UK Specific Operations Risk Assessment (UK SORA) methodology

CAP 3017

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Foreword

The introduction of UK SORA

This consultation forms part of the UK Civil Aviation Authority's (CAA) ongoing work to enable Unmanned Aircraft System operations in UK Airspace in the Specific Category, a key component of the CAA Future of Flight Programme.

UK SORA provides a structured approach to risk assessment, enabling applicants to identify hazards, and evaluate the risk of UAS operations.

Consultation approach

The CAA is consulting on our proposal to implement, as UK SORA, the Joint Authorities for Rulemaking on Unmanned Systems (JARUS) version 2.5 of the Specific Operations Risk Assessment (JARUS SORA) with the differences proposed in this document.

JARUS SORA version 2.5 was published for consultation on behalf of the UK CAA (and other member international NAAs) by JARUS. The CAA encouraged UK stakeholders to engage with this consultation via Skywise (SW2023/011 23rd January 2023). The JARUS consultation closed on the 6th of March 2023 and the final version was published in June 2024. The JARUS SORA version 2.5 documentation can be found on its website .

Noting this list is not exhaustive, the CAA is not consulting on fundamentals of JARUS SORA, which have already been consulted on as part of the consultation above:

i) Underpinning internationally agreed terminology.

ii) Internationally agreed requirements (Annex B and Annex E) except where they differ from JARUS SORA version 2.5.

iii) Qualitative methods to determine ground risk.

This consultation seeks to gather feedback on the proposed differences between the JARUS version 2.5 of the Specific Operations Risk Assessment (JARUS SORA) and the proposed UK SORA.

Applications outside of the Specific category are not in scope of this consultation.

Consultation information

Information on the UK SORA consultation, including how to respond can be found on the CAA consultations website.

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Chapter 1

UK SORA

UK UAS regulatory requirements

1.1 The UK SORA methodology has been adapted from JARUS SORA version 2.5 to meet UK regulatory requirements described under UK Regulation (EU) 2019/947 Article 11- Rules for conducting an operational risk assessment.

Operations out of scope for UK SORA

1.2 UK SORA cannot be used for the following types of operation:

i) carrying people

ii) operating unmanned aircraft with a dimension larger than 40 meters.

iii) operating unmanned aircraft with a maximum cruise speed above 200 meters per second.

iv) operating above Flight Level 660.

v) swarm operations.

vi) multiple simultaneous operations (MSO).

1.3 Before starting the UK SORA process the applicant should consider if any of the above criteria apply to the proposed operation. If the answer is yes, then the UK SORA process cannot be used for the application.

1.4 If UK SORA cannot be used, the applicant should contact the CAA regarding the options available, such as using the Certified category as defined in Article 6 of UK Regulation (EU) 2019/947.

UK SORA differences

UK SORA Application Service

1.5 Applications for UK SORA **must** be made using the digital UK SORA Application Service. The UK SORA Application Service provides step-by-step guidance to applicants during the application process, compliance evidence gathering, and CAA assessment. The UK SORA Application Service will also provide links to relevant Acceptable Means of Compliance (AMC) and Guidance Material (GM).

UK air risk model differences

1.6 The CAA is working with JARUS to update the current air risk model as part of a future version of JARUS SORA. UK SORA uses an updated version of the qualitative air risk model, which has been modified to suit UK airspace. The key differences between the UK SORA air risk model and the JARUS SORA air risk models are as follows:

1. The UK initial Air Risk Class (ARC) flowchart focuses on encounter type, the airspace ruleset and whether the air environment is either *recognised* or contains *known traffic*.
2. The UK initial ARC flowchart is to be used irrespective of whether airspace characterisation encounter rate data is available or not.
3. Strategic and tactical mitigations have been updated to align with current UK CAA policy development, including specific reference to UK flight information services and military low flying coordination.

UK SORA robustness approach

UK SORA is a new process for both industry and the CAA. During the initial implementation of UK SORA, the CAA will increase the level of assurance compliance evidence assessment until it is determined that the UK SORA process is well understood.

Compliance evidence submission

The UK SORA application process will require the applicant to provide compliance evidence for all requirements, based on the Specific Assurance and Integrity Level (SAIL) of the operation.

The CAA carefully considered the above approach in relation to the additional burden this may place on applicants. In the context of the UK SORA Application Service, the only additional action required from the applicant is to add their compliance evidence to the relevant screen during the application process. As the applicant is required to complete this work regardless, the CAA determined the additional effort is minimal.

Systematic compliance assessment

The CAA will conduct systematic compliance checking (assessment) of the following OSO's regardless of the required robustness level:

SAIL I

OSO's 08,09, 13, 16 (if applicable), 17, and 23

SAIL II

OSO's 01, 06, 08, 09, 13, 16 (if applicable), 17, and 23

SAIL III and above

All relevant OSO’s will be checked systematically during the application.

Tactical compliance assessment

The CAA may also conduct tactical compliance checks based on a range of factors including, but not limited to:

- The type of application
- Safety intelligence data
- Novel technology or aircraft design

The UK SORA process

Managing risk using SORA

1.7 The categories of harm considered in UK SORA are the potential for:

i) fatal injuries to third parties on the ground

ii) fatal injuries to first parties in the air

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

Semantic model in the context of UK SORA

1.9 UK SORA uses a semantic model with standardised terminology for phases of operation, procedures, and operational volumes.

Figure 1 - SORA Semantic Model

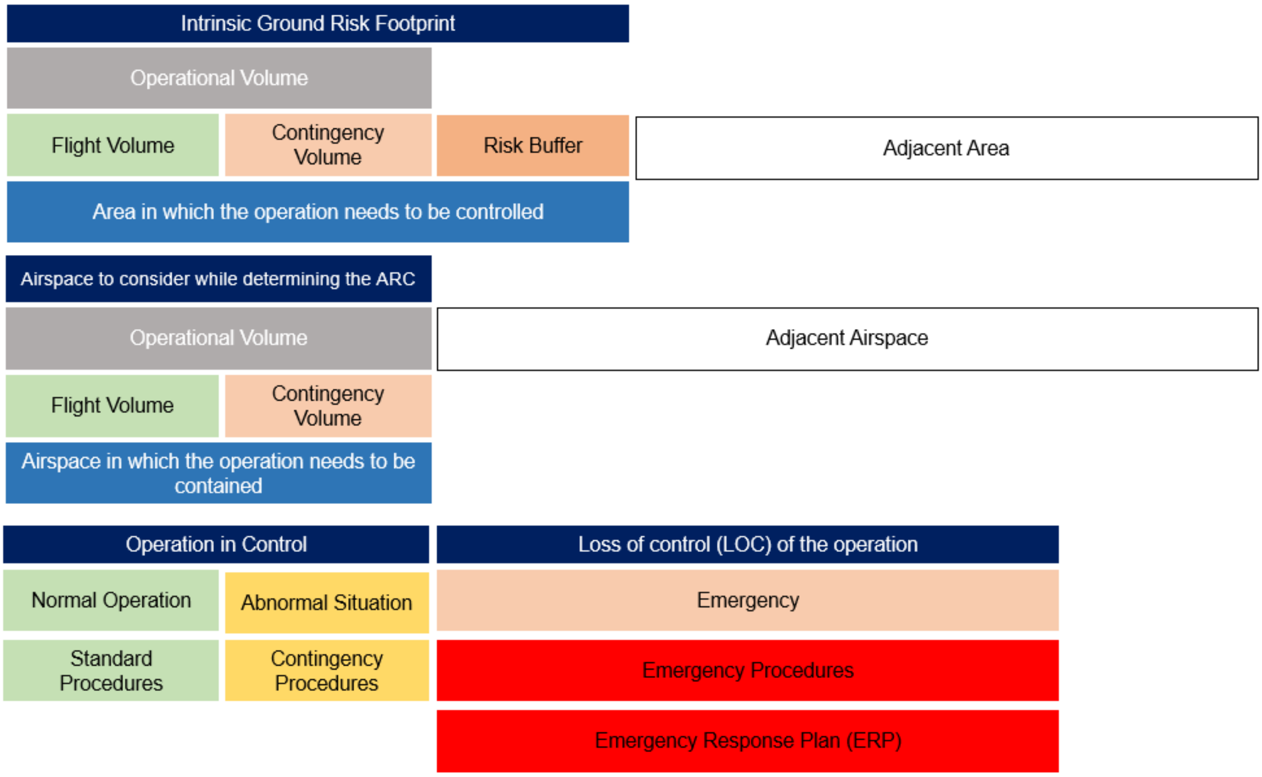
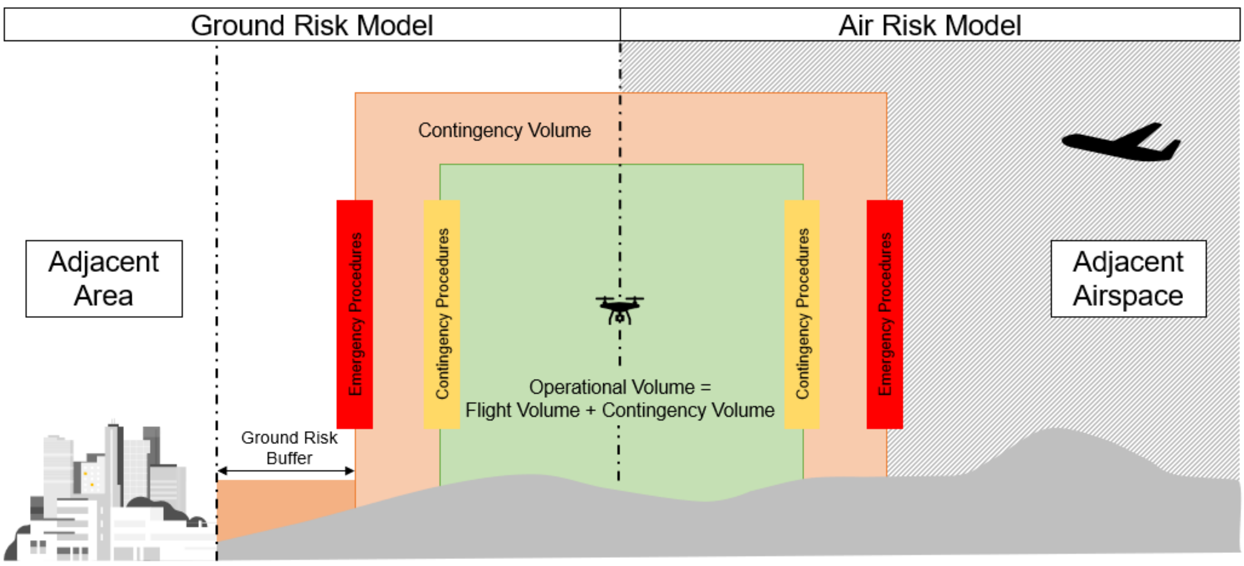


Figure 2 - The Operational Volume



Operation Control States

1.10 The UK SORA considers an operation to be either in a state of control, or loss of control.

The operational volume

1.11 The operational volume is made up of the flight volume and the contingency volume.

The flight volume

1.12 For normal operations, the UA **must** only operate inside the flight volume using standard operating procedures.

1.13 Depending on the type of operation, the flight volume can be defined as a flight corridor for each planned trajectory, a larger volume to allow for a multitude of similar flights with changing flight paths, or a set of different flight volumes fulfilling specific conditions.

1.14 The flight volume should sufficiently be large for the planned operation. Whenever a particular flight requires the UA to traverse or loiter/hold at a specific point of interest, this point must be included inside the flight volume.

The contingency volume

1.15 The contingency volume surrounds the flight volume. Refer to Annex A for further guidance.

1.16 Entry into the contingency volume is always considered an abnormal situation and requires the execution of appropriate contingency procedures to return the UA to the flight volume.

The ground risk buffer

1.17 The ground risk buffer is an area on the ground that surrounds the footprint of the contingency volume.

1.18 If the UA exits the contingency volume during a loss of control of the operation, it should end its flight within the ground risk buffer.

1.19 The size of the ground risk buffer is based on the individual risk of an operation and is driven by the flight characteristics of the UA and the containment requirements. Refer to Annex A for further guidance.

The adjacent area

1.20 The adjacent area represents the ground area where it is reasonably expected a UA may crash after a loss of control situation.

1.21 The adjacent area is calculated starting from the outer limit of the operational volume.

1.22 The size of the adjacent area depends on the UA performance.

The adjacent airspace

1.23 The adjacent airspace is the airspace where it is reasonably expected that an unmanned aircraft may fly after a loss of control.

States of operation

Operation in control

1.24 An operation is considered in control when the remote crew can continue the management of the current flight situation, such that no persons on the ground or in the air are endangered. This remains true for both normal and abnormal situations. However, the safety margins in the abnormal situation are reduced.

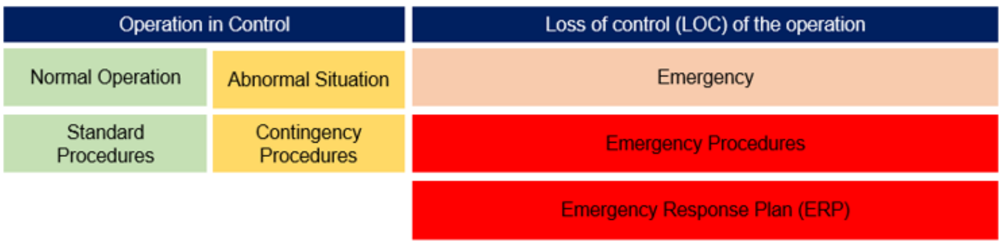
1.25 There are two states of operation in control:

i) **Normal operations** utilise standard operating procedures (SOP), which are a set of operating instructions covering policies, procedures, and responsibilities set out by the applicant.

ii) An **abnormal situation** is an undesired state where it is no longer possible to continue the flight using SOPs. However, third parties on the ground or in the air are not in immediate danger. In this case contingency procedures **must** be applied to prevent a loss of control or excursion from the operational volume.

1.26 In an abnormal situation, the remote crew **must** attempt to return the operation back into the controlled state by executing contingency procedures as soon as practicable.

Figure 3 - States of operation



Contingency procedures

1.27 Contingency procedures are designed to prevent a loss of control that has an increased likelihood of occurring due to the current abnormal situation. These procedures should return the operation to a controlled state and the use of SOP's or allow the safe termination of the flight.

1.28 Contingency procedures **must** be activated as soon as the UA deviates from its intended flight path, or behaves abnormally, to prevent it leaving the operational volume.

1.29 If contingency procedures cannot rectify the abnormal situation, or the UA approaches the outer edge of the contingency volume, emergency procedures **must** be applied to safely terminate the flight.

Loss of control (LOC) of the operation

1.30 A Loss of Control (LOC) typically has the following characteristics:

i) It could not be handled by a contingency procedure.

ii) The safe outcome of the situation relies highly on luck.

1.31 This includes situations where a UA has exited the operational volume and is potentially operating over or in an area of ground or air risk for which the UAS operator is not authorised.

1.32 The LOC state is also entered if a UA does not follow the authorised route and the remote pilot is unable to control it, an automatic failsafe is initiated, or the Flight Termination System (FTS) is activated, even if this happens inside the operational volume.

Emergency procedures

1.33 Emergency procedures **must** be executed whenever a LOC state is entered, even if it is within the operating volume. They are executed by the remote crew and may be supported by automated features of the UAS (or vice versa) and are intended to mitigate the effect of failures that cause or could lead to an unsafe outcome.

1.34 Regardless of other actions and responses by the flight crew, the emergency procedures **must** always be executed before crossing the outer edge of the contingency volume, which would otherwise result in an operational volume excursion.

Emergency Response Plan (ERP)

1.35 The ERP is used for coordinating all activities needed to respond to incidents and accidents. It is different from emergency procedures, as it does not deal with LOC but actions to be taken afterwards.

Containment

1.36 Containment consists of technical and operational mitigations that are intended to contain the flight of the UA within the defined operational volume and ground risk buffer to reduce the likelihood of a LOC, resulting in an operational volume excursion.

Robustness

1.37 Robustness is the term used to describe the combination of two key characteristics of a risk mitigation or operational safety objective:

i) the level of integrity (LOI) i.e., how good the mitigation/objective is at reducing risk.

ii) the level of assurance (LOA) i.e., the degree of certainty with which the level of integrity is ensured.

1.38 The compliance evidence used to substantiate the level of integrity and assurance of an application are detailed in the Annexes B, C, D, and E. These annexes contain AMC, GM, or reference to industry standards and practices, where accepted by the CAA.

1.39 Table 1 provides guidance to determine the level of robustness based on the level of integrity and the level of assurance.

Table 1 – Robustness Levels

	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

Note - Section 1.41 introduces the UK SORA robustness model. This paragraph contains significant differences to both JARUS SORA and EASA SORA.

1.40 The applicant must provide a compliance approach and compliance evidence for mitigations and OSOs based on the SAIL level.

1.41 The CAA will assess the approach and evidence. For some requirements, the CAA may decide that a declaration of compliance is acceptable.

1.42 Applicants should refer to Annex A for a description of the difference between compliance approach and compliance evidence.

Roles, responsibilities, and definitions

Applicant

1.43 The applicant is the individual or organisation applying for an operational authorisation. The applicant must substantiate the safety of the operation by completing the UK SORA. Supporting material for the assessment may be provided by third parties (e.g., the designer of the UAS or equipment, UTM service providers, etc.).

Operator

1.44 The responsibilities of a UAS operator are defined in the UK Regulation (EU) 2019/947, UAS.SPEC.050 Responsibilities of the UAS operator.

Designer

1.45 The legal person or design and production organisation responsible for the development and manufacture of a UAS.

Air navigation service provider (ANSP)

1.46 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.

UTM service provider

1.47 UTM service providers are entities that provide services to support safe and efficient use of airspace.

Airspace managers

1.48 Airspace managers are responsible for temporary and/or permanent restricted airspace, such as flight restriction zones (FRZs), restricted airspace temporary (RAT), temporary danger areas (TDAs), danger areas, restricted areas, prohibited areas, low flying areas, helicopter routes and NOTAMs.

Remote pilot in command and flight crew

1.49 The responsibilities of a remote pilot and crew are defined in UK Regulation (EU) 2019/947, UAS.SPEC.060 Responsibilities of the remote pilot.

Maintenance staff

1.50 Ground personnel in charge of maintaining the UAS before and after flight in accordance with UAS maintenance instructions.

Chapter 2

The UK SORA application process

> Note - Chapter 2 introduces the UK SORA phases and steps which have been developed as part of the UK SORA Application Service. This section contains significant differences to both JARUS SORA and EASA SORA.

UK SORA application phases

2.1 The UK SORA application process is divided into two broad phases, the final SAIL assessment phase 1, and the compliance evidence assessment phase 2. The table below describes the individual steps per phase of the application process.

Table 1 - UK SORA Application Phases

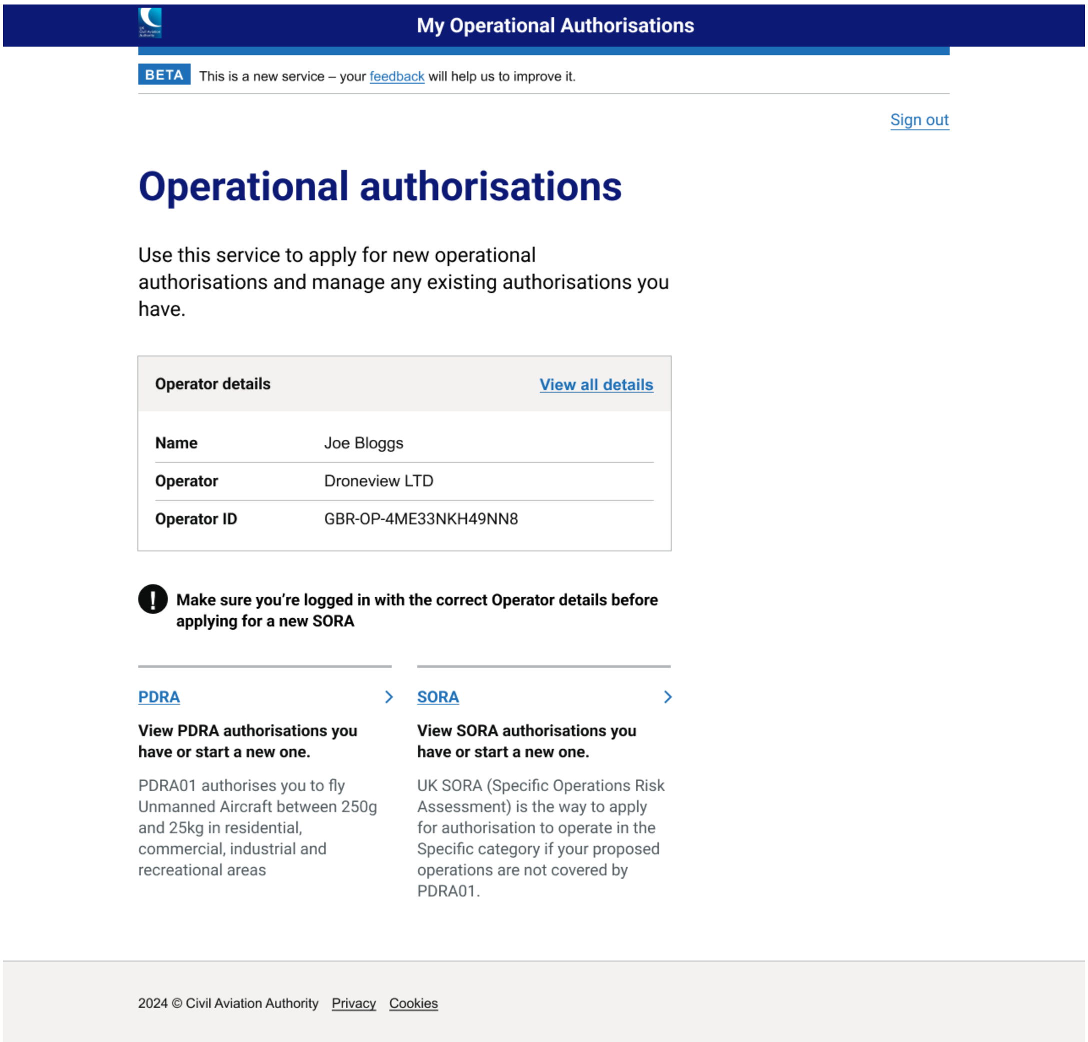
Phase	Step Number	Step Description
Phase 1 Final SAIL assessment	1	Login to the UK SORA application service
	2	Determine the intrinsic Ground Risk Class (iGRC)
	3	Apply strategic ground risk mitigations (Optional)
	4	Determine the initial air risk class (ARC)
	5	Apply strategic air risk mitigations (Optional)
	6	Initial SAIL determination
	7	Complete the operation details and provide compliance approach and evidence for mitigations
	8	Phase 1 payment and CAA assessment
	9	Final SAIL decision
Phase 2 Compliance evidence assessment	10	Provide OSO evidence compliance evidence
	11	Provide containment compliance evidence
	12	Provide TMPR compliance evidence
	13	Phase 2 payment and CAA assessment
	14	Operational authorisation decision

Step 1 Login to the UK SORA application service

Phase 1	Step 1

Introduction

2.2 In Step 1, applicants **must** login to the UK SORA application service using their operator ID.



Step 2 Determination of the intrinsic Ground Risk Class (iGRC)

Phase 1 | Step 2

Introduction

2.3 In step 2, the applicant **must** determine the intrinsic ground risk class (iGRC). The applicant **must** consider the following when determining the information to be entered into the application:

i) Determine the maximum characteristic dimension and the maximum possible speed of the UA in accordance with the manufacturer data.

ii) Identify the iGRC footprint by completing the following 3 tasks:

(1) Identify the flight volume.

(2) Calculate the contingency volume.

(3) Calculate the initial ground risk buffer.

iii) Identify the maximum population density within the iGRC footprint.

iv) Identify the iGRC of the footprint using Table 3 for the UA.

2.4 The final ground risk buffer calculation will be completed as part of the Containment step.

Guidance

Determining the UA characteristics

2.5 To establish the characteristics of the UA, the applicant **must** consider the following:

i) **Dimension:** Define the maximum size of the UA by its wingspan for fixed-wing aircraft, or maximum distance between blade tips for rotorcraft.

ii) **Maximum Speed:** This is defined as the maximum possible airspeed the UA can achieve, as specified by its Designer. It is important to note that this refers to the potential maximum speed, not the maximum speed of the proposed operation. Mitigations that reduce speed during an impact are detailed separately in Annex B.

