational authorisation from a National Authority:
  - Certified airfields
  - Restricted and dangerous areas
- Zones requiring agreement from the owner or operator:
  - Zones at risk of Industrial accident;
  - Property owned or used by the national bank etc.;
  - Military infrastructure zones;
  - Infrastructure relating to ensuring public order and security, state border security and civil protection;
  - Prisons.
- Zones where special conditions apply:
  - Schools/hospitals
  - Roads, streets, bridges;
  - Railways;
  - High-voltage power lines;
  - Cemeteries.

An example of these is given in Figure 9. Much of this information is available in formats compatible with geographical information systems (GIS) such as Google Earth. Such a GIS is the best means of storing and displaying this information (see “A4.5” below).

A4.3 FLIGHT DATA MONITORING AND ANALYSIS

Monitoring and archiving drone flight data is a challenge. However, these data help determine which volumes of airspace present safety issues. Drone activities should be monitored at irregular times and with the detection system at different physical locations, if possible.

The focus of the monitoring of drone activities is on the distance between detection system and drone and in addition to obstacles and other technical factors that affect this process. The monitoring should be performed at different times at different locations to both obtain the data and gain experience in detection and prevention of illegal UAS operations.

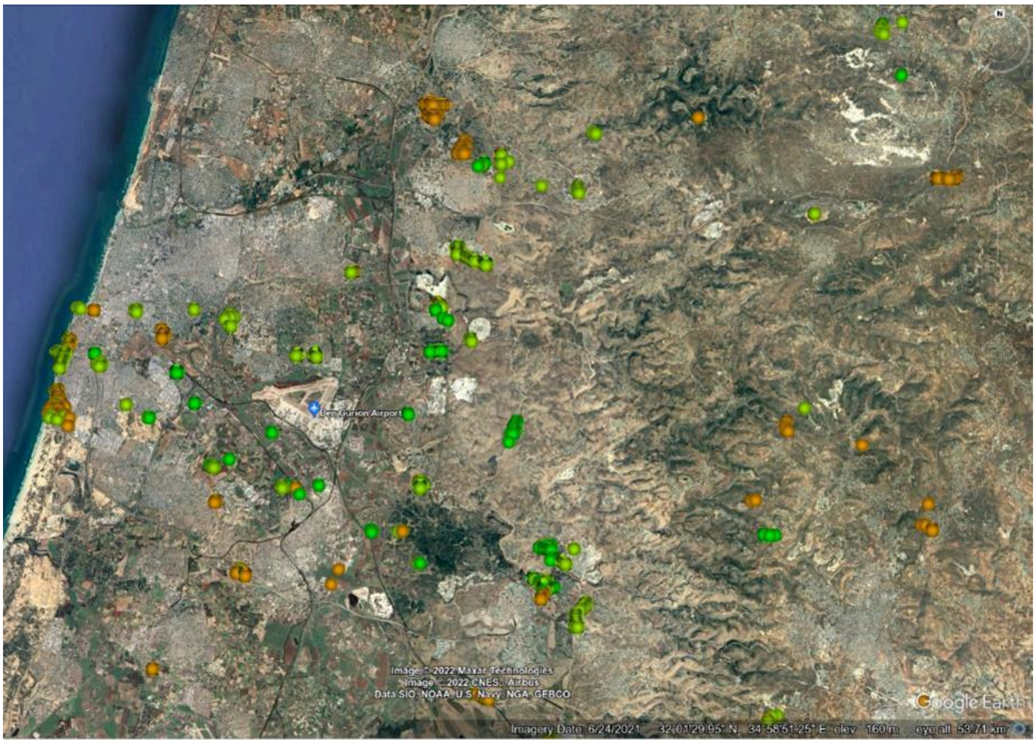

Figure 10: One day's DJI Aeroscope data for the area around Ben Gurion airport ©2023 KRONOS Group, Israel

Figure 10 shows drone detection from several DJI Aeroscopes for one day near Ben Gurion airport. Each dot represents a detected drone; a line of dots therefore represents a trajectory over time. The dots are colour-coded according to the following scheme:

- Dark green: drones flying below 50m above ground level (AGL);
- Yellow/green: drones flying between 50m and 120m AGL;
- Orange: drones flying between 120m and 500m AGL;
- Red: drones flying above 500m AGL.

The number of illegal drone flights is clearly visible.

Figure 11 shows the drone flights detected around the EUROCONTROL Innovation Hub in the Paris region. It can be seen that the data gave a comprehensive overview of the large amount of airspace use by drones.

