



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

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Abstract		
<p>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 objectives to be met for each SAIL.</p>		
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# 1. Introduction

## 1.1 Preface to the first issue of the document

- (a) This first 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 holistic model that should guide both the operator and the responsible approving 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.
- (b) This first issue of the SORA is meant to inspire operators and approving 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.

## 1.2 Purpose of the document

- (a) 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*<sup>a</sup> category.
- (b) 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.
- (c) 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 and to show compliance with safety objectives in the certified category. 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.
- (d) 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 local authority/qualified entity may also apply this methodology as a way to gain confidence that the operator is capable of conducting the operation safely.
- (e) In order to avoid repetitive individual approvals, the local authority may also apply the methodology to define "standard scenarios" for identified types of ConOps with known threats and acceptable risk mitigations.
- (f) The methodology and the related processes and values proposed in this document are

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<sup>a</sup> This category of operations is further defined in the European Aviation Safety Agency (EASA) NPA 2017-05 [1].

intended to serve as guidance to the local authorities/qualified entities when performing a risk assessment. The local authorities could decide to adapt any section of this document to their regulatory framework.

### **1.3 Applicability**

- (a) 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.
- (b) Risks associated with collisions between UAS are in the scope of the methodology and will be addressed in a future release of the document.
- (c) 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.
- (d) 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.
- (e) Privacy aspects are excluded from the applicability of this methodology.

### **1.4 Glossary**

- (a) A glossary providing all abbreviations and definitions is provided in Annex I.

### **1.5 Reference material**

- [1] EASA NPA 2017-05, Introduction of a regulatory framework for the operation of drones
- [2] EUROCAE ED-79A / SAE ARP4754A: Guidelines For Development Of Civil Aircraft And Systems, December 2010
- [3] AMC RPAS.1309, JARUS Working Group 6, Safety assessment of Remotely Piloted Aircraft Systems (RPAS), issue 02 dated November 2015
- [4] Scoping Paper to AMC RPAS.1309, JARUS Working Group 6, Safety assessment of Remotely Piloted Aircraft Systems (RPAS), issue 02 dated November 2015
- [6] EUROCAE ER-010

## 2. Holistic Risk Model

### 2.1 Introduction to Risk

- (a) 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.
- (b) The consequence of every occurrence will be a **harm** of some type.
- (c) 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 – Catastrophic Mid Air Collision (MAC) with a manned aircraft<sup>b</sup>,
  - Damage to critical infrastructure.
- (d) It is acknowledged that the local 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.
- (e) 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.
- (f) 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.
- (g) 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.

### 2.2 Holistic Risk Model (HRM)

- (a) The Holistic Risk Model (HRM) presented in this section was developed to support the assessment of the risks involved in the operation of an UAS. The HRM provides a generic framework to identify the hazards, threats and the relevant harm and threat barriers applicable to any UAS operation.
- (b) The HRM models the risk associated to a given operation of an UAS through the following steps:

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<sup>b</sup> Air risk Metric of “Fatal injuries to third parties in the air due to Catastrophic Mid Air Collision (MAC) with a manned aircraft” may change from Catastrophic MAC per FH to MAC per FH. Final decision provided in Issue 2

- a. **Harm identification:** the identification of the harms for which the risk needs to be assessed. For the scope of this document, harms under interest are defined in paragraph 2.2.1.
- b. **Hazard identification:** the identification of the hazards related to the UAS operation that may lead to the retained harm. For the scope of this document, the hazard considered under interest is defined in paragraph 2.2.2.
- c. **Identification of generic threats:** the identification of the issues that can cause the hazard to occur if not kept under control. For the scope of this document, the threats considered under interest are defined in paragraph 2.2.3.
- d. **Harm barrier identification:** the identification of the mitigations applicable to a specific harm for a defined hazard. Harm barriers affect the likelihood that, once it occurs, the hazard can cause the harm and/or the severity of the consequences of the hazard with respect to the harm.
- e. **Threat barrier identification:** the identification of the mitigations applicable to a specific threat for a defined hazard. Threat barriers affect the likelihood that a threat can cause the hazard.

(c) Figure 1 provides a bow-tie representation of the HRM. The use of a bow-tie representation is only a means chosen to illustrate the proposed risk model. It is not intended that the applicant/operator use a bow-tie tool to support their application.

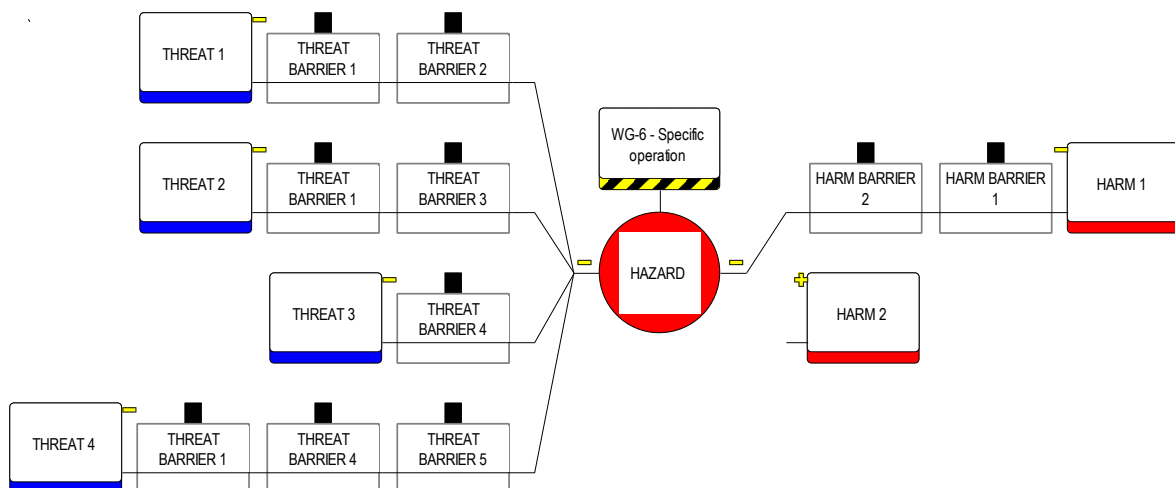


Figure 1 – Bow-tie model

## 2.2.1 Harm Identification

- (a) As explained in section 2.1(c), there are three categories of **harm** which are retained in this document:
  - a. Fatal injuries to third parties on the ground
  - b. Fatal injuries to third parties in the air (Catastrophic mid-air collision with manned aircraft)
  - c. Damage to critical infrastructure
- (b) It is the operator/applicant's responsibility to ensure that no other categories of harm, other than those excluded from the applicability by paragraph 1.3, arise due to the specific nature of the intended operation.

- (c) It is expected that each regulatory organization will establish a framework to define what constitutes critical infrastructure and what the rules for operations near these infrastructures are.

### 2.2.2 Hazard Identification

- (a) It is established that the only hazard related to the UAS operation that may lead to any of the three retained categories of harm identified in section 2.2.1 is “**UAS operation out of control**”.
- (b) The term “UAS operation out of control” is defined as an operation being conducted, outside of the approved operations. This is a much wider concept than the loss of control of the UA.
  - a. During UAS operations, especially those conducted Beyond Line of Sight (BLOS), the situational awareness of the remote crew is highly dependent on an array of items, equipment and installations that are provided to them for that purpose. As the crew is not physically on-board the aircraft, there is an inherent increase in difficulty to maintain control of the operation, especially in abnormal operating conditions. Violation of segregated areas or altitude restrictions, issuance of incorrect commands, etc. are all cases of an operation being out of control, even if only temporarily.
  - b. During Visual Line of Sight (VLOS) operation, the loss of the visual contact with the UA, even when not linked to failures of the technical system (e.g. wrong command correctly executed) is an example of an operation being out of control.
  - c. A UAS operation could be considered out of control when a near mid-air collision (NMAC) occurs between the UA and another aircraft.

### 2.2.3 Identification of generic threats

- (a) A **threat** is defined as an occurrence that in the absence of appropriate threat barriers can potentially result in the hazard (i.e. UAS operation being out of control).
- (b) The HRM identifies five generic categories of threats, potentially applicable to any UAS operation:
  - a. Technical issue with the UAS
  - b. Human error
  - c. Aircraft on collision course
  - d. Adverse operating conditions
  - e. Deterioration of external systems supporting the UAS operation
- (c) Figure 2 shows the HRM model with the identified Hazard, Threats and Harm categories.