Determination of the iGRC

2.6 Table 3 shows how the iGRC is determined.

Table 2 - iGRC Determination

Maximum UA characteristic dimension		1m	3m	8m	20m	40m
Maximum speed		*25 m/s*	*35 m/s*	*75 m/s*	*120 m/s*	*200 m/s*
Maximum iGRC population density (people/km^2)	**Controlled Ground Area**	1	1	2	3	3
	5	2	3	4	5	6
	50	3	4	5	6	7
	500	4	5	6	7	8
	5,000	5	6	7	8	9
	50,000	6	7	8	9	10
	> 50,000	7	8	**Not part of UK SORA**		

- A UA weighing less than or equal to 250g and having a maximum speed less than or equal to 25 m/s is considered to have an iGRC of 1 regardless of population density.
- A UA expected to not penetrate a standard dwelling will get a -1 GRC reduction in Step 3 from the M1(A) sheltering mitigation when not overflying large open-air assemblies of people. See Annex B for additional details.

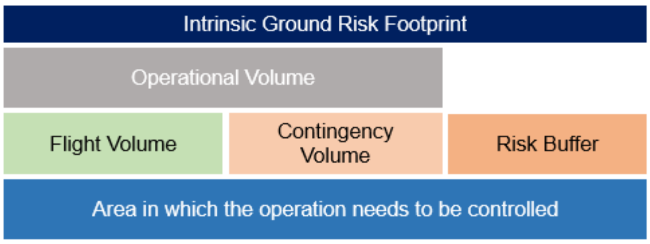
2.7 Operations that do not have a corresponding iGRC (i.e., grey coloured cells in table 3) are outside the scope of the UK SORA methodology. If UK SORA cannot be used, the applicant should contact the CAA regarding the options available, such as using the Certified category as defined in Article 6 of UK Regulation (EU) 2019/947.

iGRC footprint

2.8 The applicant **must** define the ground area at risk for the specific operation, termed the iGRC footprint. The calculation should account for the UA's ability to maintain its position in four dimensions (latitude, longitude, height, and time).

Factors such as navigation precision, flight technical errors, mapping inaccuracies, and system latencies must be considered.

Figure 4 - iGRC Footprint



2.9 The maximum population density within the iGRC must be used by the applicant.

Qualitative Ground Risk Determination

2.10 If population density values are not available, not accurate, or an applicant would rather use qualitative descriptors for the iGRC table, the following approximations can be used as guidance:

Table 3 - Qualitative ground risk

ID	Maximum Population Value (people/km^2)	Descriptor	Examples
Controlled areas and/or extremely remote places	**0**	Areas where unauthorised people are not allowed to enter and/or hard to reach areas, where it is reasonably expected that no one will be present.	Areas of land without public access Large bodies of water away from commercial, industrial or recreational users
Areas where a few people may be present	**5**	Unpopulated areas with public right of way access by road, cyclepath, footpath, bridleway, canal, etc., and/or habited rural areas smaller than a hamlet, and/or bodies of water away from commercial, industrial or recreational users.	Forests Moorland and heathland Large areas of farmland Solitary dwellings Remote recreational areas
Sparsely populated areas	**50**	Sparsely populated residential, commercial, industrial and recreational areas with large areas of land, and/or bodies of water close to residential, commercial, industrial or recreational areas.	Hamlets Clusters of small farms Residential areas with very large plots of land Small industrial and commercial areas Small recreational areas Small marinas and boat moorings
Lightly populated areas	**500**	Lightly populated residential, commercial and industrial areas with large areas of land, and/or bodies of water within lightly used commercial, industrial and/or recreational areas.	Villages Medium sized industrial and commercial areas Medium sized recreational areas Small campsites Small tourist attractions Large marinas
Moderately populated areas	**5,000**	Moderately populated residential, commercial and industrial areas with moderate areas of land, and/or bodies of water within moderately	Towns Residential homes on small plots Small blocks of flats and/or apartment complexes

		used commercial, industrial and/or recreational areas. Can contain multistorey buildings, but generally most should be low rise.	Large industrial and commercial areas Large recreational areas Large campsites Large/popular tourist attractions Harbours and ports
Heavily populated areas	**50,000**	Heavily populated residential, commercial and industrial areas with small areas of land, or bodies of water within heavily used commercial, industrial or recreational areas. Urban areas mainly consist of large multistorey buildings. Organised assemblies of people.	Cities Large blocks of flats and/or apartment complexes Large office blocks Small and medium sized festivals Small and medium sized shows and exhibitions Small and medium sized sporting events Ports with cruise ship docking areas
Largest populated areas	**> 50,000**	Densest populated residential, commercial and industrial areas consisting mainly of tall multistorey buildings or popular events with large assemblies of people.	City Centres Areas of dense high-rise buildings Large/popular festivals Large/popular shows and exhibitions Large/popular sporting events

Ground risk buffer

2.11 The applicant **must** define a ground risk buffer that includes an initial calculation and outcome. An appropriate initial ground risk buffer could be defined:

i) With a 1-to-1 principle, (UA height AGL ≤ distance away from uninvolved people) **or**

ii) A different ground risk buffer value may be proposed using the principles outlined in Annex E, Containment.

2.12 The initial ground risk buffer will normally be the same as the final ground risk buffer. However, if appropriately robust strategic mitigations are employed, there are cases where the final ground risk buffer may be different than the initial one. These could include:

i) Using a medium or high level of containment.

ii) Use of ground risk mitigations, such as a parachute.

Controlled ground areas

2.13 A controlled ground area is defined as an area that **must** only contain involved persons.

2.14 Controlled ground areas may be used to strategically mitigate the ground risk. The area that **must** be controlled is the iGRC footprint. Assurance that there will be no uninvolved persons in the iGRC footprint is the responsibility of the operator.

Population density data sources

2.15 The following population density data sources may be used when determining the iGRC:

i) ONS Census Data https://www.ons.gov.uk/census/maps/

ii) ESA Copernicus Data https://www.esa.int/Applications/Observing_the_Earth/Copernicus

iii) Survey data collected by the applicant.

iv) Other resources may be used, subject to the applicant verifying the accuracy of the data and evidencing their data verification process.

Step 3 final Ground Risk Class (GRC) determination

Phase 1 | Step 3

Introduction

2.16 This step is only required if the applicant is planning to reduce their iGRC with strategic mitigations.

2.17 Acceptable mitigations can reduce the intrinsic risk of an uninvolved person being struck a UA during a LOC. The applicant **must** identify and apply ground risk mitigations to lower the operation's iGRC. Annex B contains further guidance on how to complete this step.

Guidance

Ground Risk Mitigations

2.18 The applicant should identify the applicable mitigations listed in Table 5 that could lower the iGRC of the iGRC footprint. All mitigations must be applied in numerical sequence.

Table 4- Stratigic Ground Risk Mitigations

		Level of Robustness		
Mitigations for ground risk		Low	Medium	High
M1(A)	Strategic mitigation - Sheltering	-1	-2	N/A
M1(B)	Strategic mitigations - Operational restrictions	N/A	-1	-2
M1(C)	Tactical mitigations - Ground observation	-1	N/A	N/A
M2	Effects of UA impact dynamics are reduced	N/A	-1	-2

2.19 In case a mitigation that affects the UA aerodynamics is used, assess if the size of the ground risk buffer is still valid.

Application of Ground Risk Mitigations

2.20 The mitigations used to modify the iGRC have a direct effect on the safety objectives associated with an operation, and therefore it is important to ensure their robustness. This is particularly relevant for technical mitigations (e.g., parachute), where limitations to the robustness and effectiveness of mitigations must be considered.

2.21 The Final GRC determination is based on the availability and correct application of the mitigations. Table 5 provides a list of potential mitigations and the associated relative correction factor. All mitigations must be applied in numeric sequence to perform the assessment i.e. M1(A), M1(B), M1(C), M2. Annex B provides additional details on the robustness requirements for each mitigation.

2.22 When applying all the M1 mitigations, the final 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 ground area.

2.23 In case the mitigation influences the aerodynamics of the UA, for example by using a parachute, the ground risk buffer size should be redefined using correct assumptions including the effects of the mitigation means.

2.24 If the final GRC is higher than 7, the operation is considered to have more risk than the UK SORA is designed to support. The applicant should contact the CAA regarding the options available, such as using the Certified category as defined in Article 6 of UK Regulation (EU) 2019/947.

Step 4 Determination of the initial Air Risk Class (ARC)

Phase 1	Step 4

Introduction

2.25 In this step, the UAS operator must assess the initial Air Risk Class (ARC) of the operational volume. The initial ARC is a qualitative classification that describes the general collision risk associated with UAS operations before any strategic mitigations are applied.

> Note - The next section introduces the UK SORA air risk model which has been developed in line with UK air space policy. This section contains significant differences to both JARUS SORA and EASA SORA.

Guidance

2.26 The UK SORA Air Risk Model currently only considers encounters between UA and crewed aircraft. A Mid Air Collision (MAC) event between an UA and a crewed aircraft is always assumed to be catastrophic. Additionally, the ability of a crewed aircraft to remain well clear or to avoid collisions with the UA is not directly considered at present.

General - Aviation conflict management and BVLOS scalability

2.27 Conflict management within the existing global aviation system is premised on cockpit-based pilot see-and-avoid supporting elements of both layer two and three of the following three-layer system:

i) **Layer 1: Strategic conflict management** – Airspace design, demand & capacity balancing, traffic synchronisation. Strategic is used here to mean ‘in advance of tactical’. The objective of this layer is to minimise the need to apply the second layer.

ii) **Layer 2: Separation provision** – This is a tactical (in-flight) process where the pilot must ensure that the aircraft is not operated in such proximity to other aircraft as to create a collision hazard. Typically, this is achieved via cockpit-based see-and-avoid but may be supplemented through the application of separation minima or provision of collision hazard information by an ATM service, dependent upon the airspace classification and flight rules followed.

iii) **Layer 3: Collision avoidance** – Required when the separation mode has been compromised, this layer predominately based on cockpit view pilot ‘see & avoid’, although for some categories of aircraft, and in some categories of airspace, this may be augmented by systems such as Traffic Collision Avoidance System (TCAS).

2.28 For UAS operations BVLOS of the remote pilot and outside of segregated airspace, a DAA capability is therefore required to replace the pilot see-and-avoid responsibilities. DAA is defined within the ICAO RPAS Manual as providing “the capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action”. The DAA system therefore enables the Remote Pilot (RP) to exercise their responsibilities with regard to other aircraft, as required within the standardised rules of the air.

2.29 Within their RPAS CONOP for International IFR, ICAO also define the following:

i) Accommodation – Where UAS can operate along with some level of adaptation or support that compensates for its inability to comply within existing operational constructs.

ii) Integration – Where UAS enter airspace system routinely without requiring special provisions.

2.30 DAA, as defined above, is therefore a critical enabler for BVLOS UAS operations and the safe integration of UAS into the wider airspace environment. Where the DAA capability is not able to fully replicate the pilot cockpit see-and-avoid capability then accommodation is still possible, with the required ruleset and procedures dependent on the capability of the DAA system.

2.31 The scalability of the BVLOS solution can then be defined by the restrictions imposed on other air users for the accommodation of UAS operations. Such restrictions may include:

i) Loss of airspace access, e.g., segregation of UA from all other air users.

ii) Mandatory equipment carriage, e.g., Electronic Conspicuity (EC).

iii) Air traffic management procedures, e.g., a separation or deconfliction service to structure traffic within the airspace.

iv) Air traffic density restrictions, e.g., to enable large separation distances.

v) Air traffic speed / size restrictions, e.g., low speed light aircraft only.

2.32 The requirement for such restrictions, and hence the scalability of the BVLOS solution, is determined largely by the assured performance capability of the UAS DAA system.

Air risk model scope

2.33 The Air Risk model applies to all categories of UAS and all classes of airspace. While the SORA methodology is intended to be used to assess UAS operations within the ‘specific’ category, the risk assessment process also allows identification of operations that belong within the ‘certified’ category, and / or where certified components may be required within the ‘specific’ category.

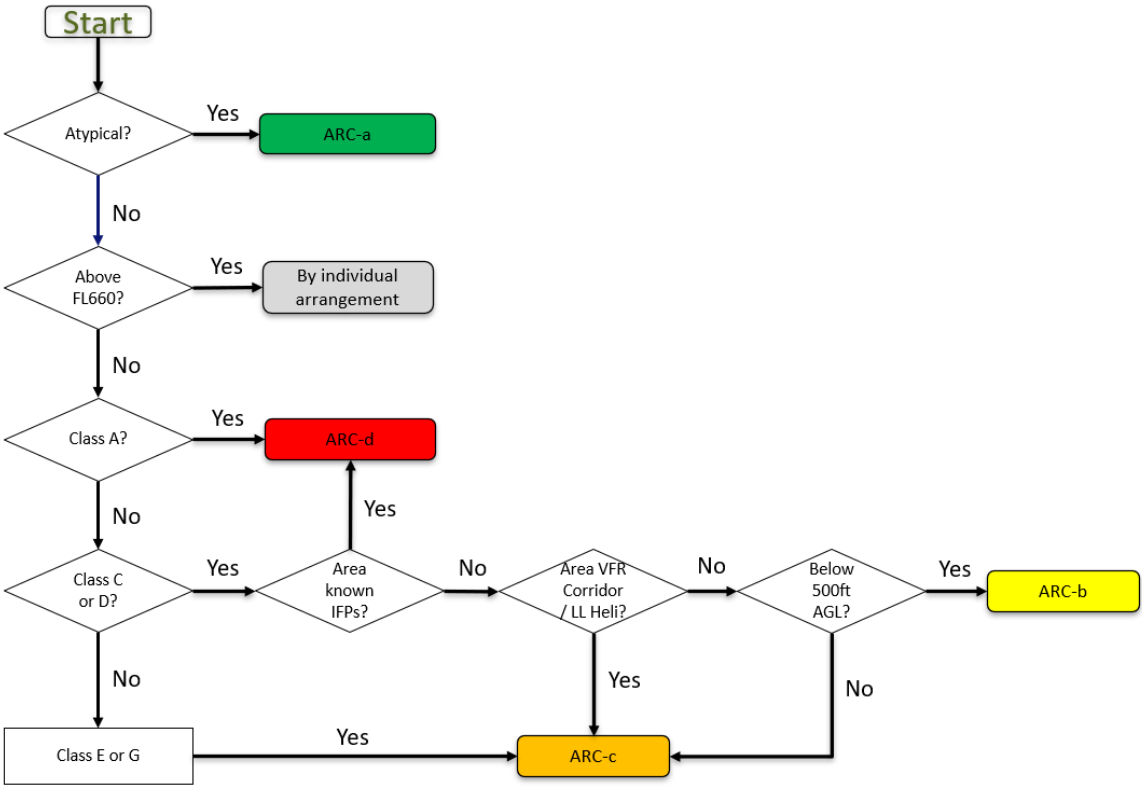
2.34 The initial version of the Air Risk Model currently only considers encounters between UA and crewed aircraft, and a Mid Air Collision (MAC) event between an UA and a crewed aircraft is always assumed to be catastrophic. UA to UA encounters are out of scope. Additionally, the ability of a crewed aircraft to remain well clear or to avoid collisions with the UA is not directly considered at present.

Quantitative air risk flow chart

2.35 Figure 6 is the underlying air risk characterisation flow chart describing the UK SORA air risk model characterisation process.

2.36 The DSCO application service guides applicants through the characterisation process.

Figure 5 - Quantitative Air Risk Flowchart



Encounter Types

2.37 Two distinct types of flight operations are considered:

i) Type-1: Operations primarily conducted under self-separation and see-and-avoid (primarily uncontrolled airspace).

ii) Type-2: Operations that occur with separation provided by an Air Navigation Service Provider (ANSP), (primarily in controlled airspace).

2.38 Encounters between UA and both type-1 and type-2 flight operations are considered, where an encounter is defined as an event associated with the presence of an intruder aircraft. An encounter is simply a measure of when the proximity of two aircraft becomes interesting, or where a simulation or timeline may start.

2.39 An encounter must be ‘big enough to include all things which may influence the tactical mitigations of the aircraft, but not so big that the actions of aircraft 300 miles away are also counted’.

Air Risk Classifications (ARC)

2.40 There are four levels of ARC: ARC-d (High risk), ARC-c (Medium risk), ARC-b (Low risk), and ARC-a (minimal risk). The UK specific flowchart focusses primarily on encounter types, the airspace ruleset and whether the air environment is either recognised or contains known traffic. The initial ARC assignment has a limited emphasis on encounter rates, which are difficult to predict in a generalised model and are considered primarily via strategic mitigations. Key elements within the flowchart and initial ARC assignment are below:

2.41 **Atypical** – An atypical air environment (AAE) is not a separate classification of airspace, and it can exist within any classification of airspace. Broadly, it can be considered to be a volume of airspace in which it can be reasonably anticipated for there to be an ‘improbable encounter rate’ with crewed air traffic due to the proximity of certain ground infrastructure rendering it hazardous for most traditional forms of aviation; for example, within 100 feet / 30.5 metres of the following:

i) Buildings or structures

ii) Ground level

2.42 **Above FL660** – Within the UK this region may contain several different types of aircraft, including crewed military, experimental crewed, High Altitude Long Endurance (HALE) UAS, Space launch, civil faster than sound, high-altitude balloons, etc. Therefore, this region cannot be considered as segregated without further consideration and potentially mitigation. Note that special consideration will also be required for ingress / egress to and from the operating volume, as well as contingency management due to potential risk to aircraft within airspace below the potential operating area. Approval to operate above FL600 is therefore by individual arrangement. The FL660 threshold is under review by the CAA and should be clarified before implementation of the UK SORA.

2.43 **Class A –** This class of airspace provides the highest level of control and is only available to Instrument Flight Rules (IFR) traffic. Air Traffic Control (ATC) clearance and continuous air-ground voice communication is required, and all traffic are under an Air Navigation Service Provider (ANSP) provided separation service. Encountered traffic is expected to be predominately (but not exclusively) large commercial transport, and within the initial ARC flowchart exclusively meets the Type-2 encounter definition. The highest severity consequences lead to the highest safety standard; therefore, an initial ARC-d assignment is appropriate.

2.44 **Class C or D –** These classes are grouped together as they both allow IFR and Visual Flight Rules (VFR) traffic and follow a similar standard ruleset where flights are subject to ATC clearance and all traffic is provided with an air traffic control service. In ‘Area of known IFPs’ (See definition below) the aircraft will be predominantly (but not exclusively) large commercial air transport, flying under IFR with a separation service and therefore encounter type 2 will be appropriate which dictates initial ARC-d. Outside of this known area, the general risk is from smaller GA aircraft flying under VFR with self-separation through see-and-avoid and therefore encounter type 1 will be appropriate which dictates initial ARC-c. The exception is in Class D below 500ft where the traffic is known, cooperative and fly’s below 500ft by exception (and with ATC knowledge), where the ability to predict a lower encounter rate in this environment allows a lower initial ARC-b characterisation. For example, a crewed aircraft is conspicuous, identified and provided with a TIS for a VFR transit within Class D airspace. A clearance to transit ‘not above 1500ft’ is given due to IFR traffic above and ATC request that the crewed aircraft report if descending below 500ft for any reason (landing, forced down by weather etc). Both the UAS and crewed aircraft are in receipt of a TIS and will be aware of the others relative position (where necessary) and as the crewed aircraft will report if descending below 500ft, it is a known and cooperative situation where the encounter rate can be controlled and predicted.

2.45 **Area of known IFPs –** Means Instrument Flight Procedures (IFPs) including airways, Standard Instrument Departures (SIDs), Standard Arrival Routes (STARs), Instrument Approach Procedures (IAPs), Flight Restriction Zones (FRZ), Runway Protection Zones (RPZ), IFP Protected Areas (Aerodrome Safeguarding) and radar manoeuvring areas. This area can be expected to contain predominantly large commercial transport aircraft, hence is assumed to meet the Type-2 encounter definition and justify an ARC-d assignment.

2.46 **Area VFR corridor / Low Level (LL) Helicopter** – Means corridors through controlled airspace with defined boundaries where aircraft can fly VFR, which have specific rules for altitudes, frequencies, and directions, but maintain the background classification and ruleset of the airspace in which they are contained.

2.47 **Class E or G –** These classes are grouped together as they both allow IFR and VFR traffic and follow a similar standard ruleset (for participating non IFR traffic), particularly where the VFR traffic is potentially unknown and uncooperative due to the lack of EC and VHF communication requirements. The decision of which encounter type to use for operations in Class E airspace, should be made on a case-by-case basis, as the proximity and type of IFR traffic could dictate type 1 or 2 encounters depending on local operations. Class E Airspace is established to ensure separation between IFR and IFR traffic, but not between IFR and VFR traffic despite the likelihood of an 'area of known IFPs'. Therefore, to be proportionate to the requirements for crewed aircraft as participating non IFR traffic, the UAS requirement equivalent to see and avoid would dictate initial ARC-c. The VFR aircraft should be predominantly small General Aviation or light commercial, self-separated using see and avoid and therefore encounter type 1 will be appropriate which also dictates initial ARC-c. There is no differentiation below 500ft in these classes of airspace as the traffic is potentially unknown, uncooperative and may fly below 500ft without warning. The ability to predict a lower encounter rate in this environment is therefore greatly reduced and does not allow a lower ARC characterisation ahead of strategic mitigation. All operations above and below 500ft in this environment are therefore initial ARC-c.

2.48 In order to navigate the generalised flowchart applicants are referred to the Aeronautical Information Publication (AIP) [NATS, electronic Aeronautical Information Service, NATS UK, NATS UK | Home (ead-it.com)] which defines UK airspace classifications, airspace structures and formal VFR routes such as London Helicopter and Manchester low level routes. Local area specifics on traffic types, informal patterns, mean traffic density and encounter rates (as confirmed via airspace characterisation) can be considered via strategic mitigations.

2.49 It should also be noted that although the initial ARC is intended to be conservative, there may be situations where that conservative assessment may be insufficient. In those situations, the CAA may disagree with the applicants initial ARC.

2.50 Irrespective of the Air Risk Class (ARC), an applicant must initially consider the expected ruleset of the airspace , Section 6 Airspace Classification, proposing changes only if necessary, and with agreement of the ANSP and authority.

2.51 Use the highest ARC score if the operating area spans multiple ARCS.

Step 5 Application of strategic mitigations to determine residual ARC (optional)

Phase 1	Step 5

Introduction

2.52 This step is only required if the applicant is planning to reduce their initial ARC with strategic mitigations.

2.53 Strategic mitigation involves procedures and operational restrictions designed to manage the types of crewed aircraft, encounter rates, or exposure times before take-off. If an applicant believes the initial Air Risk Class (ARC) is too high for the conditions in the local operational volume, they should consult Annex C for guidance on reducing the ARC. If the initial ARC is deemed appropriate for the local conditions, it is then considered the Residual ARC.

Guidance

2.54 Guidance for the application of strategic mitigations is provided in Annex C.

2.55 To understand the value of different strategic mitigations a description of the residual ARCs is provided below:

i) **Residual ARC-a**: Encounter rate with other crewed air traffic demonstrated to be negligible, therefore VLOS / BVLOS VM or DAA based tactical mitigation of the air risk is not required.

ii) **Residual ARC-b**: Encounter rate with other crewed air traffic demonstrated to be low and exclusively Type-1, but not negligible. DAA based tactical mitigation is therefore required (unless operating VLOS / BVLOS VM) but must be supported by one or more additional mitigation layers.

iii) **Residual ARC-c**: Predominately Type-1 traffic and negligible commercial air transport aircraft, with either an encounter rate that cannot be demonstrated to be low enough for ARC-b, or additional supporting strategic mitigations are not available. DAA based tactical mitigation is therefore required (unless operating VLOS / EVLOS) and expected to be used routinely rather than occasionally.

iv) **Residual ARC-d**: Predominately Type-2 traffic, therefore subject to the highest level of tactical mitigation due to highest severity consequence and highest safety standard airspace. Specific category operations likely to be exceptions (e.g., via certified DAA system) rather than the normal for this ARC.