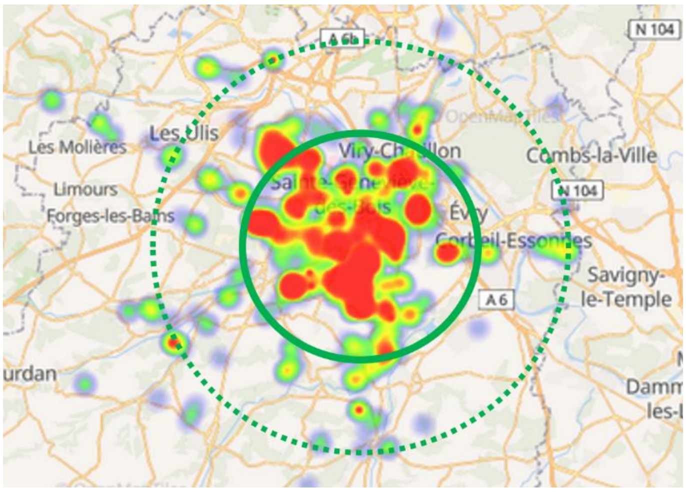

Figure 11: Heatmap of drones detected in the vicinity of EUROCONTROL Innovation Hub, France

Further analysis can reveal the somewhat concerning information that, while the great majority of these drones flew below the 150m threshold defined by the legislation, some 8% of them flew above this limit, and nearly 1.5% flew above 500m. The highest flight recording during the 17-week survey was at 2,500m (8,000ft) – well above flight paths.

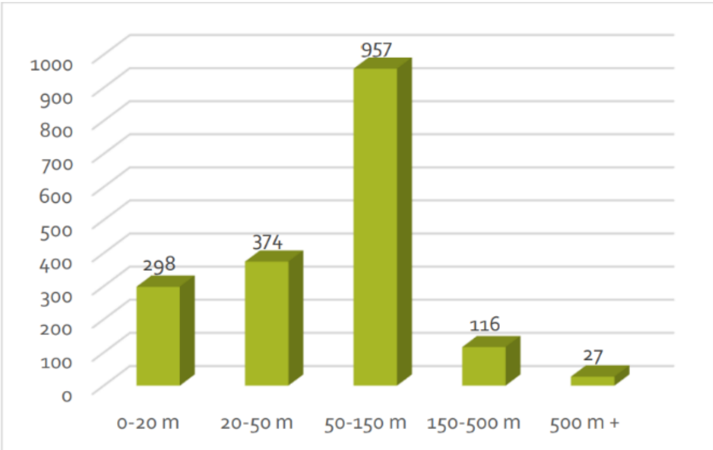

Figure 12: Altitudes of drones detected over a 17-week period

A4.4 POPULATION DATA

The ground risk due to drone flights is composed of two parts: risk to infrastructure/property; risk to human life. It is, therefore, vital to know the population density under the airspace volume being assessed. This population density will feed into the ground-risk class (GRC) used in the operational risk assessment.

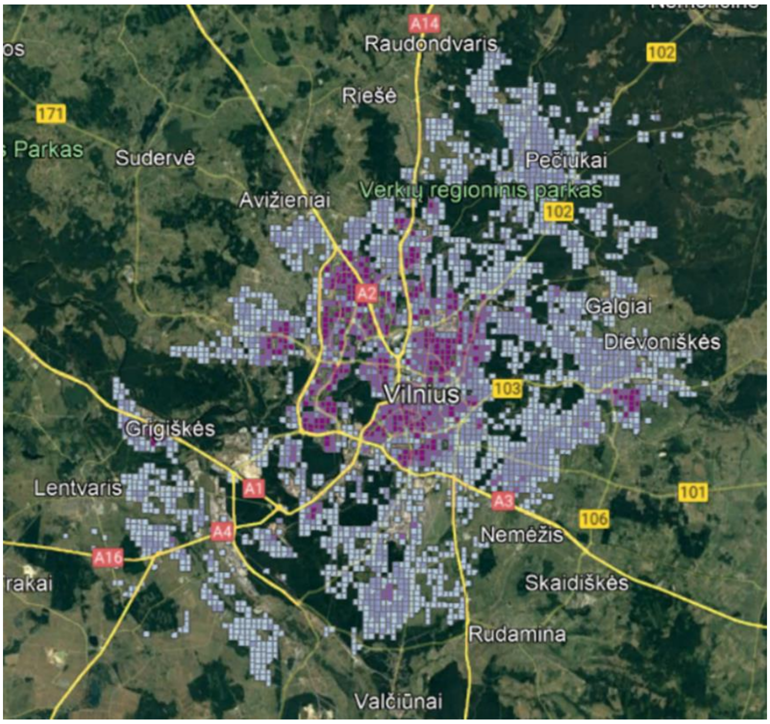

Figure 13: Population density map of Vilnius

Data such as the population density map shown in Figure 13 can only provide static information. On the other hand, many gatherings can be ephemeral, only lasting for a few hours or a few days, and may occur at many different places. Municipal police or similar can provide information about the number of public gatherings per year for various public events such as ceremonies, state government events, celebrations etc. Some of these events occur in the same location regularly, while others will be specifically planned at various locations.

