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| **JARUS guidelines on**  **Specific Operations Risk Assessment**  **(SORA)** |

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| **Abstract** | | | | | | | |
| This document recommends a risk assessment methodology to establish a sufficient level of confidence that a specific operation can be conducted safely. It allows the evaluation of the intended concept of operation and a categorization into 6 different Specific Assurance and Integrity Levels (SAIL). It then recommends operational safety objectives to be met for each SAIL. | | | | | | | |
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# Introduction

## Preface to the first issue of the document

1. This updated issue of the Specific Operation Risk Assessment (SORA) is the JARUS WG-6 consensus vision on how to safely create, evaluate and conduct an Unmanned Aircraft System (UAS) operation. The SORA provides a methodology that should guide both the operator and the competent authority in establishing whether an operation can be conducted in a safe manner. The document shall neither be used as a checklist nor be expected to provide answers to all the challenges. The SORA is a tailoring guide that allows an operation to have the best fit for the mitigation means and thus a risk reduced to an acceptable level. For this reason, it does not contain prescriptive requirements but rather objectives to be met at various levels of robustness.
2. This issue of the SORA is meant to inspire operators and competent authorities and to highlight the benefits of a harmonized risk assessment methodology. As the work on the SORA evolves, feedback from operators and authorities that use the SORA is highly beneficial. The group is therefore making a call to everyone that will use the methodology to provide this feedback. For this reason, a specific feedback form has been created at <http://jarus-rpas.org/feedback/SORA>. The feedback collected from real-life operations will form the backbone of the updates to the second revision of the document.

## Purpose of the document

1. The purpose of the Specific Operation Risk Assessment (SORA) is to propose a methodology for the risk assessment primarily required to support the application for an authorization to operate an Unmanned Aircraft System (UAS) within the *specific[[1]](#footnote-1)* category.
2. The application of this methodology is an acceptable means to evaluate the risks associated with the operation of an UAS within the specific category and to determine the acceptability of the proposed operation.
3. The SORA is not a one-stop-shop for full integration of all type of drones in all classes of airspace.
4. This methodology may be applied where the traditional approach to aircraft certification (approving the design, issuing an airworthiness approval and type certificate) may not be appropriate due to an operator/applicant’s desire to operate a UAS in a limited or restricted manner. This method may also be used to support activities necessary to determine airworthiness requirements. This assumes that safety objectives set forth in or derived from the RPAS AMC.1309 for the Certified category are consistent with the ones set forth or derived from for the Specific category.
5. The methodology is based on the principle of a holistic/total system safety risk based assessment model used to evaluate the risks related to a given operation. The model considers threats of all nature for a specified hazard, the relevant design and operational mitigations, and evaluates them systematically to determine the boundaries for a safe operation. This method is applicable to the operator/applicant as a way to determine acceptable risk levels and to validate that those levels are complied with by the proposed operations. The competent authority may also apply this methodology as a way to gain confidence that the operator is capable of conducting the operation safely.
6. In order to avoid repetitive individual approvals, the competent authority may also apply the methodology to define “standard scenarios” for identified types of ConOps with known hazards and acceptable risk mitigations.
7. The methodology and the related processes and values proposed in this document are intended to serve as guidance to the competent authorities when performing a risk assessment. The competent authorities could decide to adapt any section of this document to their regulatory framework.

## Applicability

1. The methodology presented in this document is aimed at evaluating the risks involved with the operation of Unmanned Aircraft System (UAS) of any class and size and for any type of operation (including experimental, R&D and prototyping). It is particularly suited, but not limited to “specific” operations for which a hazard and risk assessment is required.
2. Risks associated with collisions between UAS are in the scope of the methodology and will be addressed in a future release of the document.
3. The carriage of people or payloads on board the UAS (e.g. weapons) that in themselves present additional hazards should the UAS have a mishap is explicitly excluded from the scope of work of this methodology.
4. Security aspects are excluded from the applicability of this methodology (when not limited to those confined by the airworthiness of the systems), e.g. aspects relevant to the protection from unlawful electromagnetic interference.
5. Privacy aspects are excluded from the applicability of this methodology.
6. The SORA can be used to support waiving regulatory requirements applicable to the operation if it can be demonstrated that the operation can be conducted with an acceptable level of safety.
7. In addition to performing a SORA the operator has to ensure compliance to all regulatory requirements applicable to the operation not addressed by the SORA.

## Key concepts and definitions

1. A glossary providing all abbreviations and definitions is provided in Annex I.

### Semantic model

1. In order to enable effective communication of all aspects of the SORA, the methodology requires standardized use of terminology for phases of operation, procedures, and operational volumes. The provided semantic model (Figure 1) correlates these items to ensure consistent use between all users of the SORA. The graphical representation of the model (Figure 2) provides a visual reference to aid the reader in understanding the terminology used in the document.