2.56 For VLOS operations or operations where the remote pilot is supported by an airspace observer situated alongside the pilot for instantaneous communication, the initial air risk class can be reduced by one class. In certain environments an additional agreement with ATC or the airspace manager may be required.

Step 6 – Specific Assurance and Integrity Levels (SAIL) determination

Phase 1	Step 6

The SAIL determination table is provided for reference below; however, SAIL determination is calculated automatically in the UK SORA Application Service. The table uses Roman numerals following the JARUS convention; however, the SORA Application Service will use standard numbering.

Introduction

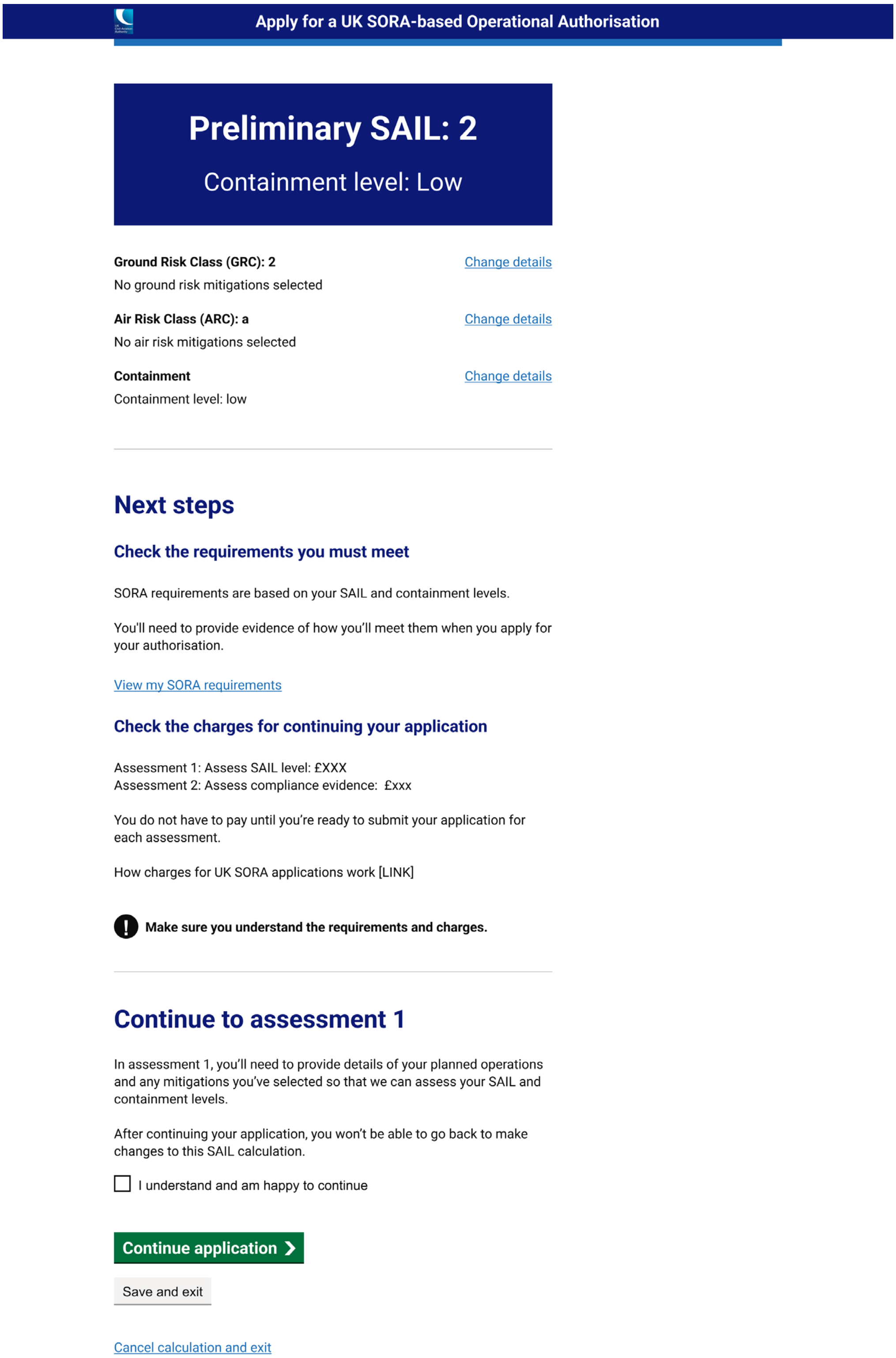
2.57 The SAIL consolidates the final ground and air risk scores. It determines the required compliance evidence the applicant must submit for assessment.

Guidance

2.58 Below is the underlying SAIL calculation table for applicant's reference.

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	Certified category			

Example preliminary SAIL score screen



Step 7 – Operation Details

Phase 1 | Step 7

Introduction

2.59 The operation details are used to describe the proposed operation and demonstrate how the SAIL calculation has been determined.

Guidance

2.60 The applicant **must** complete the operation details pages, providing the following information:

i) A brief overview of the operation.

ii) The make and model of the UA they plan to operate under their authorisation (plus details of any modifications).

iii) The industry or sector they will operate in, for example agriculture.

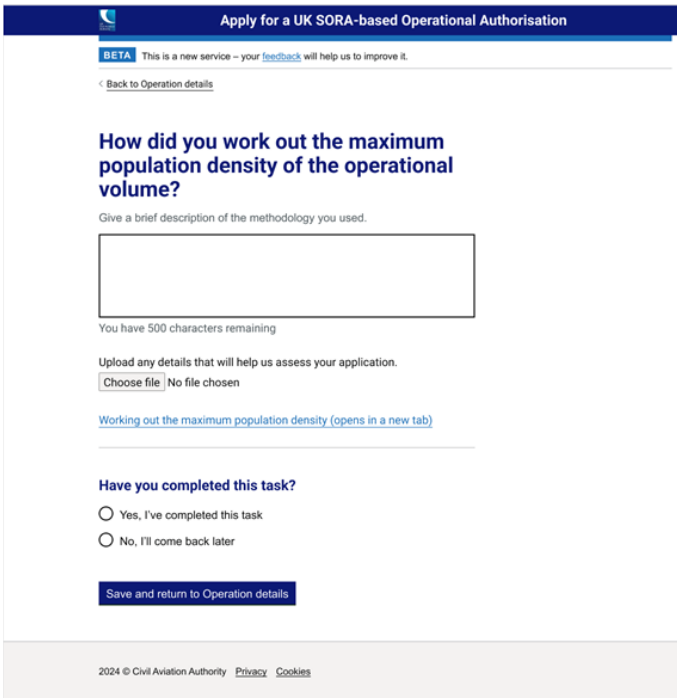
iv) Where they want to operate.

v) Details of their operational volume and ground risk buffer.

vi) Details of how they worked out the population densities for the operational area and adjacent area (if applicable).

vii) Details of any dangerous goods they intend to carry.

viii) Details of any articles they plan to drop from their UA.



Step 8 - Phase 1 Assessment

Phase 1 | Step 8

Introduction

2.61 The purpose of this step is for the applicant to submit their SAIL calculation, operational details, and compliance evidence.

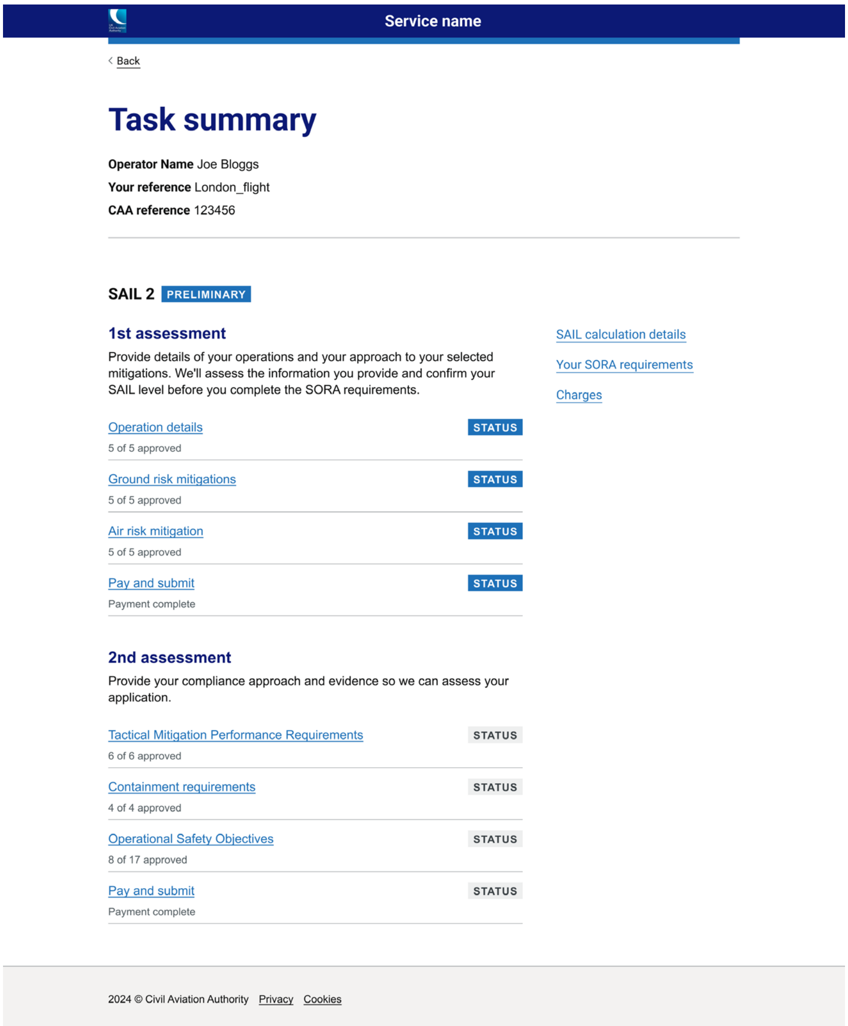
Guidance

2.62 Complete all required steps in the UK SORA application service.

2.63 Make the required Phase 1 payment when prompted.

2.64 The status of the assessment can be found in the relevant section of the UK SORA application service summary page.

2.65 Assessment feedback is provided as it becomes available to allow applicants to action findings as soon as possible.



Step 9 - Final SAIL Decision

Phase 1	Step 9

Introduction

2.66 The purpose of this step is for the applicant to receive a decision and feedback on their SAIL calculation.

Guidance

2.67 If the SAIL is approved the applicant can move to Phase 2.

2.68 If the SAIL is not approved, the applicant will receive feedback in the form of findings. The applicant **must** address the findings to move to Phase 2.

2.69 If the applicant disagrees with a finding or multiple findings, they have the right to appeal. More information about the appeals process can be found here.

Step 10 Determination of containment requirements

Phase 2	Step 10

Introduction

2.70 The containment requirements are driven by the difference between the ground risk level in the operational volume, including the ground risk buffer, and the ground risk level in the adjacent area.

2.71 The required level of containment assures that in the event of a LOC resulting in the aircraft leaving the operational volume, that the safety of the operation **must** still be maintained.

2.72 There are three possible levels of robustness for containment: Low, Medium, and High; each with a set of safety requirement described in Annex E.

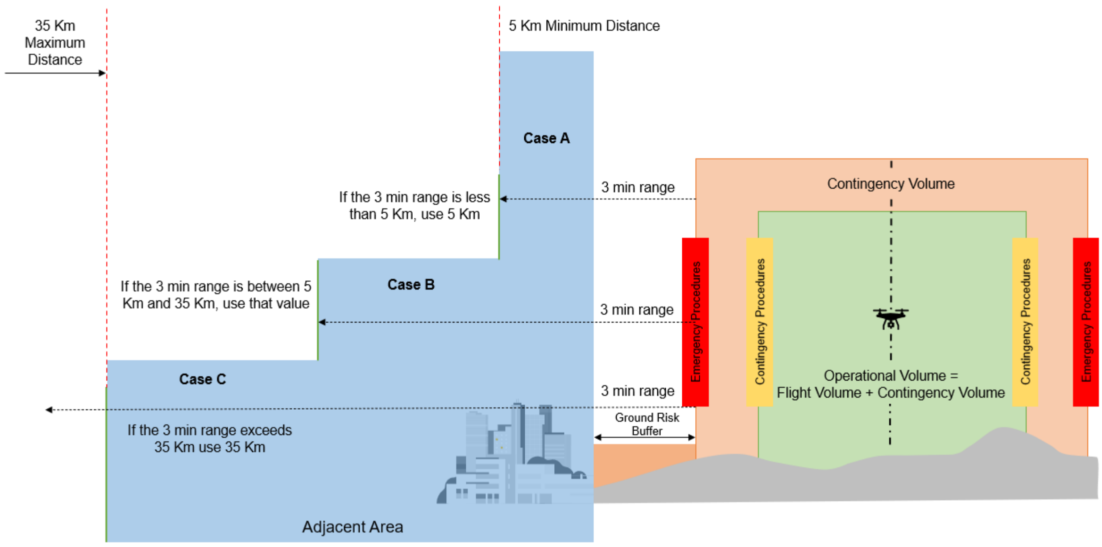
Guidance

2.73 If the ground risk buffer is larger than the adjacent area, containment requirements do not apply.

2.74 If the UA is less than 250g, the applicant **must** apply Low containment. In this case there is no requirement to account for the population in the adjacent area.

2.75 If the UA is more than 250g, the applicant **must** determine the size and population characteristics of the adjacent area.

Figure 6 - Adjacent area calculation



2.76 Calculate the size of the adjacent area for the operation. The lateral outer limit of the adjacent area is calculated from the operational volume as the distance flown in 3 minutes at the maximum capable speed of the UA:

i) If the distance is less than 5 km, use 5 km.

ii) If the distance is between 5 km and 35 km, use the distance calculated.

iii) If the distance is more than 35 km, use 35 km.

2.77 Determine the average population density between the outer limit of the ground risk buffer and the outer limit of the adjacent area.

2.78 Determine the presence of assemblies of people within 1 km of the outer limit of the operational volume.

2.79 Determine a set of operational limits (average population density allowed and assemblies allowed within 1km of the operational volume) appropriate for intended operation using the Tables 5-10.

2.80 The applicant **must**:

i) Determine the operational limits for the acceptable average population density in the adjacent area.

ii) Determine the operational limits for the acceptable size of assemblies of people within 1km surrounding the operational volume.

2.81 Use Tables 5-10 to determine the required containment robustness level for the chosen operational limits, the characteristic dimension of the UA, and the SAIL of the operation.

Table 5 - Containment requirements 1m UA

1 m UA (< 25 m/s)			
Average population density allowed	No Upper Limit		< 50,000 ppl/km^2
Assemblies allowed within 1km of the operational volume	> 400k	Assemblies of 40k to 400k	Assemblies < 40k
SAIL			
I & II	High	Medium	Low
III	Medium	Low	Low
IV - VI	Low	Low	Low
V-VI	Low	Low	Low

Table 6 - Containment requirements 3m UA (Shelter Applicable)

3 m UA (< 35 m/s) applicant claims sheltering as a mitigation				
Average population density allowed	No Upper Limit		< 50,000 ppl/km^2	< 5,000 ppl/km^2
Assemblies allowed within 1km of the operational volume	> 400k	Assemblies of 40k to 400k	Assemblies < 40k people	
SAIL				
I & II	Out of scope	High	Medium	Low

III	Out of scope	Medium	Low	Low
IV	Medium	Low	Low	Low
V & VI	Low	Low	Low	Low

Table 7 - Containment requirements 3m UA (Shelter Not Applicable)

3 m UA (< 35 m/s) applicant does not claim sheltering as a mitigation				
Average population density allowed	No Upper Limit	< 50,000 ppl/km²	< 5,000 ppl/km²	< 500 ppl/km²
Assemblies allowed within 1km of the operational volume	> 400k	Assemblies of 40k to 400k	Assemblies < 40k people	
SAIL				
I & II	Out of scope	High	Medium	Low
III	Out of scope	Medium	Low	Low
IV	Medium	Low	Low	Low
V & VI	Low	Low	Low	Low

Table 8 - Containment requirements 8m UA (Shelter Not Applicable)

8 m UA (< 75 m/s) applicant does not claim sheltering as a mitigation					
Average population density allowed	No Upper Limit	< 50,000 ppl/km²	< 5,000 ppl/km²	< 500 ppl/km²	< 50 ppl/km²
Assemblies allowed within 1km of the operational volume	> 400k	Assemblies of 40k to 400k	Assemblies < 40k		
SAIL					
I & II	Out of scope	Out of scope	High	Medium	Low
III	Out of scope	Out of scope	Medium	Low	Low
IV	Out of scope	Medium	Low	Low	Low
V	Medium	Low	Low	Low	Low
VI	Low	Low	Low	Low	Low

Table 9 - Containment requirements 20m UA (Shelter Not Applicable)

20 m UA (< 125 m/s) applicant does not claim sheltering as a mitigation					
Average population density allowed	No Upper Limit	< 50,000 ppl/km²	< 5,000 ppl/km²	< 500 ppl/km²	< 50 ppl/km²
Assemblies allowed within 1km of the operational volume	> 400k	Assemblies of 40k to 400k	Assemblies < 40k		
SAIL					
I & II	Out of scope	Out of scope	Out of scope	High	Medium
III	Out of scope	Out of scope	Out of scope	Medium	Low
IV	Out of scope	Out of scope	Medium	Low	Low
V	Out of scope	Medium	Low	Low	Low
VI	Medium	Low	Low	Low	Low

Table 10 - Containment requirements 40m UA (Shelter Not Applicable)

< 40 m UA (< 200 m/s) applicant does not claim sheltering as a mitigation					
Average population density allowed	No Upper Limit	< 50,000 ppl/km^2	< 5,000 ppl/km^2	< 500 ppl/km^2	< 50 ppl/km^2
Assemblies allowed within 1km of the operational volume	> 400k	Assemblies of 40k to 400k	Assemblies < 40k		
SAIL					
I & II	Out of scope	Out of scope	Out of scope	Out of scope	High
III	Out of scope	Out of scope	Out of scope	Out of scope	Medium
IV	Out of scope	Out of scope	Out of scope	Medium	Low
V	Out of scope	Out of scope	Medium	Low	Low
VI	Out of scope	Medium	Low	Low	Low

Adjacent area

2.82 The ground area adjacent to the ground risk buffer is defined as the adjacent area. This is the area where it is reasonably expected a UA may crash after a LOC.

2.83 The operator **must** not plan flights in this area, and it will only be overflown unintentionally in the event of a LOC.

2.84 The applicant may use a realistic estimate of the average population density for the adjacent area.

Adjacent area containment requirements

2.85 The UK SORA application service will guide the applicant to determine the containment requirements.

Adjacent area operational limitations

2.86 The operator **must** have a procedure to identify and consider whether there is an assembly of people that exceeds the operational limitations within 1 km of the operational volume.

2.87 The operator **must** have a procedure to determine a realistic estimate of the size of any assembly of people within 1 km of the operational volume.

2.88 If the ground risk buffer size exceeds 1km, the adjacent area consideration for all assemblies of people is not applicable.

Containment effects upon ground risk buffer and operational volume definitions

2.89 The applicant may need to try different SAIL calculations, with variations of their operational volume, ground risk buffer and adjacent area before settling on an appropriate combination.

2.90 If the applicant determines they require medium or high robustness containment for their operational objective, there might be a recursive effect, as these containment requirements have higher requirements on the fidelity of the ground risk buffer size calculation. It is possible, that this results in a bigger ground risk buffer size compared to the one originally defined by the operator.

Containment requirements for adjacent airspace

2.91 By containing flight to the Operational Volume and assuring the immediate cessation of the flight in case of a breach of the operational volume, low robustness containment is generally considered sufficient to allow operations adjacent to all airspaces.

Step 11 Operational Safety Objectives (OSO)

Phase 2	Step 11

Introduction

2.92 The purpose of this step is for the applicant to provide their compliance evidence for the relevant OSOs.

Guidance

2.93 The applicant is responsible for providing compliance evidence. Compliance evidence may be provided by third parties (e.g., the designer of the UAS or equipment, UTM service providers, etc.).

2.94 Table 11 indicates the corresponding OSOs per SAIL. In this table:

i) NR means not required.

ii) L means low robustness.

iii) M means for medium robustness.

iv) H means for high robustness.

2.95 The applicant should consider using low robustness even if the OSO is not required at the applicable SAIL.

884 **Table 11 - Operational Safety Objectives (OSO)**

OSO ID	OSO Description	SAIL					
		I	II	III	IV	V	VI
OSO01	Ensure the operator is competent and/or proven	NR	L	M	H	H	H
OSO02	UAS manufactured by competent and/or proven entity	NR	NR	L	M	H	H
OSO03	UAS maintained by competent and/or proven entity	L	L	M	M	H	H
OSO04	UAS components essential to safe operations are designed to an Airworthiness Design Standard (ADS)	NR	NR	NR	L	M	H
OSO05	UAS is designed considering system safety and reliability	NR	NR	L	M	H	H
OSO06	C3 link performance is appropriate for the operation	NR	L	L	M	H	H
OSO07	Conformity check of the UAS configuration	L	L	M	M	H	H
OSO08	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
OSO09	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 situation	L	L	M	M	H	H
OSO13	External services supporting UAS operations are adequate to the operation	L	L	M	H	H	H
OSO16	Multi crew coordination	L	L	M	M	H	H
OSO17	Remote crew is fit to operate	L	L	M	M	H	H
OSO18	Automatic protection of the flight envelope from Human Error	NR	NR	L	M	H	H
OSO19	Safe recovery from Human Error	NR	NR	L	M	M	H
OSO20	A Human Factors evaluation has been performed and the HMI found appropriate for the mission	NR	L	L	M	M	H
OSO23	Environmental conditions for safe operations defined, measurable and adhered to	L	L	M	M	H	H
OSO24	UAS designed and qualified for adverse environmental conditions	NR	NR	M	H	H	H

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Step 12 Tactical mitigation performance requirement (TMPR) and robustness levels

Phase 2	Step 12

Introduction

2.96 Tactical Mitigations are applied to mitigate any residual risk of a mid-air collision (as defined by the assigned residual ARC) needed to achieve the applicable airspace safety objective. Tactical Mitigations are usually applied after take-off using a “mitigating feedback loop” to reduce the rate of collisions by modifying the geometry and dynamics of aircraft in conflict, based on real time aircraft conflict information.

Guidance

2.97 Detailed guidance for the application of strategic mitigations is provided in Annex D.

VLOS Operations

2.98 The applicant **must** develop and document a VLOS deconfliction scheme, in which it is explained which methods will be used for detection.

2.99 The applicant **must** 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 must be described as well.

BVLOS Operations

2.100 Identify the applicable Detect and Avoid (DAA) requirements for the residual ARC.

Step 13 - Phase 2 Assessment

Phase 2	Step 13

Introduction

2.101 The purpose of this step is for the applicant to submit their compliance evidence for OSOs, TMPR, and Containment.

Guidance

2.102 Complete all required steps in the UK SORA application service.

2.103 Make the required Phase 2 payment when prompted.

2.104 The status of the assessment can be found in the relevant section of the UK SORA application service summary page.

2.105 Assessment feedback is provided as it becomes available to allow applicants to action findings as soon as possible.

Step 14 - Compliance Evidence Decision

Phase 2	Step 14

Introduction

2.106 The purpose of this step is for the applicant to receive a decision and feedback their compliance evidence.

Guidance

2.107 If the compliance evidence is approved the applicant will be issued an operational authorisation.

2.108 If the evidence is not approved, the applicant will receive feedback in the form of findings. The applicant **must** address the findings before an operational authorisation can be issued.

2.109 If the applicant disagrees with a finding or multiple findings, they have the right to appeal. More information about the appeals process can be found here.

APPENDIX A

Annex A - Guidance for the submission of compliance evidence to the CAA

Introduction

A1 This annex is intended to serve as guidance to support an applicant with gathering, presenting, and retaining their compliance evidence as part of their SORA application. The term compliance evidence is used to emphasise the goal of providing evidence that demonstrates compliance to a regulation, requirement, or standard.

A2 An applicant should consider what they are trying to demonstrate with their chosen compliance evidence. For example, if they are aiming to demonstrate compliance with a specific technical standard then the compliance evidence would likely be some form of technical data rather than an operations document. This is not to say that an operations document couldn't be used as evidence, but it would be unlikely that it is specific enough to be considered compliance evidence for a technical standard.