During the airspace assessment, these gatherings should be treated as dynamic data since, even though there are places where they might be usual at specific times, they are still a variable factor and static data would not therefore determine the actual operational scenario.

A4.5 DATA VISUALISATION

An airspace assessment for low level UAS operations entails the combination of multiple data sources and addresses the needs of a wide variety of local stakeholders and airspace users. The visual representation of the available data enhances situational awareness for all parties involved. Data visualisation for a specific airspace can bring together ground infrastructure, airspace structure, and operational data in an integrated picture, revealing possible interactions and conflicts.

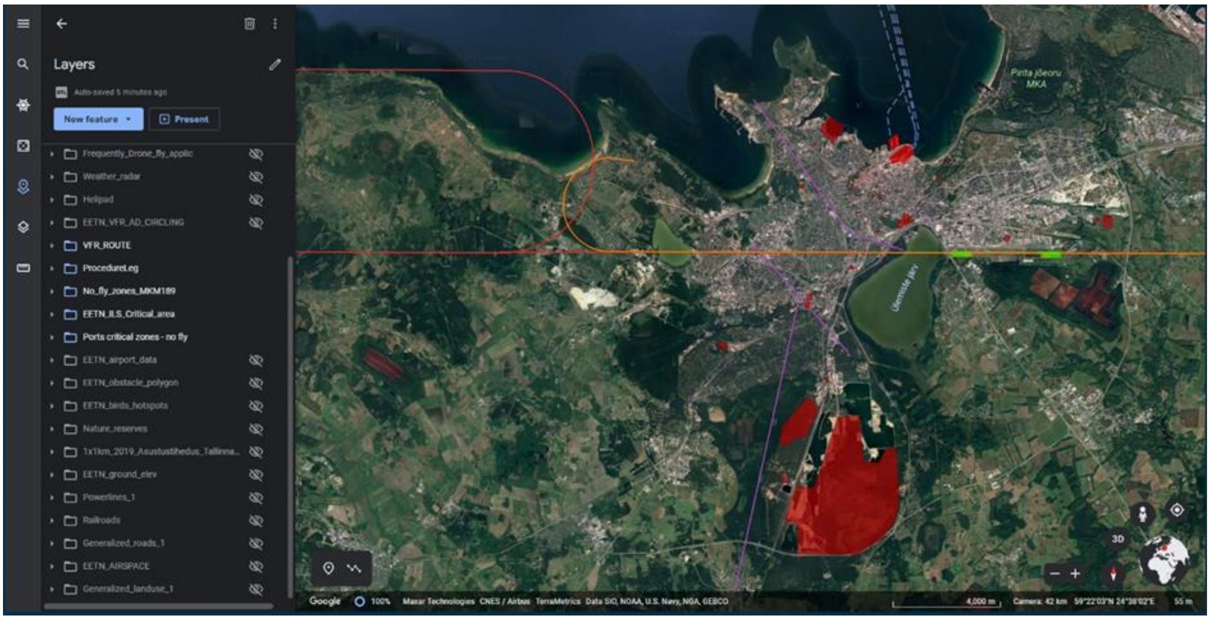

Figure 14: Google Earth GIS for Tallinn, showing a selection of the possible layers available

The process described in this section is intended to serve as an example, as there can be numerous visualisation tools and possible data sources. When choosing a 3D-visualisation tool it is important for it to have the capability to introduce volumes, image overlays, and paths/trajectories.

The visualisation should evolve alongside the progress of the airspace assessment. Some data are fixed and not expected to change (e.g. VFR maps) while others will be enriched and/or adjusted during the airspace assessment. The three layers foreseen to cover all the data collected and available for further analysis are given below, in no particular order.

A4.5.1 GROUND AND INFRASTRUCTURE LAYER

Ground map and terrain data are usually part of the chosen visualisation tool (e.g. Google Earth). The accuracy of these data is important to a certain extent, but the visualisation is not meant to produce operational outputs. This layer includes ground infrastructure such as roads, railway lines, schools, hospitals, parks, historical landmarks etc. that enable the identification of ground risks in the scope of the airspace assessment. Such areas and infrastructure could be the subject of geo-zones that restrict drone entry and protect them from accidents, privacy breeches, environmental degradation, etc. Appendix 2 provides a comprehensive list of data relevant to the airspace assessment that can also be included in the visualisation.