Figure 1 - SORA Semantic Model

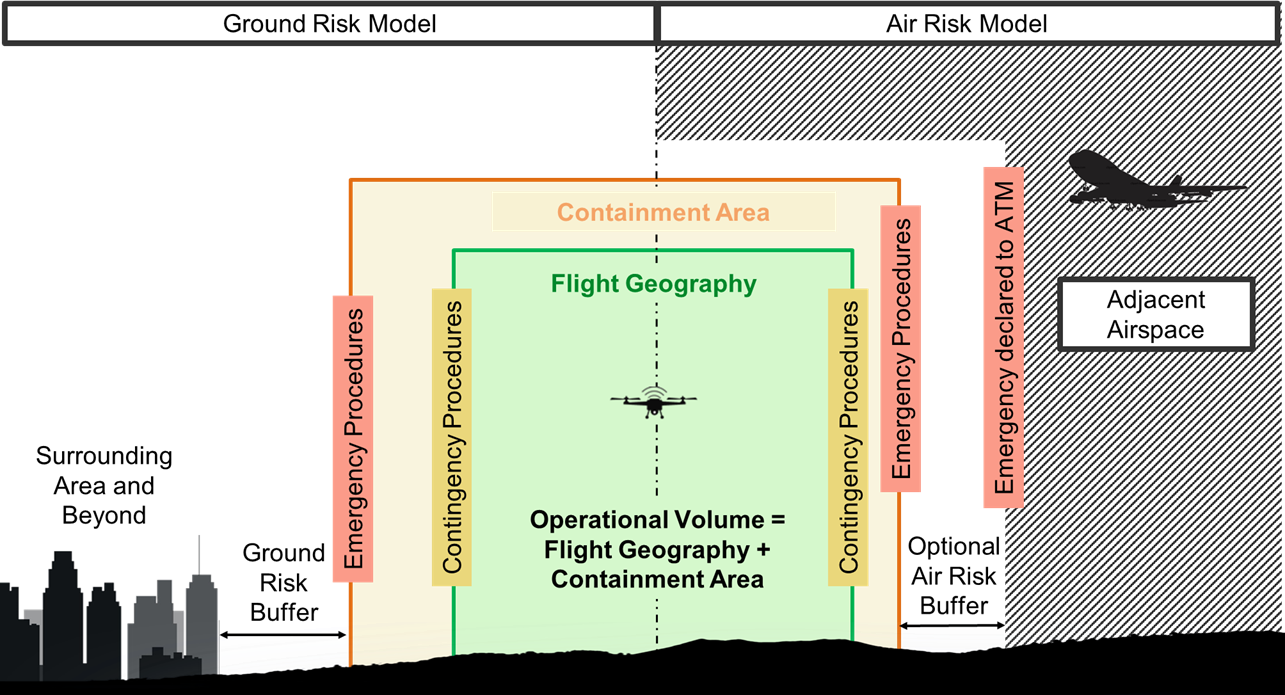


Figure 2 - Graphical Representation of SORA Semantic Model

### Introduction to robustness

1. In order to properly understand the SORA process it is important to introduce the key concept of robustness. Any given risk mitigation or operational safety objective can be demonstrated at different level of robustness. The SORA proposes the use three different levels of robustness: Low, Medium and High.
2. The **robustness** designation is achieved with consideration to both the **level of integrity** defined as the safety gain provided by each mitigation and the **level of assurance** defined as the proof that the claimed safety gain has been achieved.
3. The activities necessary to substantiate the level of integrity are detailed in the Annexes B, C, D and E. Those annexes provide guidance material or refer to industry standards and practices when applicable.
4. General guidance for the level of assurance is provided below.

A **Low** level of assurance can be one for which the operator declares that the required level of integrity has been achieved.

A **Medium** level of assurance can be one for which the operator provides supporting evidence that the required level of integrity has been achieved. This is typically achieved by means of testing (e.g. for technical mitigations) or by proof of experience (e.g. for human-related mitigations).

A **High** level of assurance is typically one for which validation of the achieved integrity has been accepted by a competent third party.

1. When different criteria for the level of assurance are described in the Annexes these take precedence over the generic criteria defined in paragraph d.
2. Competent authorities might require different activities to substantiate the level of robustness in order to accommodate national specificities that cannot (and should not) be standardized.
3. Table 1 provides guidance on how to derive a level of robustness having determined the level of integrity and the level of assurance:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Low Assurance | Medium Assurance | High Assurance |
| Low Integrity | Low robustness | Low robustness | Low robustness |
| Medium Integrity | Low robustness | Medium robustness | Medium robustness |
| High Integrity | Low robustness | Medium robustness | High robustness |

Table 1 – Determination of Robustness level

1. For example if an operator demonstrates a Medium level of Integrity with a Low level of assurance the overall robustness will be considered as Low. In other words, the robustness will always be equal to the lowest level of either integrity or assurance.

## Roles and Responsibilities

1. While performing a SORA process, several key actors might be required to interact in different phases of the process. The main actors are described in this section.
2. Operator – The operator is the party seeking operational approval, is responsible for the safety risk analysis, and obtains operational authorization from the Competent Authority/ANSP. They must substantiate the safety of their operation through operational limitations and/or evidence of acceptable safety strategy through their own means or means of a capable third party (e.g. manufacturer, service provider).
3. Applicant – This term is used interchangeably with operator throughout the document.
4. UAS Manufacturer – For the purposes of the SORA, the UAS manufacturer is the party that designs and manufactures the UAS. The manufacturer/designer has unique design evidence (e.g. system performance, system architecture, software/hardware development documentation, test/analysis documentation, etc.) that they may choose to make available to one or many UAS operator(s) to substantiate the operator’s safety case. (Three cases, targeted vs. SAIL manual) Alternatively, a potential UAS manufacturer may utilize the SORA to target design objectives for specific or generalized operations. These design objectives could be complemented by use of JARUS Certification Specifications (CS) if they are found acceptable by the competent authority in order to obtain airworthiness approval(s).
5. Component Manufacturer – The component manufacturer is the party that designs and manufactures components for use in UAS operations. The component manufacturer has unique design evidence (e.g. system performance, system architecture, software/hardware development documentation, test/analysis documentation, etc.) that they may choose to make available to one or many UAS operator(s) to substantiate a safety case.
6. Competent Authority – The competent authority is the recognized authority for approving the safety case of UAS operations. The competent authority may accept an applicant’s SORA submission in whole or in part. Through the SORA process, the applicant may need to consult with the competent authority to ensure consistent application or interpretation of individual steps. The competent authority may also have oversight of the UAS manufacturer and component manufacturer and may approve the design and/or the manufacture each.
7. Air Navigation Service Provider (ANSP) – The ANSP is the designated provider of air traffic service. Because the authoritative control requires interaction of the airspace users, ANSPs must be consulted on unique solutions produced by the SORA which do not conform to standard flight rules of the airspace.
8. UTM/U-Space Service Provider – UTM/U-Space Service Providers are recognized entities that provide services to support safe and efficient use of airspace by providing specified services to operators. These services may be managed under operator specific Service Level Agreements (SLAs) or other means. The services may support an operator in compliance with their safety obligation and risk analysis as described in Annex H.