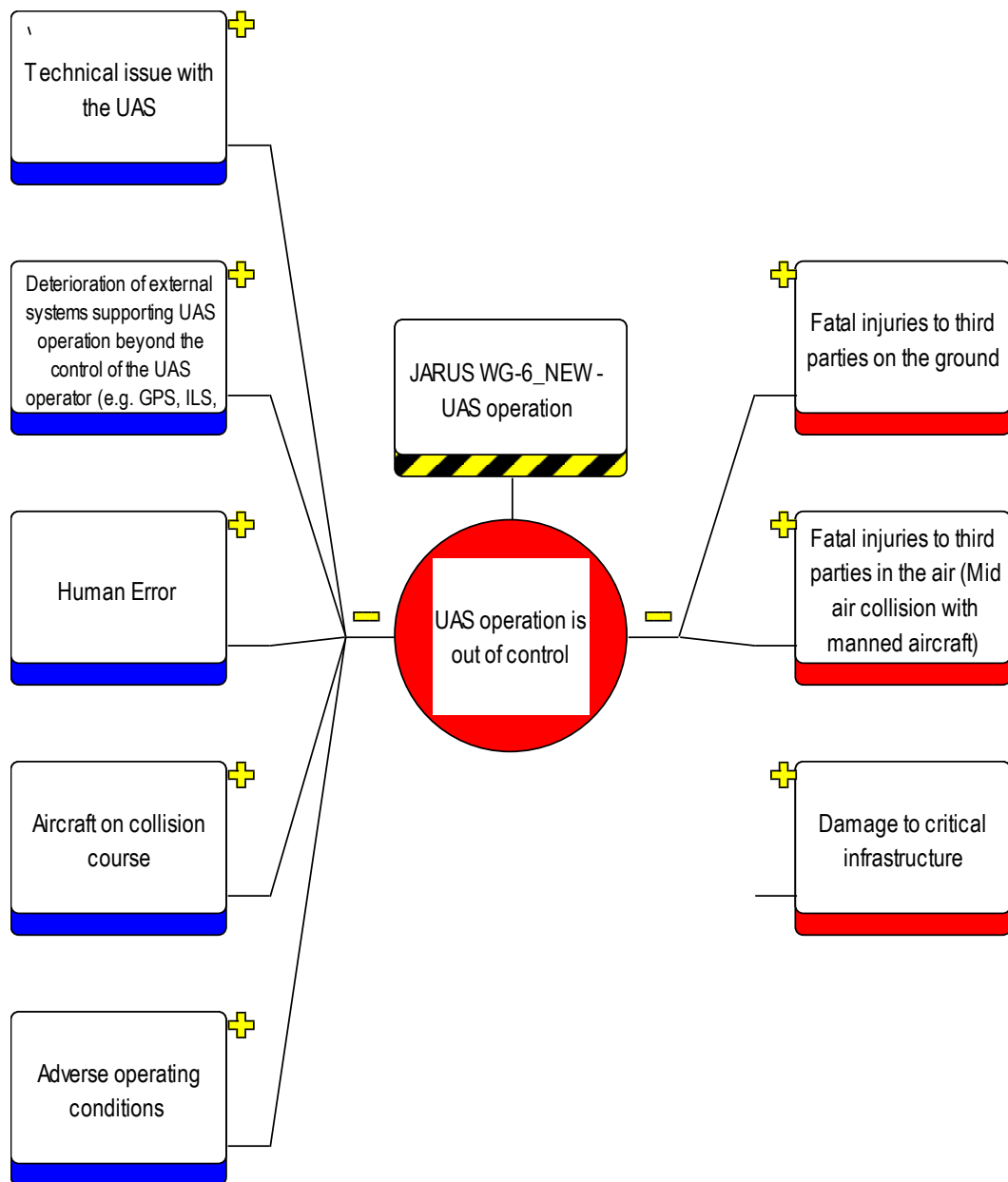


Figure 2 – Bow-tie representation of the Holistic Risk Model (HRM)

## 2.2.4 Identification of the means for risk mitigation

- (a) The risk mitigation measures might be implemented through various means (design and/or operations related) depending on the nature of the harm being controlled. In the case of fatal injuries on ground, for instance, appropriate mitigations might be linked to the control of population density and to UAS physical characteristics concerning its lethal area such as dimensions or explosion prevention capability.
- (b) The risk model identifies two complementary approaches to mitigating the risk of a UAS operation.
  - a. The first approach is to reduce the likelihood and/or mitigate the effects of the hazard – UAS operation out of control – for each category of harm. This approach is satisfied by the application of harm barriers.



- b. The second approach is to reduce the likelihood of the UAS operation being out of control through mitigations that control the threats and/or reduce their likelihood of occurrence. This approach is satisfied by the application of threat barriers.

### 2.2.4.1 Reduce the consequences of the hazard through harm barriers

- (a) On the right hand side of the bow-tie diagram represented in Figure 3, 8 harm barriers have been identified. Each of these harm barriers can:
  - a. reduce the effects of the hazard with respect to the relevant harm and/or,
  - b. reduce the likelihood that the occurred hazard will cause the harm.

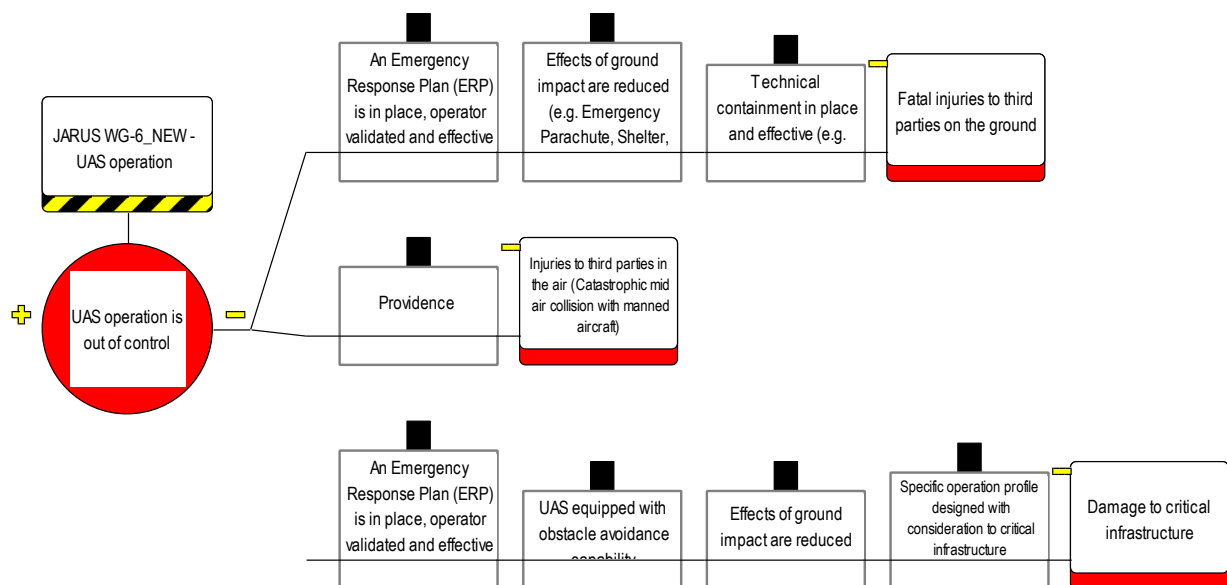


Figure 3 – Harm barriers

Figure 3 - Bow-tie representation of possible Harm barriers

- (b) Annex B to this document provides additional guidance on implementation of each harm barrier in a given operation.

### 2.2.4.2 Reduce the likelihood of the hazard through threat barriers

- (a) On the left hand side of the bow-tie diagram represented in Figure 4, 27 possible threat barriers have been identified and associated with the five generic categories of threats identified in paragraph 2.2.3. Each of these threat barriers reduce the likelihood of the hazard “UAS operation out-of-control” by:
  - a. preventing the threat from developing into the hazard or
  - b. reducing the likelihood of the threat.

