Joint Authorities for Rulemaking of Unmanned Systems

JARUS guidelines on Specific Operations Risk Assessment (SORA)

DOCUMENT IDENTIFIER : JAR-DEL-WG6-D.04

Edition Number	**:**	**2.5**
Edition Date	**:**	**08.11.2022**
Status	**:**	**Draft**
Intended for	**:**	**JARUS-SRM consultation**
Category	**:**	**Guidelines**
WG	**:**	**SRM**

DOCUMENT CHARACTERISTICS

TITLE			
Specific Operations Risk Assessment (SORA)			
		Publications Reference:	JAR-doc-SRM
		ID Number:	D.04
Document Identifier		**Edition Number:**	2.5
JAR-DEL-WG6-D.04		**Edition Date:**	08.11.2022

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.

Keywords

SORA, SAIL, Specific, Risk

Contact Person(s)	Tel	Unit
Lorenzo Murzilli – JARUS WG-SRM Leader	-	-

STATUS, AUDIENCE AND ACCESSIBILITY					
Status		**Intended for**		**Accessible via**	
Working Draft	☒	General Public	☒	Intranet	☐
Final	☐	JARUS members	☐	Extranet	☐
Proposed Issue	☐	Restricted	☐	Internet (http://jarus-UAS.org)	☒
Released Issue	☐	Internal/External consultation ☒			

DOCUMENT APPROVAL

The following table identifies the process successively approving the present issue of this document before public publication.

PROCESS	NAME AND SIGNATURE WG leader	DATE
WG	Lorenzo Murzilli	08.11.2021

DOCUMENT CHANGE RECORD

The following table records the complete history of the successive editions of the present document.

EDITION NUMBER	EDITION DATE	REASON FOR CHANGE	PAGES / SECTIONS AFFECTED
0.1	22.04.2016	Version for JARUS Internal consultation	
0.2	25.08.2016	Version for JARUS External consultation	
1.0	26.06.2017	Version for Public Release	All
1.1	29.01.2018	Version for JARUS Internal consultation	Section #1.1 (update of the Purpose of the document), Section #3.1 (update to stay consistent with the air risk model) Section #3.2.4 (addition of the Harm Barrier numbers, in line with Annex B), Section #3.2.5 (correction of a typo in reference to a table), Section #3.2.7, #3.2.8 and #3.2.9 (general Air Risk Model update), Section #3.2.10 (addition of the Threat Barrier numbers, in line with Annex E) Section #3.2.11.a (correction of a typo)
1.2	31.05.2018	Version for JARUS External consultation	Re-work of several sections of the document to account for consultation comments General editing for increased readability
2.0	30.01.2019	Public release	Re-work of several sections of the document to account for consultation comments General editing for increased readability
2.5	27.10.2021	Version for JARUS WG-SRM internal consultation	Rework of all sections for clarity and incorporation of Annex E Cyber, Annex F Ground Risk Quantitative Methods and Annex H UTM concepts. Incorporation of Ground Risk Buffer into section 2.3.1 from Annex B

			Update of Table 2, the iGRC table, based on Annex F Removal of VLOS mitigation in the iGRC table and moved to Annex B and Table 3 mitigations.
2.5	08.11.2022	Version for JARUS External consultation	Rework of all sections for clarity. Incorporation of the Executive Summary. Update of containment (previously Step 9) and dispersion of its parts throughout the SORA to more relevant locations. Relocation of containment to Step 8 before the Operational Safety Objectives (relocated to Step 9, numbering and order updated). Removal of ERP as a mitigation. General editing for increased readability and usability.

DOCUMENT CONTRIBUTORS

	Team Member		Organization
WG-SRM Lead	Lorenzo	Murzilli	Murzilli Consulting advisor to Swiss FOCA
Main Body Task Force Co-Leads	Andreea	Perca	Swiss FOCA
	Tony	Nannini	Wing
Main Body Task Force Sub Group Leads	Henri	Hohtari – Annex B	Swiss FOCA
	Alexandra	Florin – Annex E	Wing
	Natale	Di Rubbo – Annex I	EASA
	Joerg	Dittrich - Containment	DLR
Main Body Task Force Members	Michael	Allouche	Independent UAS Airworthiness Expert
	Klavs	Andersen	Special Advisor to Danish CAA
	Nicolas	Brieger	Umlaut Consulting GmbH
	Romain	Bevillard	DGAC (France)
	Fabio	Camacho	ANAC (Portugal)
	Leonardo	Capacci	EASA
	Alberto	Cunial	EASA
	Markus	Engelhart	Umlaut Consulting GmbH
	Gregoire	Faur	Azur-Drones
	Falk	Gotten	LBA (Germany)
	David	Guerin	African Drone Forum
	David	Gutierrez	UK CAA
	Stefan	Hristozov	Unmanned Systems Bulgaria
	Marcus	Johnson	NASA
	Vincenzo	Formato	ENAC (Italy)
	Roberto	Gándara Ossel	AESA (Spain)
	Eric	Mataba	SACAA
	Aurelie	Joy Pascual	Murzilli Consulting
	Arne	Malcharowitz	EASA
	Antonio	Marchetto	EASA
	Robert	Markwell	UK CAA
	Terry	Martin	Revolution Aerospace
	Paul	McKay	Transport Canada
	Ilmars	Ozols	Latvian CAA
	Tom	Putland	CASA (Australia)
	Bosko	Rafailovic	Skyguide, Swiss ANSP
	Peter	Sachs	FAA
	Segalite	Sellem-Delmar	ASD / Safran Group
	Ruggiero	Sepe	ENAC (Italy)
	Andy	Thurling	DroneUp
	Eric	Watson	Zipline
	Will	Whitelaw	CASA (Australia)
	Harrison	Wolf	Zipline
SRM Group Members	Maria	Algar-Ruiz	EASA
	Hannes	Alparslan	European Defence Agency
	Armin	Ambuehl	Wingtra
	Jacquelyn	Banas	TUM Institute of Flight System Dynamics
	Juan Jose	Banasco Sola	AESA (Spain)
	Markus	Bardach	Skyzr GmbH
	Sylvarius	Baye	UK CAA
	Jeffrey	Bergson	FAA
	Raymond	Bisse	Cameroon CAA
	John	Bush	Boeing
	Javier	Caina	DJI
	Paul	Campbell	FAA
	Rui	Carlos	ANAC
	Rita	Castonguay Hunt	Wingtra
	Justin	Chirea	CAA Romania
	Gabriel	Cox	Intel
	David	Cussons	CASA (Australia)

SRM Group Members	Giovanni	Di Antonio	ENAC (Italy)
	Marco	Ducci	Estonia (EuroUSC)
	Fabrizio	D'Urso	ENAC (Italy)
	Alexander	Engel	Eurocontrol
	Antony	Evans	Airbus
	James	Foltz	FAA
	Joao	Freire	ANAC (Portugal)
	Mike	Glasgow	Wing
	Jerry	Hancock	Inmarsat
	Sigit	Hani	Ministry of Transportation Government of Indonesia
	Liu	Hao	Secretary General JARUS
	Heather	Harris	LST
	Nathalie	Hasevoets	European Defence Agency
	Marion	Hiriart	New Zealand Department of Transportation
	Hette	Hoekema	EASA
	Kevin	Houston	Manna
	Mark	Houston	CAA New Zealand
	Clayton	Hughes	CAA New Zealand
	Bertrand	Huron	DGAC (France)
	Emanuela	Innocente	EASA
	Miles	Isted s'Jacob	Manna
	Anita	Jakus	Murzilli Consulting
	Melanie	Janin-Brusson	DGAC (France)
	Eizens	Jekabsons	CAA Latvian
	Martin	Jurovic	NSAT (Slovakia)
	Nicky	Keeley	UK CAA
	Philip	Kenul	ASTM
	Krzysztof	Kisiel	Polish Air Navigation Services Agency
	Christopher	Klann	LBA (Germany)
	Mateusz	Kotlinski	Polish Air Navigation Services Agency
	Anders	la Cour-Harbo	Aalborg University
	Andi	Lamprech	DroneUp
	Jarrett	Larrow	FAA
	Sylvain	Lemieux	Transport Canada
	Ronald	Liebsch	DJI
	John	Livesey	UK CAA
	David	Marin-Marrero	Eurocontrol
	Davide	Martini	EASA
	Aaron	Mcfadyen	QUT
	Andrew	Mercer	CAA NZ
	Ajay	Modha	ANRA Technologies
	Matteo	Natale	DJI
	Reinaldo	Negron	Wing
	Thomas	Neubauer	Teoco
	Pasi	Nikama	ANS Finland
	Fredrik	Nordstroem	Airbus
	Ifeolu	Ogunleye	FAA
	Sophie	O’Sullivan	UK CAA
	Andreas	Pallo	Ministry of Transportation Government of Indonesia
	Rafal	Paprocki	Polish Air Navigation Services Agency
	Alan	Parkinson	UK CAA
	Antonio	Pascual	Wingtra
	Brian	Patterson	MITRE
	Daniel	Phiesel	BMVI
	Corey	Price	CAA New Zealand
	Bruno	Rabiller	ECTL
	Paolo	Resmini	Matternet
	Dannick	Riteco	SORA Consulting
	Carlos	Ruella	Transport Canada
	Jarosław	Rupiewicz	Civil Aviation Authority of the Republic of Poland

SRM Group Members	Wes	Ryan	FAA
	Kazushi	Sawada	NRI (Japan)
	Veronica	Schoemer	IFALPA
	Brendan	Shanley	CAA New Zealand
	Dario	Tomasic	Croatian Agency for Civil Aviation
	Andres	Van Swalm	Unifly
	Zhu	Wang	China Academy of Civil Science and Technology
	Kevin	Woolsey	UK CAA
	Meddy	Yogastoro	Ministry of Transportation Government of Indonesia
	Victor	Zhan	DJI

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ANNEXES

(available as separate documents)

Title	Version/Status
Annex A: Guidelines on collecting and presenting system and operation information for a specific UAS operation	2.0 in preparation
Annex B: Integrity and assurance levels for the mitigations used to reduce the intrinsic Ground Risk Classes	2.5 in consultation
Annex C: Strategic Mitigation Collision Risk Assessment	1.0
Annex D: Tactical Mitigations Collision Risk Assessment	1.0
Annex E (as supplemented by the Cyber Annex): Integrity and assurance levels for the Operational Safety Objectives (OSO)	2.5 in consultation Cyber Annex - 1.0
Annex F: Theoretical Basis for Ground Risk Classification	1.0 in consultation
Annex G: Supporting data for the Air Risk Model	In preparation
Annex H: UAS Safety Services Considerations	1.0 in preparation
Annex I: Glossary	2.5 in consultation
Annex J: Guidance to Regulators, ANSPs, and Other Third Parties	In preparation

Executive summary

The SORA approach

The Specific Operations Risk Assessment (SORA) process is intended to provide a risk-proportionate method to determine the required evidence and assurances needed for an Unmanned Aircraft System (UAS) to be acceptably safe within the “specific” category of UAS Operations (as defined in JARUS document “UAS Operational Categorization”)

The SORA provides structure and guidance to both the competent authority and the operator to support an application to operate a specific UAS in a given operational environment. The benefit of this process is that both the operator and competent authority can spend their available resources and time proportional to the risk of the operation.

The SORA uses a holistic/total safety risk management process to evaluate the risks related to a given operation and then provide proportionate requirements that an operation should meet to ensure a Target Level of Safety (TLOS) is met. This TLOS is defined for people and aircraft uninvolved in the operation and is commensurate with existing crewed aviation risks to these same stakeholders. These values were chosen to ensure that UAS operations would not pose more risk to third parties than crewed aviation which are seen as socially acceptable rates (as referred in the top level principles cited in Section 5(f) in the Scoping Paper to AMC RPAS 1309 Issue 2):

i. For ground risk - less than one fatality per million hours (1E-6 fatalities per hour faced by overflown populations) (See Annex F for more details)

ii. For air risk - less than one mid-air collision per 10 million flight hours (1E-7 mid-air collisions per flight hour) for operations that primarily occur under self-separation and see-and-avoid (primarily Classes D, E and G Airspace). For operations that occur with separation provided by an Air Navigation Service Provider (primarily Classes A, B, and C Airspace), the TLOS is one mid-air collision per billion flight hours (1E-9 mid-air collisions per flight hour).