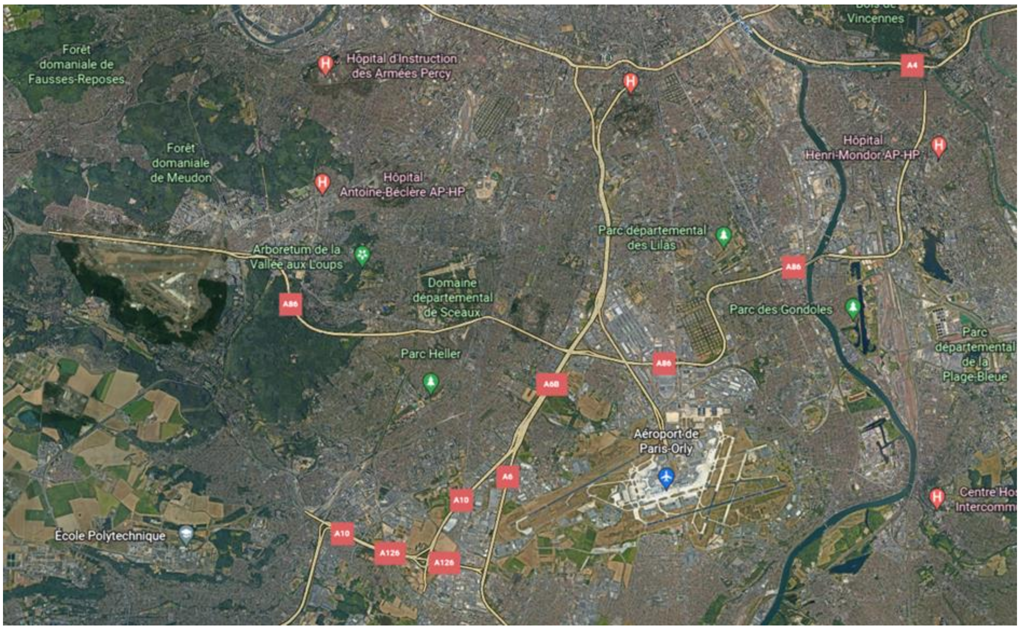

Figure 15: The main roads, hospitals, universities, and parks around Paris Orly airport

Additionally, cellular network coverage and telecommunications data can be very useful, especially for spatial variations in the composition of populations in urban environments.

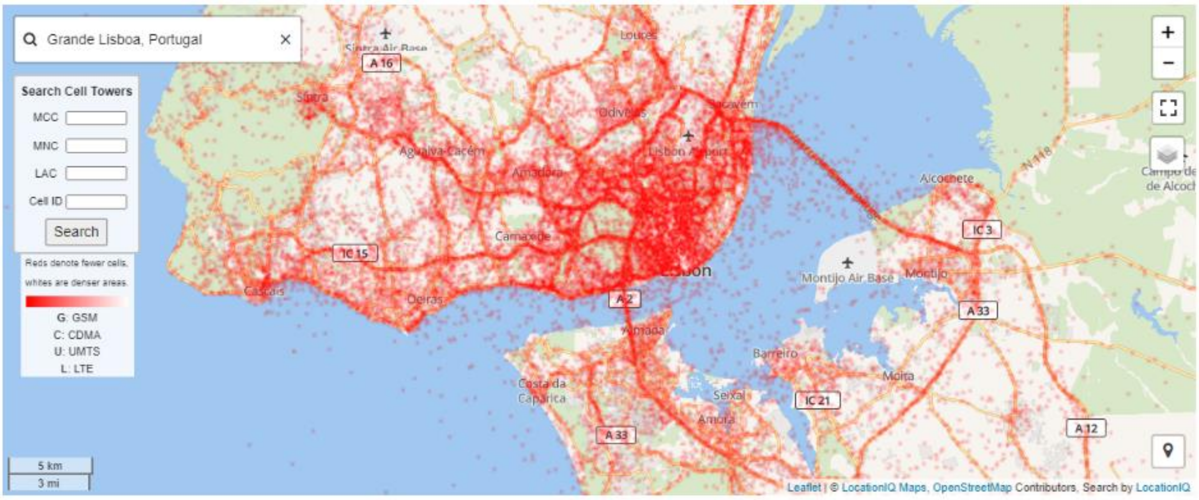

Figure 16: Location of cell connections in the greater Lisbon area

These data can deliver an added value for a more precise understanding of human movement during both the daytime and night-time.

A4.5.2 AIRSPACE DATA LAYER

This layer includes any information that is available on the airspace itself in the area being assessed. The AIP holds an extensive amount of data including ATS routes, navigation warnings, en-route chart navaids, obstacles, noise abatement areas, heliports etc. and any other data relevant to the airspace assessment. Identifying the data that are applicable to the airspace assessment can be time consuming; part of the AIP data might be available in a digital format commonly referred as the eAIP, directly from the competent authority or other validated sources.