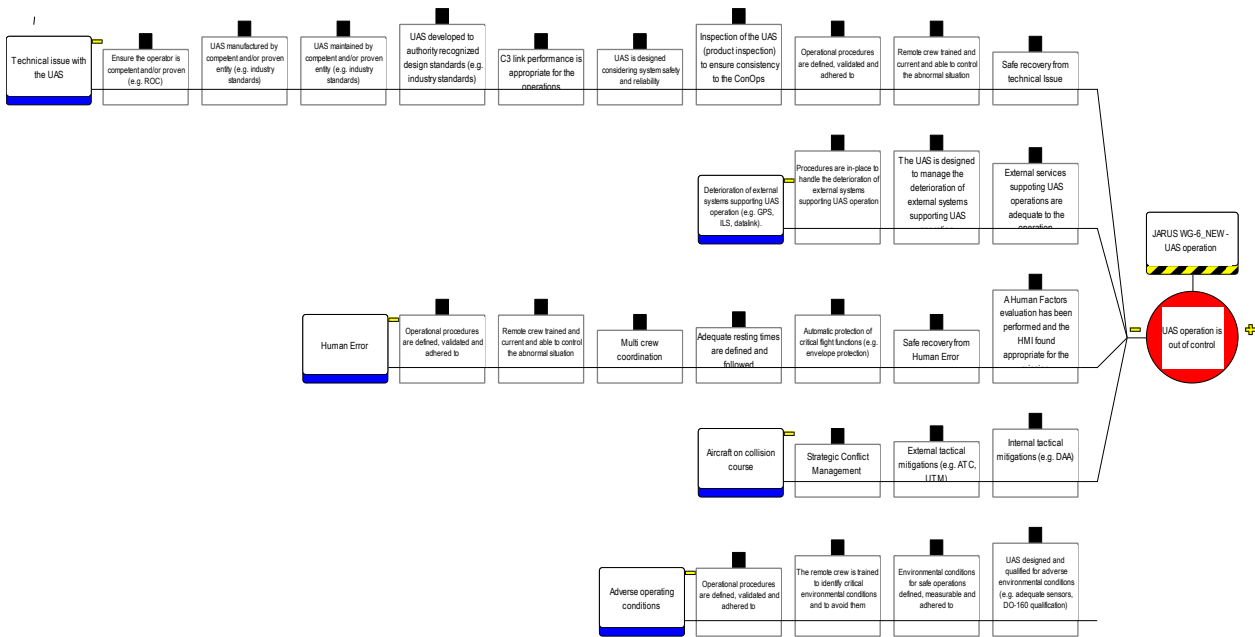


Figure 4 – Threat barriers

- (b) It is important to note that the effort to perform this step of the risk mitigation needs to be proportional to the risk of the operation with due consideration to the implemented harm barriers. For example, it is clear that by operating over unpopulated areas, the risk of hitting third parties on the ground is mitigated by an extreme application of the harm barrier of population density. In such a case, as the risk is already fully mitigated by the use of harm barriers, minimal effort should be required in implementing threat barriers. On the contrary, an operation conducted over crowded areas is likely to have a very high intrinsic risk thus requiring significant effort on reducing the likelihood of the hazard.
- (c) It is crucial to realize that UAS to be approved in the specific category might have high probabilities for the threats to occur but significant amount of barriers or vice versa. This allows great flexibility to the operator/applicant to initially operate an UAS with several barriers and high authority involvement and later develop their product to higher standards to increase operational capabilities and reduce the need for authority involvement.
- (d) Annex E to this document provides additional guidance on implementation of each threat barrier in a given operation.

### 3. Specific Operations Risk Assessment

- (a) The definition of risk provided in 2.1(a) (i.e. the combination of the *frequency* (probability) of an *occurrence* and its associated level of *severity*) requires the determination of two parameters, severity and probability, in order to assess the risks associated with a UAS operation. The Holistic Risk Model presented in chapter 2 proposes to focus the analysis only on categories of harm that are fatal to third parties or highly damaging to critical infrastructure.
- (b) Under the above assumption, the risk of an UAS operation can be tied only to the likelihood of a given category of harm to occur. The likelihood estimation or, more in general, the level of confidence that a certain category of harm will not occur, is the focus of the SORA.

#### 3.1 Categories of harm – likelihood estimation

- (a) The likelihood of each category of harm to occur can be broken into its individual component likelihoods as follows:

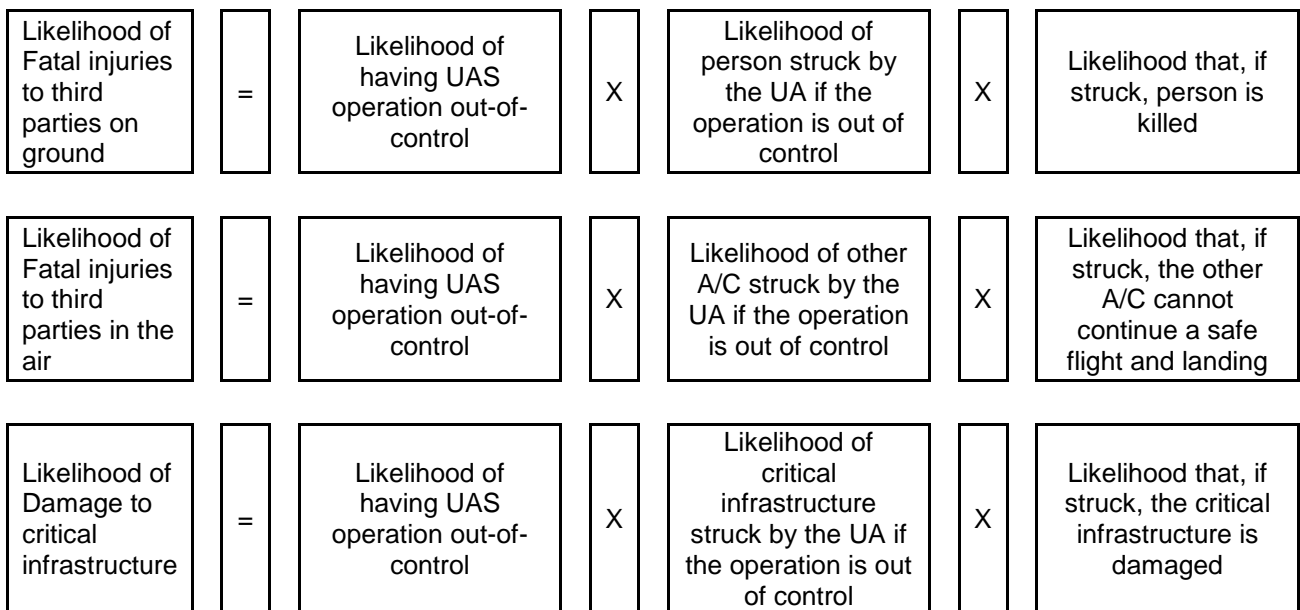


Figure 5 – Likelihood estimation

- (b) Each component can be evaluated individually in order to obtain an estimate of the likelihood of one of the categories of harm. The likelihood of having the “UAS operation out-of-control” is common to all three categories of harm, a fact that should not come to surprise having reviewed the risk model in Figure 2. This element of the equations, as discussed in paragraph 2.2, is mainly affected by the threats and relevant threat barriers. The second and the third elements of the right side of these equations are mainly affected by the relevant harm barriers.

##### 3.1.1 Approaches to risk analysis

- (a) Risk models that provide quantitative methods for risk estimation are powerful tools but not

without critics. Communication difficulties associated with quantitative risk assessments are typically due to the fundamental differences between quantitative risks expressed in the form of probability and severity and the much broader qualitative approach made by each individual in his perception of risk.

- (b) Whatever the limitations associated with quantitative assessments, these predictions provide valuable technical risk data to decision makers. The accuracy of the data is heavily dependent on the management of the uncertainties introduced in the risk model. A significant degree of uncertainty might reduce the accuracy of the data to an extent that does not justify the performance of such labour intensive analysis. In these situations, a qualitative risk assessment might be a more sensible option. It is therefore relevant to evaluate the uncertainties of the risk model in order to decide whether to recommend a labour intensive quantitative assessment or a simpler qualitative assessment, more dependent on the expertise of the involved actors.
- (c) *Completeness uncertainties* are those introduced when attempting to model complex reality. Typical models such as Failure Modes and Effect Analysis (FMEA) and Fault Tree Analysis (FTA) do not fully illustrate the complexity of real cases or scenarios. This uncertainty grows as the scenario is made more and more complex. The scenarios involved in an UAS operation are quite complex. These typically involve interactions between the UAS, the remote crew, other traffic, Air Traffic Control (ATC), etc. both in normal and abnormal operations. It is therefore reasonable to assume that a quantitative assessment of the risks involved in these operations will be subject to significant completeness uncertainties.
- (d) *Modelling uncertainties* are also a challenge. These uncertainties are particularly apparent when quantitative predictions are being made of the consequences of various occurrences. For example, if a 1kg UAS impacts at a speed of 10 m/s a third party on the ground it is necessary to provide mathematical models of the risk of injuries. There are considerable difficulties in providing mathematical models of these impacts (considering also the wide variety of shapes, materials, etc. of UAS) and the results might contain significant inaccuracies. Another significant element of inaccuracy can be introduced when attempting to quantify human reactions to emergency situations or when trying to introduce into the model external events such as EMI, adverse weather, etc.
- (e) *Parameter value uncertainties* are those related to the inaccuracy of the values to be used in the assessment. Components failure rates, atmospheric parameters, external event rates, human error rates, etc. may all be subject to large uncertainties unless significant experience with these data is available. A good illustrative example is the use of failure rate data for UAS components. Very large data set exist for a wide variety of components but these data are sensitive to component operating conditions and to operator and maintenance standard. Many components used in the UAS have very little historical data or are procured as Commercial-Off-The-Shelf (COTS). In these situations, engineering judgment is required: the value is derived in a qualitative manner. Another significant uncertainty is the statistical variability: unless significant test data is available to reduce the statistical variability to a reasonable value (typically 95% confidence level of a given rate) any value used will carry a considerable statistical uncertainty.
- (f) A quantitative assessment in the context of the approval of UAS in the specific category is subject to large uncertainties in completeness, modelling and parameter values. The conclusion of this evaluation is that the likelihood estimation should be preferably of qualitative nature.
- (g) The same argument cannot be made if credible and verifiable quantitative data is already available from in-service experience. An accident rate for a given product operating under specified conditions can be a valid parameter and should be used to support the risk assessment.