# The SORA Process

## Introduction to Risk

1. Many definitions of the word “**risk**” exist in the literature. One of the easiest and most understandable definitions is provided in the SAE ARP 4754A / EUROCAE ED-79A [2]: “the combination of the *frequency* (probability) of an *occurrence* and its associated level of *severity*”. This is the “risk” definition that is retained in this document.
2. The consequence of every occurrence will be a **harm** of some type.
3. Many different categories of harm arise from any given occurrence. Various authors have collated these categories of harm and much literature is available on the topic. For the purpose of this document, however, it is important to understand that the focus will be on occurrences (e.g. an UAS crash) that are short-lived and usually give rise to near loss of life. Chronic events (e.g. toxic emissions over a period of time) are explicitly excluded from this assessment. The categories of harm in this document are the potential for:
   * Fatal injuries to third parties on the ground
   * Fatal injuries to third parties in the air
   * Damage to critical infrastructure
4. It is acknowledged that the competent authorities may consider additional categories of harm (e.g. disruption of a community, environmental damage, financial loss, etc.) which could be assessed as well by means of this methodology.
5. Several studies have shown that the energy levels with the potential to cause fatal injuries in case of a direct hit are extremely low, in the region of few dozen Joules. The energies involved with operations addressed within this document are likely to be significantly higher and therefore the only retained harm is the potential for fatal injuries.
6. Fatal injury is a well-defined condition and in most countries, the vast majority of fatalities are known by the authorities. The risk of under-reporting is therefore almost non-existent. The quantification of the associated risk is also straightforward. The number of deaths in a particular time interval or the number of deaths for a specified circumstance (e.g. fatal accident rate per million flying hours or fatal accident rate per number of take-offs, etc.) are the usual means of measure.
7. Damage to critical infrastructure is a more complex condition and different countries might have different sensitivities to this harm. Quantification of the associated risk is also very difficult and subject to national specificities.

## SORA process outline

1. The SORA methodology provides a logical process to analyse the proposed ConOps and establish an adequate level of confidence that it can be conducted with an acceptable level of risk. There are essentially nine steps supporting the proposed SORA methodology and each of these steps is described in the following paragraphs and further detailed, when necessary, in the relevant annex.
2. The current SORA focuses on the assessment of ground and air risk. In addition to the SORA, a risk assessment of critical infrastructure should also be performed in cooperation with the responsible organization for the infrastructure, as they are most knowledgeable of the threats. The risk model provided in Figure 3 and 4 could be used to inform this assessment.



Figure 3 – The SORA process

Note: If operations are conducted in different environments, some of the steps may need to be repeated for each particular environment.

### Pre-application evaluation

1. Before commencing with the SORA process, the operator should verify that the proposed operation is feasible, not subject to specific exclusions from the competent authority or subject to a standard scenario. Things to verify include:
   1. If the operation can be covered under a “standard scenario” recognized by the competent authority
   2. If the operation falls under the “open” category
   3. If the operation is subject to specific NO-GO from competent authority
   4. If the competent authority has determined that the UAS is “harmless” for both ground and air risk.

Upon completion of this preliminary check, the operator will start the SORA process if none of the previous cases applies.

### Step #1 – ConOps description

1. The first step of the SORA requires the operator to collect and provide sufficient technical, operational and human information related to the intended use of the UAS needed for the risk assessment. Annex A of this document provides a detailed framework for data collection and compilation. The ConOps description is the foundation for all other activities and should be as accurate and detailed as possible. The ConOps should not only be a description of the operation but also provide insight into the operator/applicant’s operational safety culture. Therefore, when defining the ConOps the operator should give due consideration to all mitigations and operational safety objectives provided in Figure 3 and 4.

## The Ground Risk Process

### Step #2 – Determination of the intrinsic UAS Ground Risk Class

1. The intrinsic UAS ground risk relates to the unmitigated risk of a person being struck by the UAS (in case of loss of UAS control) and can be represented by eleven Ground Risk Classes (GRC), derived only from the intended operation and the UAS lethal area. A qualitative method to establish the GRC is provided in Table 1 - Ground Risk Classes (GRC) Determination

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Intrinsic UAS Ground Risk Class** | | | | |
| Max UAS characteristics dimension | 1 m / approx. 3ft | 3 m / approx. 10ft | 8 m / approx. 25ft | >8 m / approx. 25ft |
| *Typical kinetic energy expected* | *< 700 J (approx. 529 Ft Lb)* | *< 34 KJ (approx. 25000 Ft Lb)* | *< 1084 KJ (approx. 800000 Ft Lb)* | *> 1084 KJ (approx. 800000 Ft Lb)* |
| **Operational scenarios** |  |  |  |  |
| VLOS over controlled area, located inside a sparsely populated environment | 1 | 2 | 3 | 5 |
| BVLOS over sparsely populated environment (over-flown areas uniformly inhabited) | 2 | 3 | 4 | 6 |
| VLOS over controlled area, located inside a populated environment | 3 | 4 | 6 | 8 |
| VLOS over populated environment | 4 | 5 | 7 | 9 |
| BVLOS over controlled area, located inside a populated environment | 5 | 6 | 8 | 10 |
| BVLOS over populated environment | 6 | 7 | 9 | 11 |
| VLOS over gathering of people | 7 |  | | |
| BVLOS over gathering of people | 8 |  |  |  |