What is a compliance approach?

A3 In this context compliance approach is meant as a systematic approach used to ensure an applicant complies with the relevant regulation, requirement or standard. The UK SORA Application Service is designed to support applicants to submit their compliance approach and compliance evidence in a structured format.

What is compliance evidence?

A4 Compliance evidence is the term used to describe a piece of evidence used to demonstrate compliance to a regulation, requirement or standard. Compliance evidence can take several forms such as;

i) Flight logs.

ii) Technical data sheet.

iii) Flight tests.

iv) Design information.

A5 Evidence used to demonstrate compliance should be relevant to the intended regulation, requirement or standard i.e. if the compliance evidence is a section or paragraph within a document then that section must be clearly referenced rather than submitting the entire document as evidence. For example:

i) Acceptable: Ref: Technical Manual 7602, Section 7, page 16.

ii) Not Acceptable: Ref: Technical Manual 7602

Collecting, Presenting and Storing Evidence

A6 When collecting compliance evidence, it is crucial that all relevant information is included. Any form of compliance evidence submitted to the CAA must be in a legible and understandable format.

A7 Compliance evidence must be stored for the duration of the authorisation and be available to CAA assessors upon request. It is recommended to follow UK Gov advice on General Data Protection Regulation (GDPR).

A8 For each requirement in UK SORA, the Applicant must present compliance evidence to the CAA as follows:

i) The applicant enters a compliance statement into the UK SORA Application Service. A compliance statement is a simple statement (a single sentence typically suffices) which describes the method through which the Applicant has complied with the requirement. For example:

(1) Requirement (Authority): “Effects of impact dynamics and immediate post impact hazards, critical area or the combination of these results are reduced such that the risk to population is reduced by an approximate 1 order of magnitude (90%).”

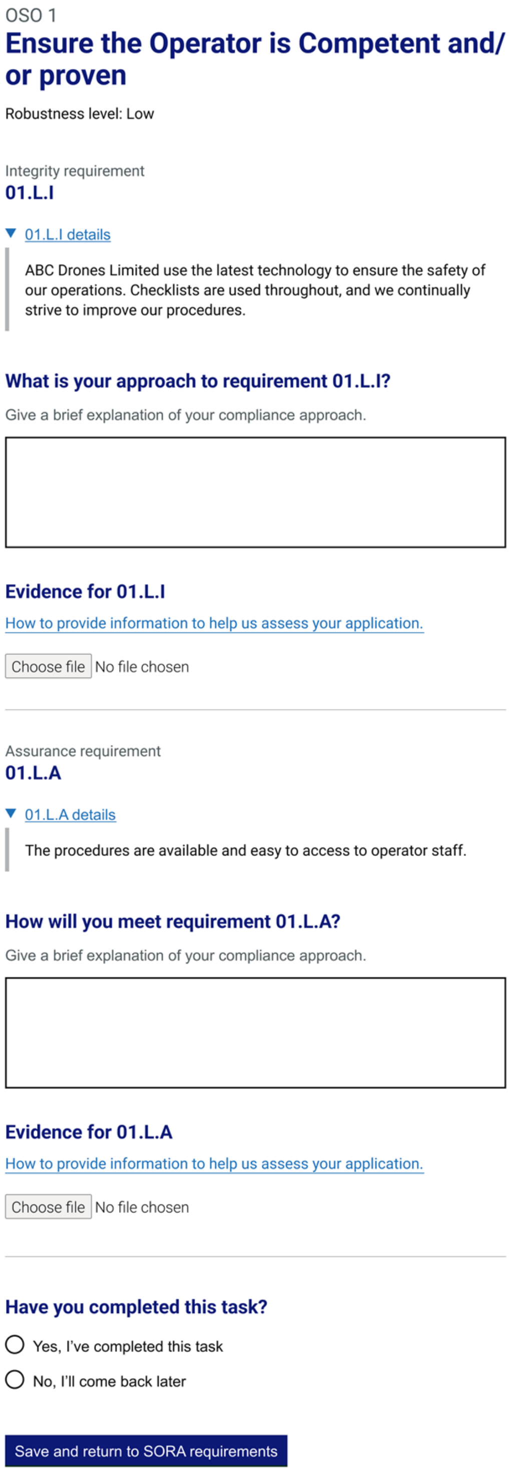
(2) Compliance statement (Applicant): “Calculation of the UAS deceleration with parachute deployed combined with flight testing shows that the ground impact is reduced by 1 order of magnitude.”

ii) Provide compliance evidence: the physical report(s) that evidence the compliance statement has been achieved. For example:

(1) Parachute deployment analysis report no.XYZ.pdf

(2) Parachute deployment flight test report no.ABC.pdf

Example compliance approach screen



Using the UK SORA annexes

A9 The CAA has developed a reference system for applicants to quickly identify requirements that are relevant to their application. Below is some guidance on how to use this system.

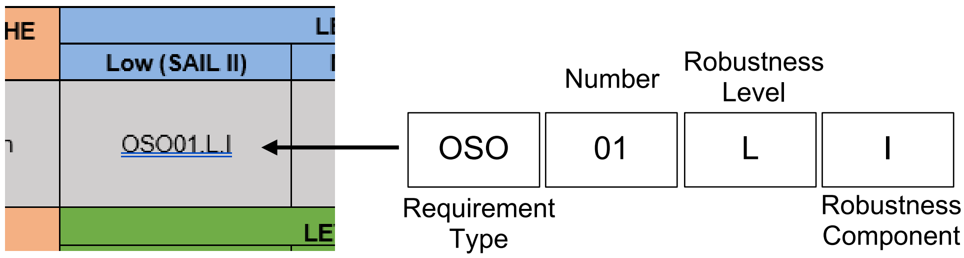
Table 12 - Example Requirements

TECHNICAL ISSUE WITH THE UAS		LEVEL of INTEGRITY		
		Low (SAIL II)	**Medium (SAIL III)**	**High (SAIL IV to VI)**
OSO01 **Ensure the operator is competent and/or proven**	Criterion	OSO01C2.L.I	OSO01.L.I OSO01.M.I	OSO01.L.I OSO01.M.I OSO01.H.I
		LEVEL of ASSURANCE		
		Low (SAIL II)	**Medium (SAIL III)**	**High (SAIL IV to VI)**
	Criterion	OSO01.L.A	OSO01.L.A OSO01.M.A	OSO01.L.A OSO01.M.A OSO01.H.A

Using requirement codes

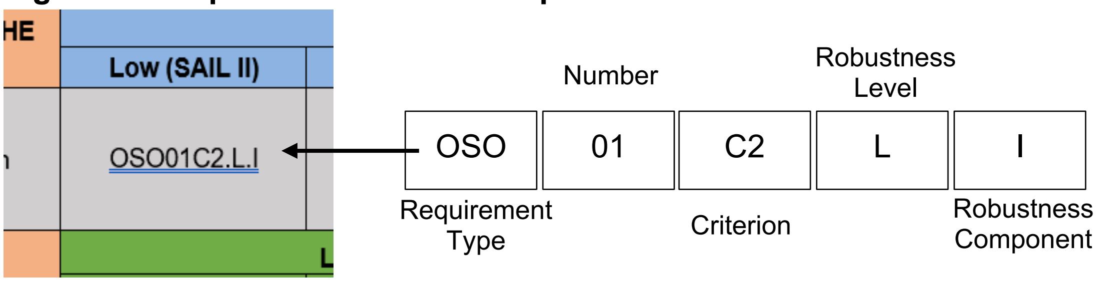
A10 All UK SORA requirements have a requirement code, which can be used to find AMC and GM. Figure 1 shows an example of a requirement code for SAIL II at low integrity with a single criterion.

Figure 7 - Requirement codes single criterion



A11 Some requirements have several criteria, this is displayed after the requirement number, prefixed by the letter C for example C2 as below.

Figure 8 - Requirement codes multiple criterion



1069 ## Using the reference system

GM	Boxes coloured in light green contain GM explaining how the applicant may comply with the requirement. Light green boxes marked GM without a requirement code are general guidance material relating to the overall requirement.

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OSO01. L.I	Boxes coloured in blue represent integrity requirements and **must** be complied with. Example: The applicant must meet the following requirements: a) Requirement 1. b) Requirement 2.

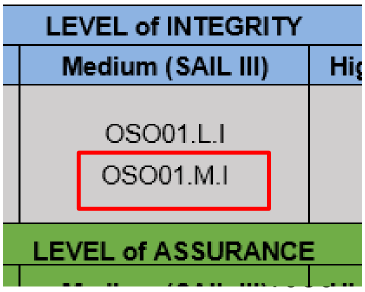
OSO01. L.A	Boxes coloured in dark green represent assurance requirements and **must** be complied with. Example: The Applicant must meet the following requirements: a) The Applicant **must** provide evidence of compliance with the Integrity requirements.

OSO01. L.I	Boxes coloured in light orange are AMC and may be used to demonstrate compliance with the requirement. This AMC relates to the **OSO 01 Low Integrity**. Where AMC relates to a specific requirement or multiple requirements, the corresponding letter is used in the AMC box. For example: b) The standard 1234 may be used to demonstrate compliance with the requirement.

OSO01. L.A	Boxes coloured in light green contain guidance material explaining how the applicant may comply with the requirement. This GM relates to the **OSO 01 Low Assurance**. Where GM relates to a specific requirement or multiple requirements, the corresponding letter is used in the GM box as per the example above.

Additional Requirements

As the SAIL level increases the robustness level and the corresponding number of requirements may also increase. Using the tables provided, the applicant can identify additional requirements. In this example, SAIL III has medium integrity requirements **OSO01.M.I** in addition to low.



A12 Above the additional requirement details section, coloured boxes with the relevant codes display any **lower** robustness requirement for ease of reference. For example:

Lower robustness level requirements to be complied with:

OSO01.L.I

OSO01.L.A

A13 Following the low robustness level requirements, additional requirements are listed in the same format as above.

APPENDIX B

Annex B - Strategic Mitigations for Ground Risk

Introduction

B1 Annex B provides the integrity and assurance requirements for the Applicant's proposed mitigations. The proposed mitigations are intended to reduce the intrinsic Ground Risk Class (iGRC) associated with a given operation. The identification and implementation of the mitigations are the responsibility of the Applicant.

B2 A proposed mitigation may or may not have a positive effect on reducing the ground risk associated with the operation. In the case where a mitigation is available but does not reduce the ground risk, its level of integrity should be considered "None".

B3 To achieve a given level of robustness, when more than one criterion exists for that level of robustness, all applicable criteria need to be met, unless specified otherwise.

B4 If a criterion is not applicable to a mitigation, e.g. passive mitigations do not require training nor activation, the criterion can be ignored.

B5 Annex B mitigations are primarily applied to the operational volume and ground risk buffer.

B6 The GRC cannot be lowered to a value less than the corresponding value for a controlled ground area.

B7 A number of requirements, such as those labelled "Technical design", would typically require the support of the UAS or equipment Designer, unless they have already been complied with by the Designer through a SAIL mark certificate.

B8 The applicant may claim more points of GRC reduction than indicated in Step 3 of the UK SORA process, when the appropriate orders of magnitude of reduction of the risk to uninvolved people can be demonstrated. Any of these claims should be fulfilled to the high robustness level. For example, a reduction by 3 points to the final GRC may be granted by the Authority for an M2 mitigation, if the Applicant can demonstrate a reduction of 3 orders of magnitude of the risk to uninvolved people. This would be achieved by showing a 99.9% reduction of the risk to uninvolved people in Criterion 1, with Criteria 2 and 3 complied with to a high robustness level.

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M1A Strategic mitigation – sheltering.

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		LEVEL of INTEGRITY		
		Low	**Medium**	**High**
M1A Sheltering	Criterion 1 (Evaluation of people at risk)	M1AC1.L.I	M1AC1.L.I M1AC1.M.I	NA
	Criterion 2 (Evaluation of penetration hazard)	M1AC2.L.I	M1AC2.L.I M1AC2.M.I	NA
		LEVEL of ASSURANCE		
		Low	**Medium**	**High**
	Criterion 1 (Evaluation of people at risk)	M1AC1.L.A	M1AC1.L.A M1AC1.M.A	NA
	Criterion 2 (Evaluation of penetration hazard)	M1AC2.L.A	M1AC2.L.A M1AC2.M.A	NA

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GM	
	M1(A) mitigation relies on the fact that people spend very little time outdoors without protection from structures. Therefore, operators of sufficiently small UAS can expect that a large percentage of the population will be sheltered from potential impacts. For larger UAS, the effectiveness of this sheltering assumption must be demonstrated. Time-based arguments, such as the claim that flying at night reduces risk because fewer people are outdoors, are not applicable at low robustness. However, these arguments are included at medium robustness. Sheltering at low robustness is considered a generally applicable mitigation based on the environmental characteristics where the UAS is operated. This mitigation does not involve any additional operational restrictions. To avoid double counting, M1(A) medium robustness mitigations cannot be combined with any M1(B) mitigations. In contrast, M1(A) low robustness, which has no operational restrictions, can be combined with M1(B) mitigations.

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1128

1129 ## Low level of robustness

M1A C1.L.I

Criterion 1- Evaluation of people at risk

If the applicant claims a reduction in ground risk due to a sheltered operational environment, the applicant **must**:

(a) Only fly over operational environments consisting of structures providing shelter.

(b) Verify that uninvolved people will be located under or inside a structure.

This mitigation cannot be applied when only overflying open-air assemblies of people or areas with no shelter.

M1A C2. L.I

Criterion 2 – Evaluation of penetration of hazard

The applicant **must** use a UA that is not expected to penetrate structures and fatally injure people under the shelter.

M1A C1. L.A

Criterion 1- Evaluation of people at risk

(a) The Applicant **must** provide evidence of compliance with the integrity requirements.

(b) The evidence should be in the form of a report that describes that the operation is in an environment that has structures providing shelter where people are generally expected to be, and the applicant does not fly over large open-air assemblies of people.

M1A C2. L.A

Criterion 2 – Evaluation of penetration of hazard

The applicant **must** submit a declaration of compliance that the UA used is under 25 kg MTOM.

OR

For UA with MTOM higher than 25 kg, the applicant **must** provide compliance evidence that the required level of integrity is achieved. This should be a report detailing testing, analysis, simulation, inspection, design review or through operational experience.

GM. M1C 1. L.I

(a) The consideration of this mitigation may vary based on local conditions. The intention is to estimate the proportion of people outside on average and not at a specific time of day or year. There will be times when at specific locations temporarily there are more people exposed, but it should be sufficient to expect that on average the proportion of people exposed outside is below 10%.

GM. M1C 2. L.I

Guidance on how to evaluate sheltering effect can be found from:

(a) ASSURE UAS Ground Collision Severity Evaluation A4 report section "4.12. Structural Standards for Sheltering (KU)", pages 103 to 111, or

(b) MITRE presentation given during the UAS Technical Analysis and Applications Center (TAAC) conference in 2016 titled 'UAS EXCOM Science and Research Panel (SARP) 2016 TAAC Update' - PR 16-3979.

In general, it can be expected that UAS weighing less than 25 kg are not able to penetrate buildings except in rare cases where the UAS speed or building materials are unusual (tents, glass roofs, etc). In cases where a UAS is still able to penetrate a structure, sheltering may not be fully effective, but can still offer a partial mitigation.

GM. M1C 1. L.A

(a) For example, a city or town consists generally of structures providing shelter. While it may also include areas that are not sheltered, the mitigation is expected to be provided in most of such cases.

1130 Medium level of robustness

1131 Lower robustness level requirements to be complied with:

M1C1. L.I	M1C2. L.I	M1C1. L.A	M1C2. L.A

Additional requirements to be complied with:

M1C1. M.I

Criterion 1- Evaluation of people at risk

(a) Same as low. In addition, the applicant **must** restrict operating times and demonstrates that an even greater proportion of uninvolved people are sheltered.

M1C2. M.I

Criterion 2 – Evaluation of penetration of hazard

No additional requirements.

M1C1. M.A	Criterion 1- Evaluation of people at risk (a) Same as Low. In addition, the applicant **must** have time-based restrictions in place and provide compliance evidence to support that a higher proportion of people are sheltered. Medium robustness M1(A) mitigation cannot be combined with M1(B) mitigations.

M1C2. M.A	Criterion 2 – Evaluation of penetration of hazard No additional requirements

1132 M1B – Strategic mitigation using operational restrictions

1133

		LEVEL of INTEGRITY		
		Low	**Medium**	**High**
M1B - Operational restrictions	Criterion 1 (Evaluation of people at risk)	NA	M1BC1.M.I	M1BC1.H.I
	Criterion 2 (Impact on at risk population)	NA	M1BC2.M.I	M1BC2.M.I M1BC2.H.I
		LEVEL of ASSURANCE		
		Low	**Medium**	**High**
	Criterion 1 (Evaluation of people at risk)	NA	M1AC1.M.A	M1BC1.H.I
	Criterion 2 (Impact on at risk population)	NA	M1AC2.M.A	M1BC2.H.I

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GM	M1(B) mitigations are intended to reduce the number of people at risk on the ground independently of sheltering. These mitigations are applied pre-flight.

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1136 Medium level of robustness

M1BC 1. M.I	Criterion 1- Evaluation of people at risk

	The applicant **must** provide spacetime-based restrictions (e.g., flying over a market square when it is not crowded) to substantiate that the actual density of people during the operation is lower than the iGRC. This **must** be done by: (a) An analysis or appraisal of characteristics of the location and time of operation. And/or. (b) Use of temporal density data (e.g., data from a supplemental data service provider) relevant for the proposed area. This can incorporate real time or historical data.
M1AC 2. M.I	Criterion 2 – Impact on at risk population The at-risk population **must** be lowered by at least 1 iGRC population band (~90%) using one or more methods described in the Level of Integrity for Criterion 1 above.
M1AC 1. M.A	Criterion 1- Evaluation of people at risk The applicant **must** provide compliance evidence of the data sources and processes used to claim lowering the density of population at risk.
M1AC 2. M.A	Criterion 2 – Impact of at-risk population The applicant **must** provide compliance evidence that the required level of integrity is achieved. This is typically achieved by means of analysis, simulation, surveys or through operational experience.
GM. M1AC 1. M.I	Characteristics of the location should be understood as land use that relates to the presence of people, e.g., industrial area, urban park or shopping centres. Time should be understood as time of day or day of the week that would influence the presence of people, e.g., weekend for industrial plants, night-time, time after opening hours of shops.

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1138 ## High level of robustness

1139 Medium robustness level requirements to be complied with:

M1C1. M.I	M1C2. M.I	M1C1. M.A	M1C2. M.A

Additional requirements to be complied with:

M1C1. H.I	Criterion 1- Evaluation of people at risk No additional requirements.
M1C2. H.I	Criterion 2 – Impact on population The at-risk population **must** be by at least 2 iGRC population bands (~99%) using one or more methods described in the Level of Integrity for Criterion 1 above.

M1C1. M.A	Criterion 1- Evaluation of people at risk No additional requirements
M1C2. M.A	Criterion 2 – Impact on population No additional requirements

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M1C – Tactical Mitigations – Ground observation

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		LEVEL of INTEGRITY		
		Low	**Medium**	**High**
M1C – Ground Observation	Criterion 1 (Evaluation of people at risk)	M1CC1.L.I	NA	NA
	Criterion 2 (Impact on at risk population)	M1CC1.L.I	NA	NA
		LEVEL of ASSURANCE		
		Low	**Medium**	**High**
	Criterion 1 (Evaluation of people at risk)	M1CC1.L.I	NA	NA
	Criterion 2 (Impact on at risk population)	M1CC1.L.I	NA	NA

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GM	M1(C) mitigation is a tactical mitigation where the remote crew or the system can observe most of the overflown area(s), allowing the detection of uninvolved people in the operational area and manoeuvring the UA, so that the number of uninvolved people overflown during the operation is significantly reduced.

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Low level of robustness

M1C C1. L.I	Criterion 1- Procedures (a) The applicant **must** implement a procedure for remote crew members observe the overflown areas during the operation and identify area(s) of less risk on the ground. (b) The remote pilot **must** reduce the number of people at risk by adjusting the flight path while the operation is ongoing (e.g., flying away from the area with a higher risk on the ground or overflying only the identified area(s) of less risk on the ground).

M1C C2. L.I	<u>Criterion 2 – Technical means</u> If the mitigation is achieved using technical means (e.g., camera(s) mounted on the UA or visual ground observers with radios/phones), these **must** provide data of sufficient quality allowing reliable detection of uninvolved people on the ground.
M1C C1. L.A	<u>Criterion 1- Procedures</u> (a) The Applicant **must** provide evidence of compliance with the integrity requirements. The procedure should include: (1) A clear communication plan which should use standard phraseology. (2) Backup procedures in event of a technical issue
M1C C2. L.A	<u>Criterion 2 – Technical means</u> The Applicant **must** provide evidence of compliance with the integrity requirements.

M2 – Effects of UA impact dynamics are reduced.

		LEVEL of INTEGRITY		
		Low	**Medium**	**High**
M2 Effects of UA impact dynamics are reduced	Criterion 1 (Technical design)	N/A	M2C1.M.I	M2C1.M.I M2C1.H.I
	Criterion 2 (Procedures)	N/A	M2C2.M.I	M2C2.M.I
	Criterion 3 (Training)	N/A	M2C3.M.I	
		LEVEL of ASSURANCE		
		Low	**Medium**	**High**
	Criterion 1 (Technical design)	N/A	M2C1.M.A	M2C1.H.A
	Criterion 2 (Procedures)	N/A	M2C2.M.A	M2C2.M.A M2C2.H.A
	Criterion 3 (Training)	N/A	M2C3.M.A	

GM. M2

(a) M2 mitigation reduces the effect of ground impact after the control of the operation has been lost. This is achieved either through:

i. Reducing the probability of lethality of the UA's impact, e.g. energy, impulse, energy transfer dynamics, etc., and/or,

ii. Reducing the size of the expected critical area as shown in the table below, e.g. with the use of parachutes, autorotation, frangibility, stalling the UA to slow the descent and increase the impact angle, etc.

The applicant should demonstrate a required total amount of reduction in either or both factors.

(b) The base assumption in SORA for UAS impact lethality before M2 mitigation is applied is that most impacts are lethal, with the following exceptions (see Annex F for more details on the calculations):

i. Impacts from a slide of the UA with a characteristic dimension less than or equal to 1 m.

	ii. Impacts from a slide of the UA with a total kinetic energy less than 290 Joules.. The critical area of impact is as defined in the table below, based on the maximum characteristic of the UA. Depending on whether the mitigation is passive, manually activated or automatically activated, the Applicant should provide correspondingly adequate evidence and procedures for a given level of robustness. Reduction of the inherent critical area of a UA by way of analysis is conducted as part of Step 2 of the SORA process and is not part of the M2 mitigation process. (c) Critical area calculations are defined in Annex F chapter 1.8. Step 2 of the SORA process assumes the following critical areas for each characteristic dimension:

Maximum characteristic dimension (m)	1	3	8	20	40
Critical area (m^2)	6.5	65	650	6500	65,000

(d) Applicants demonstrating M2 mitigation by reduction of the critical area should use the above values as baseline for comparison in their proposed mitigation. If the Applicant has used the modifications according to Annex F in Step 2 of the SORA process to show a corrected critical area and matching population density, then the custom critical area value should be used as the baseline against which the mitigation is assessed, and the custom population density value should be used as a limitation in the operation.

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1173 ## Medium level of robustness

M2C1. M.I	<u>Criterion 1 – Technical design</u> (a) Effects of impact dynamics and immediate post-impact hazards, critical area, or the combination thereof, **must** be reduced such that the risk to uninvolved people is reduced by an approximate 1 order of magnitude (90%). (b) In case of a failure that may lead to a crash, the UAS **must** contain all elements required for the activation of the mitigation. (c) Any failure of the mitigation itself **must** not adversely affect the safety of the operation.