### 3.1.2 Risk parameters

- (a) In order to establish adequate parameters for the qualitative evaluation, it is useful to understand the quantitative nature of those parameters and their variability. In order to support this understanding, an equivalence of risk between Open, Specific and Certified categories should be investigated.
- (b) So far, there are no regulatory justifications for defining the risk to people on the ground as a function of the type of UAS operating over them (i.e. by accepting higher risks for some kinds of operations and lower for others). People exposed to the risk coming from UAS operations are typically unaware of the risk and thus they should be protected equally, irrespective of the kind of operations.
- (c) Therefore, a principle of risk equivalence among various categories must be retained. The number of fatal injuries to third parties on ground (per flight hour) is chosen as the best parameter that can embody the equivalence of risk, when kept equal among the different categories (open, specific, certified).
- (d) Table 1 below analyses notional quantitative ranges for the different parameters of the equations:

	Number of fatal injuries to third parties on ground (per flight hour)	Number of hazards (per flight hour)	Number of persons struck (per hazard)	Probability that a person suffers a fatal injury, if struck
Certified Category	1E-6	1E-6 to 1E-4	1E-2 to >1	1
Specific Category	1E-6	1E-6 to 1	1E-5 to > 1	0.01 to 1
Open Category	1E-6	1E-2 to 1	1E-5 to 1E-2	0 (harmless) or 0.01 to 1

Table 1 – Range of notional probabilities for parameters affecting the likelihood of fatal injuries to third parties on ground

- (e) The objective for the number of fatal injuries to third parties on the ground (per flight hour) comes from:
  - a. A principle of equivalence with the manned aviation
  - b. A principle of equivalence of fatal injuries to third parties on the ground (per flight hour) between the open, specified and certified categories.
- (f) The ranges proposed for the number of hazards (“UAS operation out of control”) per flight hour are justified as follows:
  - a. Concerning the certified category, this is a known safety level defined by the JARUS AMC RPAS.1309 [3] and justified in its associated Scoping Paper [4].
  - b. Concerning the open category, this value ranges from the highest possible and not better than 1E-2 as experienced with some COTS UAS.
  - c. For the specific category, the entire range between the highest (1) and the lowest (1E-6) requested in specific cases in the certified category is assumed possible.
- (g) The number of persons struck per hazard are highly dependent on the kind of operation (over scarcely populated or congested area) and on UAS characteristics (e.g. lethal area); these figures are established because of the equation set to preserve the level of protection of third parties on ground. These parameters can also be used to set the thresholds needed to differentiate between categories of UAS operations.
- (h) The ranges proposed for the probability that a person suffers a fatal injury, if struck is

justified as follows:

- a. For the certified category, it is conservatively set to 1.
  - b. For the specific and open categories, the probability that a person suffers a fatal injury, if struck might range from 1 to 1E-2 or even less. Studies are being conducted and standards being written to evaluate the lethality of UAS. This document will be updated to reflect the results of those studies as soon as they become available.
  - c. A probability equal to 0 is used for the harmless category
- (i) It must be highlighted that the above table is not intended to provide quantitative figures nor quantitative safety levels. Its only aim is to provide a conceptual reference for the introduction of qualitative levels for the specific category, which is of interest in this paper.

## 3.2 The SORA process

- (a) With a solid understanding of the elements to be evaluated when dealing with risks of specific UAS operations (i.e. threats, harms and their barriers) and armed with a sound knowledge of the main parameters to be estimated, the SORA process can now be established. The entire process is depicted in the figure below.

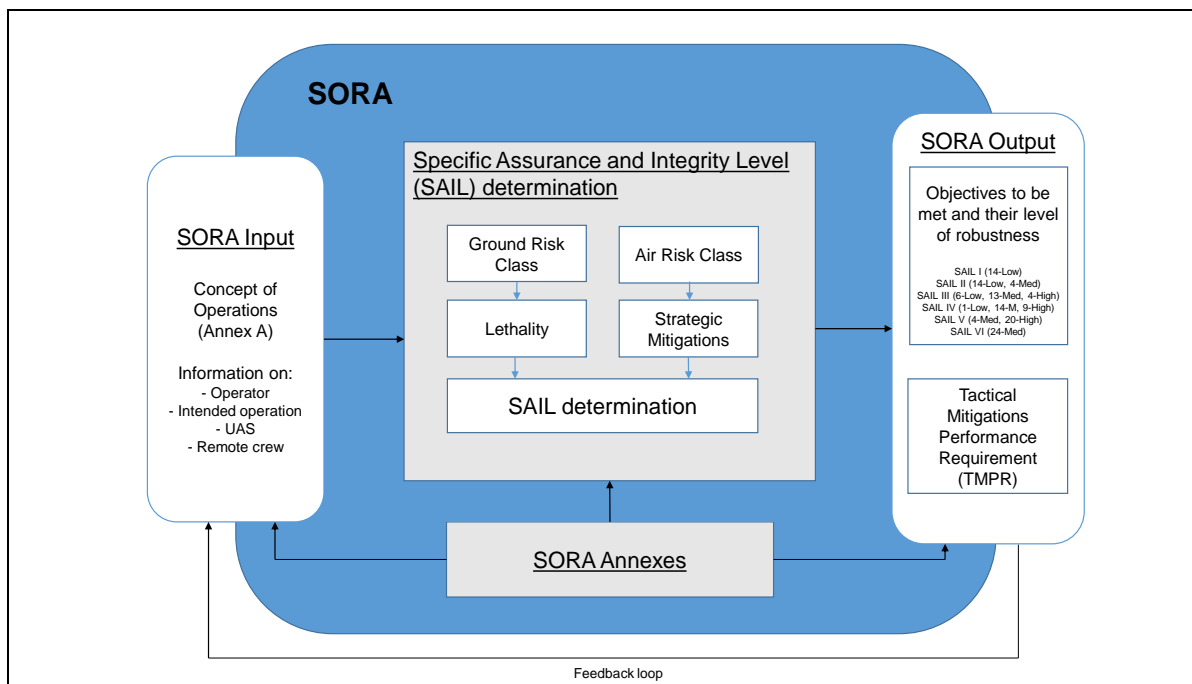


Figure 6 – SORA overview

- (b) 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.
- (c) 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 fourteen 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 appendix.