Table 2 - Ground Risk Classes (GRC) Determination

1. EVLOS[[2]](#footnote-2) operations are to be considered as BVLOS for the GRC determination.
2. A controlled area is defined as the intended UAS operational area that only involves active participants (if any).
3. An operation is defined as occurring over gathering of people if the intent of the UAS operation is to operate continuously over open-air assembly of people in which it is reasonable to assume that loss of control of the operation will result in direct hit of non-active participants.
4. The operational scenarios described attempt to provide discrete categorizations of operations with increasing number of **people at risk**. When selecting the operational scenario, consideration should be given to surrounding areas taking into account the UAS and its operation.
5. In order to establish the GRC, the operator/applicant only needs the max UA characteristic dimension (e.g. wingspan for fixed wing, blade diameter for rotorcraft, max. dimension for multicopters, etc.) and the knowledge of the intended operational scenario. The GRC can be read out of the table at the intersection between the applicable scenario and max UA characteristic dimension.
6. A detailed mathematical model to substantiate this approach is provided in Annex F.
7. Operations that do not have a corresponding GRC (i.e. grey cells on the table) are not currently supported by the SORA methodology.
8. When evaluating the typical kinetic energy expected for a given operation the operator/applicant should generally use airspeed, in particular Vcruise for fixed-wing aircraft and the terminal velocity for other aircraft. Specific designs (e.g. gyrocopters) might need additional considerations. A useful guidance to determine the terminal velocity can be found at <https://www.grc.nasa.gov/WWW/K-12/airplane/termv.html>
9. Due to the consideration of both size and energy in the ground risk determination, the nominal size of the crash area for most UAS can be anticipated. However, there are certain cases or design aspects that may not have been considered during the ground risk class that will have a significant effect on the lethal area of the UAS such as fuel, high-energy rotors/props, frangibility, material, etc. These considerations may lead to an decreased/increased GRC.

### Step #3 – Final GRC determination

1. The unmitigated risk of a person being struck by the UAS (in case of loss of UAS control) can be controlled and reduced by means of mitigations.
2. As mitigations used to modify the intrinsic GRC have a direct effect of the safety objectives associated with a particular operation, it is particularly important to ensure their robustness. This aspect assumes extreme relevance in those cases where harm barriers are of technological nature (e.g. emergency parachute).
3. This step of the process allows for determination of the **Final GRC** based on the availability of these mitigations to the operation. Table 2 provides a list of these mitigations and the relative correction factor. A positive number denotes an increase of the GRC while a negative number results in a decrease of the GRC. All barriers have to be considered in order to perform the assessment. Annex B provides additional details on how to estimate the robustness of each mitigation. Competent authorities may define additional mitigations and the relative correction factors.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Robustness | | |
| **Mitigation Number** | **GRC adaptation** | Low/None | Medium | High |
| M1 | An Emergency Response Plan (ERP) is in place, operator validated and effective | **1** | **0** | **-1** |
| M2 | Effects of ground impact are reduced[[3]](#footnote-3) | **0** | **-1** | **-2** |
| M3 | Technical containment in place and effective[[4]](#footnote-4) | **0** | **-2** | **-4** |

Table 3 – Mitigations for Final GRC determination

1. For example, we assume that a certain operation has been assigned a GRC of 3. Upon analysis of the ConOps it has been determined that the ERP is available and of Medium robustness. No containment measures are in place. In addition to all above, the operator/applicant has implemented a parachute system that has been judged by the competent authority adequate to provide a GRC adaptation of -1. The Final GRC is established by adding all correction factors (i.e. 0-1-0=-1) and adapting the GRC by the resulting number (3-1=2). Table 3 provides a visual representation of the example.

|  |  |
| --- | --- |
|  | **GRC** |
| Initial | 3 |
| An Emergency Response Plan (ERP) is in place, operator validated and effective | +0 |
| Effects of ground impact are reduced (e.g. emergency Parachute, shelter) | -1 |
| Containment in place and effective (e.g. tether) | +0 |
| Final | 2 |

Table 4 – Example of Final GRC determination

1. If the Final GRC is higher than 7, the operation is not supported by the SORA process.

## The Air Risk Process

### Air Risk Process Overview

1. The SORA uses the airspace of operation as baseline to evaluate the intrinsic risk of mid-air collision through determination of the air risk category (ARC). The ARC is then addressed by means of strategic and tactical mitigation means. Strategic mitigations may lower the ARC level when applied. A typical example of strategic mitigations to reduce collision risk consist in limiting risk by operating during certain times or within certain boundaries. Any residual risk of mid-air collision is addressed by means of tactical mitigations.
2. Tactical mitigations take the form of detect and avoid systems or alternate means, such as ADS-B/ATC separation services, FLARM, UTM/U-Space services or operational procedures. Depending on the residual risk of mid-air collision, the Tactical Mitigation Performance Requirement may vary.
3. As part of the SORA process, the Operator should cooperate with the relevant service provider for the airspace (ANSP or UTM/U-Space service provider) and obtain the necessary authorizations. Alternatively generic local authorisations or local procedures allowing access to a certain portion of controlled airspace may be used if available (e.g. Low Altitude Authorization and Notification Capability – LAANC – system in the United States).
4. The SORA recommends that irrespective of the results of the risk assessment the operator pay particular attention to all features that may increase the detectability of the UA in the airspace. For this reason, the implementation of technical solutions that improve the electronic conspicuity is recommended.