M2C2. M.I	<u>Criterion 2 – Procedures</u> Any equipment used to reduce the effect of the UA impact dynamics **must** be installed and maintained in accordance with the Designer’s instructions.
M2C3. M.I	<u>Criterion 3 – Training</u> (a) When use of the mitigation requires action from the remote crew, then appropriate training must be provided for the remote crew by the operator. (b) The operator must ensure that the personnel responsible (internal or external) for the installation and maintenance of the mitigation measures are qualified for the task.
M2C1. M.A	<u>Criterion 1 – Technical design</u> (a) The Applicant **must** provide evidence of compliance with the Integrity requirements. (b) If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified.
M2C2. M.A	<u>Criterion 2 – Procedures</u> (a) The installation and maintenance procedures **must** be developed to a standard or means of compliance acceptable to the CAA. (b) The adequacy of the procedures **must** be demonstrated through either of the following methods: i. Dedicated flight test. ii. Simulation, provided that the representativeness of the simulation is proven valid for the intended purpose with positive results. (c) If (a), (b) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that the procedures developed by the Designer in (a) are followed by the Operator. (d) The Applicant **must** provide evidence of compliance with the Integrity requirements.
M2C3. M.A	<u>Criterion 3 – Training</u> (a) The applicant has developed a training syllabus which must be competency based. (b) The operator provides competency-based, theoretical, and practical training for the remote crew.

	(c) Personnel responsible for installation and maintenance of the mitigation measures must have completed relevant training. (d) The Applicant must provide evidence of compliance with the Integrity requirements.
AMC. M2C1. M.A	<u>Criterion 1 – Technical design</u> (a) A UAS with an MTOM less than or equal to 900g and a maximum speed of 19m/s may provide automatic compliance with the requirement.
AMC. M2C2. M.A	<u>Criterion 2 – Procedures</u> (b) The following standard may be used to demonstrate compliance with the requirement: Refer to E5, proposing a standard as an AMC.
GM. M2C1. M.I	Criterion 1 – Technical design (a) Examples of immediate post-impact hazards include fire or release of high energy parts. The reduction in risk detailed here is equivalent to a “System Risk Ratio” which requires that the combination of functional performance (i.e. the reduction in risk when the mitigation functions as intended) and reliability (i.e. the probability that the mitigation functions as intended) meets the requirement. Latest research on UAS impacts estimates injuries using the Abbreviated Injury Scale (AIS) developed for automotive impact tests and test dummies. An impact that has a 30% chance of causing an injury of AIS level 3 or greater is estimated to have a 10% probability of death. The SORA methodology only considers fatalities and does not provide guidance on the injury levels or thresholds beyond which an injury should be considered as a fatality. Further Guidance on how to evaluate impact severity measurement may be found in the following documents: • DOI 10.1007/s10439-017-1921-6 Ranges of Injury risk associated with impact from UAS. • ASSURE A4 UAS Ground Collision Severity Evaluation • ASSURE A14 UAS Ground Collision Severity Evaluation (b) This excludes failures of the mitigation. If the mitigation is the frangibility of the UAS structure, all elements required for the activation of it are inherently contained within the UAS.

	No single failure should lead simultaneously to the loss of control of the operation and loss of the effectiveness of the M2 mitigation. (c) This includes inadvertent activation of the mitigation.
GM. M2C1. M.A	<u>Criterion 1 – Technical design</u> (a) Compliance evidence is typically provided through testing, analysis, simulation, inspection, design review or through operational experience. Although not required to achieve a medium level of robustness, the use of industry standards is encouraged when developing mitigations used to reduce the effect of ground impact, e.g. CEN prEN 4709-001, ASTM F3389/F3389M, ASTM F3322-18.
GM. M2C2. M.A	<u>Criterion 1 – Procedures</u> (c) Designer data is found on the SAIL mark certificate.

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1175 ## High level of robustness

1176 Lower robustness level requirements to be complied with:

M2C1. M.I	M2C2. M.I	M2C2. M.A	M2C3. M.I	M2C3. M.A

Additional requirements to be complied with:

M2C1. H.I	<u>Criterion 1 – Technical design</u> (a) Effects of impact dynamics and immediate post-impact hazards, critical area, or the combination thereof, **must** be reduced such that the risk to uninvolved people is reduced by an approximate 2 orders of magnitude (99%). (b) The activation of the mitigation **must** be automated.
M2C2. H.I	<u>Criterion 2 – Procedures</u> No additional requirements.
M2C3. H.I	<u>Criterion 3 – Training</u> No additional requirements.

M2C1. H.A	<u>Criterion 1 – Technical design</u> The Integrity requirements **must** be complied with to a standard or means of compliance acceptable to the CAA.
M2C2. H.A	<u>Criterion 2 – Procedures</u> (a) The flight tests performed to validate the procedures **must** cover the entire flight envelope or be demonstrated to be conservative. (b) If (a) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that the flight envelope of the intended operation is the same as or contained within the flight envelope considered by the Designer.
M2C3. H.A	<u>Criterion 3 – Training</u> No additional requirement
AMC. M2C1. H.A	<u>Criterion 1 – Technical design</u> The following standard may be used to demonstrate compliance with the requirement: [Standard will be added later]
GM. M2C1. H.I	<u>Criterion 1 – Technical design</u> (b) No single failure should lead simultaneously to the loss of control of the operation and loss of the effectiveness of the M2 mitigation. The applicant may still implement a manual activation function, additional to the automated function.

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APPENDIX C

Annex C - Strategic Mitigation Collision Risk Assessment

Determining the final air risk class

Overview

C1 The initial ARC is a generalised qualitative classification of a UAS operational collision risk before any strategic mitigations are applied. Strategic Mitigation consists of procedures and operational restrictions intended to control the crewed aircraft type, encounter rates or time of exposure, prior to take-off. Strategic Mitigations may be used to adjust the initial ARC into the residual ARC which is then used to define Tactical Mitigation Performance Requirements (TMPRs) and the Specific Assurance and Integrity Level (SAIL).

C2 Strategic mitigations are broadly subdivided into two categories:

i) **Mitigation by operational restriction**, which are mitigations that are controlled by the UAS operator, in that they are not reliant on the cooperation of other airspace users to implement an effective mitigation.

ii) **Mitigation by common rules and structures**, which are mitigations that rely on all aircraft within a certain class of airspace to follow the same structure and rules. All aircraft in the airspace must participate, with the specific ruleset defined by the CAA and / or the ANSP.

C3 Both of these categories are discussed further below, followed some generic guidelines on the use of strategic mitigations to reduce an initial ARC assignment to a residual ARC.

Strategic mitigation by operational restriction

C4 Three types of operational strategic mitigations are considered, each discussed below.

C5 **SM1 - Operational restriction by boundary** – Limiting the UAS BVLOS operation to a boundary limited volume enables the use of airspace characterisation (discussed further in Section 7) to adjust the expectation of traffic types, density and encounter rates beyond that in the generalised flowchart. For example, the generalised Class G assumption that results in an initial ARC-c assignment is due to the unknown traffic density and the potential for many types of crewed aircraft to be encountered, including many types of GA, Helicopter Emergency Medical Service (HEMS), Police, SAR, military, pipeline / powerline survey aircraft, etc. However, it may be possible to demonstrate that a specific remote rural location has a significantly reduced traffic density and / or encounter type from the generalised Class G assumption, potentially supporting a reduction in the ARC.

C6 **SM2 - Operational restriction by chronology** – Limiting the UAS BVLOS operation to specific times of the day provides a further opportunity for airspace characterisation (discussed further in Section 7) to adjust the expectation of traffic type, density and encounter rates below that expected for the volume as a whole. For example, it may be possible to demonstrate a reduced number of GA VFR flights during the hours of darkness.

C7 **SM3 - Operational restriction by time of exposure** – Accepting a higher operational risk only for a limited time. An example of this within crewed aviation is the Minimum Equipment List which allows in certain situations a commercial airline to fly for three to ten days with an inoperative Traffic Collision Avoidance System (TCAS). The safety argument is that three days is a very short exposure time compared to the total life-time risk exposure of the aircraft. This short time of elevated risk exposure is justified to allow for the aircraft to return to a location where proper equipage maintenance can take place. Appreciating this may be a difficult argument for the UAS operation to make, the operator is still free to pursue this line of reasoning for a reduction in collision risk by applying a time of exposure argument. The cumulative impact of such a mitigation must be considered.

Strategic mitigation by common rules and structure

C8 Several types of operational strategic mitigations are considered, each discussed below.

C9 SM4 - Special Use Airspace (SUA), including:

i) *Danger Area (DA) / Temporary Danger Area (TDA)* – Airspace of defined dimensions within which activities dangerous to the flight of aircraft may exist at specified times [4]. This structure may be used to provide segregation within Class G airspace and in controlled airspace over the high seas [12]. A TDA typically only last 6 months, although under certain circumstances this may be extended up to 12 months.

ii) *Temporary Segregated Areas (TSA)* – A TSA is a defined volume of airspace, temporarily segregated and allocated for the exclusive use of a particular user during a determined period of time and through which other traffic will not be allowed to transit. This structure may be used to provide segregation within UK controlled airspace [12].

iii) *Temporary Reserved Area (TRA)* – A TRA is airspace that is temporarily reserved and allocated for the specific use of a particular user during a determined period of time and through which other traffic may or may not be allowed to transit in accordance with the air traffic management arrangements notified for that volume of airspace. The use of a TRA for UAS BVLOS is currently enabled by a CAA policy concept [12] as the current approach for trialling a managed form of integration, based on a bespoke ruleset applied by a controlling ANSP, including the potential for equipment carriage, traffic types and traffic density restrictions.

C10 SM5 - Other airspace requirements, including:

i) *Transponder Mandatory Zone (TMZ)* – A TMZ is airspace of defined dimensions wherein the carriage and operation of pressure-altitude reporting transponders is mandatory (unless operating in compliance with alternative provisions prescribed for that particular airspace by the TMZ Controlling authority that will achieve a cooperative electronic conspicuity environment). Deployment of a TMZ creates a ‘recognised traffic environment’, and assuming appropriate surveillance is available then operation within a TMZ removes non-cooperative traffic from the crewed aircraft encounter set that must be considered by a DAA capability. However, a TMZ alone does not alone require two-way radio communications, provide any control of traffic types or density or imply any form of UTM or air traffic service provision.

ii) *Radio Mandatory Zone (RMZ)* – A RMZ is airspace of defined dimension where pilots are required to establish two-way radio communication prior to entry (unless in compliance with alternative provisions prescribed for that area) [4]. Operation within a RMZ enables real-time two-way interaction with other air traffic via the appropriate ANSP, which, as discussed in Section 5.5, potentially enables strategic mitigation assuming appropriate support agreement from the appropriate ANSP.

iii) All of the above airspace types are established in accordance with the requirements of the CAA’s Airspace Change Process contained within CAP 1616 [10] and promulgated in the Aeronautical Information Publications (AIP). Where a temporary rather than permanent change to the notified airspace design is required, the procedure in [11] should be followed.

iv) **SM6 - Pre-agreement of any ANSP services to be used in-flight** – Several potential options for ANSP support are listed below, each of which require review and approval of operating procedures and any potential changes to the usual ANSP functional system:

(1) *Procedure based segregation* – For example approving UAS BVLOS operation when it is known that other aircraft are not within the area.

(2) *A Basic Service* – is a service provided for the purpose of giving advice and information useful for the safe and efficient conduct of flights. This may include weather information, changes of serviceability of facilities, conditions at aerodromes, general airspace activity information, and any other information likely to affect safety. The avoidance of other traffic is solely the pilot’s responsibility. Basic Service relies on the pilot avoiding other traffic, unaided by controllers/ FISOs. It is essential that a pilot receiving this service

remains alert to the fact that, unlike a Traffic Service and a Deconfliction Service, the provider of a Basic Service is not required to monitor the flight. For these reasons, a DAA system will be required, particularly if this is the sole strategic mitigation.

(3) *Traffic Information* - is a surveillance-based service, where in addition to the provisions of a Basic Service, the controller provides specific surveillance derived traffic information to assist the pilot in avoiding other traffic. Controllers may provide headings and/or levels for the purposes of positioning and/or sequencing; however, the controller is not required to achieve deconfliction minima, and the pilot remains responsible for collision avoidance. For these reasons, a DAA system will be required, particularly if this is the sole strategic mitigation.

(4) *Deconfliction Service* - is a surveillance-based service where, in addition to the provisions of a Basic Service, the controller will provide specific surveillance derived traffic information and issues headings and/or levels aimed at achieving planned deconfliction minima, or for positioning and/ or sequencing. However, the avoidance of other traffic is ultimately the pilot's responsibility. For these reasons, a DAA system will be required, particularly if this is the sole strategic mitigation. A Deconfliction Service will only be provided to flights under IFR outside controlled airspace, irrespective of meteorological conditions and, as IFR flight is currently not available to civil UAS, is mentioned for awareness of potential future use only.

(5) *Radar Control Service* – is provided to all Instrument Flight Rules (IFR) flights in controlled airspace classes A to E. Radar Control Service is a service under which pilots follow mandatory instructions to enable the prescribed separation minima between Air Systems to be maintained. Such mandatory instructions will generally be associated with essential details of conflicting traffic. Pilots will not change heading or level without prior approval of the Radar Controller (except to ensure the safety of the aircraft). As IFR flight is currently not available to civil UAS, radar control service is mentioned for awareness of potential future use only.

C11 **SM7 - Pre-agreement of any Unmanned Traffic Management (UTM)** services to be used in-flight – Several UTM operational concepts have been proposed with the objective to enable safe and efficient UAS operation within a volume of airspace. A UK CAA policy for UTM is currently under development, which may include one or more of the services listed below. Mitigation via UTM services ahead of CAA UTM policy adoption will be subject to CAA scrutiny on a case-by-case basis. Services that maybe considered include:

i) *Geo-consciousness service* – Including provision of mapping data, aeronautical information, meteorological data, etc.

ii) *Common altitude reference provision* – Ensuring that altitude or level information is in a format that is harmonised and compatible with existing altitude referencing methods.

iii) *Traffic information service* – Using ground infrastructure to detect other air traffic and provide a known or recognised traffic environment [see definitions].

iv) *Trajectory deconfliction service* – Verifying that the 4D trajectory plans of all aircraft within the area are deconflicted to an appropriate separation minimum. Note that this is distinct from the use of flight plans within crewed aviation, which focus predominantly on airspace capacity and the workload limits of the air traffic controller who provides the required tactical separation and deconfliction services.

v) *Take-off approval service* – Validating that an approved deconflicted 4D trajectory is still valid and it is safe to begin the flight.

vi) *Conformance monitoring & alerting service* – Based on an approved deconflicted 4D trajectory.

vii) *Conflict monitoring and alerting service* – Based on both a surveillance service and an approved deconflicted 4D trajectory.

viii) *Segregation, separation and / or deconfliction instruction or advice service* – Using a surveillance capability to maintain separation minima and hence reduce the residual intruder encounter rate.

C12 **SM8 - NOTAM of intended operation** – Note that while in some locations value may be gained from this approach it is not considered scalable for routine operations. Therefore, the use of NOTAMs may be limited to specific heights, locations or for new or novel operations.

C13 **SM9 - Military low flying notification** – Military low flying occurs in most parts of the United Kingdom at any height up to 2,000 ft above the surface. However, the greatest concentration is between 250 ft and 500 ft and civil pilots areFT advised to avoid flying in that height band whenever possible. The Low-Level Civil Aircraft Notification Procedure (CANP) as described within the AIP [14] ENR 1.10 FLIGHT PLANNING allows low level civil aerial operators to notify such activity to military low flying units. Before commencing any low flying sortie, military pilots receive a comprehensive brief on all factors likely to affect their flight, including relevant CANP details.

C14 **SM10 - Outreach to local flying clubs and pilots** – Airspace characterisation (discussed further in Section 7) also enables a local flying community in the region of the UAS operational area to be identified, and this may enable coordination and / or direct notification of the UAS operations and vice versa. For example, an agreement could be reached for local flyers to inform the UAS operator of upcoming periods of busier than usual activity, or vice versa.

Description of residual ARCs

C15 In order to understand the value of different strategic mitigations a description of the residual ARCs is required. In accordance with the wider SORA methodology agreement of a residual ARC then results in the assignment of TMPRs that reduce any residual collision risk down to the appropriate target level of safety. Broad descriptions of each residual ARC are as follows:

C16 **Residual ARC-a**: Encounter rate with other crewed air traffic demonstrated to be negligible, therefore DAA based tactical mitigation of the air risk is not required.

C17 **Residual ARC-b**: Encounter rate with other crewed air traffic demonstrated to be low and exclusively Type-1, but not negligible. DAA based tactical mitigation is therefore required but must be supported by one or more additional mitigation layers.

C18 **Residual ARC-c**: Predominately Type-1 traffic and negligible commercial air transport aircraft, with either an encounter rate that cannot be demonstrated to be low enough for ARC-b, or additional supporting strategic mitigations are not available. DAA based tactical mitigation is therefore required and expected to be used routinely rather than occasionally.

C19 **Residual ARC-d**: Predominately Type-2 traffic, therefore subject to the highest level of tactical mitigation due to highest severity consequence and highest safety standard airspace. Specific category operations likely to be exceptions (e.g., via certified DAA system) rather than the normal for this ARC.

Generic guidance on the use of strategic mitigations

C20 This section provides some generic guidance on the application of the strategic mitigations discussed within Section 5.2 and Section 5.3 in order to meet the expectations of the residual ARCs described in Section 5.4. Applicants are encouraged to assess and make use of these strategic mitigations, or others that may be available. However, each application will still be assessed on a case-by-case basis and may not result in credit being given in the form of a reduced residual ARC. Applicants must also consider making use of additional mitigations to further reduce the safety risk to a level that is "as low as reasonably practicable (ALARP).

C21 Irrespective of the Air Risk Class (ARC), an applicant must initially consider the expected ruleset of the airspace, Section 6 Airspace Classification, proposing changes only if necessary, and with agreement of the ANSP and authority.

C22 Regarding strategic mitigation by pre-agreement of the use of ANSP services, it is worth noting that several different levels of service are currently used by crewed aircraft. Within UK airspace the level of service is in accordance with the classification of the airspace [4, 15, 19]. For uncontrolled airspace and for VFR traffic within Class E a range of Flight Information Services may be available as described within CAP 774 [16], including Basic, Traffic, Deconfliction and Procedural Services. ANSP services within both controlled and uncontrolled airspace typically fall into one of the following categories:

i) *Separation or deconfliction services* – These are used to provide structure to the traffic flow, hence reducing the crewed aircraft encounter rate to below the average traffic density of the operating area. Within crewed aviation an ANSP separation or deconfliction service is supported by a cockpit based 'see-and-avoid' layer, and hence is not typically a single layer mitigation (unless operating under IMC). A UAS under a normal separation or deconfliction service would therefore generally be required to be supported by a tactical DAA capability, with the performance requirement defined by the encounter types and rates within the operating area.

ii) *Traffic Information services* – These are typically used to alert a pilot to the presence of other aircraft, supporting visual acquisition (in support of visual deconfliction) rather than providing real-time intruder tracks for deconfliction. A traffic information service therefore typically only provides a secondary mitigation, alerting a remote pilot to potential traffic, and would therefore need to be supported by a tactical DAA capability, with the performance requirement defined by the encounter types and rates within the operating area.

C23 It must also be noted that, dependent on the specific class of airspace and other services also being provided, the timeliness of an ANSP service may be affected by the current workload of the Air Traffic Controller or Flight Information Service Officer (FISO). Care must therefore be taken when utilising such services without the cockpit see-and-avoid layer upon which airspace safety is premised. Finally, instructions issued by controllers to pilots operating outside controlled airspace are not mandatory; however, the ATS rely upon pilot compliance with the specified terms and conditions so as to promote a safer operating environment for all airspace users.

C24 Strategic mitigations suitable for residual ARC-a assignment are as follows:

i) *Segregated airspace*, e.g., DA, TDA, TSA.

ii) *Atypical air environment*.

iii) *Segregation by procedure*, e.g., using appropriate operating area surveillance and / or contact requirements to enable UA landing ahead of entry by crewed aircraft into the operating area.

C25 However, it should be noted that segregation of UA from crewed aircraft is not considered to be a scalable solution, hence the strategic direction of the CAA, as set out within the Airspace Modernisation Strategy (AMS) [17, 18], is towards integration of UA with crewed traffic.

C26 Strategic mitigations in support of residual ARC-b assignment include:

i) *TRA Special Use Airspace*, in accordance with CAA's current BVLOS airspace policy concept [12] this airspace structure is currently required where a DAA capability is present, but the UAS is unable to fully comply within the accepted ruleset. Establishment of a TRA also enables use of a bespoke ruleset for all participants, e.g., requiring mandatory contact, carriage of EC, or potentially carriage of EC-In to support detection and avoidance of UAS with limited visual signature by crewed aircraft.

ii) *Restriction by boundary and / or chronology*, using airspace characterisation to validate a default low encounter rate and the presence of only Type-1 traffic.

iii) *Density control of crewed traffic*, allowing crewed aircraft encounters to be controlled to the required level, and limited to Type-1 only. Note that this may be enabled via either crewed aircraft access request (e.g., within a TRA) or an UAS Operating procedure that prohibits BVLOS flights when the traffic density is too high, which relies either on suitable surveillance or mandatory contact requirement ahead of entry, as potentially available within a CTR or TRA (assuming this is part of the bespoke ruleset).

iv) *Separation or deconfliction service*, providing a level of structure to the traffic within the airspace to reduce the expected rate of crewed aircraft encounters *below the mean for the area* (which may already have been artificially reduced traffic density control).

v) *Traffic information service*, alerting the remote pilot to the presence of other aircraft, therefore providing a secondary mitigation and enhancement to self-separation.

vi) *Conflict alerting service*, alerting the remote pilot to a potential hazard, therefore providing a secondary mitigation and enhancement to self-separation.

vii) *Promulgation of BVLOS UAS activity*, for example via NOTAM, CANP and / or outreach to the local flying community, potentially reducing crewed aircraft encounter rate by increasing awareness of UAS and crewed aircraft activity within a specific region.

C27 Depending on the specificities of the proposed operating area one or more of the above mitigations may be required to achieve a residual ARC-b assignment. It should be noted that a residual ARC-b assignment provides a limited form of integration of UAS with crewed aircraft, relying on one or more accommodation measures as defined above. Such measures are required to justify a reduction in tactical mitigation performance requirement for DAA below that required for ARC-c, where DAA based tactical mitigation may be the sole replacement for cockpit based ‘see-and-avoid’.

C28 **Mitigations in support of residual ARC-c** assignment (from initial ARC-d) are required to demonstrate the absence of both IFR traffic and Type-2 traffic. This may be achieved using an operational restriction by boundary and / or chronology supported by airspace characterisation. Dependent on the airspace classification some form of pre-agreement of ANSP support may also be required.

Airspace characterisation

C29 Airspace characterisation data is expected to be used at several stages within the UK SORA air risk model. This section defines what is meant by airspace characterisation data, discusses different levels of data integrity, then provides some examples of the expected use.

C30 Airspace characterisation data allows an applicant to account for local specificities in the proposed operating area, providing a level of granularity beyond the generalised air risk model. Examples of airspace characterisation data that support the UK SORA air risk assessment process include the following:

i) **Types of aircraft**, e.g., typical airspeeds & equipment carriage, potentially defined by different height bands.

ii) **Surveillance coverage**, e.g., primary, secondary, ADS-B, multilateration, etc.

iii) **Traffic activity for each type**, e.g., traffic movements, density of traffic in a given area, actual positions / paths, nominal encounter rates, e.g., total or per traffic type, airprox reports, TCAS events etc.

C31 Given the potentially safety critical implications of the use of airspace characterisation data it is important to understand the associated level of integrity of the data source and any processing. The data integrity requirement can be expected to increase with the associated ARC. Three distinct data sources and associated levels of integrity are expected:

i) **ANSPs**, based on actual movement numbers and primary and secondary radar data which can be expected to provide historical 4D trajectory information.

ii) **Crowd sourced organisation**, such as OpenSky.

iii) **Qualitative local area surveys**, e.g., via contacting the local flying communities and estimating typical traffic types, patterns and rates.

C32 Example usage of airspace characterisation data within the air risk model include:

i) **Initial Generalised ARC Flowchart guidance**, e.g., demonstrating that a proposed operation avoids known IFR structures and / or known VFR traffic.

ii) **Local estimation of encounter types and rates**, e.g., supporting a strategic mitigation of operational restriction by boundary, and / or chronology.

iii) **Definition of intruder aircraft encounter sets**, used to navigate the air risk model and to assess tactical mitigations, e.g., DAA systems.

iv) **Quantitative cross check of proposed operation against the TLOS.** Quantitative methods are not directly considered within this initial version of the air risk model but will be included in a future update.