The SORA has been developed using assumptions expected to be both credible and conservative across a wide range of UAS Operations.

Under the “specific” category, different operations will have different levels of inherent risk and thus will need to demonstrate varying levels of ability to maintain control of the operation to meet the TLOS. To do this, the SORA has developed the Specific Assurance and Integrity Levels (SAIL), which map the maximum allowable loss of control rate to operational, organisational, personnel, design, and manufacturing risk controls that, when implemented correctly at the required level, ensures that an operation meets the TLOS. This means a large UA operating in a high risk environment (example: over a large city near an airport) would have to demonstrate more to the regulator than a small UA operating in a low risk environment (example: at a closed test range and below 50 feet).

The SORA methodology

The SORA methodology consists of ten systematic steps:

Step #1: Documentation of the proposed operation(s)

Step#1 constitutes the primary tool of communication that enables the Competent Authority to evaluate the proposed operation against the subsequent SORA steps. The documentation created consists of operator manual, compliance evidence and risk assessment.

The operator manual on one hand describes the UAS operator and the operation(s) that they intend to conduct (such as flight path information, type of airspace and overflown population density). This can be a stand-alone document, or a collection of documents specific to the operator. This information allows the applicant and competent authority to agree upon the required evidence needed to satisfy the claims made in the risk assessment (i.e. via a compliance matrix). This information can be complemented by the compliance evidence, containing the necessary evidence supporting the claims of the risk assessment that do not form part of the operator manual, i.e. test data and evaluation.

Step#2: Intrinsic Ground Risk Class (iGRC)

The intrinsic Ground Risk Class (scaled from 1 to 11) is first determined, depending on the UA characteristics (maximal dimensions and maximal cruise speed) as well as the overflown population density. The intrinsic GRC is determined for both the area at risk (section 2.3.1) and the adjacent area (section 2.3.2) respectively.

Step#3: Final Ground Risk Class

The Final Ground Risk Class is determined considering two potential mitigation measures (as described in Annex B), which may have a significant effect on the likelihood of a fatality after loss of control of the operation:

i. Strategic mitigations intended to reduce the number of people at risk on the ground;

ii. Mitigations intended to reduce the effect of a ground impact once the control of operation is lost.

The Final Ground Risk Class is also determined for both the area at risk (section 2.3.3), as an input to Step#7 (SAIL determination) and the adjacent area (section 2.3.4), as an input to Step#8 (containment requirements).

A final GRC in the area at risk higher than 7 is out of the scope of SORA.

Step #4 : Initial Air Risk Class (ARC)

The determination of Air Risk Class in a qualitative manner, involves two steps (Steps 4 & 5). In Step #4, the initial ARC is assessed based on a generalised encounter rate in the airspace identified in Step #1. The parameters that define the four categories of ARC (a, b, c, d) are: if the airspace is atypical (e.g. segregated), altitude, controlled by air traffic versus uncontrolled, airport environment versus non-airport, and airspace over urban versus rural environments (section 2.4.2.1). The initial ARC of the adjacent airspace shall also be determined in Step#4 (section 2.4.2.2) as an input to Step#9 (containment requirements)

Step #5: Residual Air Risk Class

The Residual ARC is obtained after applying any relevant strategic mitigation measures in order to possibly lower the Initial Air Risk Class. Two types of strategic mitigation measures (as described in Annex C) exist in the SORA. Air risk mitigations are either operational restrictions (e.g. boundaries, time of operation) controlled by the UA operator or by the structure of the airspace and the associated rules for operating in that airspace, controlled by the relevant authorities (e.g. UTM, U-Space).

Step #6: Tactical Mitigation Performance Requirement (TMPR) and Robustness Levels

Tactical mitigations are applied during the conduct of the operation, and are used to mitigate the identified residual risk of a mid-air collision that may remain after the strategic mitigations have been applied.

Tactical Mitigation Performance Requirements (TMPR) address the functions of detect, decide, command, execute and feedback loop (see Annex D), for each Residual Air Risk Class.

Step #7: Specific Assurance and Integrity Level (SAIL) determination

A SAIL (scaled from I to VI) is then determined using the information given in Step#1 and the outputs of Steps #3 (final GRC) and #5 (Residual ARC).

Step #8: Identification of containment requirements

This step addresses the risk posed by an operational loss of control that could infringe on areas adjacent to the operational volume and buffers. The ground risk (in the adjacent area) and air risk in the adjacent airspace dictate the level of safety requirements to be met by containment design features and operational procedures. The detailed containment requirements can be found in Annex E. There are 5 levels of containment: none, low (previous requirements of JARUS SORA 2.0 Step 9 applicable for all operations), medium, high (previous SORA 2.0 Ch. 2.5.3.(c)) and to consult with the authority. In general, most operations are expected to only need a low level of containment.

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

The SAIL identifies a Level of Integrity and Assurance (Low, Medium, High) to be met for each OSO, according to criteria provided in Annex E. Where cyber security threats apply and may have an impact on safety, a sub-Annex to Annex E provides guidelines to ensure that reasonable and proportionate cyber safety considerations are applied.

For the assigned SAIL, the operator is required to show compliance with each of the 18 OSOs at the defined robustness level (some OSOs may be not required for lower SAILs). These OSOs cover, among others, the following areas pertaining to either the UAS manufacturer, or the UAS Operator: UAS technical aspects, deterioration of external systems, human error, adverse environmental conditions.

Step #10: Comprehensive Safety Portfolio

A Comprehensive Safety Portfolio is a suite of documents that provides a complete SORA safety case for a proposed operation and includes all the necessary compliance evidence required by the SORA assessment. The Comprehensive Safety Portfolio will show that all the requirements resulting from the SORA steps are met.

If the Comprehensive Safety Portfolio does not provide a complete argument aligned with the SORA process at the given SAIL, changes to the proposed operation (e.g. reducing the intrinsic risk of the operation), additional mitigation measures, or further analysis/evidence may be needed.

1. Introduction

1.1 Preface

(a) This updated issue of the Specific Operation Risk Assessment (SORA) is the JARUS WG-SRM consensus vision on how to safely create, evaluate and conduct an Unmanned Aircraft System (UAS) operation. The SORA provides a methodology to guide both the applicant and the competent authority in determining whether an operation can be conducted in a safe manner. The document shall not be used as a checklist, nor be expected to provide answers to all the challenges related to integration of the UAS into airspace. The SORA is a guide that allows an operator to identify the risk and, if needed, reduce it to an acceptable level by tailoring their mitigation efforts for the operation. This involves meeting or exceeding the Target Level of Safety (TLOS) regardless of the complexity of the operation, drone size, or the area of operation. The TLOS of operations under the categories covered by SORA is equivalent to that of the category A “open” and C “certified” categories. For this reason, it does not contain prescriptive requirements but rather safety objectives to be met at various levels of robustness commensurate with risk.

(b) The SORA is meant to inspire operators and competent authorities and it highlights the benefits of a harmonized risk assessment methodology. The feedback collected from real-life operations will form the backbone of updates to the upcoming revisions of the document.

1.2 Purpose of the document

(a) The purpose of the SORA is to propose a methodology for the risk assessment to support an application for authorization to operate a UAS within the “*specific”*[1] category.

(b) Due to the operational differences and expanded level of risk, the “specific” category cannot automatically take credit for the safety and performance data demonstrated with the large number of UAS operating in the “open” category. Therefore, the SORA provides a consistent approach to assess the additional risks associated with the expanded and new operations not covered by the “open” category.

(c) This methodology is proposed as an acceptable means to evaluate the safety risks and determine the acceptability of a proposed operation of UAS within the “specific” category. This also includes security and cybersecurity risks if they directly contribute to a safety hazard.

(d) The SORA is not intended as a "one-stop-shop" for allowing full integration of all types of drones into all airspace classes. The SORA indicates the type of performance goal(s) for airspace segregation/integration measures necessary to meet the target levels of safety for the given airspace volume.

(e) 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 and proportionate to the safety risk presented by an application to operate in a limited or restricted manner. This methodology may also support activities necessary to determine associated airworthiness requirements.

(f) 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 the most common safety threats associated with a specified hazard, the relevant

[1] This category of operations is further defined in the European Union Aviation Safety Agency (EASA) Opinion 01/2018.

design, and the proposed operational mitigations for a specific operation(s). The SORA then helps to evaluate the risks systematically and determine the boundaries required for a safe operation. This method allows the applicant 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 to gain confidence that the operator can conduct the operation safely.

(g) The competent authority may request additional measures or requirements to what the SORA stipulates for operations.

(h) The methodology, related processes, and values proposed in this document are intended to guide an applicant when performing a risk assessment of an intended operation for the purpose of obtaining an operational approval by the competent authority. For that purpose, the competent authority could decide to adapt any section of this document into their regulatory framework.

1.3 Applicability

(a) The methodology presented in this document is aimed at evaluating the safety risks involved with the operation of one or multiple[2] UAS of any class and size and type of operation (including military, experimental, R&D and prototyping). It is particularly suited, but not limited to UAS operations for which a hazard and risk assessment is required. The methodology is designed to be applicable to all levels of automation.

(b) Safety risks associated with collisions between UA and manned aircraft are in the scope of the methodology. The risk of collision between two UA or between a UA and a UA carrying people is currently deemed to be small and thus will be addressed in future revisions of the document. It is recommended that concurrent high volume operators have a deconfliction strategy for their own UA.

(c) The carriage of people is not within the scope of the SORA. The carriage of dangerous goods on board the UAS (e.g. weapons, munitions of war, explosives, hazardous medical samples) that present additional hazards are excluded from the scope of this methodology and might require additional safety considerations (e.g. demonstration of the container characteristics and the ability to contain the dangerous good). Additional, separate approval for the carriage of dangerous goods is required to be made by the applicant as part of an overall application for an operational approval to the competent authority.

(d) Security aspects are covered in the supplemental Cyber Annex for Annex E and are not limited to those confined by the airworthiness of the systems (e.g. aspects relevant to the protection from unlawful electromagnetic interference).

(e) Privacy, environmental and financial aspects are excluded from the applicability of this methodology.

(f) In addition to performing the SORA process, the operator must also ensure compliance to all other regulatory requirements applicable to the operation that are not necessarily addressed by the SORA, i.e. The SORA does not preclude any additional regulatory requirements implemented by the competent authority.

(g) The SORA may be used to support waiving regulatory requirements applicable to the operation in some States if allowed.

[2] **A multiple UA operation (different from a swarm operation)** is one where more than one UA, assigned to separated sections of the flight geography and controlled independently from one another, are used at the same time to perform the intended operation.

(h) The SORA can be used to get operational approval in multiple locations, but in that situation, the operator needs to provide a SORA that is applicable to all these areas to show that the target level of safety will be met for all flights performed under the operational approval. If an applicant can demonstrate that they have sufficient procedures in place to correctly allocate operational volumes and buffers, a generic location operational approval may be considered by the competent authority.

1.4 Key concepts and definitions

A glossary providing all abbreviations and definitions related to the SORA is provided in Annex I.

1.4.1 Semantic model

(a) To facilitate effective communication of all aspects of the SORA, the methodology requires standardized use of terminology for phases of operation, procedures, and operational volumes. The semantic model shown in Figure 1, provides a consistent use of terms for all SORA users. Figure 2 provides a graphical representation of the semantic model and a visual reference to further aid the reader in understanding the SORA terminology[3].