### Step #4 - Determination of the Initial Air Risk Class (ARC)

1. The competent authority, ANSP, or UTM/U-space service provider, may elect to directly map the airspace collision risks using airspace characterization studies. These maps would directly show the initial Air Risk Class (ARC) for a particular airspace. If the competent authority, ANSP, or UTM/U-space service provides an air collision risk map (static or dynamic), the operator should use that service to determine the initial ARC, and skip to section 2.4.3 Application of Strategic Mitigations to reduce the initial ARC.

#### Operator Determination of Initial ARC

1. Figure 4 categorizes all airspace into 14 aggregated collision risk categories. These categories were characterized by altitude, controlled versus uncontrolled airspace, airport versus non-airport environments, airspace over urban versus rural environments, and lastly atypical versus typical airspace.
2. To find the proper ARC for the type of UAS operation, the operator should use the flow chart in Figure 4.

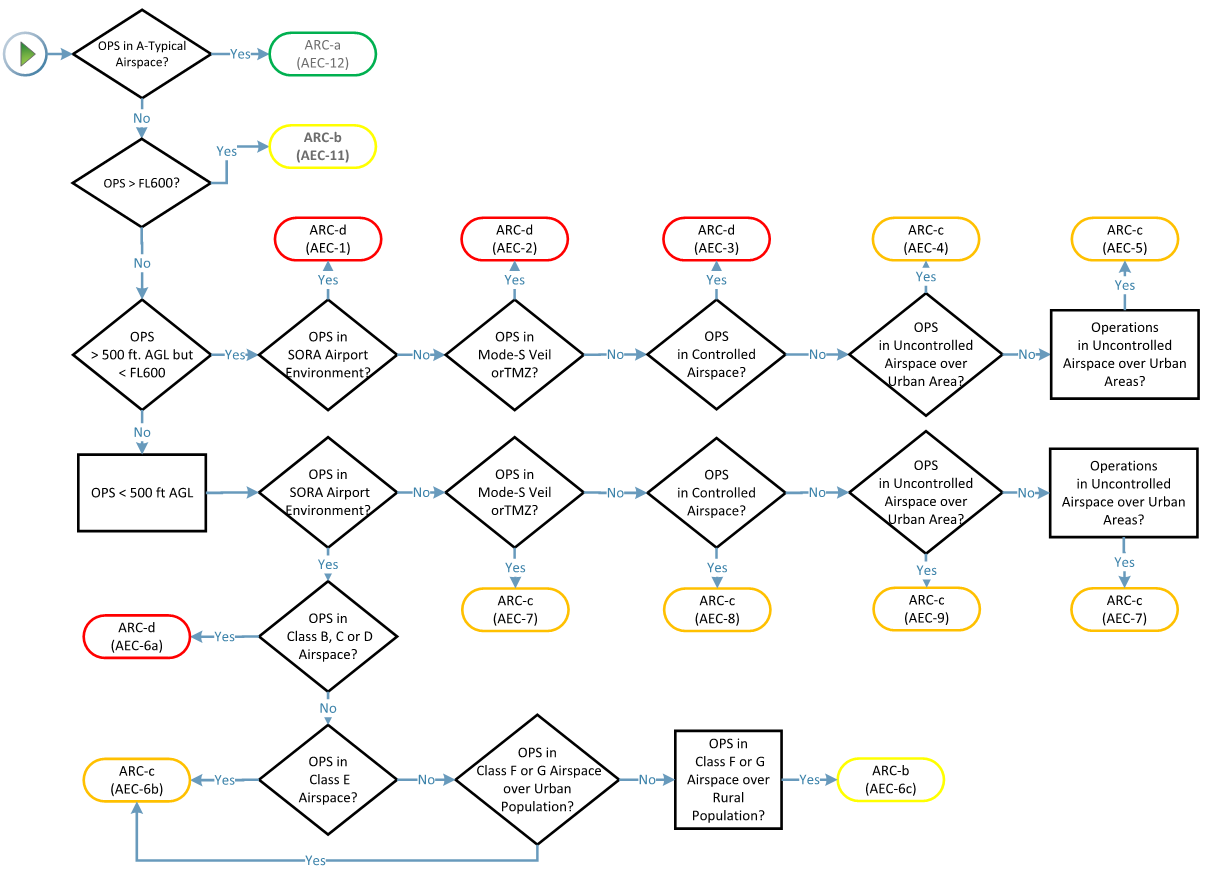


Figure 4 – ARC assignment process

Note: The AEC is only relevant in cases where the operator is seeking to reduce the initial ARC based on strategic mitigation as per 2.4.3. Further guidance is provided in Annex C.