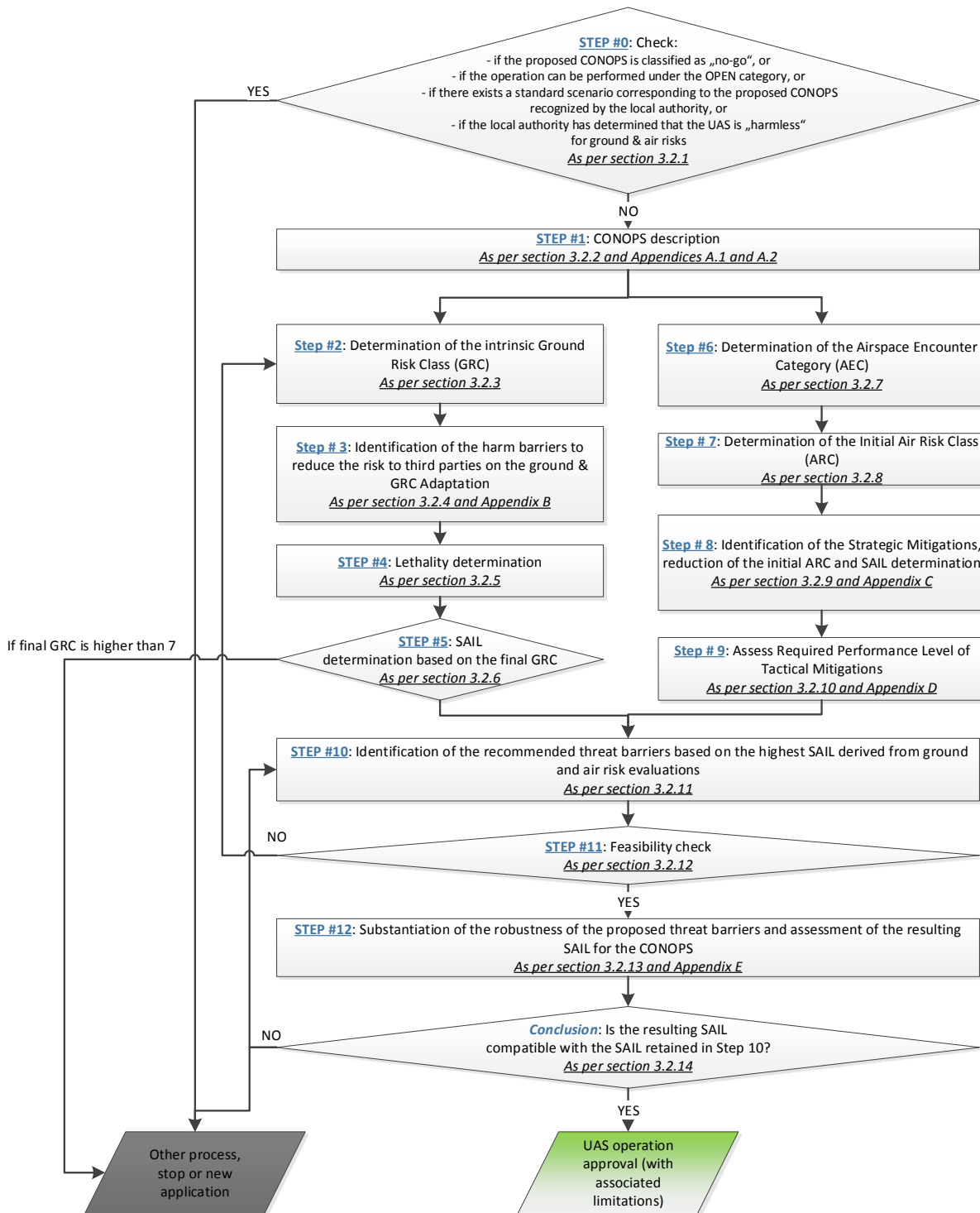


Figure 7 – The SORA process

### 3.2.1 Step #0 – Initial evaluation

- (a) In this preliminary step, the operator/applicant is tasked to verify that the proposed operation is feasible, not subject to specific exclusions from the local authority or subject to

a standard scenario. Things to verify include:

- a. If the operation can be covered under a “standard scenario” recognized by the local authority
- b. If the operation falls under the “open” category
- c. If the operation is subject to specific NO-GO from local authority
- d. If the local authority has determined that the UAS is “harmless” for both ground and air risk.

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

### 3.2.2 Step #1 – ConOps description

- (a) The first step of the SORA requires the operator/applicant 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 elements of the threat and harm barriers provided in Figure 3 and 4.

### 3.2.3 Step #2 – Determination of the initial UAS Ground Risk Class

- (a) The initial 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 Figure 8.

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
<i>Typical kinetic energy expected</i>	<i>&lt; 700 J (approx. 529 Ft Lb)</i>	<i>&lt; 34 KJ (approx. 25000 Ft Lb)</i>	<i>&lt; 1084 KJ (approx. 800000 Ft Lb)</i>	<i>&gt; 1084 KJ (approx. 800000 Ft Lb)</i>
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	
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Figure 8 – Ground Risk Classes (GRC) Determination

- (b) EVLOS<sup>°</sup> operations are to be considered as BVLOS for the GRC determination.
- (c) A controlled area is defined as the intended UAS operational area that only involves active participants (if any).
- (d) 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.
- (e) 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.
- (f) 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.
- (g) A detailed mathematical model to substantiate this approach is provided in Annex F.
- (h) Operations that do not have a corresponding GRC (i.e. grey cells on the table) are not currently supported by the SORA methodology.
- (i) When evaluating the typical kinetic energy expected for a given operation the operator/applicant should generally use airspeed, in particular  $V_{\text{cruise}}$  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>

### 3.2.4 Step #3 – Harm barriers and GRC adaptation

- (a) As discussed in Para 2.2.4.1, the use of harm barriers is an effective way to reduce the risk intrinsic to any specific operation. This step of the process allows for adaptation of the GRC based on the harm barriers available for the operation. Table 2 provides a list of harm barriers and the relative correction factor. A positive number denotes an increase of the risk class while a negative number results in a decrease of the risk class. 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 harm barrier. Local authorities may define additional harm barriers and the relative correction factors.

<sup>°</sup> 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.

Harm barriers for GRC adaptation	Robustness		
	Low/None	Medium	High
An Emergency Response Plan (ERP) is in place, operator validated and effective	1	0	-1
Effects of ground impact are reduced <sup>d</sup> (e.g. emergency parachute, shelter)	0	-1	-2
Technical containment in place and effective <sup>e</sup> (e.g. tether)	0	-2	-4

Table 2 – Harm barriers for GRC adaptation

- (b) 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 local 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 3 – Example of GRC adaptation

- (c) If the GRC cannot be reduced to a level of 7 or below, the proposed operation cannot be approved by means of the SORA methodology.

### 3.2.5 Step #4 – Lethality determination

- (a) The next step of the process is to evaluate the UAS Lethality. As discussed in Para. 3.1.2(h), this document acknowledges that different UA might have different lethality characteristics. The likelihood that a person would suffer fatal injuries if struck by an UA is, like many other parameters in this document, subject to extensive studies. At the time of writing, it has been agreed to define the lethality with three qualitative descriptors: High, Average or Low.
- (b) Due to the consideration of both size and energy during the ground risk determination, the nominal lethality of the crash area for most UAS can be anticipated. This lethality is expressed as AVERAGE in Table 5. However, there are certain cases or design aspects

<sup>d</sup> This harm barrier is meant as a means to reduce the energy absorbed by the people of the ground upon impact.

<sup>e</sup> This harm barrier is meant as a means to reduce the number of people at risk

that may not have been considered during the ground risk class that will have a significant effect on the lethality of the UAS such as fuel, high-energy rotors/props, frangibility, material, etc. These considerations may either increase or decrease the calculated SAIL.

- (c) Future revisions of the document will provide additional information on how to establish the lethality of a UA as on-going studies will mature.

### 3.2.6 Step #5 – Specific Assurance and Integrity Levels (SAIL)

- (a) With the final ground risk class and the lethality parameter being determined, it is now possible to define the Specific Assurance and Integrity Level (SAIL) and the associated objectives to be met in order to establish a sufficient level of confidence that the likelihood of losing control of the UAS operation is commensurate with the proposed ConOps.
- (b) The chosen parameter to consolidate all data and to drive the required activities is the **SAIL**. The SAIL represents the level of confidence that the UAS operation will stay under control.
- (c) The level of confidence represented by the SAIL is not quantitative but instead corresponds to:
  - a. Objectives to be complied with,
  - b. Description of activities that might support the compliance with those objectives, and
  - c. Evidence to indicate the objectives have been satisfied.
- (d) A SAIL is assigned to the ground risk using Table 4.

Ground Risk SAIL							
Lethality	UAS Ground Risk Class						
	7	6	5	4	3	2	1
HIGH	VI	VI	V	IV	III	II	I
AVERAGE	VI	V	IV	III	II	I	0
LOW	V	IV	III	II	I	0	0

*Table 4 – SAIL determination for Ground Risk*

- (e) As an example, we can assume that a given operation has a final GRC of 3. Lethality has been assigned HIGH for the ground impact. The SAIL for Ground Risk will be **III**.
- (f) A SAIL 0 is assigned for those operations where no further activities are required other than verification of harm barriers. A SAIL 0 is also applicable to operations with a negative Ground Risk Class resulting from application of harm barriers with a cumulative correction factor higher than the initial ground risk.

### 3.2.7 Step #6 – Determination of the Airspace Encounter Category (AEC)

- (a) The airspace encounter category (AEC) is a grouping of airspace types that best reflect perceived levels of collision risk. The AEC is grouped by operational altitude, airport environment, controlled airspace, uncontrolled Mode C veil/TMZ airspace, and in uncontrolled airspace over rural and/or urban populations, into 12 categorizations (Figure 9).
- (b) An operation in which the UAS will operate in more than one AEC airspace will require an assessment for each AEC to insure that there is an acceptable collision risk throughout the entire operation.