(b) An **operation** is considered **in control**, when the remote crew is able to continue the management of the current flight situation, such that no persons on the ground or in the air onboard manned aircraft are put in immediate danger. This holds true for both normal and abnormal situations, however the safety margins in the abnormal situation are reduced. In this abnormal state, it is the remote crews' duty to try to return the operation back into the normal state by executing contingency procedures as soon as practical.

i. **Normal Operation** utilizes **Standard Operating Procedures**, a set of instructions covering policies, procedures, and responsibilities set out by the applicant that supports operational personnel in ground and flight operations of the UA safely and consistently.

ii. In an **Abnormal Situation** it is no longer possible to continue the flight using normal procedures, but the safety of the aircraft or persons on the ground or in the air is not in danger. **Contingency Procedures** are designed to potentially prevent a significant future event (e.g. loss of control of the operation) that has an increased likelihood to occur due to the current abnormal state of the operation. These procedures should return the operation to a normal state and allow the return to using standard operating procedures, or allow the safe cessation of the flight.

(c) **Loss of control of the operation** is a state that corresponds to situations: where the outcome of the situation highly relies on providence; or which could not be handled by a contingency procedure; or when there is imminent grave and imminent danger fatalities among uninvolved persons. In the context of the semantic model, this includes situations where a UA has exited the operational volume and is potentially operating over or in an area of higher ground or air risk for which it is not suited. The "loss of control" state is also entered, if a UA loses flight control and crashes or if a flight termination sequence is executed, even if this happens inside the operational volume.

i. **Emergency Procedures** are executed by the remote crew and may be supported by automated features of the UAS and are intended to mitigate the effect of failures that cause or lead to an emergency condition. They deal with affecting the UA to either return to a state where the operation is "in control" or to minimise hazards until the flight has ended.

ii. The **Emergency Response Plan (ERP)** deals with the potential hazardous secondary or escalating effects after a loss of control of the operation and is decoupled from the Emergency Procedures, as it does not deal with the control of the UA. The ERP may include procedures that are triggered in parallel with the

[3] An operation may be a single mission, multiple flights of the same mission, or many flights across different missions that are assessed under a single SORA process.

Emergency Procedures, while other procedures may only be triggered after the UA ends its flight.

iii. **Containment** is a function consisting of technical and operational mitigations that contain the flight of the UA within the defined operational volume and ground risk buffer.

(d) The **Operational Volume** is defined as the volume in which the operation takes place safely. It is split up into the Flight Geography and the Contingency Volume. This volume is also the basis to determine the Air Risk Class of an operation. The main SORA process is applied to the operational volume and ground risk buffer. In order to protect the surrounding areas and airspace the operation should be contained within the operational volume.

i. For normal operation, the UA shall operate inside the **Flight Geography**. Depending on the type of the mission, the flight geography can be defined as a flight corridor for each planned trajectory, or as a larger volume to allow for a multitude of similar missions with changing flight paths. Whenever a particular mission requires the UA to traverse or loiter at a specific point of interest, this point shall be included inside the flight geography. The outer boundary of the Flight geography shall include the total system error (TSE) of the UA. The UAS operator should, therefore, establish sufficient margins to cater for such errors.

ii. The **Contingency Volume** surrounds the Flight Geography. An entry into this volume is always considered to be an Abnormal Situation and requires the execution of appropriate Contingency Procedures to return the UA into the Flight Geography. It should be noted that an Abnormal Situation may also occur inside the Flight Geography.

(e) The **Ground Risk Buffer** is an area on the ground that surrounds the footprint of the Contingency Volume. If an operation loses control in a way that the UA exits the Operational Volume, it shall be contained to end its flight inside the Ground Risk Buffer. The appropriate size of the Ground Risk Buffer is based on the individual risk of an operation and is driven by the identified containment requirement of the SORA. The footprint of the Operational Volume plus the Ground Risk Buffer is the reference area to determine the Ground Risk Class (see Figure 2 below).

(f) Ground areas and airspace volumes outside of the operational volume and ground risk buffer are addressed through Steps #2, #3 and #8 of SORA. The containment requirements determined in Step #8 are intended to ensure an acceptable level of safety for those at risk in these adjacent areas. These areas are split into the Adjacent Area, and the Adjacent Airspace:

i. The **Adjacent Area** is the ground area adjacent to the Ground Risk Buffer. The extent of the adjacent area depends on the particular UA performance and the resulting likelihood of flying into an area with an increased ground risk.

ii. The **Adjacent Airspace** is the airspace adjacent to Operational Volume and depends on the particular UA performance and the resulting likelihood of flying into an airspace with an increased air risk.

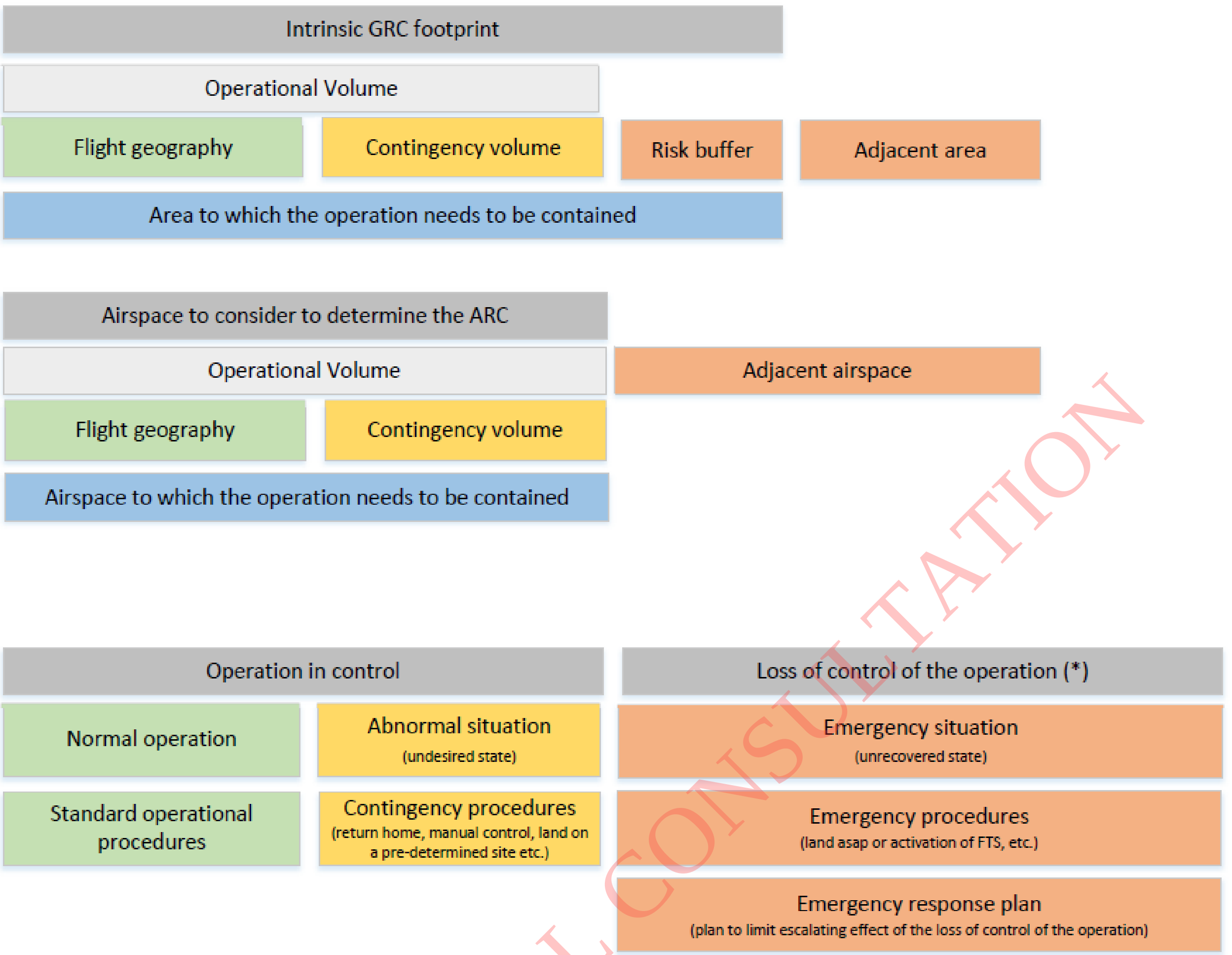

Figure 1 – SORA Semantic Model

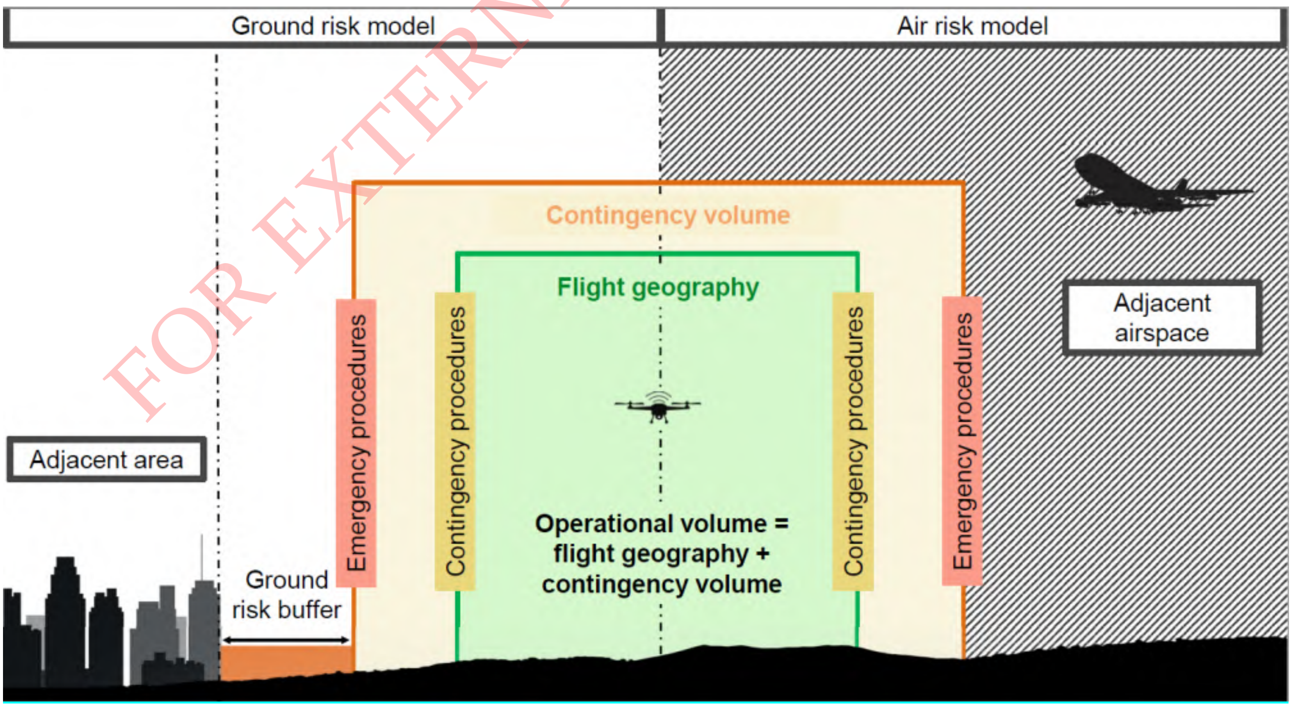

Figure 2 – Graphical Representation of SORA Semantic Model

1.4.2 How SORA measures risk mitigations - introduction to robustness

(a) To properly understand the SORA process, it is important to introduce the key concept of robustness.

(b) **Robustness** is the term used to describe the combination of two key characteristics of a risk mitigation or operational safety objective; the **level of integrity** (i.e. how good is the mitigation/objective at reducing risk), and the **level of assurance** (i.e. how much confidence is there that the level of integrity will be provided when it is needed).