C33 Airspace characterisation should also consider the impact of special events on routine traffic patterns. Such events can expect to be promulgated via NOTAM, but airspace characterisation may allow routine events to be identified in advance.

C34 Finally, the Air Risk task force within the JARUS Safety and Risk Management group are currently developing an airspace risk characterisation document which will provide guidance for regulators, ANSPs and operators on methods for determining intrinsic air risk via airspace characterisation and encounter rate determination. It is expected that this document may be referenced for further information when available.

APPENDIX D

Annex D - Tactical Mitigation Performance Requirements (TMPR)

Introduction

D1 The target audience for Annex D, is the UAS operator who wishes to apply Tactical Mitigation Performance Requirement (TMPR), Robustness, Integrity, and Assurance Levels for their operation. Annex D provides the tactical mitigation(s) used to reduce the risk of a Mid Air Collision (MAC). The TMPR is driven by the residual collision risk of the airspace. Some of these tactical mitigations may also provide a means of compliance with ICAO Annex 2 section 3.2, codified in 14 CFR 91.113, “See & Avoid,” SERA 3201, and additional requirements by various states.

D2 The Air Risk Model has been developed to provide a holistic method to assess the risk of an air encounter, and to mitigate the risk that an encounter develops in a Mid Air Collision. The SORA Air Risk Model guides the operator, competent authority, and/or Air Navigation Service Provider (ANSP) in determining whether an operation can be conducted in a safe manner. This Annex is not intended to be used as a checklist, nor does it provide answers to all the challenges of Detect and Avoid (DAA). The guidance allows an operator to determine and apply a suitable mitigation means to reduce the risk of a Mid-Air Collision (MAC) to an acceptable level. This guidance does not contain prescriptive requirements but rather objectives to be met at various levels of robustness.

Tactical Mitigations

D3 Several tactical mitigation options are presented below:

i) **TM1 - Operations under VLOS / BVLOS-with-visual-mitigations** – Both VLOS and BVLOS-with-visual-mitigations, following current UK CAA regulations and guidance, are acceptable mitigations for air risk for all ARC levels. The operator is also advised to consider additional means to increase situational awareness with regard to air traffic operating in the vicinity of the operational volume, e.g., via additional tactical mitigations discussed below. In some situations, the CAA and/or ANSP may decide that VLOS does not provide sufficient mitigation for the air risk and may require compliance with additional rules and/or requirements. It is the operators’ responsibility to comply with these rules and requirements.

ii) **TM2 - Detect and Avoid (DAA) capability** – A UK CAA policy concept for DAA across the different ARCs is currently in progress and is expected to be published in Q1 2024, allowing testing across 2024 and ahead of full adoption.

i) **TM3 – Carriage of EC out**, enhancing the detectability of the UA to other participants.

ii) **TM4 - Monitoring VHF radio**, increasing the situation awareness of a UAS pilot of local air traffic. Note that this mitigation may require some degree of training to understand the monitored radio conversations.

iii) **TM5 - Monitoring local cooperative traffic**, either via low-cost EC receivers or publicly available aircraft tracking applications to increase the situation awareness of an UAS pilot of local air traffic.

iv) **TM6 - Anti-collision lighting or high visibility colours on the UA**, used to enhance the visual detectability of the US by the pilot of a conflicting crewed aircraft or any ground personnel.

v) **TM7 - Local area real-time weather monitoring**, helping to anticipate likelihood of unusual crewed-aircraft traffic patterns.

D4 Depending on the specificities of the proposed operating area, one or more of the above mitigations may be required in addition to DAA requirements. The applicant is also encouraged to follow the As Low As Reasonably Practical (ALARP) principle and apply more tactical mitigations than are required to meet the minimum requirement, if reasonably practicable to do so.

APPENDIX E

Annex E - Integrity and assurance levels for the Operational Safety Objectives (OSO)

Introduction

E1 Annex E provides Low/Medium/High assessment requirements for the integrity (i.e. the safety gain) and assurance (i.e. the method of proof) of the Operational Safety Objectives (OSO) to be complied with by an Applicant.

E2 Where more than one criterion exists for a given level of robustness in an OSO, all the criteria need to be met at the required robustness level in order to comply with the OSO.

E3 A number of OSOs propose an alternative Functional Test Based (FTB) approach to complying with the OSO criteria.

E4 Where AMC or GM specifies a letter, it is applicable to the related requirement. E.g. GM.OSO3.L.I (a) is guidance material to the requirement OSO3.L.I (a).

E5 The CAA will adopt standards to be used as AMC in the future and is actively working with standards bodies. The Applicant may propose AMC to certain requirements to the CAA. The Applicant may consult the following documents to identify standards that they wish to propose to the CAA as AMC:

i) JARUS SORA 2.5 (where comments identify standards to be used as AMC)

ii) SHEPHERD D2.1-D3.1 – Identification of satisfactory industry standards and justification for not acceptable industry standards

iii) SHEPHERD D2.2-D3.2 – Identification of satisfactory industry standards and justification for not acceptable industry standards

OSO 1 – Ensure the UAS Operator is competent and/or proven.

TECHNICAL ISSUE WITH THE UAS		LEVEL of INTEGRITY		
		Low (SAIL II)	Medium (SAIL III)	High (SAIL IV to VI)
OSO1 **Ensure the operator is competent and/or proven**	Criterion	OSO1.L.I	OSO1.L.I OSO1.M.I	OSO1.H.I
		LEVEL of ASSURANCE		
		Low (SAIL II)	**Medium (SAIL III)**	**High (SAIL IV to VI)**
	Criterion	OSO1.L.A	OSO1.M.A	OSO1.H.A

Low level of robustness (SAIL II)

OSO1. L.I.	The applicant **must** have knowledge of the UAS and have the following operational procedures: (a) UA checklists (b) technical logbook for each UA (c) flight crew currency and training log (d) allocation of responsibilities prior to operating

OSO1. L.A	The applicant **must** provide evidence of compliance with the Integrity requirements.

OSO1. L.I	(a) The applicants UAS knowledge should include monitoring of any related airworthiness directives or recommendations issued by National Aviation Authorities and designer recommendations (Service Bulletin, Service Information Letter, etc.). The UAS operator should produce checklists for every stage of the UAS operation in order to ensure the UAS is safe to be flown. In addition to standard operating procedures, checklists should be produced for emergency scenarios and maintenance. Checklists should be accessible to the flight crew and easy to use, to prevent human error. If the flight crew consists of only a single remote pilot, critical checklists must be memorised or made accessible in such a way that it does not detract them from operating the UAS in a safe and legal manner. Further guidance can be found by reviewing:

(1) CAP 676 Guidance on the Design, Presentation and Use of Emergency and Abnormal Checklists

(2) CAP 708, Guidance on the Design, Presentation and Use of Electronic Checklists

(b) Operational procedures (checklists, maintenance, training, etc.) should be presented in the context of other applicable OSOs. A technical logbook should be held for each UAS. The technical logbook is used to record all pertinent information relating to the UAS, including operation activities, maintenance, repairs and upgrades. The logbook should be kept secure and made available for inspection by the CAA for a period of at least three years.

(c) Flight crew currency should be monitored and maintained by the UAS operator. If a remote pilot falls out of currency, a procedure should be in place to regain currency in a safe environment, by practicing flight skills for standard operating procedures and emergency scenarios. The amount of time for this training should, as a minimum, amount to the same amount of time that the remote pilot has lapsed (i.e if a remote pilot lapses currency by 1 hour, the training flights must equate to the same amount of time or more). The remote pilot must successfully complete this competence training before being tasked on a UAS operation. This competency training must be recorded in the UAS operator's training log. The training log should be used to record any training that the flight crew undertake, either through an RAE or other similar entity, external or internal training. The logbook should be kept secure and made available for inspection by the CAA. The logbook should be kept for a period of at least three years.

(d)

The UAS operator must choose a suitably qualified and competent flight crew prior to each UAS operation. The flight crew should be given a briefing by the remote pilot before the UAS operation commences, to ensure each member of the flight crew understand their role and responsibilities.

Allocation of flight crew roles and responsibilities for each UAS operation should be recorded in the technical logbook and the flight crew flight logs.

The UAS operator is responsible for ensuring that all nominated personnel are sufficiently competent to conduct the flight and ensuring that all nominated personnel are sufficiently briefed on the tasks that they are required to perform.

1630

1631

Medium level of robustness (SAIL III)

1632 Lower robustness level requirements to be complied with:

OSO1 L.I	

The applicant **must** have the following additional procedures:

OSO01 M.I	(a)	A method to continuously evaluate whether the operator is operating in accordance with the terms of their operational authorisation (OA) and check whether the mitigations proposed as part of the OA are still appropriate.
	(b)	Occurrence analysis procedures and reporting to the designer in case of design-related in-service events.

OSO1 M.A	The applicant **must** provide evidence of compliance with the Integrity requirements.

AMC. OSO1 M.I	(b) UK Regulation (EU) 2019/947, AMC1 Article 19(2) Safety Information.

1633

1634

High level of robustness (SAIL IV to VI)

Requirements to be complied with:

OSO1 H.I.	The operator has a safety management system in place in accordance with ICAO Annex 19 principles.

OSO1 H.A	The applicant **must** provide evidence of compliance with the Integrity requirements.

1635

1636
OSO 2 – UAS manufactured by competent and/or proven entity

1637

TECHNICAL ISSUE WITH THE UAS		LEVEL of INTEGRITY		
		Low (SAIL III)	**Medium (SAIL IV)**	**High (SAIL V, VI)**
OSO2 **UAS manufactured by competent and/or proven entity**	Criterion	OSO2.L.I	OSO2.L.I OSO2.M.I	OSO2.L.I OSO2.M.I OSO2.H.I
		LEVEL of ASSURANCE		
		Low (SAIL III)	**Medium (SAIL IV)**	**High (SAIL V, VI)**
	Criterion	OSO2.L.A	OSO2.L.A OSO2.M.A	OSO2.L.A OSO2.M.A OSO2.H.A

1638

1639
Low level of robustness (SAIL III)

OSO2 L.I.

The manufacturing procedures **must** cover:

(a) The specifications of materials used.

(b) The processes necessary to allow for manufacturing repeatability and conformity within acceptable tolerances.

(c) Configuration control.

OSO2 L.A

(a) The manufacturing procedures **must** be developed to a standard or means of compliance acceptable to the CAA.

(b) The Applicant **must** provide evidence of compliance with the Integrity requirements.

AMC. OSO2 L.A

Refer to E5, proposing a standard as an AMC.

1640

1641
Medium level of robustness (SAIL IV)

1642 Lower robustness level requirements to be complied with:

OSO2 L.I | OSO2 L.A

Additional requirements to be complied with:

OSO2 M.I	The manufacturing procedures **must** cover: (a) The verification of incoming products, parts, materials, and equipment. (b) Identification and traceability. (c) In-process and final inspections, which **must** include testing. (d) Control and calibration of tools. (e) Handling and storage all products. (f) Handling of non-conforming items.
OSO2 M.A	The Applicant **must** provide evidence that each UAS is verified to have been manufactured in conformance to its design.
AMC. OSO2 M.I	Refer to E5, proposing a standard as an AMC.
AMC. OSO2 M.A	The Applicant may use a combination of methods such as (but not limited to) physical inspections and flight testing to demonstrate that each requirement listed in the design specification is satisfied by the finished UAS product.

1643

1644 ## High level of robustness (SAIL V and VI)

1645 Lower robustness level requirements to be complied with:

OSO2 L.I	OSO2 L.A	OSO2 M.I	OSO2 M.A

Additional requirements to be complied with:

OSO2 H.I.	The manufacturing procedures **must** cover: (a) Personnel competence and qualifications. (b) Supplier control.
OSO2 H.A	The manufacturing procedures and conformity of the UAS to its design **must** be recurrently verified through process or product audit.
AMC. OSO2 H.I	Refer to E5, proposing a standard as an AMC.

AMC. OSO2 H.A	An audit programme may be established and agreed between the Applicant and the CAA that will allow the CAA to obtain and assess the evidence of conformity during an audit. The frequency of audits may be agreed with the CAA as part of the audit programme.

1648

OSO 3 – UAS maintained by competent and/or proven entity

1649

TECHNICAL ISSUE WITH THE UAS		LEVEL of INTEGRITY		
		Low (SAIL I, II)	**Medium (SAIL III, IV)**	**High (SAIL V, VI)**
OSO 3 **UAS maintained by competent and/or proven entity**	Criterion	OSO3.L.I	OSO3.L.I OSO3.M.I	OSO3.L.I OSO3.M.I OSO3.H.I
		LEVEL of ASSURANCE		
		Low (SAIL I, II)	**Medium (SAIL III, IV)**	**High (SAIL V, VI)**
	Criterion 1 (Procedures)	OSO3C1.L.A	OSO3C1.L.A OSO3C1.M.A	OSO3C1.L.A OSO3C1.M.A
	Criterion 2 (Training)	OSO3C2.L.A	OSO3C2.L.A OSO3C2.M.A	OSO3C2.L.A OSO3C2.M.A OSO3C2.H.A

1650

1651

Low level of robustness (SAIL I and II)

OSO3.L.I

(a) Operator maintenance requirements and maintenance instructions **must** be defined and adhered to.

(b) Maintenance requirements and instructions **must** include those developed by the UAS Designer where applicable.

(c) The maintenance Personnel **must** be competent and **must** have received an authorisation to carry out maintenance on the UAS.

OSO3C1.L.A

Criterion 1 – Procedures

(a) Any maintenance conducted on the UAS **must** be recorded in a maintenance log system.

(b) A list of maintenance Personnel authorised to carry out maintenance on the UAS **must** be established and kept up to date.

(c) The Applicant **must** provide evidence of compliance with the Integrity requirements.

OSO3C2.L.A

Criterion 2 – Training

(a) A record of all relevant qualifications, experience and/or training completed by the maintenance staff is established and kept up to date.

AMC.

OSO3.L.I	(b)	The Operator may only use the UAS designer requirements and instructions, or may include additional requirements and instructions over and above those of the UAS Designer.
	(c)	The maintenance may be performed by an organisation other than the Operator (e.g. use of a third party).

GM.OSO3.L.I	(a)	The maintenance requirements are the needs for maintenance on the UAS, e.g. inspection after hard landing, regular check of lighting system. The Operator ensures that these requirements are covered in the maintenance instructions. The maintenance instructions are the information establishing how to carry out the needed maintenance or repairs. These instructions are followed by the maintenance staff while performing maintenance.
	(b)	The UAS Designer maintenance instructions are sometimes referred to as Instructions for Continued Airworthiness (ICA).

GM.OSO3C1.L.A	Criterion 1 – Procedures	
	(a)	The purpose of the maintenance log is to record all the maintenance performed on the UAS and the reason why it was performed, e.g. defects or malfunctions rectification, modification, scheduled maintenance, etc. The maintenance log may be requested for inspection/audit by the Authority during oversight activities.

Medium level of robustness (SAIL III and IV)

Lower robustness level requirements to be complied with:

OSO3.L.I.	OSO3C1.L.A	OSO3C2.L.A

Additional requirements to be complied with:

OSO3.M.I	(a)	A maintenance programme **must** be developed which includes scheduled preventative maintenance of the UAS, derived from the UAS Designer’s scheduled maintenance requirements and adapted to the specificities of the intended operation.
	(b)	Maintenance and releases to service **must** be recorded in the maintenance log system.

	(c)	A maintenance release **must** be accomplished by Personnel that has received maintenance release authorisation for that UAS model.

OSO3 C1. M.A

Criterion 1 – Procedures

(a) The layout of the UAS maintenance programme **must** be developed to a standard or means of compliance acceptable to the CAA.

(b) A list of maintenance Personnel authorised to accomplish maintenance releases **must** be established and kept up to date.

OSO3 C2. M.A

Criterion 2 – Training

(a) Initial training syllabus and training standard including theoretical/practical elements, duration, etc. is defined and commensurate with the authorisation held by the maintenance staff.

(b) For staff holding an authorisation to release to service, the initial training is specific to the UAS type.

(c) All maintenance staff have undergone initial training.

AMC. OSO3. M.I

Refer to E5, proposing a standard as an AMC.

1655

1656
High level of robustness (SAIL V and VI)

1657 Lower robustness level requirements to be complied with:

OSO3. L.I	OSO3 C1. L.A	OSO3 C2. L.A	OSO3. M.I	OSO3 C1. M.A	OSO3 C2. M.A

Additional requirements to be complied with:

OSO3. H.I

A maintenance procedure manual **must** be developed which:

(a) Provides information and procedures relevant to the UAS Operator maintenance facility, records, maintenance instructions, maintenance schedule, release to service, tools, material, components, and defect deferrals.

(b) Is followed by the maintenance Personnel to carry out maintenance on the UAS.

OSO3 C1. H.A	Criterion 1 – Procedures No additional requirements.
OSO3 C2. H.A	Criterion 2 – Training Same as Medium. In addition: (a) A programme for recurrent training of staff holding an authorization to release to service is established; and (b) This programme is validated by a competent third party.

1658

OSO 4 – UAS components are designed to an Airworthiness Standard

TECHNICAL ISSUE WITH THE UAS		LEVEL of INTEGRITY		
		Low (SAIL IV)	**Medium (SAIL V)**	**High (SAIL VI)**
OSO 4 **UAS components essential to safe operations are designed to an Airworthiness Design Standard**	Criterion	OSO4.L.I	OSO4.M.I	OSO4.H.I
	Alternative FTB method	OSO4FT.L.I	N/A	N/A
		LEVEL of ASSURANCE		
		Low (SAIL IV)	**Medium (SAIL V)**	**High (SAIL VI)**
	Criterion	OSO4.L.A	OSO4.L.A	OSO4.L.A
	Alternative FTB method	OSO4FT.L.A	N/A	N/A

GM. OSO4

(a) The UAS components essential to safe operations are those whose failure would significantly impair the capability of the Operator to meet the target level of safety for loss of control of the operation.

(b) Starting at SAIL IV, it is considered that the safety objective associated with the SAIL of the operation (e.g. probability of loss of control of the operation below 10^{-4}/FH for a SAIL IV operation) cannot be achieved without UAS components essential to safe operation being designed to an Airworthiness Design Standard, unless an FTB approach is chosen).

(c) OSO 4 does not duplicate requirements that are addressed by other design related OSOs. OSO 4 aims at ensuring that the UAS as a whole is designed according to an Airworthiness Design Standard (e.g. the design and construction, structure, flight performance are addressed by the standard), whereas other design related OSOs focus on specific systems or functionalities of the UAS and or specific technical disciplines:

(1) OSO 5 (system safety)
(2) OSO 6 (C3 link)
(3) OSO 7 (UAS conformity check)
(4) OSO 13 (external services)
(5) OSO 18 (automatic protection of the flight envelope)
(6) OSO 20 (HMI)

	(7) OSO 23, 24 (environmental conditions).

1663

1664
Low level of robustness (SAIL IV)

OSO4. L.I	The UAS components essential to safe operations **must** be designed to an Airworthiness Design Standard considered adequate by the Authority and/or in accordance with a means of compliance acceptable to the Authority to contribute to the overall safety objective of 10^{-4}/FH for the loss of control of the operation.
OSO4 FT. L.I	The applicant **must** conduct at least 30,000 FTB flight hours meeting one of the set of conditions described in FTB policy.
OSO4. L.A	(a) The Applicant **must** provide evidence of compliance with the Integrity requirements. (b) If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified.
OSO4 FT. L.A	(a) The FTB flying hours **must** be conducted per a standard or means of compliance acceptable to the CAA. (b) The Applicant **must** provide evidence of compliance with the Integrity requirements.
AMC. OSO4. L.I	Refer to E5, proposing a standard as an AMC.
AMC. OSO4 FT. L.A	Refer to E5, proposing a standard as an AMC.
GM. OSO4. L.I	The Applicant is free to propose their own Airworthiness Design Standard(s) to the Authority. When aspects of an Airworthiness Design Standard is covered by an OSO (e.g. OSO 5), the OSO requirement takes precedence.
GM. OSO4.	(a) Compliance evidence is typically provided through testing, analysis, simulation, inspection, design review or through operational experience.

L.A	

Medium level of robustness (SAIL V)

Lower robustness level requirements to be complied with:

OSO4. L.A	

Additional requirements to be complied with:

OSO4. M.I	The UAS components essential to safe operations **must** be designed to an Airworthiness Design Standard considered adequate by the Authority and/or in accordance with a means of compliance acceptable to the Authority to contribute to the overall safety objective of 10^{-5}/FH for the loss of control of the operation.
OSO4. M.A	No additional requirements.

High level of robustness (SAIL VI)

Lower robustness level requirements to be complied with:

OSO4. L.A	

Additional requirements to be complied with:

OSO4. H.I	The UAS components essential to safe operations **must** be designed to an Airworthiness Design Standard considered adequate by the Authority and/or in accordance with a means of compliance acceptable to the Authority to contribute to the overall safety objective of 10^{-6}/FH for the loss of control of the operation.
OSO4. H.A	No additional requirements.

OSO 5 – UAS is designed considering system safety and reliability

		LEVEL of INTEGRITY		
		Low (SAIL III)	**Medium (SAIL IV)**	**High (SAIL V, VI)**
OSO 5 **UAS is designed considering system safety and reliability**	Criterion	OSO5.L.I	OSO5.L.I OSO5.M.I	OSO5.H.I
		LEVEL of ASSURANCE		
		Low (SAIL II, III)	**Medium (SAIL IV)**	**High (SAIL V, VI)**
	Criterion	OSO5.L.A	OSO5.L.A OSO5.M.A	OSO5.L.A OSO5.M.A

GM. OSO5		
	(a)	(OSO 5 ensures that the contribution of the UAS and any external system supporting the operation to the loss of control of the operation inside the operational volume is commensurate with the acceptable level of risk associated with each SAIL. OSO 5 safety objectives are to be considered in conjunction with the containment safety requirements (Step11) and, when applicable, the ground risk mitigation requirements (Annex B, and in particular M2 Criterion 1 requirements). In combination, these three sets of safety objectives ensure that whatever the SAIL of the operation, the target level of safety is achieved and no single failure is expected to lead to a catastrophic effect.
	(b)	Note on SAIL II operations: some UAS designs may employ novel or complex features which have limited demonstrable operational history. If such features are identified by the Authority or Applicant, the Applicant may be required to comply with OSO 5 requirements at a low level of robustness.

Low level of robustness (SAIL III)

OSO5. L.I	The equipment, systems and installations **must** be designed to minimise hazards in the event of a probable failure of the UAS or of any external system supporting the operation.

OSO5. L.A		
	(a)	A Functional Hazard Assessment and a design and installation appraisal **must** be used to demonstrate that hazards are minimized.
	(b)	If (a) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that the external

	systems used for the intended operation have been considered by the Designer in their compliance to the requirements.
AMC OSO5. L.A	Refer to E5, proposing a standard as an AMC. The design and installation appraisal may consist of a written justification which includes functional diagrams, describes how the system works and explains why the Integrity requirement is met.
GM OSO5. L.I	The Integrity requirement correlates with the contribution of the UAS and external systems to the loss of control of the operation, thus the SAIL of the operation. As an example, at SAIL III, the contribution of the UAS and external systems to the loss of control of the operation rate may be 10^{-4}/FH, assuming a traditional 10% attribution to technical failures. The term “hazard” should be interpreted as a failure condition which may lead to a major or hazardous event. Catastrophic events are excluded from SAIL III to IV as the TLOS is considered to be met for SAIL III to IV operations per the previous paragraph and, if applicable, Annex B M2 mitigation requirements. A probable failure is anticipated to occur one or more times in the entire operational life of the UAS. External systems supporting the UAS operation are defined as systems that are not an integral part of the UAS, but are used to for example: • Launch / take-off the UAS. • Undertake pre-flight checks. • Support operations of the UA within the operational volume (e.g. GNSS, Satellite Systems, Air Traffic Management, UTM).
GM OSO5. L.A	(a) When developing the Functional Hazard Assessment, the severity of failure conditions (e.g. no safety effect, minor, major, hazardous) should be determined in accordance with the definitions provided in JARUS AMC RPAS.1309 Issue 2. (b) Designer data is found on the SAIL mark certificate.