Furthermore, this layer enables visualisations of the position and profile of routes, airspace volumes, and airspace sectorisation in the volume of airspace being assessed.

VFR charts are an important element of this layer since they include a mix of ground and aeronautical information that is useful for low-level airspace users such as helicopters, general aviation, hobbyists etc. It is common for VFR charts to be provided by relevant national authorities, either freely accessible as an online map or as a purchasable product. A number of online communities offer VFR map data in various forms (pdf, raw data, various data formats) but the data validity and accuracy need to be verified.

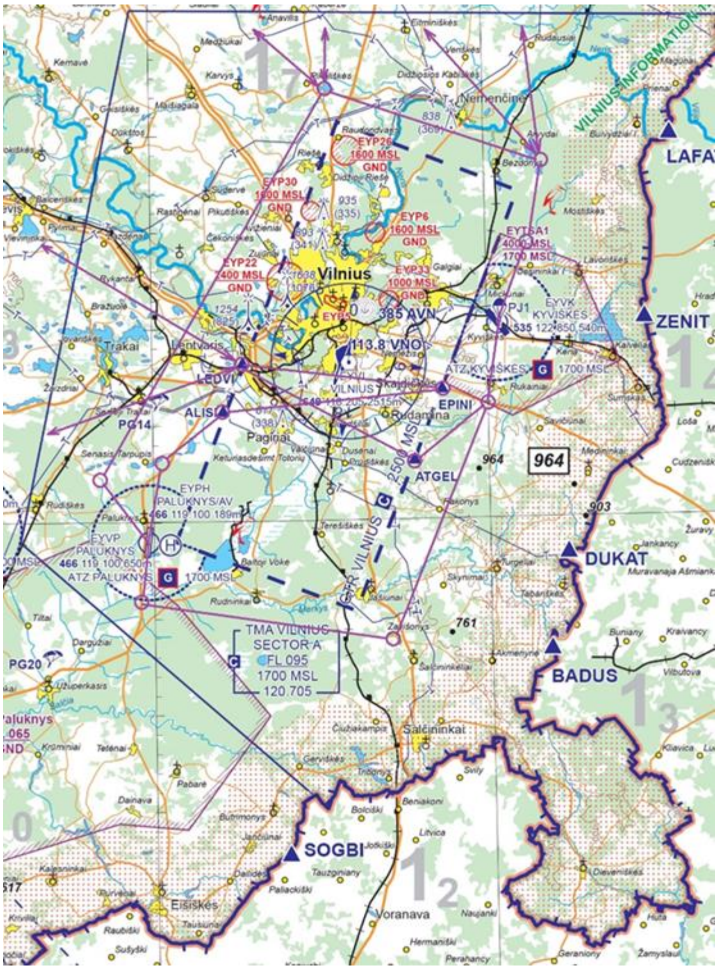

Figure 17: Most common routes in and around Vilnius CTR ("Vilnius Tech AGAI")

eAIP data is provided by ANSPs in xml format to be efficiently used by downstream users. The eAIP file published by each stakeholder can therefore be manipulated in a way that allows its visualisation. The data are usually visualised in online tools hosted on the relevant ANSP websites; some even convert NOTAMS into a visual 3D representation. On the other hand, online communities provide AIP data directly in popular geospatial data formats (e.g. GeoJSON, KML, KMZ) and even offer tools that convert the eAIP files into these formats.