(c) The activities used to substantiate the level of integrity and assurance are detailed in the Annexes B, C, D and E. These annexes provide either guidance material or reference industry standards and practices where applicable.

(d) Any given risk mitigation or operational safety objective can be demonstrated at differing levels of robustness. The SORA proposes three different levels of robustness: Low, Medium and High, commensurate with risk:

- A **Low** level of assurance is where the applicant simply declares that the required level of integrity has been achieved.
- A **Medium** level of assurance is one where the applicant provides supporting evidence that the required level of integrity has been achieved. This could be achieved by means of testing or by proof of experience.
- A **High** level of assurance is where the achieved integrity has been found to be acceptable by a competent third party.

(e) The specific criteria defined in the SORA Annexes take precedence over the criteria defined in paragraph (d) above.

(f) To accommodate national specificities that cannot and should not be standardised, the competent authorities might require different activities to substantiate the level of robustness. National specificities could include nationally sensitive infrastructure, protection of environmental areas, etc.

(g) Table 1 provides guidance to determine the level of robustness based on 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

(h) For example, if an applicant 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.

1.5 Roles and Responsibilities

(a) While performing a SORA process and assessment, several key actors might be required to interact in different phases of the process. The main actors applicable to the SORA are described in this section.

(b) Applicant – The applicant is the party seeking operational approval. The applicant must substantiate the safety of the operation by performing the SORA. Supporting material for the assessment may be provided by third parties (e.g. the manufacturer of the UAS or equipment, UTM service providers, etc.).

(c) Operator – The operator has received an operational approval from the competent authority. It allows the operator to perform a series of flights, provided that they are performed in accordance with the operational approval, based on the SORA compliance demonstration. The operator is responsible for safe operation of the UAS. Hence the compliant execution of the procedures, training and other applicable programs as well as the observation of the limits and other requirements of the applicable concept of operations are the operator's obligation. The competent authority may identify geographical zones where for safety, security, privacy, environmental or other reason, a flight authorisation may be requested for each flight. Such flight authorisation is different from the operational approval and independent of the category of the operation.

(d) UAS Manufacturer – For the purposes of the SORA, the UAS manufacturer is the party that designs and produces the UAS. It may be expected that sometimes design and production are carried out by two different organisations. The 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) or the competent authority to help substantiate the operator's SORA safety case. Alternatively, a UAS manufacturer may utilise the SORA to target design objectives for specific or generalised operations, tailored to the relevant SAIL. To obtain airworthiness approval(s), these design objectives could be complemented by use of JARUS Certification Specifications (CS) or industry consensus standards if they are found acceptable by the competent authority.

(e) Competent Authority – The competent authority is the recognized authority for approving the SORA safety case of UAS operations. The competent authority may accept an applicant's submission of an operational manual with an associated SORA based risk assessment. 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 of each. The competent authority also provides the operational approval to the operator.

(f) Competent Third Party – A competent third party is responsible for reviewing supporting evidence for mitigations and operational safety objectives of an application. The competent authority may designate or recognise organizations that perform this task for all or a selection of review items. The competent authority may also decide to perform this task by themselves, thus becoming the competent third party.

(g) Air Navigation Service Provider (ANSP) – The ANSP is the designated provider of air traffic service in a specific area of operation (airspace). The ANSP assesses and/or should be consulted whether the proposed operation can be safely conducted in the particular airspace that they cover. Whether an ANSP approval would be required may depend on whether the particular operation may be considered as being compliant with the rules of the air or should be managed as a contained hazard. Annex J, when published, has additional information on ANSP roles, responsibilities, and interactions with applicants[4].

(h) UTM/U-Space Service Provider – UTM/U-Space Service Providers are entities that provide services to support safe and efficient use of airspace. These services may support an operator's compliance with their safety obligation and risk analysis as described in Annex H.

(i) Remote Pilot in Command – The remote pilot that is designated by the operator as being in command and charged with the safe conduct of the flight.

(j) Remote Crew – The remote crew includes all operator personnel involved in the operation of the UAS, with duties essential to the safe operation of the UAS. The remote pilot in Command is part of the Remote Crew.

(k) Maintenance staff – Ground personnel in charge of maintaining the UAS before and after flight in accordance with UAS maintenance instructions.

[4] The role of ANSP as a function is distinct from that of the aviation regulator or the function of safety oversight, however in different jurisdictions this may vary.

2. The SORA Process

2.1 Introduction to Risk

(a) This definition of “risk” as provided in the SAE ARP 4754A / EUROCAE ED-79A: “the combination of the frequency (probability) of an occurrence and its associated level of severity” is used here.

(b) The consequence of an occurrence will be designated as a harm of some type.

(c) Many different categories of harm arise from any given occurrence. Various authors on this topic have collated these categories of harm as supported by literature. This document will focus on occurrences of harm (e.g. an UAS crash) that are short-lived and usually give rise to potential 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:

i. Fatal injuries to third parties on the ground[5]é;

ii. Fatal injuries to third parties in the air.

(d) As the SORA only addresses safety risk, it is acknowledged that the competent authorities, when appropriate, may consider additional categories of harm (e.g. privacy, disruption of a community, environmental damage, financial loss, etc.)

(e) Fatal injury is a well-defined condition and, in most countries, known by the authorities. Therefore, the risk of under-reporting fatalities is almost non-existent. The quantification of the associated risk of fatality is straightforward. The usual means to measure fatalities are by the number of deaths within a particular time interval (e.g. fatal accident rate per million flying hours), or the number of deaths for a specified circumstance (e.g. fatal accident rate per number of take-offs).

(f) Damage to critical infrastructure is a more complex condition and different countries may have differing sensitivities to this harm. Therefore, the quantification of the associated risks may be difficult and subject to national specificities, thus it is not addressed within the SORA and should be subject to a separate risk assessment. This should be done in cooperation with the organisation responsible for the infrastructure, as they are most knowledgeable of the threats.

2.2 SORA Process Outline

(a) The SORA methodology provides a logical process to analyse the proposed operation and establish an adequate level of confidence that the operation can be conducted with an acceptable level of risk. There are ten steps supporting the SORA methodology, as shown in Figure 3. Each of these steps is described in the following paragraphs and further detailed, when necessary, in the relevant annexes.

(b) The SORA process is an iterative process, meaning that the flowchart in Figure 3 may be repeated more than once until the documentation and the risk assessment have converged to an acceptable safety case. The comprehensiveness of the documentation should be verified by the applicant in Step# 10.

[5] Risk to involved persons is not included as they are informed of the risk of the UAS operation and have consented to accepting the risk.

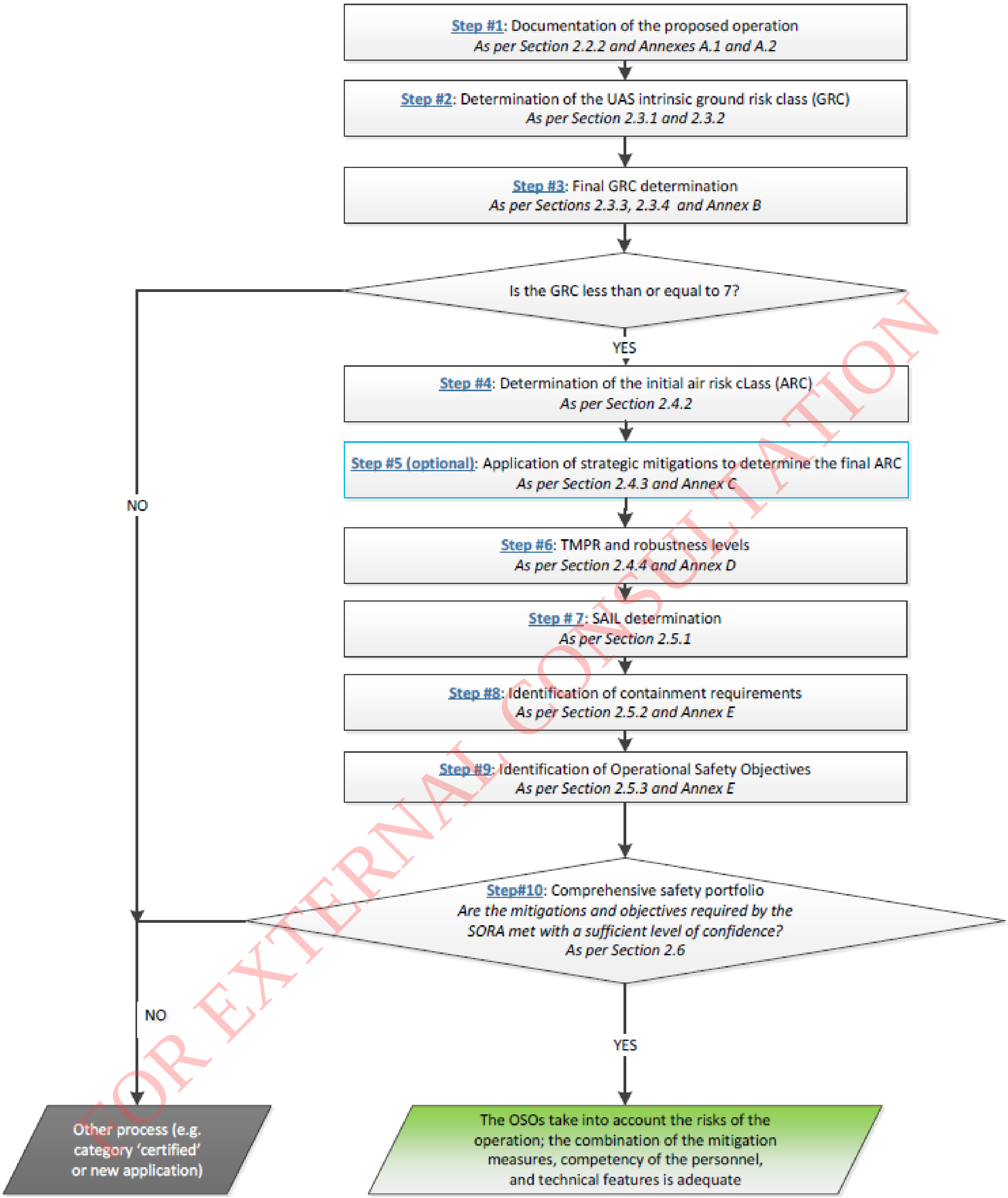

Figure 3 – The SORA Process

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

2.2.1 Pre-application Evaluation

(a) Before starting the SORA process, following aspects should be verified:

i. If the operation falls under the “open” category or if the competent authority has determined that the UAS is “harmless” (the worst credible case is negligible or minor in consequence) in terms of the risk presented by the operation;

ii. If the operation is covered by a “standard scenario” recognized by the competent authority;

iii. If the operation falls under the “certified” category;

iv. If the operation is subject to specific “no-go” criteria from the competent authority.

(b) If none of the above cases applies, the SORA process should be applied.

2.2.2. The phases of the SORA process

This iterative process may be split into two phases, as described below. This approach should minimise the risk of further iterations in the UAS design, in the envisaged operations and the envisaged risk mitigations:

i. Phase 1 - An initial set of iterations based on a preliminary operation description, resulting in a preliminary SAIL level including the associated requirements. At this phase:

   a. the applicant should analyse the requirements for their intended operation and how feasible it is that these can be fulfilled,

   b. an operator’s manual and compliance evidence is not required (but may be available),

   c. The results of this phase may be the basis for a pre-application evaluation by the competent authority. The competent authority may not be able to provide a formal agreement until the submission of final compliance evidence data (covered in phase 2).

   d. It is recommended that the applicant gets in contact as early as possible with the competent authority in order to present the available information and reach a common initial understanding on the final GRC, Residual ARC, subsequent SAIL as well as the risk level of the adjacent area.

ii. Phase 2 - a final set of iterations where the required documentation (operator manual, compliance evidence and SORA safety case) is developed. The final result is a complete comprehensive safety portfolio for submission to the competent authority.