Medium level of robustness (SAIL IV)

Lower robustness level requirements to be complied with:

OSO5. L.I	OSO5. L.A

Additional requirements to be complied with:

OSO5. M.I	A strategy **must** be developed for the detection, alerting and management of any failure or combination thereof, which may lead to a hazard.
OSO5. M.A	(a) The safety assessment **must** be developed to a standard or means of compliance acceptable to the CAA. (b) The strategy for detection of single failures of concern **must** include pre-flight checks.
AMC OSO5. M.A	Refer to E5, proposing a standard as an AMC.

1682

1683 ## High level of robustness (SAIL V and VI)

1684 Lower robustness level requirements to be complied with:

OSO5. L.A	OSO5. M.A

Additional requirements to be complied with:

OSO5. H.I	(a) A major failure condition **must** be no more frequent than Remote. (b) A hazardous failure condition **must** be no more frequent than Extremely Remote. (c) A catastrophic failure condition **must** be no more frequent than Extremely Improbable. (d) A single failure **must** not result in a catastrophic failure condition. (e) Software and airborne electronic hardware whose development errors could directly lead to a failure affecting the operation in such a way that it can be reasonably expected that a fatality will occur, **must** be developed to a standard or means of compliance acceptable to the CAA.
OSO5. H.A	No additional requirements.

GM OSO5. H.I	(a) (b) (c) Safety objectives may be derived from JARUS AMC RPAS.1309 Issue 2 Table 3 depending on the UAS class. (e) Development assurance levels for software and airborne electronic hardware may be derived from JARUS AMC RPAS.1309 Issue 2 Table 3 depending on the UAS class.

1687

OSO 6 – C3 link characteristics

1688

TECHNICAL ISSUE WITH THE UAS		LEVEL of INTEGRITY		
		Low (SAIL II, III)	**Medium (SAIL IV)**	**High (SAIL V, VI)**
OSO 6 **C3 link characteristics (e.g. performance, spectrum use) are appropriate for the operation**	Criterion	OSO6.L.I	OSO6.L.I	OSO6.L.I OSO6.H.I
		LEVEL of ASSURANCE		
		Low (SAIL II, III)	**Medium (SAIL IV)**	**High (SAIL V, VI)**
	Criterion	OSO6.L.A	OSO6.L.A OSO6.M.A	OSO6.L.A OSO6.M.A

1689

GM. OSO6

(a) In this OSO, the term "C3 link" encompasses:

(1) The Command and Control (C2) link, and

(2) Any communication link required for the safety of the flight.

(b) To correctly assess the integrity of this OSO, the applicant should identify:

(1) The C3 links performance requirements necessary for the intended operation.

(2) All C3 links, together with their actual performance and Radio Frequency (RF) spectrum usage.

The specification of performance and RF spectrum for a C2 Link is typically documented by the UAS designer in the UAS manual.

Main parameters associated with C2 link performance (RLP) and the performance parameters for other communication links (e.g. RCP for communication with ATC) include, but are not limited to the following:

(i) Transaction expiry time

(ii) Availability

(iii) Continuity

(iv) Integrity

The Applicant should refer to ICAO references for definitions, and to JARUS RPAS "Required C2 Performance" (RLP) concept.

(3) The RF spectrum usage requirements for the intended operation (including the need for authorization if required).

The UAS operator should ensure that the radio spectrum used for the C3 Link and for any payload communications complies with the relevant Ofcom requirements and that any licenses required for its operation have been obtained. The operator should ensure that the appropriate aircraft radio licence has been obtained for any transmitting radio equipment that is installed or carried on the aircraft, or that is used in connection with the conduct of the flight and that operates in an aeronautical band. There are no specific frequencies allocated for use by UAS in the UK, however the most used frequencies are 35 MHz, 2.4 GHz and 5.8 GHz. 35 MHz is a frequency designated for model aircraft use only, with the assumption that clubs and individuals will be operating in a known environment to strict channel allocation rules. It is therefore not considered to be a suitable frequency for more general UAS operations (i.e., not in a club environment). 2.4 GHz is a licence free band, although this is considered to be far more robust to interference than 35 MHz, operators must act with appropriate caution in areas where it is expected that there will be a high degree of 2.4 GHz activity. 5.8 GHz is a licenced band which requires a minimum payment and registration with Ofcom.

(4) Environmental conditions that might affect the C3 links performance.

Low level of robustness (SAIL II and III)

OSO6.L.I	(a) The performance, RF spectrum usage and environmental conditions for C3 links **must** be adequate to safely conduct the intended operation. (b) The remote pilot **must** have the means to continuously monitor the C3 performance and to ensure that the performance continues to meet the operational requirements.
OSO6.L.A	The Applicant **must** provide evidence of compliance with the Integrity requirements.
AMC.OSO6.L.I	(a) The use of unlicensed frequency bands may be acceptable under certain conditions, such as: (1) The Applicant demonstrates compliance with other RF spectrum usage requirements (e.g. Directive 2014/53/EU, CFR Title 47 Part 15 Federal Communication Commission (FCC) rules). Demonstration may be shown by the FCC marking on the equipment. And,

		(2) The Applicant provides evidence of the use of mechanisms to protect against interference (e.g. FHSS frequency deconfliction by procedure).
	(b)	This may be demonstrated by monitoring the C2 link signal strength and receiving an alert from the UAS HMI if the signal becomes too low (SAIL II and III only).
GM. OSO6. L.I	(b)	The remote pilot should have continuous and timely access to the relevant C3 information that could affect the safety of flight.

1692

1693 ## Medium level of robustness (SAIL IV)

1694 Lower robustness level requirements to be complied with:

OSO6. L.I	OSO6. L.A

Additional requirements to be complied with:

OSO6. M.I	No additional requirements.
OSO6. M.A	The C3 link performance **must** be demonstrated per a standard or means of compliance acceptable to the CAA.
AMC. OSO6. M.A	Refer to E5, proposing a standard as an AMC.
GM. OSO6. M.I	Depending on the intended operation: (a) The use of licensed frequency bands may be required by the CAA. (b) The use of non-aeronautical bands (e.g. licensed bands for cellular network) may be acceptable.

1695

1696 ## High level of robustness (SAIL V and VI)

1697 Lower robustness level requirements to be complied with:

OSO6.L.I	OSO6.L.A	OSO6.M.I	OSO6.M.A

Additional requirements to be complied with:

OSO6.H.I	Licensed frequency bands **must** be used for the C2 link.
OSO6.H.A	No additional requirements.
AMC.OSO6.H.I	Depending on the operation: The use of non-aeronautical bands (e.g. licensed bands for cellular network) may be acceptable. The use of bands allocated to the aeronautical mobile service for the use of C2 Link (e.g. 5030 – 5091 MHz) may be required.
GM.OSO6.H.I	The use of licensed frequency bands ensures a minimum level of performance and is not limited to aeronautical licensed frequency bands (e.g. licensed bands for cellular network). Nevertheless, some operations may require the use of bands allocated to the aeronautical mobile service for the use of C2 Link (e.g. 5030-5091 MHz). In any case, the use of licensed frequency bands requires authorisation.

1700
OSO 7 – Conformity check of the UAS configuration

1701

		LEVEL of INTEGRITY		
		Low (SAIL I, II)	**Medium (SAIL III, IV)**	**High (SAIL V, VI)**
OSO 7 **Conformity check of the UAS configuration**	Criterion	OSO7.L.I	OSO7.L.I	OSO7.L.I
		LEVEL of ASSURANCE		
		Low (SAIL I, II)	**Medium (SAIL III, IV)**	**High (SAIL V, VI)**
	Criterion 1 (Procedures)	OSO7C1.L.A	OSO7C1.L.A OSO7C1.M.A	OSO7C1.L.A OSO7C1.M.A
	Criterion 2 (Training)	OSO7C2.L.A	OSO7C2.M.A	OSO7C2.M.A OSO7C2.H.A

1702

GM. OSO7

The intent of OSO 7 is that the Operator assures that the configuration of the UAS intended to be used for the operation c conforms to the UAS design data considered under the SORA process.

This OSO does not describe a pre- or post-flight inspection as part of normal operations, which is addressed in OSO 8.

1703

1704
Low level of robustness (SAIL I and II)

OSO7.L.I

Conformity check procedures **must** be developed which periodically ensures the following:

(a) The UAS intended to be used for the operation is in a condition for safe operation.

(b) The UAS configuration conforms to the UAS design data, including any design limitations, considered under the approved concept of operation.

OSO7 C1. L.A

Criterion 1 – Procedures

(a) The UAS conformity check procedure **must** include the UAS Designer instructions, if available.

(b) The Applicant **must** provide evidence of compliance with the Integrity requirements.

OSO7 C2 L.A	<u>Criterion 2 – Training</u> (a) The remote crew is trained to perform the UAS conformity check. (b) The Applicant **must** provide evidence of compliance with the Integrity requirements.
GM. OSO7 C1 L.I	(a) The periodicity of the conformity check should be included in the procedures. (b) An example of design limitation is the maximum payload mass.

1705

1706 ## Medium level of robustness (SAIL III and IV)

1707 Lower robustness level requirements to be complied with:

OSO7. L.I	OSO7 C1. L.A

Additional requirements to be complied with:

OSO7. M.I.	No additional requirements.
OSO7 C1. M.A	<u>Criterion 1 – Procedures</u> The UAS conformity check procedures **must** make use of checklists.
OSO7 C2. M.A	<u>Criterion 2 – Training</u> (a) A training syllabus including a UAS conformity check procedure is available. (b) Evidence of theoretical and practical training is available. (c) The Applicant **must** provide evidence of compliance with the Integrity requirements

1708

1709 ## High level of robustness (SAIL V and VI)

1710 Lower robustness level requirements to be complied with:

OSO 7. L.I	OSO 7C1. L. A	OSO 7C2. M.A

Additional requirements to be complied with:

OSO 7. H.I	No additional requirements.
OSO 7C1. H.A	<u>Criterion 1 – Procedures</u> No additional requirements.
OSO 7C2. H.A	<u>Criterion 2 – Training</u> No additional requirements.

OSO 8 – Operational procedures are defined, validated, and adhered to

Operational Procedures		**LEVEL of INTEGRITY**		
		Low (SAIL I)	**Medium (SAIL II)**	**High (SAIL III to VI)**
OSO 8 **Operational procedures are defined, validated, and adhered to.**	Criterion 1 (Procedures)	OSO8C1.L.I	OSO8C1.L.I	OSO8C1.L.I
	Criterion 2 (Human Error)	OSO8C2.L.I	OSO8C2.M.I	OSO8C2.M.I OSO8C2.H.I
	Criterion 3 (Emergency Response Plan)	OSO8C3.L.I	OSO8C3.L.I	OSO8C3.L.I
		LEVEL of ASSURANCE		
		Low (SAIL I, II)	**Medium (SAIL III, IV)**	**High (SAIL V, VI)**
	Criterion 1 (Procedures) Criterion 2 (Human Error) Criterion 3 (Emergency Response Plan)	OSO8.L.A	OSO8.M.A	OSO8.M.A OSO8.H.A
	FTB	FTOSO8.L.A	FTOSO8.L.A	FTOSO8.L.A

GM. OSO8

(a) Operational procedures 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.

(b) Standard Operating Procedures (SOP) are 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 during normal situations.

(c) 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 enable the return to using standard operating procedures or allow the safe cessation of the flight.

(d) Emergency Procedures are intended to mitigate the effect of failures that cause or lead to an emergency condition.

(e) The Emergency Response Plan (ERP) deals with the potential hazardous secondary or escalating effects after a loss of control of the operation (e.g., in the case of ground impact, mid-air collision or flyaway) and is decoupled from the Emergency Procedures, as it does not deal with the control of the UA

Low level of robustness (SAIL I)

OSO8 C1. L.I

Criterion 1 – Procedures

Operational procedures appropriate for the proposed operation **must** be defined and as **must** cover the following elements:

(a) Flight planning.
(b) Pre and post-flight inspections.
(c) Procedures to evaluate environmental conditions before and during the mission (i.e. real-time evaluation) including assessment of meteorological conditions (METAR, TAFOR, etc.) with a simple recording system.
(d) Procedures to cope with unintended adverse environmental conditions (e.g. when ice is encountered during an operation not approved for icing conditions).
(e) Normal procedures.
(f) Contingency procedures (to cope with abnormal situations).
(g) Emergency procedures (to cope with emergency situations),
(h) Pre-flight procedures including briefing of any involved persons about the potential risks and actions to take in case of misbehaviour of the UA.
(i) Occurrence reporting procedures.

If available, operational procedures provided by the UAS designer should be utilised.

OSO8 C2. L.I

The operational procedures **must** provide:

(a) A clear distribution and assignment of tasks
(b) An internal checklist to ensure staff are adequately performing assigned tasks.

OSO8 C3. L.I

The (ERP) **must**:

(a) be suitable for the situation.
(b) effectively mitigates all anticipated hazardous secondary effects after the initial crash.

	(c) clearly delineates Remote Crew member(s) duties during an emergency. (d) Is easily accessible and practical to use. (e) The Remote Crew have received training and can execute the procedures effectively under stress. The ERP **must** contain at minimum: (a) the list of anticipated emergency situations with secondary effects; (b) the procedures for each of the identified anticipated emergency situation (including criteria to identify each of these situations); (c) the list of relevant contacts to reach (e.g. Air Traffic Control, police, fire brigade, first responders)
OSO8. L.A	Criterion 1, 2, and 3 The Applicant **must** provide evidence of compliance with the Integrity requirements.
OSO8 FT L.A	Criterion 1, 2, and 3 using FTB method FUNCTIONAL TEST-BASED METHODS (for SAILs up to IV included) The applicant has evidence of FTB flight hours proportionate to the risk/SAIL of the operation meeting one of the set of conditions described either in section 3(c) or section 3(d) which have been executed: (a) within the full operational scope/envelope intended by the UAS Operator, and (b) following the operational procedures referred to in the operational authorization, then the assurance that the operational procedures are adequate is met at the level corresponding to the SAIL being demonstrated by the functional test-based approach.
GM. OSO8 C1 L.I	(a) A feasibility study shall initially be conducted as part of the flight planning to identify potential hazards. The feasibility study should comprise of the following: (1) Identification of the AOO, TOLAs, holding/loiter areas and emergency landing areas (2) Identification of the landowner for TOAL and any permissions required (3) Identification of the airspace, the likely amount of air traffic and any permissions required (4) Identification of public access points (5) On site hazards (6) Offsite hazards

(b) The UAS system shall be assembled and checked it is safe to be flown by the remote pilot. Materials to assist with this include the following:
- (1) Manufacturers guidance
- (2) The user manuals for the UAS, payload and ancillary equipment
- (3) In-house procedures and checklists

(c) The following weather conditions shall be checked before flight and monitored throughout the flight:
- (1) Wind strength at the operating height
- (2) Wind direction
- (3) Urban effects (wind shear, vortices, and turbulence)
- (4) Precipitation
- (5) Visibility

(d)

(e)

(f)

(g)

(h) The emergency procedures should as a minimum include:
- (1) Abnormal environmental conditions - Visibility
- (2) Abnormal environmental conditions - Wind
- (3) Air incursion
- (4) Air excursion
- (5) Control signal loss
- (6) Fire
- (7) LOC
- (8) GNSS signal loss
- (9) Ground incursion
- (10) Landing gear failure - Fixed wing
- (11) Landing gear failure - Multirotor
- (12) Loss of control
- (13) Power loss - CU
- (14) Power loss (partial)
- (15) Power loss (full)
- (16) Propulsion system loss (full or partial) - Fixed wing
- (17) Propulsion system loss (full) - Multirotor
- (18) Propulsion system loss (single motor) -
- (19) Propulsion system loss (multiple motors)
- (20) Navigation light failure at night
- (21) Pilot incapacitation
- (22) Structural failure

(i) The following occurrences shall be reported:
- (1) Technical failure:
  - (i) Technical failure during transfer to/from launch control/mission control stations
  - (ii) Functional failures
  - (iii) Loss of C2 link
  - (iv) Loss of navigation function
  - (v) Command unit configuration changes/errors
  - (vi) Loss of communication between remote pilot stations
  - (vii) Display failures

(viii) Structural failures that resulted in control difficulties or loss of the aircraft
(ix) Airspace infringement
(x) Any technical failure that resulted in injury to a third party

(2) Human factors
(i) Human error during transfer to/from launch control/mission control stations
(ii) Functional failures of the UAS which led to loss of situational awareness
(iii) Mishandling by the pilot in command including mis-selection of flight parameters via the Command Unit (CU)
(iv) Crew resource management failures / confusion
(v) Human errors
(vi) Pilot incapacitation
(vii) Any human error that resulted in injury to a third party

A full list of reportable occurrences can be found in UK Reg (EU) No 2015/1018 (the UK MOR Occurrences Regulation).

(3) Mandatory Occurrence Reporting Scheme (MORS).

All occurrences shall be reported as an MOR within 72 hours in accordance with UK Reg (EU) No 376/2014 (the UK Mandatory Occurrence Reporting Regulation).

MORs are submitted online via ECCAIRS2 web portal:
https://aviationreporting.eu/
Any serious accident or incident must also be reported to the Air Accident Investigation Branch:

Air Accidents Investigation Branch
Farnborough House
Berkshire Copse Road
Aldershot
HANTS
GU11 2HH
24 hour accident/incident reporting line: +44 (0) 1252 512299
Administration and general enquiries Tel: +44 (0) 1252 510300
Fax: +44 (0) 1252 376999
E-mail: enquiries@aaib.gov.uk

(4) Occurrence investigation. In the event of an occurrence the UAS operator shall be informed immediately. A full investigation shall be conducted to find out what occurred and why. To aid the investigation, evidence shall be gathered in the form of:
(i) Photographs
(ii) Witness statements
(iii) Digital flight logs
(iv) Onsite paperwork, including the risk assessment
(v) Weather conditions at the time

(5) Occurrence outcome actions
(i) All flight crew will be debriefed about the occurrence to ascertain how and why it happened. The results of the investigation will form the basis of new procedures to prevent the same occurrence happening again. All flight crew will be informed of the investigation outcome and trained in any new procedures.

GM. OSO8 C2 L.I	
GM. OSO8 C3 L.I	The Emergency Response Plan (ERP) should be used after an occurrence. The priorities are: 1. Protect uninvolved people 2. Protect property 3. Gather evidence 4. Submit and occurrence report 5. Conduct an investigation 6. Deliver outcome actions to prevent a repeat occurrence

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1721 ## Medium level of robustness (SAIL II)

1722 Lower robustness level requirements to be complied with:

OSO8 C1 L.I	OSO8 C3 L.I

Additional requirements to be complied with:

OSO8 C2. M.I	The operational procedures **must** take human error into consideration.
OSO8 M.A	<u>Criterion 1, 2, and 3.</u> (a) Operational procedures and ERP are developed to standards considered adequate by the CAA and/or in accordance with a means of compliance acceptable to the CAA. (b) Adequacy of the Contingency and Emergency procedures is proven through: (1) Dedicated flight tests. (2) Simulation provided the simulation is proven valid for the intended purpose with positive results. (c) The Applicant **must** provide evidence of compliance with the Integrity requirements.

OSO8 FT M.A	No additional requirements

High level of robustness (SAIL III to VI)

Lower robustness level requirements to be complied with:

OSO8 C1 L.I	OSO8 C3 L.I	OSO8 C2 M.I	OSO8 M.A

Additional requirements to be complied with:

OSO8 C2. H.I	Same as Medium. In addition, the Remote Crew receives Crew Resource Management (CRM) training.

OSO 8 H.A	Same as Medium. In addition: (a) Flight tests performed to validate the procedures and checklists cover the complete flight envelope or are proven to be conservative.

OSO 8FT. H.A	No additional requirements

1729

OSO 9 – Remote crew trained and current

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REMOTE CREW COMPETENCIES		LEVEL of INTEGRITY		
		Low (SAIL I & II)	**Medium (SAIL III & IV)**	**High (SAIL III to VI)**
OSO 09 **Remote crew trained and current**	Criterion 1 Remote Pilot Competence	OSO9C1.L.I	OSO9C1.L.I	OSO9C1.L.I
	Criterion 2 Type Training	OSO9C2.L.I	OSO9C2.L.I	OSO9C2.L.I
		LEVEL of ASSURANCE		
		Low (SAIL I, II)	**Medium (SAIL III, IV)**	**High (SAIL V, VI)**
	Criterion 1 Remote Pilot Competence	OSO9C1.L.A	OSO9C1.L.A	OSO9C1.L.A
	Criterion 2 Type Training	OSO9C2.L.A	OSO9C2.L.A	OSO9C2.L.A

1731

GM OSO9

OSO 9 is divided into two criteria for UK SORA to consider the remote pilot competence framework due to implemented in 2024.

C1 sets out how the applicant should demonstrate that remote pilots and crew are competent.

C2 sets out how the applicant should demonstrate the operator has trained its flight crew on the specific UA type and the operator SOPs.

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Low level of robustness (SAIL I & II)

OSO9 C1. L.I

(a) The remote pilot **must** have the following theoretical knowledge:

(1) UAS regulation

(2) UAS airspace operating principles

(3) Airmanship and aviation safety

(4) Human performance limitations

(5) Meteorology and assessment of meteorological conditions

(6) Navigation/Charts

(7) UA knowledge

(8) Operational procedures and ERP

	(9) Use of external services, including service limitations and system recovery if any (b) The remote pilot **must** hold a valid remote pilot competence certificate. (c) The remote pilot **must** be current in accordance with conditions of the remote pilot competence certificate. (d) Other members of the flight crew **must** be competent.
OSO9 C2 L.I	A training programme **must** be developed by the operator. The training **must** be proportional to the risk of the operation but as a minimum **must** cover the following subjects: (a) UA specific technical knowledge (b) Operator specific procedures including (1) Operator specific SOPs (2) ERP (c) Use of external services, including service limitations and system recovery if any.
OSO9 C1 L.A	(a) Remote pilot competence has been assessed by a CAA approved Recognised Assessment Entity (RAE) and a remote pilot certificate has been issued by the CAA.
OSO9 C2 L.A	The Applicant **must** provide evidence of compliance with the Integrity requirements.
AMC. C1 OSO9. L.I	(a) The remote pilot has a valid remote pilot competence certificate issued by a CAA approved Recognised Assessment Entity (b) The privileges and conditions of the certificate are sufficient for the proposed operation in accordance with UK Regulation (EU) 2019/947 Article 8 AMC(1).
AMC. C2 OSO9. L.I	Refer to E5, proposing a standard as an AMC

Medium level of robustness (SAIL III & IV)

Lower robustness level requirements to be complied with:

OSO 9. L.I	OSO 9. L.A

No additional requirements

High level of robustness (SAIL V & VI)

Lower robustness level requirements to be complied with:

OSO 9. L.I	OSO 9. L.A

No additional requirements

OSO 13 – External services supporting UAS operations are adequate to the operation

DETERIORATION OF EXTERNAL SERVICES SUPPORTING UAS OPERATION		LEVEL of INTEGRITY		
		Low (SAIL I & II)	**Medium (SAIL III)**	**High (SAIL IV to VI)**
OSO 13 **External services supporting UAS operations are adequate to the operation**	Criterion	OSO13.L.I	OSO13.L.I	OSO13.L.I
		LEVEL of ASSURANCE		
		Low (SAIL I, II)	**Medium (SAIL III)**	**High (SAIL IV, VI)**
	Criterion	OSO13.L.A	OSO13.L.A	OSO13.L.A

GM OSO13	For the purpose of the SORA and this specific OSO, the term “External services supporting UAS operations“ encompasses any interaction with an external Service Provider critical for the safety of the flight, e.g. ● Communication Service Provider (CSP), ● Navigation Service Provider (e.g. Global navigation satellite system), ● UTM Service Providers (including surveillance Supplemental Data Service Provider (SDSP), weather SDSP), ● Externally provided electrical power (e.g. in the case where no emergency backup generator is available and the safety of the flight is dependent on continuous power delivery). The interface between the UAS Operator and the external services may take the form of a Service Level Agreement (SLA).