(c) Atypical airspace (Very Low Density) in the context of the SORA is defined as:

- Restricted Airspace or Danger Areas;
- Airspace where normal manned aircraft cannot go (e.g. airspace within 400 ft. of buildings or structures);
- Airspace characterization where the encounter rate of manned aircraft (encounter is defined as proximity of 3000 ft. horizontally and  $\pm$  350 ft. vertically) can be shown to be less than 1E-6 per flight hour during the operation;
- Airspace not covered in Airspace Encounter Categories (AEC) 1 through 11;

Airspace Encounter Categories (AEC)	Operational Airspace
1	Operations within Class A, B, C, D, E, or F Non-Airport Environment above 500 ft AGL
2	Operations within an Airport Environment above 500 ft AGL
3	Operations within Class G airspace above 500 ft AGL within Mode C Veil/TMZ
4	Operations within Class G airspace above 500 ft AGL over Urban population
5	Operations in Class G airspace above 500 ft AGL over Rural population
6	Operations within Class A, B, C, D, E, or F Non-Airport Environment below 500 ft AGL
7	Operations within an Airport Environment below 500 ft AGL
8	Operations within Class G airspace below 500 ft AGL within Mode C Veil/TMZ
9	Operations within Class G airspace below 500 ft AGL over Urban population
10	Operations within Class G airspace below 500 ft AGL over Rural population
11	Operations in airspace above FL600
12	Operations in atypical airspace

*Figure 9 – AEC determination*

*Note: it is inferred that there is a direct correlation between population density and manned aircraft density; higher amounts of aircraft density can be found over urban populations than over rural populations.*

(d) Although Figure 9 is a good overview of the operational airspaces that make up the AEC, determining the AEC from this figure could be misleading. To find the proper AEC for the type of UAS operation, the operator/applicant should use the flow chart in Figure 10.

## Airspace Encounter Categories (AEC)

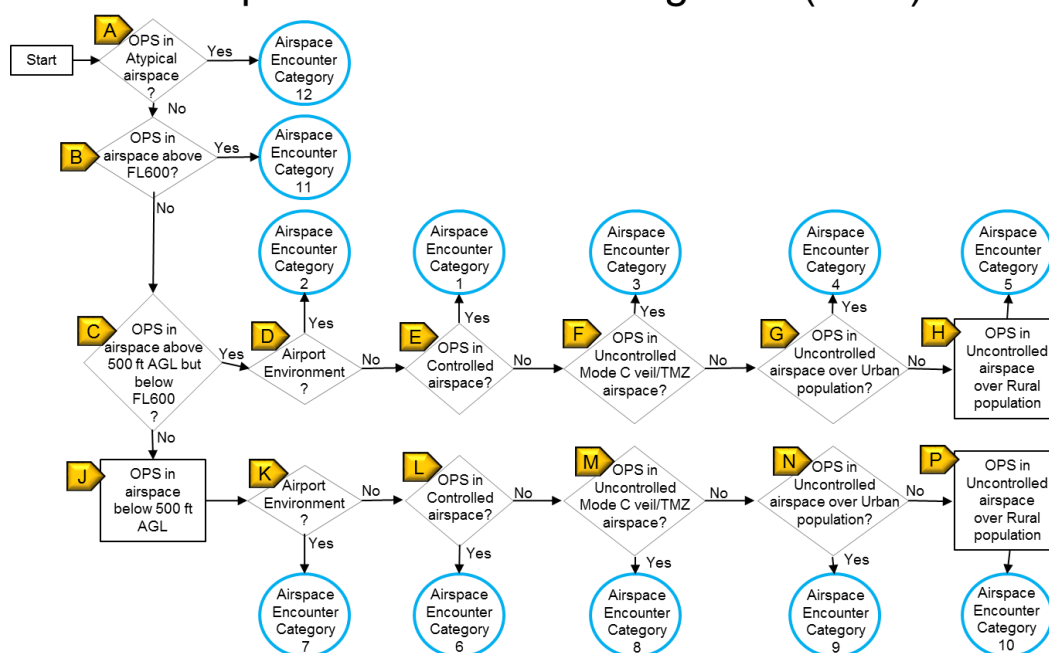


Figure 10 – AEC assignment process

*Example 1; the CONOPS states that the operation will be crop-dusting a field. A check of the local aeronautical maps finds that most flights are in class G airspace but some fields are within the boundary of a Class D airfield. The CONOPS also states that the UAS will not fly higher than 200 ft. AGL for the entire operation.*

- The portion of the flight in class G airspace, below 200 ft. AGL, over rural areas, is AEC 10.
- The portion of the flight in class D airspace, below 200 ft. AGL, over rural areas, is AEC 7.

*Example 2; the CONOPS states that the operation will be to take pictures of a city from 3000 ft. AGL. A check of the local aeronautical maps finds that the take-off and landing site is in class G airspace, over a city, however, as the UAS climbs through 1,200 ft. AGL, it enters Class E, controlled airspace, where it begins to take pictures.*

- The portion of the flight in class G airspace, below 500 ft. AGL, over urban areas, is AEC 9.
- The portion of the flight in class G airspace, above 500 ft. AGL, over urban areas, is AEC 4.
- The portion of the flight when the UAS enter into class E at 1200 ft. AGL, is AEC 1.

### 3.2.8 Step #7 – Initial assessment of the Air-Risk Class

- The ARC is a qualitative classification of the rate at which a UAS would encounter a manned aircraft in typical generalized civil airspace.

- (b) The ARC is based on the assessment of the following three parameters:
- a. Rate of Proximity – (sometimes called “encounter rate”) The more aircraft in the airspace, the higher the rate of proximity, the greater the risk of collision. A collision requires two aircraft, and that those two aircraft are in proximity of each other. In general terms, the more aircraft in a given volume of airspace, the more opportunities there are for aircraft to be proximal to each other. The rate at which aircraft proximity happens is approximately equal to the square of the number of aircraft within that system. Therefore, the rate at which aircraft will be proximal to each other grows exponentially by the number of aircraft.
  - b. Geometry - An airspace which sets or allows aircraft on collision courses increases risk of collision. One of the ways to reduce collision risk is to control the geometry of the aircraft within an airspace. An everyday example of this is a road. All cars on one side of the road go one direction, all cars on the other side of the road go the other direction. In this way, the geometries of the cars are controlled and collision risk between cars is greatly reduced. By controlling the geometry of aircraft through airspace structures, procedures, and regulations, collision risk between aircraft is greatly reduced.
  - c. Dynamics - The faster the speed of the aircraft in the airspace the higher the rate of proximity, the greater the risk of collision. Simply put, the faster the closing speed of a collision pair, the faster they will collide. In general terms, over a single flight hour, a volume of airspace where the average closing speed of the collision pairs is 200 mph, will have twice as many collisions than if the average closing speed is 100 mph. Faster aircraft mean faster closing speeds, meaning more chances for proximity, which means more collision risk, over a set amount of time.
- (c) Airspace where there is a higher density of manned aircraft, few airspace structural controls, and high aircraft closing speeds, will experience higher airspace encounter rates than in airspace where there is low density, high airspace structure and slow speeds. The SORA Annex G provides details on how those three parameters can be used to derive the ARC.
- (d) The ARC is an initial assignment of generic collision risk, before mitigations are applied. Actual collision risk of a specific local area of operation could be much different and will be addressed in later steps.
- (e) The operator/applicant should use the Table 5, with the AEC, to find the assigned initial ARC.

	Airspace Encounter Categories (AEC)	Operational Airspace	Air Risk Class (ARC)
Integrated Airspace Operations above 500 ft.	1	Operations within Class A, B, C, D, or E airspace above 500 ft. AGL	4
	2	Operations within an Airport Environment above 500 ft. AGL	4
	3	Operations within Class G airspace above 500 ft. AGL within Mode C Veil /TMZ	4
	4	Operations within Class G airspace above 500 ft. AGL over urban environment	3
	5	Operations within Class G airspace above 500 ft. AGL over rural environment	3
VLL Airspace Operations below 500 ft.	6	Operations within Class A, B, C, D, or E airspace below 500 ft. AGL	3
	7	Operations within an Airport Environment below 500 ft. AGL	4
	8	Operations within Class G airspace below 500 ft. AGL within Mode C Veil /TMZ	3
	9	Operations within Class G airspace below 500 ft. AGL over urban environment	3
	10	Operations within Class G airspace below 500 ft. AGL over rural environment	2
VHL	11	Operations in airspace above FL600	2
Any	12	Operations in Atypical Airspace	1

*Table 5 – Air-Risk Class (ARC) determination*

- (f) ARC 1 is generally defined as airspace where the risk of collision between a UAS and manned aircraft is acceptably safe without the addition of any collision mitigation. However, even though the ARC is technically safe to fly from an air collision risk standpoint; it does not fulfil the 14 CFR 91.113, SERA 3201, or ICAO Annex 2 section 3.2 “See and Avoid” requirement. Those requirements must be addressed to the satisfaction of the competent authority.
- (g) ARC 2 is generally defined as airspace where the risk of collision between a UAS and manned aircraft is very low. This collision risk class requires some sort of collision mitigation but the amount of mitigation, and performance level of that mitigation will be low.
- (h) ARC 3 is generally defined as airspace where the risk of collision between a UAS and manned aircraft is low to moderate. This collision risk class requires some more collision mitigation than Class 2 but less than Class 4. The amount of mitigations and performance level of those mitigations will be low to moderate.
- (i) ARC 4 is defined as airspace where the risk of collision between a UAS and manned aircraft is moderate to high. This is airspace where manned aircraft are expected to be found operating. In this airspace, the UAS is operating in Integrated Airspace and must comply with existing operating rules and procedures for manned aircraft, without reducing existing capacity, decreasing safety, negatively affecting current operators, 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.