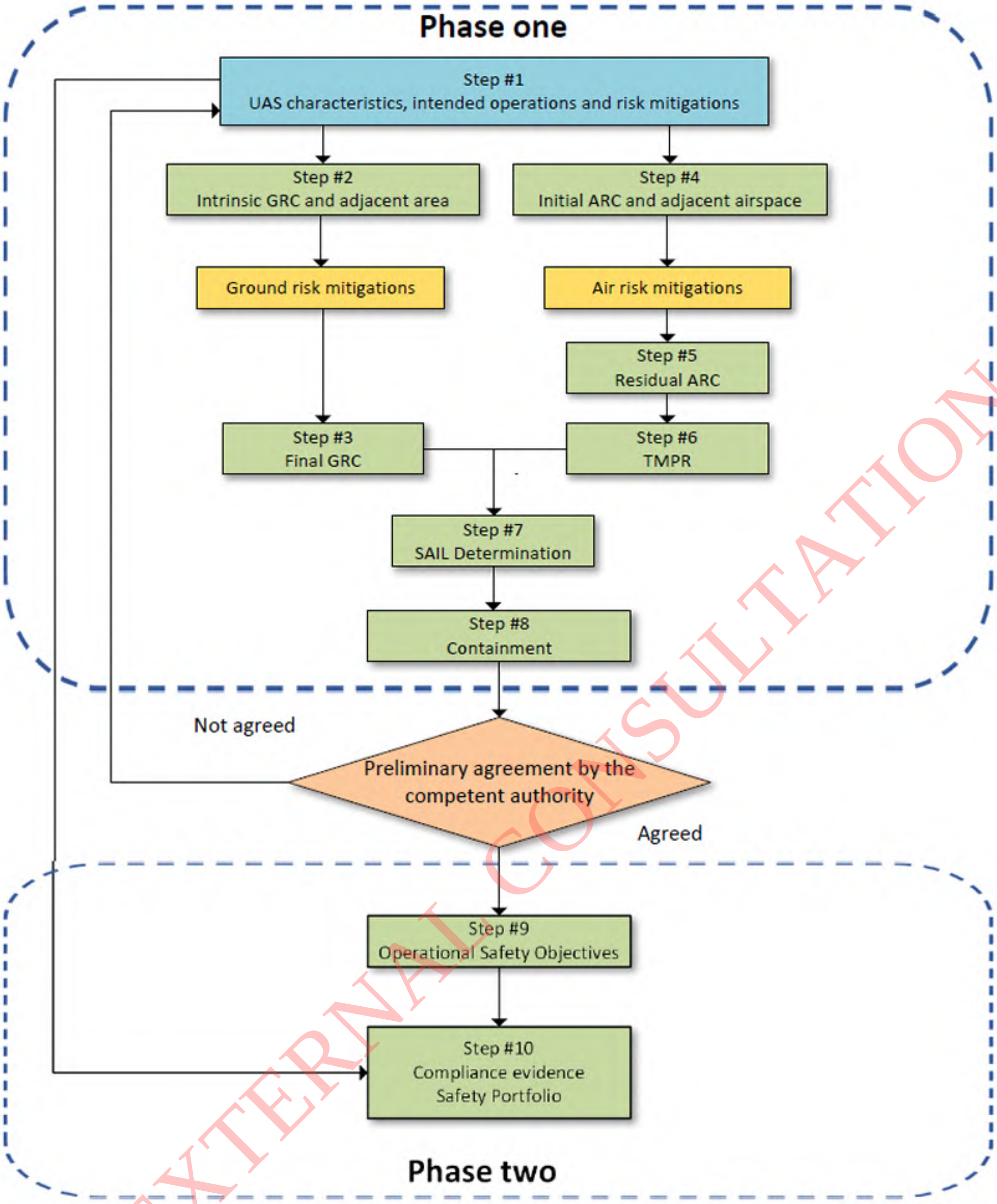

Figure 4 – The SORA Stages

2.2.3. Step #1 – Documentation of the proposed operation(s)

(a) The purpose of this step is to describe the documentation set that should be compiled and presented to the competent authority for assessment after Step #10 completion. This usually consists of the:

i. Operator manual,
ii. Compliance evidence,
iii. SORA safety case.

(b) The operator manual is an operator-centred document which is intended to collect and present all information and data, such that:

i. this completely describes the proposed operation(s) with all its limitations, which allows for a SORA risk analysis to be performed.

ii. it should be used as material for the actual operation(s) and for the training of operator personnel as well.

iii. it should be used by the competent authority as a reference for issuing an operational approval, and subsequent auditing of an operator for an approved operation as a part of a risk-based oversight programme.

(c) The compliance evidence document only collects necessary evidence supporting the claims of the risk assessment that do not form part of the operator manual, i.e. test data and evaluation.

(d) The risk assessment might be presented to the competent authority using the form in Annex A, section 3.

(e) With all these objectives satisfied by the applicant, the operator manual document becomes the basis for the operational approval. When the competent authority authorises a specific operation, it will usually do that, by accepting and therefore authorising an operator manual. The competent authority will only authorise operations when all the risks have been shown acceptably low in accordance with SORA.

(f) The first step of the SORA requires the applicant to collect and provide the relevant technical, operational and system information needed to assess the risk associated with the intended operation of the UAS. Annex A of this document provides a detailed framework for data collection and presentation. The operator manual description is the foundation for all other activities and should be as accurate and detailed as possible. The operator manual should not only describe the operation, but also provide insight into the operator's operational safety culture. It should also include how and when to interact with ANSP. Therefore, when defining the operator manual the operator should give due consideration to all steps, mitigations and operational safety objectives provided in Figures 3 and 4.

(g) Developing an operator manual together with the SORA safety case is an iterative process. As the process is applied, additional mitigations and limitations may be identified, requiring additional associated operational and technical information to be provided/updated in the operator manual. This should result with an operator manual that comprehensively describes the proposed operation as envisioned.

(h) The structure of the operator manual should allow the identification of the elements/sections verified by the competent authority and the elements/sections not verified. If needed, changes to the operator manual might have an applicability date.

(i) The applicant should only put information into the operator manual and compliance evidence document as it is required by the items mentioned above. If a requirement has a low robustness (ref. Section 1.4.2 How SORA measures risk mitigations - introduction on robustness), it is mostly sufficient to self-declare the compliance by a statement in the compliance evidence document. Documents dealing with handling such a declarative requirement can be kept internal to the operator's organisation and are not submitted to the competent authority, thus not being subject to version control by the authority. The competent authority may however decide to request further documents, if considered necessary for the given operation.

(j) The operator manual can be a stand-alone document, or a collection of documents specific to the operator. It can be modularized and consist of multiple sub-documents. The document information can be structured in sub-documents and sub-sections to accommodate the need to perform multiple operations, varying local conditions, varying types of locations (different GRCs, ARCs or adjacent airspaces/areas), different types of UAS, different training programmes, or different procedures. Appropriate references and version control applies to all subsections and sub-documents.

(k) The operator manual and the accompanying compliance evidence is the basis for the issue of an operational approval. The operator manual should be kept up to date and all changes introduced should be properly traced. Any change with an impact on the SAIL determination may require prior approval by the competent authority. The management of changes should be described in the operator manual and the following categories should be identified:

i. Changes requiring prior approval by competent authority,

ii. Changes not requiring prior approval by competent authority.

2.3 The Ground Risk Process

2.3.1 Step #2 – Determination of the intrinsic UAS Ground Risk Class (GRC)

(a) The intrinsic UAS ground risk relates to the risk of a person being fatally struck by the UAS (in the case where the UAS operation is out of control) absent any mitigations being present.

(b) To establish the intrinsic GRC (iGRC), the applicant needs the max UA characteristic dimension (e.g. wingspan for fixed wing, blade diameter for rotorcraft, max. dimension for multi-copters, etc.), the maximum cruise speed and the knowledge of the maximum population density intended to be flown over.

(c) The applicant needs to have defined the area at risk when conducting the operation including:

i. The operational volume which is composed of the flight geography and the contingency volume. To determine the operational volume the applicant should consider the position keeping capabilities of the UAS in 4D space (latitude, longitude, height and time). In particular the accuracy of the navigation solution, the flight technical error of the UAS, the path definition error (e.g. map error) and latencies should all be considered and addressed in this determination;

ii. The area at risk is defined to be the iGRC footprint, which is composed from the operational volume footprint plus the ground risk buffer as shown below in Figure 5;

Figure 5 – The iGRC Footprint

iii. The maximum population density in the area;

iv. An appropriate ground risk buffer with at least a 1-to-1 principle[6];

v. A smaller ground risk buffer value may be proven by the applicant:

a. for a rotary wing UA using a ballistic methodology approach acceptable to the competent authority, or

[6] *The 1-to-1 'principle' is a simple principle (as opposed to an exact rule in law) which can be used to quickly calculate what ground risk buffer is risk appropriate for most cases. If the UA is planned to operate at 150m altitude, the ground risk buffer should at least be 150m.*

b. based on an analysis taking into account malfunctions or failures (including the projection of high energy parts such as rotors and propellers) which would lead to an operation outside of the operational volume and all the following elements when the containment system is activated:

c. Meteorological conditions (e.g. wind),

d. UAS latencies (e.g. latencies that affect the timely manoeuverability of the UA),

e. UA behavior when activating a technical containment measure (e.g. parachute deployment),

f. UA performance.

(d) The 1-to-1 principle may in certain cases not be sufficient to meet the target level of safety. In such a case, the authority may ask a refinement of the definition of the ground risk buffer, based on criteria defined in Step #8 depending on the adjacent air and ground risks.

(e) Table 2 illustrates the iGRC used in the iGRC Determination. The iGRC is found at the intersection of the applicable maximum population density and the column matching both the max UA characteristic dimension and the maximum cruise speed expected.

Intrinsic UAS Ground Risk Class						
Max UA characteristics dimension		1 m	3 m	8 m	20 m	40 m
Max cruise speed		*25 m/s*	*35 m/s*	*75 m/s*	*150 m/s*	*200 m/s*
Maximum iGRC population density (ppl/km²)	**Controlled ground area**	1	2	3	4	5
	< 25	3	4	5	6	7
	< 250	4	5	6	7	8
	< 2,500	5	6	7	8	9
	< 25,000	6	7	8	9	10
	< 250,000	7	8	9	10	11
	> 250,000	7	9	Category C Operations (Not part of SORA)		

Table 2 – Intrinsic Ground Risk Class (GRC) Determination

(f) An UA weighing less than 250g and having a maximum cruise speed less than 25m/s is considered to have iGRC of 1 regardless of the population density.

(g) In the event that population density values are not available or an authority would rather use qualitative descriptors for the iGRC Table, the following approximations can be used as guidance:

Quantitative Population Value (ppl/km²)	< 25	< 250	< 2,500	< 25,000	< 250,000	> 250,000

Qualitative Description	Rural	Sparsely Populated	Suburban	Urban	Dense Urban	Assembly of People[7]

Table 3 – Quantitative Population Values to Qualitative Descriptions

(h) The iGRC Footprint, defined in section 2.3.1 (c) should be used to determine the population density. It is expected that for many flight operations, the iGRC footprint may cover segments with different population densities. The segment with the highest population density should be used when determining the iGRC.

(i) Determining the population density to calculate the iGRC in Step #2 needs to be done using the highest resolution static maps appropriate to the operation and available to the operator, unless maps for Step #2 are required by the authority. Guidance in the Flight Safety Analysis Handbook suggests that cell resolution should be approximately equivalent to the dispersion area of an operation[8]. Competent authorities may require specific maps to be used for determining population densities. If high resolution or dynamic maps are to be used, the operator must justify the usage of the maps and show the reduction of risk. See Annex F for additional information.