1. The ARC is a qualitative classification of the rate at which a UAS would encounter a manned aircraft in typical generalized civil airspace. The ARC is an initial assignment of the aggregated collision risk for the airspace, before mitigations are applied. Actual collision risk of a specific local Operational Volumes could be much different and can be addressed in the Application of Strategic Mitigations to reduce the ARC section (this step is optional, see annex C).
2. Although the static generalized risk put forward by the ARC is conservative, there may be situations where that conservative assessment may not be enough. It is important that both the competent authority and operator take great care to understand the Operational Volume and under what circumstances the definitions in Figure 4 could be invalidated. In some situations, the competent authority may raise the Operational Volume ARC to a level which is higher than that advocated by the Figure 4.
3. ARC-a is generally defined as airspace where the risk of collision between a UAS and manned aircraft is acceptable without the addition of any tactical mitigation.
4. ARC-b, ARC-c, ARC-d are generally defining airspace with increasing risk of collision between a UAS and manned aircraft.
5. During the UAS operation, the UAS Operational Volume may span many different airspace environments. The operator needs to do an air risk assessment for the entire range of the Operational Volume. An example scenario of operations in multiple airspace environments is provided at the end of Annex C.

### Step #5 – Application of Strategic Mitigations to determine Final ARC (optional)

1. As stated before, the ARC is a generalized qualitative classification of the rate at which a UAS would encounter a manned aircraft in the specific airspace environment. However, it is recognized that the UAS Operational Volume may have collision risk different than the generalized Initial ARC assigned.
2. If an operator considers that the generalized Initial ARC assigned is too high for the condition in the local Operational Volume, then refer to Annex C for the ARC reduction process.
3. If the operator considers that the generalized Initial ARC assignment is correct for the condition in the local Operational Volume, then that ARC becomes the Final ARC

### Step #6 – Adjacent Airspace Considerations

1. The objective of this section is to address the risk posed by a loss of control of the operation resulting in an infringement of the adjacent airspace. The adjacent airspace may vary with different flight phases. It is important that the operator identifies all the adjacent airspaces to the Operational Volume, through all phases of flight.
2. In those phases of flight where the operators Final ARC is ARC-d, there is no need to define the Containment Integrity level. The necessary requirements to operate in ARC-d have already been met.
3. If the Final ARC is other than ARC-d, use Figure 10 to identify the ARC of all adjacent airspaces to the Operational Volume, both horizontal and/or vertical, during any phase of flight.
4. In those phases of flight where the operators Final ARC is other than ARC-d, and the UAS Operational Volume is adjacent to ARC-d (AEC 1, 2, 3, or 6a – See Annex C), the Containment Integrity level is High
5. In those phases of flight where the operators Final ARC is other than ARC-d, and the UAS Operational Volume is not adjacent to ARC-d (AEC 1, 2, 3, or 6a – See Annex C), the Containment Integrity level is Low
6. The activities required to meet the Containment Objectives are provided in annex C.

|  |  |  |  |
| --- | --- | --- | --- |
| Containment Objectives | | | |
| Operational Case | Final ARC is ARC-d | The final ARC is other than ARC-d and he operation is **not** conducted adjacent to ARC-d airspace | The final ARC is other than ARC-d and he operation is conducted adjacent to ARC-d airspace |
| Containment Robustness Level | N/A | Low | High |

Table 5 – Uncontained Integrity Levels

1. Because not all local situations can be anticipated, the operator, the competent authority and the ANSP must use sound judgement with regards to the definition of “adjacent airspace”. For example, for a small UAS with limited range, it is not intended to include busy airport environments 30 kilometres away. The airspace bordering the UAS volume of operation should be the starting point of the determination of adjacent airspace. In exceptional cases, the airspace(s) beyond those bordering of the UAS volume of operation may also have to be considered.
2. An operator finding that the “adjacent airspace” requires a High Containment integrity Level, may wish to lower all or part of the integrity requirements for a high level by moving the Operational Volume away from the adjacent airspace, to form an Air Risk buffer. The reduction achieved by the Air Risk buffer on the Containment Integrity Level is entirely dependent on the local situation, operational environment, and requires the concurrence of the competent authority and ANSP.

### Step #7 – Tactical Mitigation Performance Requirement (TMPR) and Robustness Levels

1. Tactical Mitigations are applied to mitigate any residual risk of a mid-air collision in order to achieve the applicable airspace safety objective. Tactical Mitigations will take the form of either “See and Avoid” (i.e. operations under VLOS) or may require a system which provides an alternate means of achieving the applicable airspace safety objective (operation using a DAA, or multiple DAA systems). Annex D provides the method for applying Tactical Mitigations.

#### Operations under VLOS/EVLOS

1. VLOS is considered an acceptable Tactical Mitigation for collision risk for all ARC levels.
2. Operational UAS flights under VLOS do neither have to meet the TMPR nor the TMPR robustness requirements. If there are multiple segments of the flight, those segments done under VLOS do not have to meet the TMPR or the TMPR robustness requirements for those flight segments.
3. EVLOS is a subset of VLOS operations. In general, all VLOS requirements are applicable to EVLOS. EVLOS may have additional requirements over and above VLOS. EVLOS verification and communication times between pilot and observers should be less than 15 seconds.
4. Notwithstanding the above, the operator should have a documented VLOS de-confliction scheme, in which the operator explains which methods will be used for detection and what the criteria are that will be applied for the decision to avoid incoming traffic. In case the remote pilot relies on detection by observers, the use of phraseology will have to be described as well.
5. For VLOS operations, it is assumed that an observer will not be able to detect traffic beyond 2 NM. (Note that the 2 NM range is not a fixed value and may largely depend on atmospheric conditions, aircraft size, geometry, closing rate, etc. The operator may have to adjust the operation and /or procedures accordingly)
6. The use of VLOS as a strategic mitigation does not exempt the operator from addressing all safety requirements of the SORA air collision risk model. In those situations where VLOS is used as both a strategic and tactical mitigation, care should be taken as to not double count the VLOS contribution to mitigation.