### **3.2.9 Step #8 – Establish Strategic Mitigations**

- (a) The operator may wish to lower the initial ARC assessment because the local conditions of the proposed operation are not indicative of the generalizations made in the AEC. In these cases, the competent authority can review the evidence and arguments made by the operator and decide on whether they concur and grant a lowering of the ARC.
- (b) Mitigations within the Air Risk Model of the SORA are separated and applied in two phases.
  - Strategic Mitigation
  - Tactical Mitigation (addressed in the next chapter)
- (c) Strategic Mitigation is applied to reduce the ARC while tactical mitigation are applied to meet residual risk of the ARC.
- (d) The operator/applicant may propose strategic mitigations to reduce the ARC. The purpose of reducing the ARC is to provide a way for the operator/applicant to lower the required Tactical Mitigation as well as reducing the SAIL associated with the operation.
- (e) For the purposes of this assessment, Strategic Mitigations take the form of operational restriction of time or space taken prior to take-off aimed at reducing aircraft density and/or exposure time and thereby reducing encounter rates:
  - a. Restriction by time (e.g. fly at night, etc.)
  - b. Restriction by space (e.g. remain inside a prescribed airspace volume, etc.)
  - c. Restriction by time-of-exposure (e.g. the UA is predominantly intended to fly in an airspace but it will cut the corner of another one for a very limited amount of time. Risk in the corner cutting airspace is limited because of the short amount of time in that airspace, etc.)
  - d. Strategic separation by procedure<sup>f</sup> - all participants in the airspace are equipped and follow procedures designed to control the geometry of all aircraft.
- (f) By proper application of the strategic mitigations, it may be possible in certain environments to partially or even fully mitigate the Air Risk.
- (g) The level of robustness of the strategic mitigation must be proportional to the ARC reduction. In detail:
  - a. For an ARC reduction of 3 levels, the strategic mitigations need to be proven to a High level of Robustness.
  - b. For an ARC reduction of 2 levels, the strategic mitigations need to be proven to a Medium level of Robustness.
  - c. For an ARC reduction of 1 level, the strategic mitigations need to be proven to a Low level of Robustness.
- (h) In order to be allowed to reduce the ARC, the operator/applicant will need to demonstrate to the competent authority that operational restrictions imposed on the UAS can lower the risk of collision, by showing that the local airspace aircraft density under the operational

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<sup>f</sup> Strategic mitigation can work in ways other than operational restrictions. One of those ways is a process called strategic separation. This is a process where all aircraft in the airspace adhere to rules and procedures of the airspace. An example of this is the IFR/VFR cruising altitudes flight rules, based on the aircraft's course. This has the effect of reducing the collision geometries, and thus the collision risk. However, in order for strategic separation schemes to work, all aircraft in the airspace must adhere to the scheme. Because there are no such schemes for VLL airspace at this time, and trying to determine effectiveness of the schemes in Integrated Airspace is very difficult, the strategic separation process is not used as a mitigation in this assessment. This is not to say that in the future, a system like UTM, may be an acceptable means of strategic mitigation, the key is that all aircraft must be participants for strategic separation to work.



restrictions, are much lower than the generalized ARC assessment density. This assessment would normally take the form of a local airspace characterization study to show that the local density, under the operational restrictions, can support a reduction in the ARC. The amount of credit (and therefore ARC reduction) shall be agreed between the competent authority and the operator/applicant. Details on how to perform this evaluation are provided in Annex C of the SORA. The following examples might be used to illustrate the reasoning:

*Example 1, the operator/applicant wishes to fly in airspace designated ARC 4. The operator/applicant puts together a compelling case and presents it to the competent authority. The competent authority looks at the operator/applicant data, does some independent investigation and concludes that the operator/applicant is correct. The competent authority lowers the ARC from ARC 4 to ARC 2. Because the ARC is lowered by 2 levels, the compelling case needs to be shown at a Medium level of robustness.*

*Example 2, the operator/applicant wishes to fly in airspace designated ARC 4. The operator/applicant puts together a compelling case and presents it to the competent authority. The competent authority looks at the operator/applicant data, does some independent investigation and concludes that the operator/applicant is incorrect. The operator/applicant states that they are willing to except operational restrictions, which only allow UAS operations to fly at night when the local aircraft density is even lower. The competent authority agrees to the operational restriction and lowers the ARC from ARC 4 to ARC 3. Because the ARC is lowered by 1 level, the compelling case needs to be shown at a Low level of robustness.*

Having established the final ARC (ARC post strategic mitigation), it is now possible to derive the SAIL associated with the Air Risk.

Air Risk Class	Specific Assurance and Integrity Level (SAIL)
ARC 4	SAIL VI
ARC 3	SAIL IV
ARC 2	SAIL II
ARC 1	SAIL I

*Table 6 – SAIL determination*

- (i) The SORA process should not be used to support operations of a UA in a given airspace without the equipment required to operate in that airspace (e.g. equipment required to ensure interoperability with other airspace users). In these cases, specific exemptions have to be granted by the air navigation authority. Those exemptions are outside the scope of the SORA.

### **3.2.10 Step #9 – Assess Required Level of Tactical Mitigation**

- (a) Tactical Mitigations are applied to meet residual risk of the ARC. Residual risk is the remaining collision risk from the ARC threat needed to achieve the airspace safety objective.
- (b) For the purposes of this assessment, Tactical Mitigations are procedures with a very short time horizon (seconds to a few minutes) which change the UAS encounter geometry to mitigate collision risk and may take the form of a “See, Decide, Avoid, Feedback Loop

(SDAF loop)”.

*Examples of Tactical Mitigations:*

- *Traffic Collision Avoidance System (TCAS),*
- *Air Traffic Control (ATC),*
- *Airborne Collision Avoidance System (ACAS-X),*
- *Mid-Air Collision Avoidance System (MIDCAS),*
- *Detect and Avoid (DAA),*
- *Airborne-Based Sense And Avoid (ABSAA),*
- *Ground-Based Sense And Avoid (GBSAA),*
- *See and Avoid,*
- *Visual Line of Sight (VLOS), etc.*

(c) With the ARC, the operator/applicant will use Table 7 below to determine the Tactical Mitigation Performance Requirement (TMPR).

<b>Air Risk Class</b>	<b>Tactical Mitigation Performance Requirements (TMPR)</b>
ARC 4	High Performance
ARC 3	Medium Performance
ARC 2	Low Performance
ARC 1	Optional - the operator/applicant may still need to show some form of mitigation as deemed necessary by the local authority/qualified entity

*Table 7 – Tactical Mitigation Performance Requirement (TMPR)*

- (d) The TMPR is the total performance required by all tactical mitigation means combined. When combining multiple tactical mitigations, it is important to recognize that the mitigation means will interact with each other and the robustness is not additive or multiplicative.
- (e) The operator/applicant might decide to equip the UAS with DAA capabilities as one way to meet the required TMPR. In this case, the operator/applicant must know or assess the performance level of the DAA system on the UAS performing the operation. DAA or similar systems performance levels are generally described in the form of risk ratios (RR).
- (f) Annex D provides information on how to determine the performance levels of tactical mitigations, including details on system Risk Ratios as well as information on how to satisfy the TMPR based on the available tactical mitigations.
- (g) Figure 11 below shows an overview of the Air Risk mitigation process. First AEC assignment (purple box at bottom of figure), followed by initial ARC assignment, the use of strategic mitigation to reduce ARC, and finally the assignment of the TMPR to address residual risk.