(j) A controlled ground area is defined as the intended UAS operational area where only involved persons (if any) are present. Controlled ground areas are a way to strategically mitigate the risk on ground (similar to flying in segregated airspace); the assurance that there will be uninvolved persons in the area of operation is under full responsibility of the operator.

(k) The maximum cruise speed is conservatively defined as the maximum possible commanded airspeed of the UA, as defined by the manufacturer. This is not the mission specific maximum commanded airspeed of the UA as reducing the mission airspeed may not necessarily reduce the impact area. See Annex F, for more details. Mitigations that limit the airspeed below this value during an impact can be accounted for in Annex B, part of Step #3.

(l) The GRC is found at the intersection of the applicable maximum population density and the column matching both the max UA characteristic dimension and the maximum cruise speed expected. In case of a mismatch between the Max UAS characteristic dimension and the maximum cruise speed, the applicant should choose the left most column that meets both criteria or provide substantiation for the chosen column.

(m) A generally conservative size of the critical area for most UAS can be anticipated by considering both the size and speed used in the iGRC determination. There are certain cases or design aspects that are non-typical and may have a significant effect on the critical area of the UAS such as fuel, high-energy rotors/propellers, etc. These may not have been considered in the iGRC table, but may lead to an increase in iGRC. See Annex F for further guidance.

(n) Operations that do not have a corresponding iGRC (i.e. grey cells on the table) are not currently supported by the SORA methodology and the operation should be classified in the certified category.

(o) A generally conservative size of the critical area for most UAS can be anticipated by considering both the size and speed used in the iGRC determination. The applicant may feel that the iGRC is too conservative for their operation. Therefore, an applicant may decide to calculate the actual critical area applying a mathematical model defined in Annex. If the calculated critical area corresponds to the critical area identified in Annex F for a UA of a smaller size, then the applicant may use the corresponding iGRC.

[7] An assembly of people is expected to be over 10,000 people, which is the minimum number of people needed to treat a grouping of people as an assembly of people).
[8] See ss. 9.4.2 of the Flight Safety Analysis Handbook (FAA 2011)

2.3.2 Determination of the adjacent area size and adjacent area intrinsic GRC

(a) The adjacent area size models a reasonably probable ground area where an UA may fly or crash after a flyaway.

(b) The lateral outer limit of the adjacent area is calculated from the operational volume as:

1. either the maximum range remaining of the UA once it leaves the operational volume if it is less than 5 km from the edge of the operational volume, or
2. the distance flown in 3 minutes at maximum cruise speed of the UA:
   2.1. If the distance is less than 5 km, use 5 km.
   2.2. If the distance is between 5 km and 35 km, use the distance calculated.
   2.3. If the distance is more than 35 km, use 35 km.

The inner limit of the adjacent area is the outer limit of the ground risk buffer (i.e. the ground risk buffer is not part of the adjacent area).

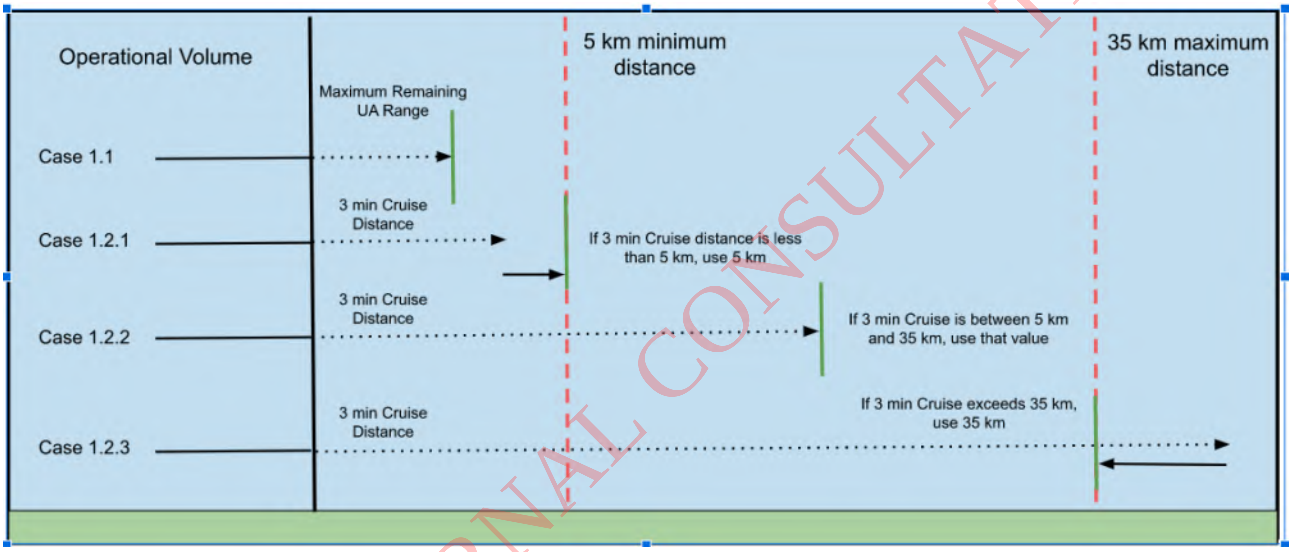

Figure 6 – Adjacent Area Lateral Distance Calculation

(c) If the applicant or competent authority considers the previous criteria are not appropriate for determining the size of the adjacent area, the competent authority may ask for or accept an alternative means of calculating the adjacent area. The UA's inherent flight characteristics in a loss of control situation can be used to argue for a different size of the adjacent area.

(d) In order to determine the intrinsic ground risk for the adjacent area, the applicant needs to complete the following steps:

1. Determine the average population density value
   1.1. Calculate the average population density of the adjacent area identified in the previous section,
   1.2. Identify potential locations for non-sheltered assemblies of people 1km beyond the outer limits of the operational volume during the time of operation. If the adjacent area has assemblies of people then assign the following average population density:
      1.2.1. < 25,000 ppl/km^2 if the assembly of people exceeds ~20,000 ppl[9];

[9] e.g. Sports event at a stadium, concert, large assemblies in beaches/parks.

1.2.2. < 250,000 ppl/km^2 if the assembly of people exceeds ~200,000 ppl[10];

1.3. Use the higher value of bullet 1 and 2 above for the Adjacent Area Average Population Density Value.

2. Calculate Adjacent Area Ground Risk Class Score by assigning an adjacent area intrinsic GRC to the adjacent area based on the identified average population density value, using Table 2, the UA platform characteristics, and the average population density.

(e) Although the SORA process does not support a final GRC higher than 7, the value is acceptable for the adjacent area, since the operation is not expected to happen in this area.

(f) Conservative simplifications for calculating the average population density should be accepted to allow more practical calculation means. Unlike the iGRC table, the average value is used as it is a reasonable assumption that the likelihood of a flyaway event occurring in different portions of the Adjacent Area is close to uniform.

(g) There is a difference in which population density value is used when determining the ground risk of the iGRC footprint area (maximum) and the adjacent area (average). When determining the population density to use for the iGRC in the iGRC footprint (operational volume + ground risk buffer) the maximum population density is conservatively used as the operator may choose to spend a significant portion of their flight time over the maximum population density area in the approved area.

(h) For the adjacent area, the operator is not approved to plan flights in this area and will only reach the adjacent area in the event of a loss of control and fly away event. In that situation, the direction and duration of the fly away is assumed to be random, thus the average population density used.

2.3.3 Step #3 – Final GRC Determination

(a) The intrinsic risk of a person being struck by the UAS (in case of loss of control of the operation) can be reduced by means of acceptable mitigations.

(b) The mitigations used to modify the intrinsic GRC have a direct effect on the safety objectives associated with a particular operation, and therefore it is important to ensure their robustness. This has particular relevance for technical mitigations associated with ground risk (e.g. emergency parachute).

(c) The Final GRC determination is based on the availability and correct application of these mitigations to the operation. Table 4 provides a list of potential mitigations and the associated relative correction factor. All mitigations must be applied in numeric sequence 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.

	Level of Robustness		
Mitigations for ground risk	**Low**	**Medium**	**High**

[10] e.g. Large festivals, large crowds during political demonstrations, large parades or similar street events.

M1(A) - Strategic mitigations for ground risk	-1	-2	-3
M1(B) - Visual Line of Sight (VLOS) - avoid flying over people	-1	N/A	N/A
M2 - Effects of UA impact dynamics are reduced	0	-1	-2 / -3

Table 4 – Mitigations for Final GRC Determination

(d) In general, a quantitative approach to mitigation allows a reduction in the intrinsic GRC by 1 point if the mitigation reduces the at-risk population to the next lowest iGRC population band, which in most cases is approximately a factor of 10 (90% reduction) compared to the risk that is assessed before the mitigation means are applied. Such quantitative criteria should be used to validate the risk reduction that is claimed when applying Annex B to SORA.

(e) When applying mitigation M1, the GRC cannot be reduced to a value lower than the lowest value in the applicable column in Table 2. This is because it is not possible to reduce the number of people at risk below that of a controlled area.

- For example, in the case of a 2.5m UAS at a max cruise speed below 35m/s (second column in Table 2) flying over a population density below 10 ppl/km^2, the intrinsic GRC is 4. Upon analysis of the Operator Manual the applicant claims to reduce the ground risk by first applying M1 at High Robustness (a -3 GRC reduction). In this case, the result of applying M1 is a GRC of 2, because the GRC cannot be reduced any lower than the lowest value for that column. The applicant then applies M2 using a parachute system resulting in a further reduction of -1 (i.e. GRC 1). The Final GRC is established by adding all correction factors (i.e. -2-1=-3) and adapting the GRC by the resulting number (4-3=1).

(f) No credit is possible for higher resolution static maps, unless maps with lower resolution were imposed on to the operator by the authority.

(g) If an applicant has multiple partial mitigations that do not meet the criteria within Annex B individually, but when taken together achieve cumulative order(s) of magnitude reductions, the applicant can work with the Competent Authority and use the process described within Annex F to justify a reduction of the final GRC score.

(h) If the Final GRC is higher than 7, the operation is considered to have more risk than the SORA is designed to support. Discuss with the competent authority for how to proceed, such as using the Certified Category.

(i) Additional guidance on commonly used mitigations can be found in the following documents:

i. Sheltering as a reduction of people at risk in M1(A) in Annex B[11]

ii. Visual Line of Sight as a strategic and tactical mitigation in M1(B) in Annex B

iii. Multirotors and their reduced critical area in M2 in Annex B and Annex F

2.3.4 Determination of final adjacent area GRC

(a) Mitigations might be applied to reduce the GRC of the adjacent area. Mitigations that may be used for the adjacent area GRC without additional justification:

[11] It is expected that sheltering can be used for most operations where the UA is not flying over large crowded outdoor assemblies (i.e.: concert, parade, festival, beach/park during peak times).

i. M1 for using the assumption of sheltering;

ii. M2 mitigations based on passive designs or inherent UA characteristics, like frangibility, may be used to lower the adjacent area intrinsic GRC. M2 mitigations like parachutes or special descent manoeuvres may not be used by default.

(b) Applicants may provide justification to the Competent Authority for additional mitigations as long as they are still applicable and in a fly away scenario.

(c) Mitigations whose failures would lead to a fly away scenario should not be given credit[12].

(d) After mitigations have been applied, calculate the final adjacent area GRC of the using the same process as Step #3 in above.

2.4 The Air Risk Process

2.4.1 Air Risk Process Overview

(a) The SORA uses the operational airspace defined in the operators manual as the baseline to evaluate the intrinsic risk of mid-air collision and by determining the air risk class (ARC). The ARC may be modified/lowered by applying strategic and tactical mitigation means. Application of strategic mitigations may lower the ARC level. An example of strategic mitigations to reduce collision risk may be by operating during certain times or within certain boundaries. After applying strategic mitigations any residual risk of mid-air collision is addressed by means of tactical mitigations.