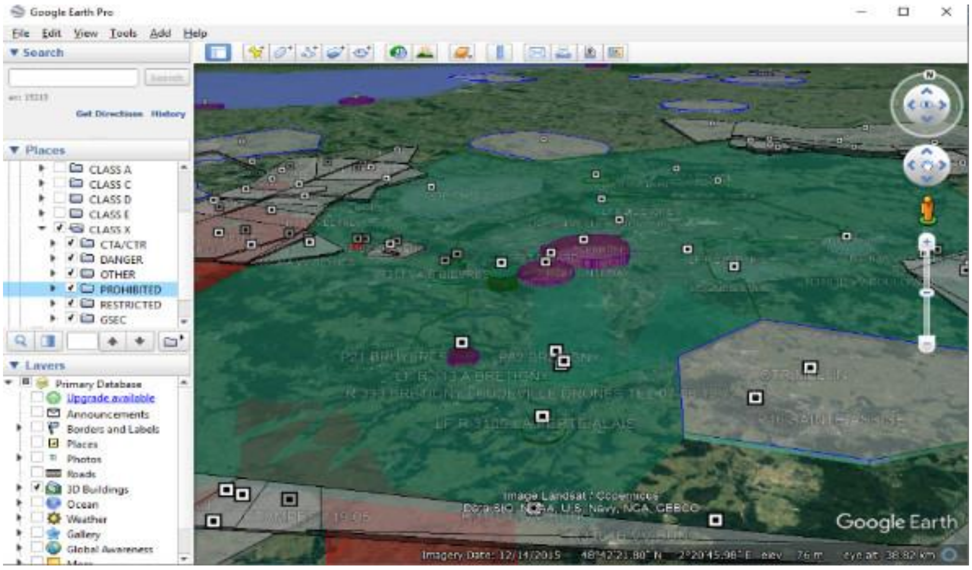

Figure 18: Visualisation of the airspace structure above Paris

There are many airspace users other than "normal" IFR and VFR aircraft traffic. Paragliders, wingsuits, and hot-air balloons are all users of the airspace and areas and times where such pursuits take place should be recorded. While the first of these are generally quite limited in the volumes they occupy, hot-air balloons may travel great distances in whichever direction the wind takes them (see Figure 19).

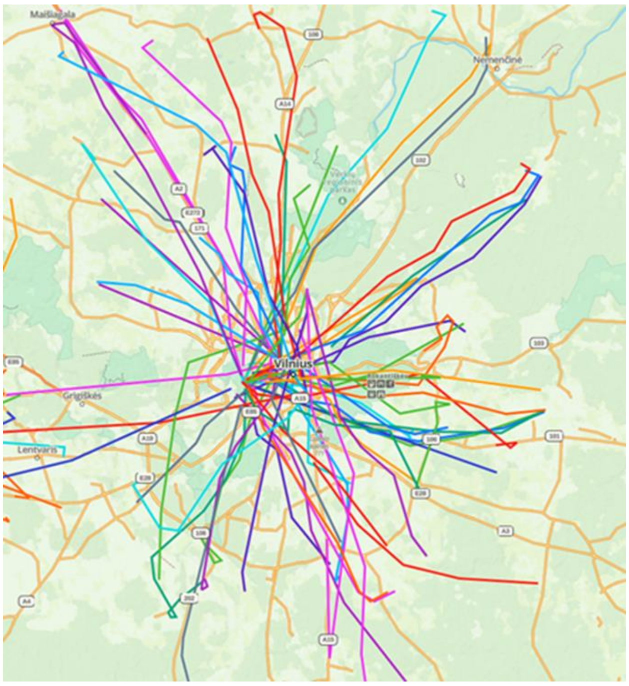

Figure 19: Hot air balloons routes in Vilnius CTR during flying season

A4.5.3 OPERATIONAL DATA LAYER

In contrast to the previous layers that hold fixed and pre-defined data, this layer shows how airspace users actually operate within the volume being examined. In this layer, it is important to identify the operational safety risks and therefore add procedures such as Standard Instrument Departure (SID) and Standard Arrival (STAR), as well as ATS routes.

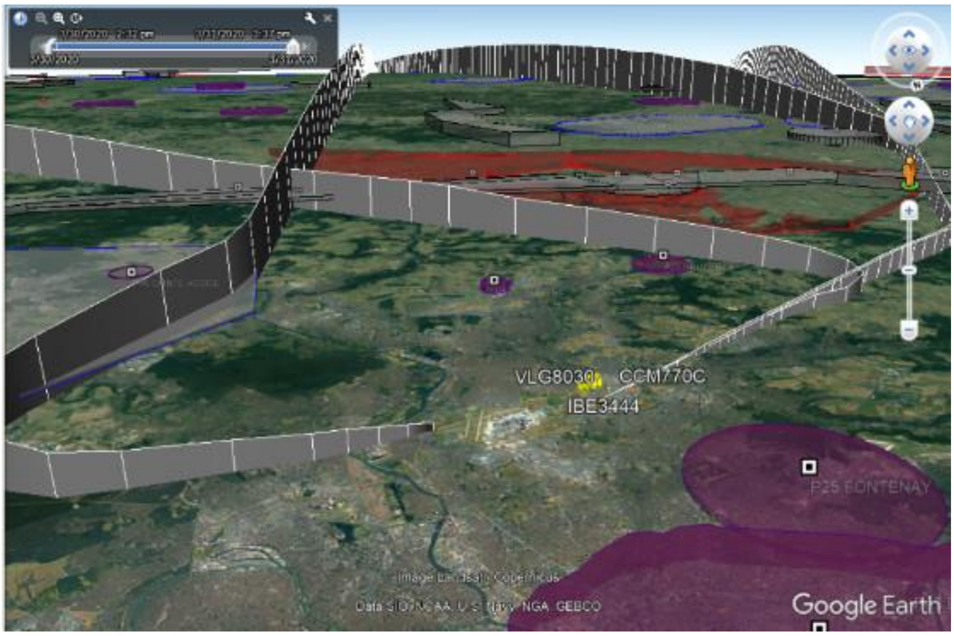

Figure 20: ADS-B trajectories of arrivals and departures at Paris-Orly airport

In addition, it is imperative to visualise the trajectories of manned aircraft, which may be simplified or approximate for many reasons. ADS-B trajectories can be retrieved from a number of sources and directly inserted into visualisation tools such as Google Earth. Inserting a number of departure and arrival trajectories can reveal important information about the true trajectories flown (e.g. altitude, deviations) but this information has to be validated/confirmed and analysed with the local ANSP.