#### Operations under a DAA System - Tactical Mitigation Performance Requirement (TMPR)

1. For operations other than VLOS, the operator, with the Final ARC, will use Table 6 below to determine the Tactical Mitigation Performance Requirement (TMPR).

| **Final ARC** | **Tactical Mitigation Performance Requirements (TMPR)** | **TMPR Level of Robustness** |
| --- | --- | --- |
| ARC-d | High | High |
| ARC-c | Medium | Medium |
| ARC-b | Low | Low |
| ARC-a | No requirement | No requirement |

Table 6 – Tactical Mitigation Performance Requirement (TMPR) and TMPR Level of Robustness Assignment

1. High TMPR (ARC-d): This is airspace where the manned aircraft encounter rate is high and/or the available Strategic Mitigations are Low. As a consequence, the resulting residual collision risk is high, and therefore the TMPR must be high. In this airspace, the UAS may be operating in Integrated Airspace and will have to comply with the operating rules and procedures applicable to that airspace, without reducing existing capacity, decreasing safety, negatively impacting current operations with manned aircraft, or increasing the risk to airspace users or persons and property on the ground, any more than the integration of comparable new and novel technologies in manned aviation would. The performance level(s) of those Tactical mitigations and/or the required variety of Tactical mitigations is generally higher than for the other ARCs. If operations in this airspace are conducted more routinely, the competent authority is expected to require the operator to comply with the recognised DAA system standards developed by RTCA SC-228 and/or EUROCAE WG-105.
2. Medium TMPR (ARC-c): A medium TMPR will be required for operations in airspace where there is a reasonable chance to encounter manned aircraft and/or the Strategic Mitigations available are medium. Operations with a medium TMPR will likely be supported by systems currently used in aviation to aid the pilot with detection of other manned aircraft, or on systems designed to support aviation that are built to a corresponding level of robustness. Traffic avoidance manoeuvres could be more advanced than for a low TMPR.
3. Low TMPR (ARC-b): A low TMPR will be required for operations in airspace where the probability of encountering another manned aircraft is low but not negligible and/or where Strategic Mitigations address most of the risk and the resulting residual collision risk is low. Operations with a low TMPR are supported by technology that is designed to aid the pilot in detecting other traffic, but which may be built to lesser standards. For example, for operations below 500ft, the traffic avoidance manoeuvres are expected to mostly be based on a rapid descend to an altitude where manned aircraft are not expected to ever operate.
4. No Performance Requirement (ARC-a): This is airspace where the manned aircraft encounter rate is expected to be extremely low, and therefore there is no requirement for a TMPR[[5]](#footnote-5). It is generally defined as airspace where the risk of collision between a UAS and manned aircraft is acceptable without the addition of any Tactical mitigation. An example of this may be UAS flight operations in some parts of Alaska or northern Sweden where the manned aircraft density is so low that the airspace safety threshold could be met without any tactical mitigation.
5. Annex D provides information on how to satisfy the TMPR based on the available tactical mitigations and the TMPR Level of Robustness.

#### Consideration of Additional Airspace / Operation Requirements

1. Modifications to the initial and subsequence approvals may be required by the competent authority or ANSP as safety and operational issues arise.
2. The operator and competent authority need to be cognizant that the ARCs are a generalized qualitative classification of collision risk. Local circumstances could invalidate the aircraft density assumptions of the SORA, for example with special events. It is important that both the competent authority and operator take great care to understand the airspace and air-traffic flows, and develop a system which can alert operators to changes to the airspace on a local level, which will allow the operator to safely address the increased risks associated with these events.
3. There are many airspace, operational and equipage requirements which have a direct impact on the effectiveness of the collision risk of all aircraft in the airspace. Some of these requirements are general and apply to all airspaces, some of them are local and are required only for a particular airspace. This assessment cannot possibly cover all the additional requirements which may, or may not, be required by the competent authority for the condition in which the operator may wish to operate. The operator and the competent authority need to work together closely in addressing these additional requirements.
4. The SORA process should not be used to support operations of a UAS in a given airspace without the UAS being equipped with the required equipment for operations in that airspace (e.g. equipment required to ensure interoperability with other airspace users). In these cases, specific exemptions should be granted by the air navigation authority. Those exemptions are outside the scope of the SORA.
5. Operations in controlled airspace, an airport environment or a Mode-C Veil/Transponder Mandatory Zone (TMZ) likely require prior approval from the ANSP. The operator should pay particular attention to involve the ANSP/authority prior to commencing operations in these environments.

## Final SAIL and Operational Safety Objectives (OSO) Assignment

### Step #8 SAIL determination

1. The chosen parameter to consolidate the ground and air risk analysis and to drive the required activities is the **SAIL**. The SAIL represents the level of confidence that the UAS operation will stay under control.
2. Having established the Final GRC and ARC, it is now possible to derive the SAIL associated with the proposed ConOps.
3. The level of confidence represented by the SAIL is not quantitative but instead corresponds to:
   1. Objectives to be complied with,
   2. Description of activities that might support the compliance with those objectives, and
   3. Evidence to indicate the objectives have been satisfied.
4. A SAIL is assigned to the ConOps using Table 7

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SAIL Determination | | | | |
|  | Final ARC | | | |
| Final GRC | a | b | c | d |
| 1 | **I** | **II** | **IV** | **VI** |
| 2 | **I** | **II** | **IV** | **VI** |
| 3 | **II** | **II** | **IV** | **VI** |
| 4 | **III** | **III** | **IV** | **VI** |
| 5 | **IV** | **IV** | **IV** | **VI** |
| 6 | **V** | **V** | **V** | **VI** |
| 7 | **VI** | **VI** | **VI** | **VI** |
| >7 | Category C operation | | | |