(b) Tactical mitigations take the form of detect and avoid systems or alternate collaborative means, such as ADS-B, Systems transmitting on SRD 860 frequency band, UTM/U-Space services or operational procedures. Depending on the residual risk of mid-air collision, the Tactical Mitigation Performance Requirement(s) may vary.

(c) As part of the SORA process, the Operator should cooperate with the relevant service provider for the airspace (e.g. ANSP or UTM/U-Space service provider) and obtain the necessary authorizations. Additionally, generic local authorizations 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 used in the United States). The competent authority or ANSP may impose additional strategic or tactical mitigations on airspace authorizations, taking into account uncertainties related to UA reliability, conspicuity, and other factors.

(d) 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. Therefore, technical solutions that improve the electronic conspicuousness or detectability of the UAS are recommended.

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

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/residual Air Risk Class (ARC) for a particular airspace. If the competent

[12] For example, if the flight termination system triggers a parachute, in the event of a fly away, it is assumed the parachute system has failed, unless proven otherwise by the applicant.

authority, ANSP, or UTM/U-space service provides an air collision risk map (static or dynamic), the applicant should use that service to determine the initial/residual ARC, and go directly to section 2.4.3 "Application of Strategic Mitigations" to reduce the initial ARC.

2.4.2.1 Determination of Initial ARC

(a) As seen in Figure 5, the airspace is categorized into 12 aggregated collision risk categories. These categories were characterized by altitude, controlled versus uncontrolled airspace, airport/heliport versus non-airport/non-heliport environments, airspace over urban versus rural areas, and lastly atypical (e.g. segregated) versus typical airspace. The categories correspond to the Airspace Encounter Classes (AECs), which provide a further qualitative delineation of unmitigated collision risk that is elaborated in Annex C.

(b) To find the initial ARC for the location of UAS operation, the applicant should use the decision tree found in Figure 7.

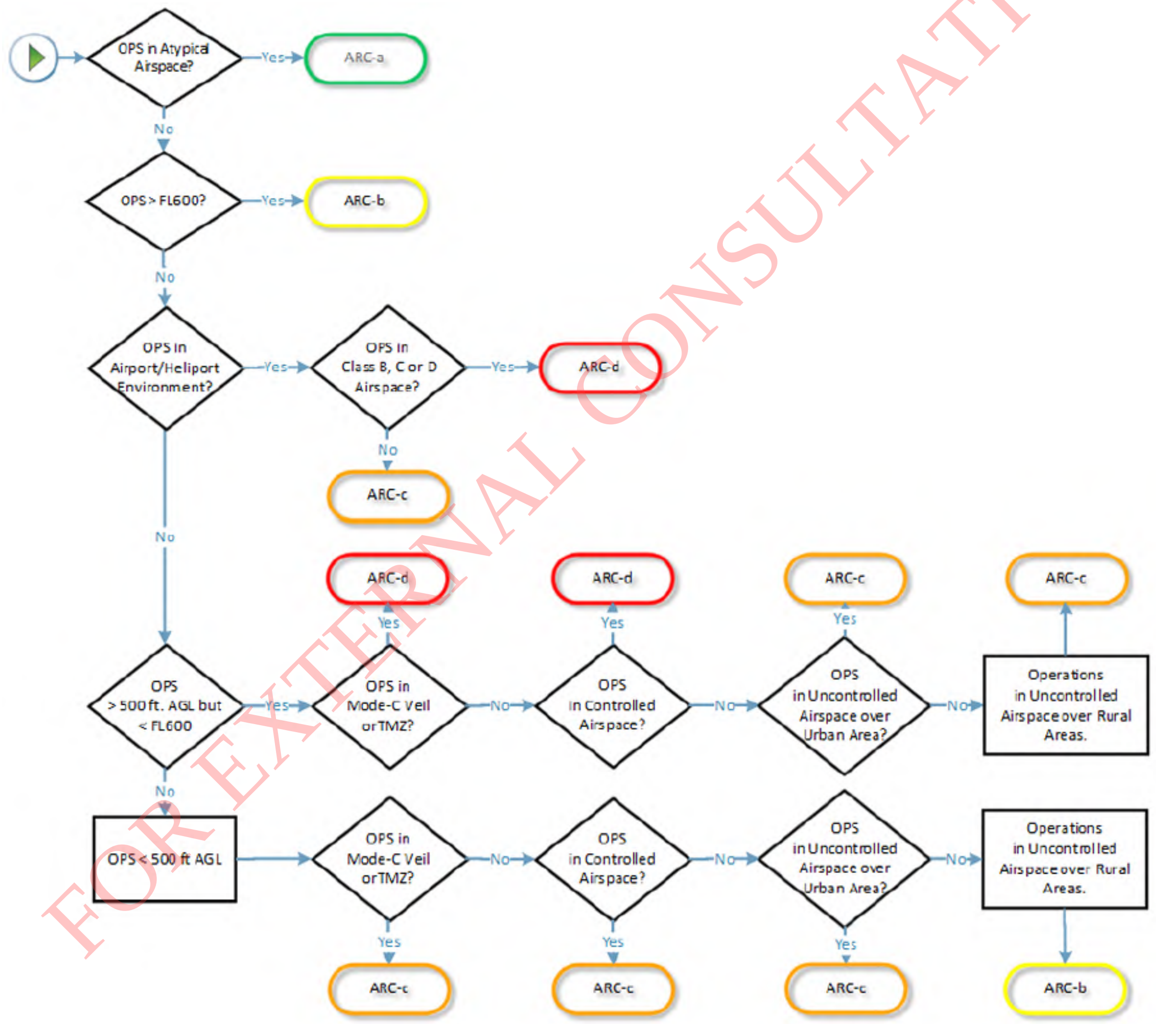

Figure 7 – ARC Assignment Process

(c) The ARC is a qualitative classification of the rate at which a UAS would typically encounter a manned aircraft within that volume of 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 Volume could be much different and can be addressed in the

Application of Strategic Mitigations to reduce the ARC section (this step is optional, see section 2.4.3, Step #5).

(d) Although the unmitigated risk captured by the ARC is conservative, there may be situations where that conservative assessment may not suffice. 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 7 could be invalidated. In some situations, the competent authority may raise the Operational Volume ARC to a level which is higher than that indicated by Figure 7. The ANSP should be consulted to assure that the assumptions related to the Operational Volume are accurate.

(e) ARC-a is defined as airspace where the risk of collision between a UAS and manned aircraft is acceptably low without the addition of any tactical mitigation. This is usually the case, when it can be generally expected, that no manned aircraft use the airspace volume intended for the operation. Examples may include operation in reserved or restricted airspaces, or operation at very low altitudes (including in close proximity to obstacles) where manned aircraft generally do not operate. A competent authority may also designate parts of their airspace as atypical. ARC-b, ARC-c, ARC-d are generally defining airspace with increasing risk of collision between a UAS and manned aircraft.

(f) During the UAS operation, the UAS Operational Volume may span many different airspace environments. The applicant 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.

2.4.2.2 Determination of adjacent airspace size

(a) The adjacent airspace size models the reasonably probable airspace where an UA may fly after a loss of control situation.

(b) The lateral limit of the adjacent airspace is the same as for the adjacent area.

(c) The vertical limits of the Adjacent Airspace are calculated as:

1. Maximum Altitude:
    - 1.1. Calculate the altitude gained in 3 minutes using the maximum climb rate of the UA and add it to the maximum altitude of the operational volume;
    - 1.2. If the above value is less than 500m above the maximum altitude of the operational volume, use 500m above the maximum altitude.
2. Minimum Altitude: if the operational volume does not reach the ground, any airspace below the operational volume is considered adjacent airspace.

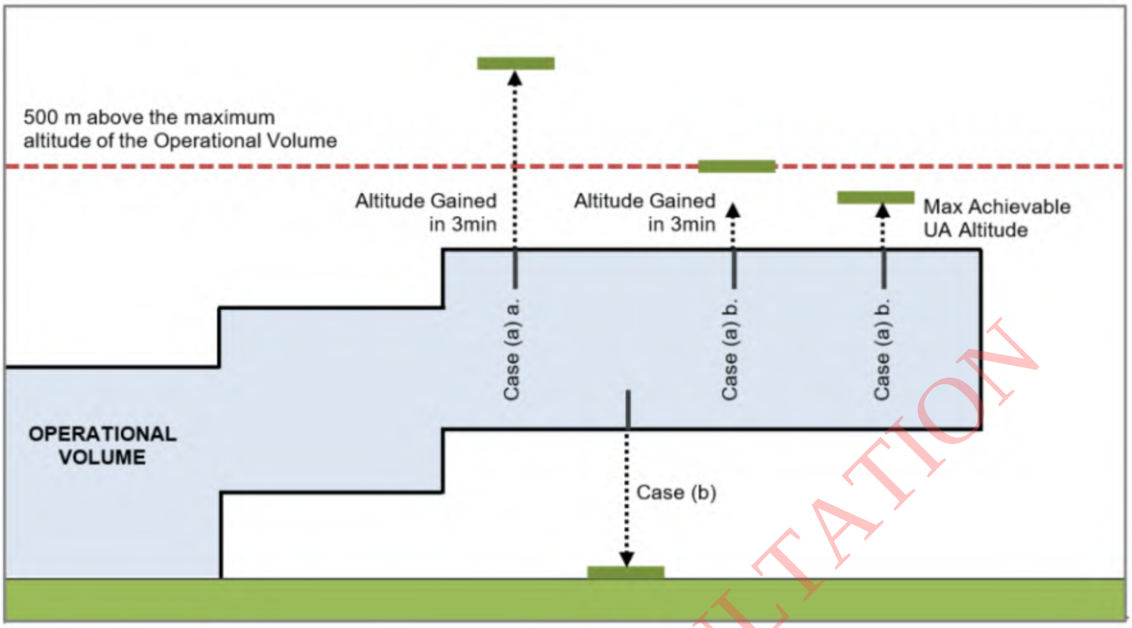

Figure 8 – Determination of the vertical outer limits of the adjacent airspace

(d) If the applicant or Competent Authority considers the previous criteria are not appropriate for determining the size of an adjacent area and airspace, the Competent Authority may ask for or accept an alternative means of calculating the size of the adjacent area or airspace. Applicants can provide evidence of the UA's inherent physical flight characteristics in a loss of control situation in order to argue for a different size of the adjacent area and airspace.

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

(a) As stated before, the ARC is a qualitative classification of the rate at which a UAS would encounter a manned aircraft in a given airspace environment. However, it is recognized that the UAS Operational Volume may have a collision risk that differs from the Initial ARC assigned.

(b) If an applicant considers that the initial ARC assigned is too high for the condition in the local Operational Volume, then refer to Annex C for the ARC reduction process.

(c) If the applicant considers that the initial ARC assignment is correct for the condition in the local Operational Volume, then that ARC becomes the Residual ARC.

(d) The strategic mitigation by operational limitation (restriction by boundary and chronology) may be used to reduce the air risk by one class in the case of VLOS operations with a considerably low time of exposure[13].

[13] This information will be reflected in a later version of Annex C.

2.4.4 Step #6 – Tactical Mitigation Performance Requirement (TMPR) and Robustness Levels

Tactical Mitigations are applied to mitigate any residual risk of a mid-air collision needed 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 Detect and Avoid (DAA) system, or multiple DAA systems). Annex D provides the method for applying Tactical Mitigations.

2.4.4.1 Operations under VLOS/EVLOS[14]

(a) VLOS is considered an acceptable Tactical Mitigation for collision risk for all ARC levels. Notwithstanding the above, the operator is advised to consider additional means to increase situational awareness with regard to air traffic operating in the vicinity of the operational volume

(b) Operational UAS flights under VLOS do not need to meet the TMPR, nor the TMPR robustness requirements. In the case of multiple segments of the flight, those segments done under VLOS do not have to meet the TMPR nor the TMPR robustness requirements, whereas those done BVLOS do need to meet the TMPR and the TMPR robustness requirements.