Unmanned aircraft trajectories are a very useful component of the visualisation as they can reveal the extent/nature of drone operations in the volume being assessed and underline the importance of the airspace assessment. Drone flight data are not readily available and obtaining them is not easy. One option is to use the data collected by the national entities: drone manufacturers and/or local authorities may already provide software for flight planning and position reporting purposes. However, another option is to collect data during the airspace assessment by deploying dedicated receivers (e.g. DJI's Aeroscope).

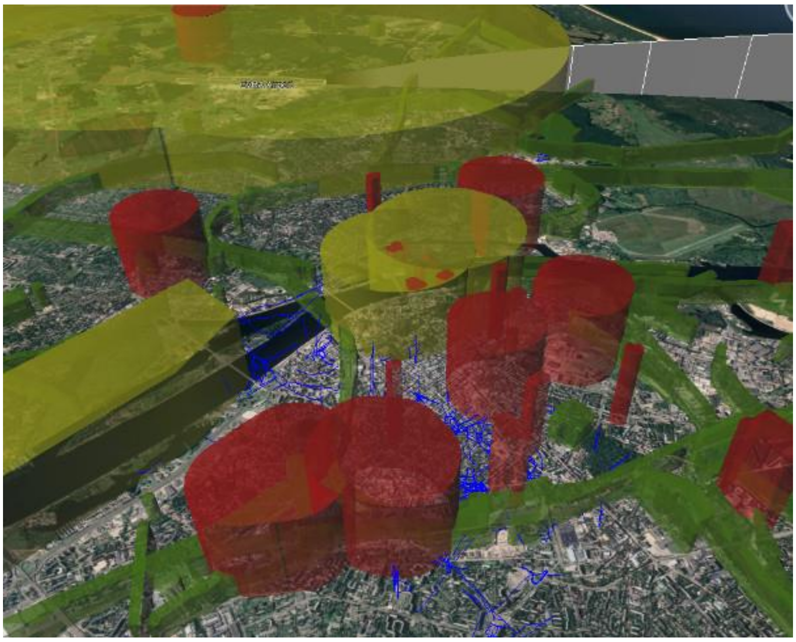

Figure 21: Visualisation of the airspace assessment in Riga CTR (elements from all layers)

APPENDIX 5 CONTENT OF THE CONOPS AND DESIGN DOCUMENTS

The definition of the ConOps, supplemented by a series of design documents, is a pre-requisite to the Assessment Phase of an ARA for evaluating safety, security, privacy, and environmental risks. The ConOps necessary for conducting an ARA that supports the designation of U-space airspaces(s) must describe how operations will be performed in the U-space airspace after it has been designated, thus defining the change that will be assessed. This description concerns decision-making that goes beyond the scope of the ARA, including for instance decisions made at a national level. Hence, it is anticipated that the ConOps will be provided as an input to the Assessment phase of the ARA project, having considered the outputs of the Reference Scenario phase for its definition. Later, the ConOps, along with the related design documents, will be updated according to the findings of the Assessment phase.

[EU, 2021/664], and its AMC/GM [EASA, 2023] are the main sources for describing how U-space airspaces function and should serve as the baseline reference for the ConOps. Additional relevant information is available in [EU, 2021/665] and [EU, 2021/666]. While [EU, 2021/664] mandates most aspects related to the functioning of U-space airspaces, there are certain aspects that are left to individual states' discretion for national implementation, based on their specific requirements. Therefore, the ConOps should address both the general and specific aspects describing the functioning of the planned U-space airspace(s), complemented by the findings of the Reference Scenario phase.