Table 7 – SAIL determination

### Step #9 - Identification of Operational Safety Objectives (OSO)

1. The last step of the SORA process is to evaluate the defenses within the operation in form of operational safety objectives (OSO) and the associated level of robustness depending on the SAIL. Table 8 provides a qualitative methodology to make this determination. In this table, O is Optional, L is recommended with Low robustness, M is recommended with Medium robustness, H is recommended with High robustness. The various OSO are grouped based on the threat they help to mitigate. Some OSO may therefore be repeated in the table.
2. Table 8 is a consolidated list of common OSO that have been historically used to ensure safety of UAS operations. It collects the experience of many experts and is therefore a solid starting point to determine the required safety objectives for a specific operation. Competent authorities may define additional OSO and the relative level of robustness.

| OSO Number (in line with Annex E) |  | **SAIL** | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **I** | **II** | **III** | **IV** | **V** | **VI** |
|  | **Technical issue with the UAS** |  |  |  |  |  |  |
| OSO#01 | Ensure the operator is competent and/or proven | O | L | M | H | H | H |
| OSO#02 | UAS manufactured by competent and/or proven entity | O | O | L | M | H | H |
| OSO#03 | UAS maintained by competent and/or proven entity | L | L | M | M | H | H |
| OSO#04 | UAS developed to authority recognized design standards[[6]](#footnote-6) | O | O | O | L | M | H |
| OSO#06 | C3 link performance is appropriate for the operation | O | L | L | M | H | H |
| OSO#05 | UAS is designed considering system safety and reliability | O | O | L | M | H | H |
| OSO#07 | Inspection of the UAS (product inspection) to ensure consistency to the ConOps | L | L | M | M | H | H |
| OSO#08 | Operational procedures are defined, validated and adhered to | L | M | H | H | H | H |
| OSO#09 | Remote crew trained and current and able to control the abnormal situation | L | L | M | M | H | H |
| OSO#10 | Safe recovery from technical issue | L | L | M | M | H | H |
|  | **Deterioration of external systems supporting UAS operation** |  |  |  |  |  |  |
| OSO#11 | Procedures are in-place to handle the deterioration of external systems supporting UAS operation | L | M | H | H | H | H |
| OSO#12 | The UAS is designed to manage the deterioration of external systems supporting UAS operation | L | L | M | M | H | H |
| OSO#13 | External services supporting UAS operations are adequate to the operation | L | L | M | H | H | H |
|  | **Human Error** |  |  |  |  |  |  |
| OSO#14 | Operational procedures are defined, validated and adhered to | L | M | H | H | H | H |
| OSO#15 | Remote crew trained and current and able to control the abnormal situation | L | L | M | M | H | H |
| OSO#16 | Multi crew coordination | L | L | M | M | H | H |
| OSO#17 | Remote crew is fit to operate | L | L | M | M | H | H |
| OSO#18 | Automatic protection of the flight envelope from Human Error | O | O | L | M | H | H |
| OSO#19 | Safe recovery from Human Error | O | O | L | M | M | H |
| OSO#20 | A Human Factors evaluation has been performed and the HMI found appropriate for the mission | O | L | L | M | M | H |
|  | **Adverse operating conditions** |  |  |  |  |  |  |
| OSO#21 | Operational procedures are defined, validated and adhered to | L | M | H | H | H | H |
| OSO#22 | The remote crew is trained to identify critical environmental conditions and to avoid them | L | L | M | M | M | H |
| OSO#23 | Environmental conditions for safe operations defined, measurable and adhered to | L | L | M | M | H | H |
| OSO#24 | UAS designed and qualified for adverse environmental conditions | O | O | M | H | H | H |

Table 8 – Recommended operational safety objectives (OSO)

## Step #10 Comprehensive Safety Portfolio

1. The SORA process provides the operator, the competent authority and the ANSP with a methodology which includes a series of mitigations and safety objectives to be considered to ensure an adequate level of confidence that the operation can be safely conducted. These are, in particular:
   1. Mitigations used to modify the intrinsic GRC
   2. Strategic mitigations for the Initial ARC
   3. Tactical mitigations for the Final ARC
   4. Containment objectives
   5. Operational Safety Objectives
2. Satisfactory substantiation of mitigations and objectives required by the SORA process provides a sufficient level of confidence that the proposed operation can be safely conducted.
3. The operator should make sure to address any additional requirements to those identified by the SORA process (e.g. security, environmental protection, etc.) as well as the relative stakeholders (e.g. environmental protection agencies, national security bodies, etc.). The activities performed within the SORA process will be likely needed to address those additional needs but should not be considered sufficient at all times.

1. This category of operations is further defined in the European Aviation Safety Agency (EASA) NPA 2017-05 [1]. [↑](#footnote-ref-1)
2. EVLOS - An Unmanned Aircraft System (UAS) operation whereby the Pilot in Command (PIC) maintains an uninterrupted situational awareness of the airspace in which the UAS operation is being conducted via visual airspace surveillance, possibly aided by technology means. The PIC has a direct control of the UAS at all time. [↑](#footnote-ref-2)
3. This mitigation is meant as a means to reduce the energy absorbed by the people of the ground upon impact. [↑](#footnote-ref-3)
4. This mitigation is meant as a means to reduce the number of people at risk [↑](#footnote-ref-4)
5. Please refer to annex C, section 3.15 SORA Definition of Encounter. [↑](#footnote-ref-5)
6. The robustness level does not apply to mitigations for which credit has been taken to derive the risk classes. This is further detailed in para. 3.2.11(a). [↑](#footnote-ref-6)