(c) In general, all VLOS requirements are applicable to Extended Visual Line of Sight (EVLOS). EVLOS may have additional requirements over and above VLOS. EVLOS verification and communication latency between remote pilot and observers should be less than 15 seconds.

(d) Notwithstanding the above, the applicant should have a documented VLOS de-confliction scheme, in which the applicant explains which methods will be used for detection, and define the associated criteria 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.

(e) For VLOS operations, it is assumed that an observer is not 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.) Therefore, the operator may have to adjust the operation and /or procedures accordingly.

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

(a) For operations other than VLOS, the applicant will use the Residual ARC and Table 5 below to determine the Tactical Mitigation Performance Requirement (TMPR).

Residual 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 5 – Tactical Mitigation Performance Requirement (TMPR) and TMPR Level of Robustness Assignment

(b) High TMPR (ARC-d): This is airspace where either the manned aircraft encounter rate is

[14] EVLOS operations whereby the remote Pilot in Command maintains an uninterrupted situational awareness of the airspace in which the UAS operation is being conducted via visual airspace surveillance through one or more human observers, possibly aided by technology means are to be considered as BVLOS for the purposes of M1(b), and not VLOS

high, and/or the available Strategic Mitigations are Low. Therefore, the resulting residual collision risk is high, and the TMPR is also 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. This is no different than the requirements for the integration of comparable new and novel technologies in manned aviation. 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 (e.g. those developed by RTCA SC-228 and/or EUROCAE WG-105).

(c) Medium TMPR (ARC-c): A medium TMPR will be required for operations in airspace with a moderate likelihood of encounter with manned aircraft, and/or where the strategic mitigations available are medium robustness. Operations with a medium TMPR will likely be supported by systems currently used in aviation to aid the remote 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.

(d) Low TMPR (ARC-b): A low TMPR will be required for operations in airspace where the likelihood 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 remote pilot in detecting other traffic, but which may be built to lesser standards. For example, for operations below 500 feet AGL, the traffic avoidance manoeuvres are expected to mostly be based on a rapid descent to an altitude where manned aircraft are not expected to ever operate.

(e) No TMPR (ARC-a): This is airspace where the manned aircraft encounter rate is expected to be extremely low, and therefore there is no need for a TMPR. It is 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.

(f) Annex D provides information on how to satisfy the TMPR based on the available tactical mitigations and the TMPR Level of Robustness.

2.4.4.3 Consideration of Additional Airspace / Operation Requirements

(a) Modifications to the initial and subsequent approvals may be required by the competent authority or ANSP as safety and operational issues arise.

(b) 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 fully understand the airspace and air-traffic flows and develop a system which can alert operators to changes to the airspace on a local level. This will allow the operator to safely address the increased risks associated with these events.

(c) There are many airspace, operational and equipage requirements which have a direct impact on the collision risk of all aircraft in the airspace. Some of these requirements are general and apply to all airspaces, while some are local and are required only for a particular airspace. The SORA cannot possibly cover all the possible requirements required by the competent authority for all conditions in which the operator may wish to operate. The applicant and the competent authority need to work closely together to define and address these additional requirements.

(d) 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 may be granted by the competent authority. Those exemptions are outside the scope of the SORA.

(e) Operations in controlled airspace, an airport/heliport environment or a Mode-C Veil/Transponder Mandatory Zone (TMZ) will likely require prior approval from the ANSP. The applicant should ensure that they coordinate with the relevant ANSP/authority prior to commencing operations in these environments.

2.5 Final Specific Assurance and Integrity Levels (SAIL) and Operational Safety Objectives (OSO) Assignment

2.5.1 Step #7 SAIL determination

(a) The SAIL parameter consolidates the ground and air risk analyses and drives the required activities. The SAIL represents the level of confidence that the UAS operation will stay under control.

(b) After determining the Final GRC and Residual ARC, it is now possible to derive the SAIL associated with the proposed operation.

(c) The level of confidence that the operation will remain in control is represented by the SAIL. The SAIL is not quantitative but instead corresponds to:

i. OSOs to be complied with (see Table 6),

ii. Description of activities that might support compliance with those objectives, and

iii. The evidence that indicates the objectives have been satisfied.

(d) The SAIL assigned to a particular operation is determined using Table 6:

SAIL Determination				
	Residual ARC			
Final GRC	a	b	c	d
≤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 (Certified) operation[15]			

Table 6 – SAIL Determination

[15] Reference document: http://jarus-rpas.org/sites/jarus-rpas.org/files/imce/attachments/wg_7_-_annex_c_-_boundaries_cat_b_-_c.pdf

2.5.2 Step #8 – Identification of containment requirements

(a) Using the Final SAIL of the operation and the adjacent area final GRC calculated above, the adjacent area containment requirement using Table 7 below can be identified:

Adjacent area final GRC	SAIL					
	I	II	III	IV	V	VI
≤3	N					
4	L	N				
5	L[16]	L	N			
6	M	M	L	N		
7	H	H	M	L	N	
8	C	C	C	M	L	N
9				C	M	L
10					C	M

Table 7 – Adjacent Area Containment Requirements

where:

- N = No containment,
- L = Low containment,
- M = Medium containment,
- H = High containment,
- C = Consult with authority

(b) The adjacent airspace requirements can be identified using Table 8 below:

Highest Adjacent Airspace	SAIL I, II, III, IV	SAIL V, VI
ARC-a or ARC-b	None	None
ARC-c or ARC-d	Low	None

Table 8 – Adjacent Airspace Containment Requirements

(c) If there is either ARC-c or ARC-d in the adjacent airspace, and the operation is SAIL IV or lower, then low containment is required to mitigate the adjacent air risk. Otherwise, no additional containment requirements are necessary beyond the OSO requirements for the SAIL.

(d) The final containment requirements to be applied to the system are the highest from the Adjacent Area containment level determination and Adjacent Airspace containment level determination as shown in Table 9.

[16] Basic containment sets a floor probability for fly-away events of 10-4 , so SAIL I operations will crash more often than SAIL II, but will not fly-away more often.

		Adjacent Area Containment Requirements			
Adjacent Airspace Containment Requirements		None	Low	Medium	High
	None	None	Low	Medium	High
	Low	Low	Low	Medium	High

Table 9 – Final Containment Requirements

(e) Please refer to Annex E Section 4 – Containment Requirements for the requirements associated with each level of robustness of the requirements above.

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

(a) This step of the SORA process is to use the SAIL to evaluate the threat barriers utilised within the operation in the form of operational safety objectives (OSO) and to determine the associated level of robustness. Table 6 provides a qualitative methodology to make this determination. In this table:

i. NR stands for not required to show compliance to the competent authority, however, the operator is encouraged to consider the operational safety objective at a low integrity level,

ii. L is recommended with Low robustness,

iii. M is recommended with Medium robustness,

iv. H is recommended with High robustness.

(b) Table 6 is a consolidated list of common OSOs that historically have been used to ensure safe UAS operations. It represents the collected 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 OSOs for a given SAIL and the associated level of robustness. While the applicant is the organisation responsible for showing compliance for all OSOs, some of the evidence may be developed by other organisations such as manufacturers or training organisations according to the distribution identified in Table 6.

New OSO	Old OSO		SAIL						Operator	Training org.	Manufacturer
			I	II	III	IV	V	VI			
# I	#01	Ensure the operator is competent and/or proven	NR	L	M	H	H	H	x		
# II	#02	UAS manufactured by competent and/or proven entity	NR	NR	L	M	H	H			x
# III	#17	Remote crew is fit to operate	L	L	M	M	H	H	x	x	

New OSO	Old OSO		SAIL						Operator	Training org.	Manufacturer
			I	II	III	IV	V	VI			
# IV	#08, #11, #14, #21	Operational procedures are defined, validated and adhered to address normal, abnormal and emergency situations potentially resulting from technical issues with the UAS or external systems supporting UAS operation, human errors or critical environmental conditions	L	M	H	H	H	H	x		
# V	#03	UAS maintained by competent and/or proven entity	L	L	M	M	H	H	Crit. 1 Crit. 2		Crit. 1
# VI	#07	Conformity check of the UAS configuration	L	L	M	M	H	H	Crit. 1	Crit. 2	
# VII	#23	Environmental conditions for safe operations are defined, measurable and adhered to	L	L	M	M	H	H	Crit. 2	Crit. 3	Crit. 1
# VIII	#13	External services supporting UAS operations are adequate for the operation	L	L	M	H	H	H	x		
# IX	#16	Multi-crew coordination	L	L	M	M	H	H	Crit. 1 Crit. 3	Crit. 2	
# X	#09, #15, #22	Remote crew trained and current and able to control the normal, abnormal and emergency situations potentially resulting from technical issues with the UAS or external systems supporting UAS operation, human errors or critical environmental conditions	L	L	M	M	H	H		x	

New OSO	Old OSO		SAIL						Operator	Training org.	Manufacturer
			I	II	III	IV	V	VI			
# XI	#19	Safe recovery from human error	NR	NR	L	M	M	H	Crit. 1 Crit. 2	Crit. 2	Crit. 3
# XII	#04	UAS components essential to safe operations are designed to an Airworthiness Design Standard (ADS)	NR	NR	NR	L	M	H			x
# XIII	#05	UAS is designed considering system safety and reliability	NR	NR	L	M	H	H			x
# XIV	#18	Automatic protection of the flight envelope from human error	NR	NR	L	M	H	H			x
# XV	#20	A human factors evaluation has been performed and the human machine interface (HMI) found appropriate for the mission	NR	L	L	M	M	H			x
# XVI	#06	C3 link characteristics (e.g. performance, spectrum use) are appropriate for the operation	NR	L	L	M	H	H			x
# XVII	#24	UAS designed and qualified for adverse environmental conditions (e.g. adequate sensors, DO-160 qualification)	NR	NR	M	H	H	H			x
# XVIII	#10, #12	Safe recovery from technical issue with the UAS or external systems supporting UAS operation	L	L	M	M	H	H			x

Table 10 Recommended operational safety objectives (OSO)

2.6 Step #10 Comprehensive Safety Portfolio

(a) As mentioned in Step #1, the Comprehensive Safety Portfolio may consist of:

i. the operator manual,

ii. Compliance evidence(s) (e.g. tests of a parachute, report of table-top exercise), and

iii. Documentation of the SORA process (including the compliance matrix with the SORA, an example is provided in Annex A).

(b) This final step gives the applicant the opportunity to document all elements of the risk assessment and to check that all the requirements of the SORA steps have been complied with. This will allow the applicant and the competent authority to be able to assess a standardised document that provides assurance that the SORA process has been completed in full. This is achieved by having a sufficiently comprehensive operator manual, which will be documented in this final step. The comprehensive safety portfolio needs to address the description and supporting information/evidence on:

i. the operational volume and risk buffers is sufficient to identify intrinsic GRC and initial ARC

ii. the applied mitigations used to modify the iGRC and ARC if used by the applicant.

iii. the applied tactical mitigations for the Residual ARC.

iv. adequacy of the containment provisions with respect to the Adjacent Area/Airspace associated with the operational volume.

v. the means by which the operator meets the required levels of robustness of the OSOs.

(c) In the case the operator uses external service(s), reference(s) to Service Level Agreement(s) (SLA) providing a delineation of responsibilities between the Service Provider(s) and the operator. This should also detail the functionality, limitations and performance of the service and should be included as part of the Safety Portfolio. This will allow the competent authority to get clear oversight into which services are being used, the functions they perform, and how they contribute to the overall operational safety. It also allows verification that responsibilities have been correctly allocated, and that there are no unallocated responsibilities.