At the very least, the ConOps and related design documents should cover the following aspects (note: an initial version of the ConOps might have a reduced content, in which case it should be completed during the Assessment phase to cover the following aspects):

1. Objectives: Clearly state the objectives of the U-space airspace, such as improving safety, increasing efficiency, and promoting innovation in the UAS industry. This section should also define the scope of the U-space system, including the types of UAS operations and the airspace where U-space will be implemented.
2. Roles and Responsibilities: Identify the roles and responsibilities of U-space service providers, UAS operators, and other stakeholders involved in the U-space system. This section should outline the requirements for UAS registration, pilot training, and certification, as well as the responsibilities of U-space service providers for airspace design, flight planning, and conflict resolution.
3. Airspace Design: Describe the airspace design for the U-space airspace functional system, including the classification of airspace and the limitations to UAS operations that will be applied in each area. This section should also include the requirements for UAS communication and surveillance equipment, as well as the procedures for accessing and using the U-space system.
4. Operational Concepts: Describe the operational concepts and procedures for the U-space functional system, including the flow of information between U-space service providers, UAS operators, and other stakeholders. This section should also include the procedures for reporting incidents and accidents involving UAS.
5. Technical Requirements: Outline the technical requirements for the U-space functional system, including the communication protocols, data exchange formats, and software interfaces that will be used to exchange information between U-space service providers and UAS operators. This section should also describe the performance standards for UAS equipment, such as navigation and surveillance systems.
6. Architectural Concepts: Describe the architectural concepts and principles that will guide the design and implementation of the U-space functional system. This could include the use of open standards and interfaces, the integration of existing airspace management systems, and the

scalability and adaptability of the U-space system to accommodate future growth in the UAS industry.

7. Regulatory Conditions: Outline the regulatory conditions that will govern the operation of UAS in the U-space airspace, including the applicable laws and regulations, certification requirements for UAS and U-space service providers, and any modifications that are considered at a national level. This section should also describe the coordination and collaboration with other national and international aviation authorities and organisations.
8. Performance Monitoring: Describe the performance monitoring and evaluation process for the U-space functional system, including the metrics that will be used to assess the safety and efficiency of UAS operations. This section should also outline the procedures for conducting audits and inspections of U-space service providers and UAS operators to ensure compliance with regulatory requirements.

With respect to the ARA, it would be convenient for the ConOps to detail information regarding the following points:

- **Direct application from the EU U-space regulatory package.** The ConOps should provide a summary of any aspects required by [EU, 2021,664], [EU, 2021,665], [EU, 2021,666], or covered by their related AMC/GM, that are directly applicable to the ConOps. To avoid duplication of content, references should be used as considered necessary.

- **Operational architecture of the U-space airspace.** The ConOps should describe the operational architecture model of the U-space airspace, based on the decision of the state regarding the designation (or not) of a single CISP, as described in Article 5(6) of [EU,2021/664]. If an entity will be designated as a single CISP and is already known, it should be named in the ConOps to ensure a proper coordination during ARA. In addition, if there are any planned technological means to interface the involved stakeholders (e.g. a national U-space platform to which USSPs and CISPs connect to exchange information), their basic functionalities should be described in the ConOps.

- **Optional U-space services considered mandatory.** If a decision regarding the mandatory requirement to provide a weather information service and/or conformance monitoring service is made before starting the Assessment Phase (e.g. by means of a national-level policy), the ConOps should state that the provision of such service(s), as applicable, is mandatory. Otherwise, the Assessment Phase should include considerations regarding whether to mandate or not the optional U-space services as part of the assessment.

- **State and military UAS operations in U-space airspace.** State and military operations are not subject to the application of [EU,2021/664]. Nonetheless, it is the responsibility of states to ensure the safety of these operations. The ConOps should describe the national approach regarding the applicability of U-space requirements and constraints to military and state operations. These requirements and constraints might range from fully applicable to partially applicable with a series of exemptions and conditions, or not applicable at all. Ultimately, it the responsibility of each state to decide how to handle these operations while ensuring the safety of all U-space airspace users.

It is important to note that the ConOps is a dynamic document that evolves throughout the project lifecycle to ensure that the final implementation meets the goals and objectives of the U-space functional system.

APPENDIX 6 FINAL REPORT TEMPLATE

1. Project Plan
   - Problem Statement
   - Objective and Scope
   - Current situation
2. General Considerations
   - Stakeholders and Decision Makers Involved
   - Regulatory Considerations
   - Assumptions
3. Preparatory process
   - Creation of a Core and Support Team
   - Identifying External Contributors
4. Regulatory Gap Analysis
   - Applicable regulations, current and proposed, including environment and planning
   - Regulatory implementation for current UAS operations
   - Future UAS/UAM operations expected
   - Regulatory requirements for future UAS operations
   - Regulatory changes and additions required
5. Reference Scenario
   - Process
   - Challenges
   - Data Collection
   - Visualisations
6. Assessment Phase
   - Security assessment report
   - Privacy assessment report
   - Environmental assessment report
   - Safety assessment report
7. Conclusions/Recommendations

Reports			
Report Type	Due Date	Person Responsible	Consultation Period
Draft Report			
Review			
Final Report			

Outstanding Actions/Issues		
Action	Due date	Person Responsible