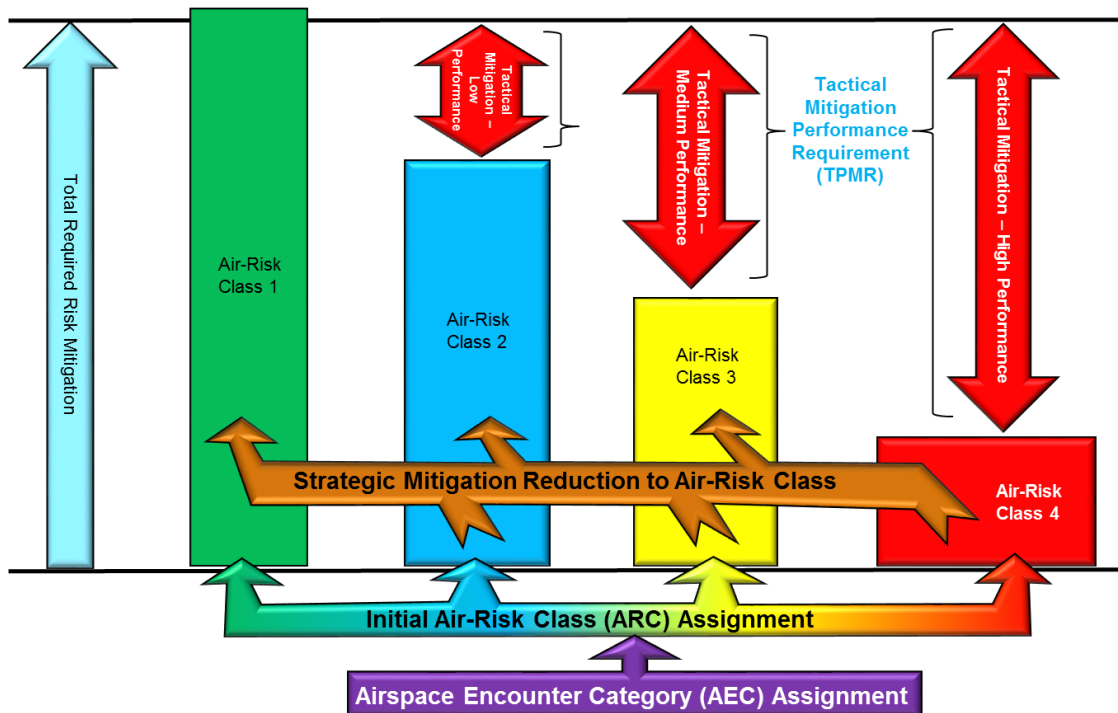


Figure 11 – The Air Risk Process

### 3.2.11 Step #10 Identification of recommended threat barriers

- (a) The next step of the SORA process is to evaluate the recommended threat barriers and the associated level of integrity depending on the SAIL (the highest SAIL derived from the ground and the air risk evaluation applies). 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 threat barriers are grouped based on the threat they help to mitigate. Some barriers may therefore be repeated in the table.
- (b) Table 8 is a consolidated list of common threat barriers 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 barriers for a specific operation. Local authorities may define additional threat barriers and the relative level of robustness.

	SAIL					
	I	II	III	IV	V	VI
<b>Technical issue with the UAS</b>						
Ensure the operator is competent and/or proven (e.g. ROC)	O	L	M	H	H	H
UAS manufactured by competent and/or proven entity (e.g. industry standards)	O	O	L	M	H	H
UAS maintained by competent and/or proven entity (e.g. industry standards)	L	L	M	M	H	H
UAS developed to authority recognized design standards (e.g. industry standards) <sup>9</sup>	O	O	O	L	M	H

<sup>9</sup> The robustness level does not apply to harm barriers for which credit has been taken to derive the risk

C3 link performance is appropriate for the operation	O	L	L	M	H	H
UAS is designed considering system safety and reliability	O	O	L	M	H	H
Inspection of the UAS (product inspection) to ensure consistency to the ConOps	L	L	M	M	H	H
Operational procedures are defined, validated and adhered to	L	M	H	H	H	H
Remote crew trained and current and able to control the abnormal situation	L	L	M	M	H	H
Safe recovery from technical issue	L	L	M	M	H	H
<b>Human Error</b>						
Operational procedures are defined, validated and adhered to	L	M	H	H	H	H
Remote crew trained and current and able to control the abnormal situation	L	L	M	M	H	H
Multi crew coordination	L	L	M	H	H	H
Adequate resting times are defined and followed	L	L	M	M	H	H
Automatic protection of critical flight functions (e.g. envelope protection)	O	O	L	M	H	H
Safe recovery from Human Error	O	O	L	M	M	H
A Human Factors evaluation has been performed and the HMI found appropriate for the mission	O	L	L	M	M	H
<b>Aircraft on collision course</b>						
<i>The use of mitigations directly related to the risk of collision has been addressed in previous steps of the SORA.</i>						
<b>Adverse operating conditions</b>						
Operational procedures are defined, validated and adhered to	L	M	H	H	H	H
The remote crew is trained to identify critical environmental conditions and to avoid them	O	L	M	M	M	H
Environmental conditions for safe operations defined, measurable and adhered to	L	L	M	M	H	H
UAS designed and qualified for adverse environmental conditions (e.g. adequate sensors, DO-160 qualification)	O	O	M	H	H	H
<b>Deterioration of external systems supporting UAS operation</b>						

classes. This is further detailed in para. 3.2.11(a).

Procedures are in-place to handle the deterioration of external systems supporting UAS operation	L	M	H	H	H	H
The UAS is designed to manage the deterioration of external systems supporting UAS operation	L	L	M	H	H	H
External services supporting UAS operations are adequate to the operation	L	L	M	H	H	H

Table 8 – Recommended threat barriers

### 3.2.12 Step #11 - Feasibility check

- (a) With the SAIL assigned to the operation and with full understanding of the recommended objectives to be met, it is now possible to review the feasibility of the proposed ConOps and decide to continue with the application or, alternatively, to revise the ConOps in order to lower the SAIL. Additional harm barriers or simpler operational scenarios can be implemented to achieve lower SAILs.
- (b) For example, an operator/applicant might decide to implement an emergency parachute to lower the GRC or, alternatively, to move his operation from populated to sparsely populated areas. Similarly, the ARC can be lowered by limiting the operation to lower density airspaces (e.g. by operating in restricted airspaces).

### 3.2.13 Step #12 – Verification of robustness of the proposed barriers

- (a) Step 12 is the process with which the operator/applicant substantiates the robustness of the proposed barriers. It should be executed to verify both harm barriers and threat barriers. As harm barriers are used to alter the SAIL 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).
- (b) The **robustness** designations of each barrier define both the level of integrity required to meet the SAIL (e.g. the safety gain provided by each mitigation) and the level of assurance required to show the SAIL objective has been satisfied (e.g. the proof that the claimed safety gain has been achieved). The level of integrity required for each barrier is described in the Annexes B, C, D and E. Those annexes provide guidance or refer to industry standards and practices. General guidance for the level of assurance is provided below.

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

A **Medium** level of assurance can be one for which the operator/applicant 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.

- (c) The SORA provides specific recommendations on how to determine the level of integrity and assurance of each barrier in Annexes B, C, D and E. It is envisaged that individual local authorities/qualified entities might require slightly different activities to substantiate the level of robustness in order to accommodate national specificities that cannot (and should not) be standardized.
- (d) Having determined the level of integrity and the level of assurance for each barrier, the

robustness level can be derived by Table 9

	Low Assurance Level	Medium Assurance Level	High Assurance Level
Low Integrity Level	LOW	LOW	LOW
Medium Integrity Level	LOW	MEDIUM	MEDIUM
High Integrity Level	LOW	MEDIUM	HIGH

*Table 9 – Determination of robustness level*

- (e) The step 12 concludes the SORA. A successful evaluation of robustness and effectiveness of all proposed barriers would result in the acceptability of the proposed operation.

# **ANNEX A – Guidelines on collecting and presenting system and operation information for a specific UAS operation**

**Please refer to Annex A document**

**A.1 Guidance for collection and presentation of operation relevant information.**

**A.2 Guidance for collection and presentation of technical relevant information**

## **ANNEX B – Harm Barriers**

Reserved



## **ANNEX C – Strategic Mitigations**

Reserved

# **ANNEX D – Tactical Mitigations**

**Reserved**

# **ANNEX E – Threat Barriers**

**Reserved**

# **ANNEX F – Ground Risk Model**

**Reserved**

# **ANNEX G – Air Risk Model**

**Reserved**

# **ANNEX H – Unmanned Traffic Management (UTM) implications for SORA**

**Reserved**

# **ANNEX I – Glossary of Terms**

**Please refer to Annex I document**

# **ANNEX J – Standard Scenario Template**

**Reserved**