Low level of robustness (SAIL I and II)

OSO13. L.I	
	(a) The applicant **must** ensure that the level of performance for any externally provided service critical for the safety of the flight is adequate for the intended operation. (b) If the externally provided service requires communication between the Operator and the Service Provider, the applicant **must** ensure there is effective communication to support the service provisions. (c) Roles and responsibilities between the applicant and the external Service Provider **must** be defined.

OSO13 L.A	The Applicant **must** provide evidence of compliance with the Integrity requirements. The supporting evidence **must** demonstrate that the required level of performance for any externally provided service required for the safety of the flight can be achieved for the full duration of the mission.

AMC OSO13. L.A	Refer to E5, proposing a standard as an AMC

GM OSO13 L.I	Supporting evidence may take the form of a Service-Level Agreement (SLA) or any official commitment that prevails between a Service Provider and the applicant on relevant aspects of the service (including quality, availability, responsibilities). As an example, if an applicant uses an external surveillance service they should have evidence available supporting the claim that the service meets performance requirements in Annex D

Medium level of robustness (SAIL III)

Lower robustness level requirements to be complied with:

OSO 13. L.I	OSO 13. L.A

No additional requirements

High level of robustness (SAIL IV to VI)

Lower robustness level requirements to be complied with:

OSO 13. L.I	OSO 13. L.A

No additional requirements

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OSO 16 – Multi crew coordination

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HUMAN ERROR		LEVEL of INTEGRITY		
		Low (SAIL I, II)	Medium (SAIL III, IV)	High (SAIL V, VI)
OSO 16 Multi crew coordination	Criterion 1 (Procedures)	OSO16C1.L.I	OSO16C1.L.I	OSO16C1.L.I
	Criterion 2 (Training)	OSO16C2.L.I	OSO16C2.L.I OSO16C2.M.I	OSO16C2.L.I OSO16C2.M.I
	Criterion 3 (Communication devices)	N/A	OSO16C3.M.I	OSO16C3.M.I OSO16C3.H.I
		LEVEL of ASSURANCE		
		Low (SAIL I, II)	Medium (SAIL III, IV)	High (SAIL V, VI)
	Criterion 1 (Procedures)	OSO16C1.L.A	OSO16C1.M.A	OSO16C1.M.A OSO16C1.H.A
	Criterion 2 (Training)	OSO16C2.L.A	OSO16C2.M.A	OSO16C2.H.A
	Criterion 3 (Communication devices)	N/A	OSO16C3.M.A	OSO16C3.M.A
	Alternative FTB method for Criterion 1	OSO16FT.L.A	OSO16FT.L.A	N/A

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GM. OSO 16	This OSO is only applicable when multiple personnel are directly involved in the flight operation.

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1764
Low level of robustness (SAIL I and II)

OSO 16C1.L.I

Criterion 1 – Procedures

(a) The applicant **must** develop procedure(s) to ensure coordination between the crew members and as a minimum cover:

(1) Definition of crew roles and responsibilities

(2) Assignment of tasks to the crew

	(3) Communication plan, including the use of correct aviation phraseology between the remote crew members and third parties where applicable.
OSO 16C2 L.I	<u>Criterion 2 – Training</u> The applicant **must** conduct Remote Crew training which covers multi crew coordination prior to operating.
OSO 16C1. L.A	<u>Criterion 1 – Procedures</u> The Applicant **must** provide evidence of compliance with the Integrity requirements. The procedure does not need to conform to an industry standard accepted by the CAA, however, it is recommended.
OSO 16C2 L.A	<u>Criterion 2 – Training</u> The Applicant **must** provide evidence of compliance with the Integrity requirements. The procedure does not need to conform to an industry standard accepted by the CAA, however, it is recommended.
OSO 16FT. L.A	<u>Criterion 1 – Procedures</u> The applicant **must** provide evidence of FTB flight hours proportionate to the risk/SAIL of the operation meeting one of the set of conditions described in the FTB policy. (a) Within the full operational scope/envelope of the intended operation, and (b) Following the operational procedures referred to in the OA application.
GM. OSO 16FT. L.A	The FTB method is an alternative means of compliance with OSO16 Criterion 1 (Procedures) assurance requirements. Compliance with the requirement provides assurance that the operational procedures are adequate at the level corresponding to the SAIL being demonstrated by the FTB approach. As an example, if the number of test cycles supporting the FTB flying hours is proportionate to the risk of a SAIL III operation (i.e. 3,000 FH), the assurance level for OSO16 Criterion 1 (Procedures) is satisfied at a medium level of robustness.

1767 ## Medium level of robustness (SAIL III and IV)

1768 Lower robustness level requirements to be complied with:

OSO 16C1. L.I	OSO 16C2. L.I

Additional requirements to be complied with:

OSO 16C1. M.I	Criterion 1 – Procedures No additional requirements.
OSO1 6C2 M.I	Criterion 2 – Training (a) Same as Low. In addition, the Remote Crew receives Crew Resource Management (CRM) training.
OSO 16C3. M.I	Criterion 3 – Communication devices (a) The performance of communication devices **must** be adequate to safely conduct the intended operation. (b) The remote crew **must** have the means to verify the performance of the communication devices at intervals deemed appropriate to ensure the performance continues to meet the operational requirements.
OSO 16C1. M.A.	Criterion 1 – Procedures The Applicant **must** provide evidence of compliance with Integrity requirements. The procedures **must** meet a standard an accepted by the CAA or AMC.
OSO 16C2. M.A.	Criterion 2 – Training The Applicant **must** provide evidence of compliance with Integrity requirements. The procedures **must** meet a standard an accepted by the CAA or AMC.
OSO 16C3. M.A.	Criterion 3 – Communication devices (a) The Applicant **must** provide evidence of compliance with Integrity requirements.

	(b)	If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified.
	(c)	If (a), (b) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that the performance and limitations of the communication devices provided by the Designer are adequate for the intended operation.

OSO 16FT. M.A.

Criterion 1 – Procedures

The Applicant **must** comply with the requirements of OSO16FT.L.A.

GM. OSO 16C3. M.A

Criterion 3 – Communication devices

(a) Compliance evidence is typically provided through testing, analysis, simulation, inspection, design review or through operational experience.

(c) Designer data is found on the SAIL mark certificate.

GM. OSO 16C3. M.A

Criterion 3 – Communication devices

(a) Compliance evidence is typically provided through testing, analysis, simulation, inspection, design review or through operational experience.

(c) Designer data is found on the SAIL mark certificate.

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1770 ## High level of robustness (SAIL V and VI)

1771 Lower robustness level requirements to be complied with:

OSO16 C1. L.I	OSO16 C2. L.I	OSO16 C1. M.A	OSO16 C2. M.I	OSO16 C2. M.A	OSO16 C3. M.I	OSO16 C3. M.A

Additional requirements to be complied with:

OSO16 C1. H.I

Criterion 1 – Procedures

No additional requirements.

OSO16 C2. H.I

Criterion 2 – Training

No additional requirements.

OSO16 C3. H.I	Criterion 3 – Communication devices (a) The communication devices **must** be redundant. (b) The communication devices **must** be developed to a standard or means of compliance acceptable to the CAA.
OSO16 C1. H.A.	Criterion 1 – Procedures No additional requirements.
OSO16 C2. H.A.	Criterion 2 – Training No additional requirements.
OSO16 C3. H.A.	Criterion 3 – Communication devices No additional requirements.
AMC. OSO16 C3. H.I	(b) Refer to E5, proposing a standard as an AMC
GM. OSO16 C3. H.I	(a) This implies the provision of an extra device to mitigate the risk of failure of the first device.

1781

OSO 17 – Remote crew is fit to operate

HUMAN ERROR		LEVEL of INTEGRITY		
		Low (SAIL I & II)	Medium (SAIL III & IV)	High (SAIL V & VI)
OSO 17 Automatic protection of the flight envelope from human errors	Criterion	OSO17.L.I	OSO17.M.I	OSO17.M.I
		LEVEL of ASSURANCE		
		Low (SAIL III)	Medium (SAIL IV)	High (SAIL V, VI)
	Criterion	OSO17.L.A	OSO17.L.A OSO17.M.A	OSO17.L.A OSO17.M.A

1782

GM. OSO 17	For this assessment, the expression “fit to operate” should be interpreted as physically and mentally fit to perform duties and discharge responsibilities safely. Fatigue and stress are contributory factors to human error. Therefore, to ensure vigilance is maintained at a satisfactory level of safety, consideration may be given to the following: • Remote Crew workload and duty times; • Regular breaks; • Rest periods; • Handover/Take Over procedures; • Personal Protective Equipment (PPE); • Workplace environment, including ergonomics of the workstation.

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Low level of robustness (SAIL I & II)

OSO 17. L.I	(a)	The Applicant **must** have a policy defining the criteria and the means for the remote crew to declare themselves fit before starting their duty and report themselves unfit, if required, during their shift.
	(b)	Where the certificate of remote pilot competence for any crew member requires a formal medical certificate, the applicant **must** have a procedure to periodically check its validity.
OSO 17. L.A	(a)	The Applicant **must** provide evidence of compliance with Integrity requirement.

AMC. OSO 17. L.A

(a) A crew briefing including a record of an 'IMSAFE' check for all crew members is sufficient

GM. OSO 17. L.I

The regulatory requirement is that remote pilots must not perform their duties under the influence of alcohol. [UAS.SPEC.060(1)(a)].

While no actual limits are specified, because of the more advanced nature of flying in the Specific category, and in particular the requirement to comply with the precise conditions of the operational authorisation, the limits prescribed for manned aviation in Railways and Transport Safety Act 2003 (RTSA 2003) Section 93 should be complied with. •

These limits are:

Level of alcohol	All UK nations
Micrograms per 100 millilitres of breath	9
Micrograms per 100 millilitres of blood	20
Micrograms per 100 millilitres of urine	27

Summary of alcohol limits set out within the RTSA 2003

Personnel carrying out support functions that are directly related to the safe operation of the UA while in flight, such as unmanned aircraft observers, or airspace observers, should comply with the same limitations.

1785 ## Medium level of robustness (SAIL III & IV)

1786 Lower robustness level requirements to be complied with:

OSO 17. L.I

OSO 17. L.A

Additional requirements to be complied with:

OSO 17. M.I.

Same as Low. In addition:

(a) The maximum flight crew duty period and resting times for the remote crew **must** be defined by the applicant and adequate for the operation.

(b) The Operator defines requirements appropriate for the remote crew to operate the UAS.

OSO 17. M.A	Same as Low. In addition: The Applicant **must** provide evidence of compliance with Integrity requirements including: (a) Remote crew duty, flight duty and the resting times policy is documented. (b) Remote crew duty cycles are logged and cover at a minimum: (c) when the remote crew member's duty day commences, (d) when the remote crew members are free from duties, (e) resting times within the duty cycle.
AMC. OSO 17. M.A	Refer to E5, proposing a standard as an AMC
GM. OSO 17. M.I	Fatigue and stress are contributory factors which are likely to increase the propensity for human error. Therefore, to ensure that vigilance is maintained at a satisfactory level in terms of safety, consideration must be given to the following: • Crew duty times; • Regular breaks; • Rest periods and opportunity for napping during circadian low periods; • Health and Safety requirements • Handover/Take Over procedures; • The crew responsibility and task/cognitive workload (including the potential for 'boredom'); • Ability to mitigate the effects from non-work areas (e.g. financial pressure causing anxiety). The work regime across the crew must take this into account. Where required, an effective Fatigue Reporting System should be implemented within the organisation to increase awareness of fatigue or stress risks and mitigate them accordingly.

Further information to support Fatigue Management approaches for safety relevant workers can be found in the ICAO Fatigue Management guidance material (Doc. 9966).

High level of robustness (SAIL V and VI)

Lower robustness level requirements to be complied with:

OSO 17. L.A | OSO 17. M.A | OSO 17. M.I

Additional requirements to be complied with:

OSO 17. H.I. — No additional requirements.

OSO 17. H.A — No additional requirements.

1791 1792 OSO 18 – Automatic protection of the flight envelope from human errors

1793

HUMAN ERROR		LEVEL of INTEGRITY		
		Low (SAIL III)	**Medium (SAIL IV)**	**High (SAIL V, VI)**
OSO 18 **Automatic protection of the flight envelope from human errors**	Criterion	OSO18.L.I	OSO18.M.I	OSO18.M.I
		LEVEL of ASSURANCE		
		Low (SAIL III)	**Medium (SAIL IV)**	**High (SAIL V, VI)**
	Criterion	OSO18.L.A	OSO18.L.A OSO18.M.A	OSO18.L.A OSO18.M.A

1794

GM. OSO 18	UA are designed with a flight envelope that describes their safe performance limits with regard to minimum and maximum operating speeds and operating structural strength. Automatic protection of the flight envelope is intended to prevent the remote pilot from operating the UA outside its flight envelope. If the Applicant can demonstrate that the remote pilot is not in the loop, OSO 18 is not applicable. The automatic protection function ensures that the UA is operated within an acceptable flight envelope margin even in the case of incorrect remote-pilot control input (human error). UAS without automatic protection function are susceptible to incorrect remote-pilot control inputs which may result in the loss of the UA if the performance limits of the aircraft are exceeded. Failures or development errors of the flight envelope protection function are addressed in OSO 5.

1795

1796 Low level of robustness (SAIL III)

OSO 18. L.I	The UAS **must** include an automatic protection of the flight envelope function which prevents a single input from the remote pilot under normal operating conditions from: (a) Causing the UA to exceed its flight envelope, or, (b) Preventing the UA from recovering in a timely fashion.

OSO 18. L.A	The Applicant **must** provide evidence of compliance with Integrity requirements.
AMC. OSO 18. L.A	The automatic protection of the flight envelope may have been developed in-house or may be a commercial off-the-shelf equipment not designed to any specific standard.
GM. OSO 18. L.I	An input from the remote pilot causing the UA to exceed its flight envelope or preventing the UA from recovering from a flight envelope exceedance is considered an erroneous input caused by human error.

1797

1798 ## Medium level of robustness (SAIL IV)

1799 Lower robustness level requirements to be complied with:

OSO 18. L.A	

Additional requirements to be complied with:

OSO 18. M.I.	The UAS **must** include an automatic protection of the flight envelope function which prevents a single or multiple inputs from the remote pilot under any operating conditions from: (a) Causing the UA to exceed its flight envelope, or, (b) Preventing the UA from recovering in a timely fashion.
OSO 18. M.A	The automatic protection of the flight envelope function **must** be developed to a standard or means of compliance acceptable to the CAA.
AMC. OSO 18. M.A	Refer to E5, proposing a standard as an AMC
GM. OSO	The multiple inputs should be considered as happening simultaneously or during the time period when the UA is recovering from the first input.

18. M.I	“Any operating conditions” means that both normal and abnormal (including emergency) operating conditions should be considered.

1800

1801 ## High level of robustness (SAIL V and VI)

1802 Lower robustness level requirements to be complied with:

OSO 18. L.A | OSO 18. M.A | OSO 18. M.I

Additional requirements to be complied with:

OSO 18. H.I.	No additional requirements.
OSO 18. H.A	No additional requirements.

1803

1804

1805

OSO 19 – Safe recovery from human error

1806

HUMAN ERROR		LEVEL of INTEGRITY		
		Low (SAIL III)	**Medium (SAIL IV, V)**	**High (SAIL VI)**
OSO 19 **Safe recovery from Human Error**	Criterion	OSO19.L.I	OSO19.M.I	OSO19.M.I
		LEVEL of ASSURANCE		
		Low (SAIL III)	**Medium (SAIL IV, V)**	**High (SAIL VI)**
	Criterion	OSO19.L.A	OSO19.L.A	OSO19.L.A

1807

GM. OSO19	OSO19 addresses the risk of human errors that may affect the safety of the operation if they are not prevented or are not detected and recovered in a timely fashion. Any person involved in the operation is at risk of human errors, e.g.: • The crew incorrectly loading the payload onto the UA, causing the payload to fall off the UA during the operation. • The crew incorrectly extending or deploying an antenna mast, reducing the C2 link coverage. OSO19 covers the UAS design, i.e. systems detecting and/or recovering from human errors, e.g. functional tests, safety pins, use of acknowledgment features, fuel or energy consumption monitoring function, etc. Operational procedures and training are addressed in OSO 8 and OSO 9 respectively. Flight envelope protection from human error is addressed in OSO 18

1808

1809

Low level of robustness (SAIL III)

OSO 19. L.I	The systems detecting and/or recovering from human errors **must** be developed to industry's best practices.

OSO 19. L.A	(a)	The Applicant **must** provide evidence of compliance with the Integrity requirements.
	(b)	If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified.

GM. OSO 19. L.A	(a)	Compliance evidence is typically provided through testing, analysis, simulation, inspection, design review or through operational experience.

1810

1811 Medium level of robustness (SAIL IV and V)

1812 Lower robustness level requirements to be complied with:

OSO 19. L.A

Additional requirements to be complied with:

OSO 19. M.I.	The systems detecting and/or recovering from human errors **must** be developed to a standard or means of compliance acceptable to the CAA.
OSO 19. M.A	No additional requirements.

1813

1814 High level of robustness (VI)

1815 Lower robustness level requirements to be complied with:

OSO 19. L.A   OSO 19. M.I

Additional requirements to be complied with:

OSO 19. H.I.	No additional requirements.
OSO 19. H.A	No additional requirements.

OSO 20 – Human factors evaluation

<table>
<tr><th colspan="2" rowspan="2">HUMAN ERROR</th><th colspan="3">LEVEL of INTEGRITY</th></tr>
<tr><th>Low (SAIL II, III)</th><th>Medium (SAIL IV, V)</th><th>High (SAIL VI)</th></tr>
<tr><td rowspan="5">OSO 20

A Human Factors evaluation has been performed and the HMI found appropriate for the mission</td><td>Criterion</td><td>OSO20.L.I</td><td>OSO20.L.I</td><td>OSO20.L.I
OSO20.H.I</td></tr>
<tr><td rowspan="2"></td><th colspan="3">LEVEL of ASSURANCE</th></tr>
<tr><th>Low (SAIL II, III)</th><th>Medium (SAIL IV, V)</th><th>High (SAIL VI)</th></tr>
<tr><td>Criterion</td><td>OSO20.L.A</td><td>OSO20.M.A</td><td>OSO20.M.A</td></tr>
<tr><td>Alternative FTB method</td><td>OSO20FT.L.A</td><td>OSO20FT.L.A
(SAIL IV only)</td><td>N/A</td></tr>
</table>

Low level of robustness (SAIL II and III)

OSO 20. L.I

(a) The UAS information and control interfaces **must** be clearly and succinctly presented and **must** not confuse, cause unreasonable fatigue, or contribute to remote crew error that could adversely affect the safety of the operation.

(b) If an electronic means is used to support the remote crew members in their role to maintain awareness of the position of the unmanned aircraft, its HMI:

(1) **Must** be sufficient to allow the remote crew members to determine the position of the UA during operation.

(2) **Must** not degrade the remote crew members' ability to scan the airspace visually where the UA is operating for any potential collision hazard.

(3) **Must** not degrade the remote crew members' ability to maintain effective communication with the remote pilot at all times.

OSO 20. L.A

(a) The Applicant **must** conduct a human factors evaluation of the UAS to demonstrate that the HMI is appropriate for the mission.

(b) The HMI evaluation **must** be based on inspection or analysis.

(c) If (a), (b) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that the HMI is appropriate for the intended operation.

	(d) The Applicant **must** provide evidence of compliance with Integrity requirements.
OSO 20FT. L.A	The applicant **must** provide evidence of FTB flight hours proportionate to the risk/SAIL of the operation meeting one of the set of conditions described either in FTB policy. (a) Within the full operational scope/envelope of the intended operation, and (b) Following the operational procedures and the remote crew training referred to in the OA application.
AMC. OSO 20. L.A	Refer to E5, proposing a standard as an AMC
GM. OSO 20. L.A	(c) This may take the form of a report explaining the rationale behind the choice of UAS and aspects of the HMI that make it suitable for the intended operation.
GM. OSO 20FT. L.A	The FTB method is an alternative means of compliance with OSO 20 assurance requirements. Compliance with the requirement provides assurance that the operational procedures are adequate at the level corresponding to the SAIL being demonstrated by the FTB approach. As an example, if the number of test cycles supporting the FTB flying hours is proportionate to the risk of a SAIL III operation (i.e. 3,000 FH), the assurance level for OSO 20 is satisfied at a low level of robustness.

1821

1822 ## Medium level of robustness (SAIL IV and V)

1823 Lower robustness level requirements to be complied with:

OSO 20. L.I

Additional requirements to be complied with:

OSO 20. M.I	No additional requirements.
OSO 20. M.A	(a) The Applicant **must** conduct a human factors evaluation of the UAS to demonstrate that the HMI is appropriate for the mission. (b) The HMI evaluation **must** be based on demonstrations or simulations. (c) If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified. (d) If (a), (b), (c) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that the HMI is appropriate for the intended operation. (e) The Applicant **must** provide evidence of compliance with Integrity requirements.
OSO 20FT. M.A	The Applicant **must** comply with the requirements of OSO20FT.L.A (SAIL IV only).
AMC. OSO 20. M.A	Refer to E5, proposing a standard as an AMC
GM. OSO 20. M.A	(d) This may take the form of a report explaining the rationale behind the choice of UAS and aspects of the HMI that make it suitable for the intended operation.

1824

1825
High level of robustness (SAIL VI)

1826 Lower robustness level requirements to be complied with:

OSO 20. L.I	OSO 20. M.A

Additional requirements to be complied with:

OSO 20. H.I	The Human factors evaluation **must** include: (a) An appraisal to verify that the remote crew workload remains acceptable in both normal and emergency situations. (b) An appraisal of the efficiency of the emergency procedures in terms of efficacy of the actions and the expected potential latencies. (c) An analysis to verify the correct prioritisation of alarms in an emergency situation.
OSO 20. H.A	The human factors evaluation **must** be witnessed by the Authority.
GM. OSO 20. H.I	(c) In an emergency situation, multiple failures may lead to multiple alarms that distract and prevent the remote pilot from determining the appropriate response. If this is the case, alarms of lesser importance might be minimised or ignored by design or procedure.

1827

OSO 23 – Environmental conditions

ADVERSE OPERATING CONDITIONS		LEVEL of INTEGRITY		
		Low (SAIL I, II)	**Medium (SAIL III, IV)**	**High (SAIL V, VI)**
OSO 23 **Environmental conditions for safe operations defined, measurable and adhered to**	Criterion	OSO23.L.I	OSO23.L.I	OSO23.L.I
		LEVEL of ASSURANCE		
		Low (SAIL I, II)	**Medium (SAIL III, IV)**	**High (SAIL V, VI)**
	Criterion	OSO23.L.A	OSO23.L.A	OSO23.L.A

GM. OSO 23	Environmental conditions include meteorological conditions such as wind, rain, and icing, as well as external factors that may interfere with the performance of systems such as High-Intensity Radiated Field (HIRF).

Low level of robustness

OSO 23. L.I	(a) Environmental condition for safe operations **must** be defined and reflected in the flight manual or equivalent document. (b) The defined environmental conditions **must** include those provided by the UAS Designer, if available.

OSO 23. L.A	The Applicant **must** provide evidence of compliance with Integrity requirements.

Medium level of robustness

Lower robustness level requirements to be complied with:

OSO 23. L.I

OSO 23. L.A

Additional requirements to be complied with:

OSO 23.	No additional requirements.

M.I

OSO 23. M.A — No additional requirements.

High level of robustness

Lower robustness level requirements to be complied with:

OSO 23. L.I

OSO 23. L.A

Additional requirements to be complied with:

OSO 23. H.I — No additional requirements.

OSO 23. H.A — No additional requirements.

1841

OSO 24 – UAS designed and qualified for adverse conditions

1842

		LEVEL of INTEGRITY		
		N/A	**Medium (SAIL III)**	**High (SAIL IV, V, VI)**
OSO 24 **UAS designed and qualified for adverse environmental conditions**	Criterion	N/A	OSO24.M.I	OSO24.M.I OSO24.H.I
		LEVEL of ASSURANCE		
		N/A	**Medium (SAIL III)**	**High (SAIL IV, V, VI)**
	Criterion	N/A	OSO24.M.A	OSO24.M.A
	Alternative FTB method	N/A	OSO24FT.M.A	OSO24FT.M.A (SAIL IV only)

1843

GM. OSO 24

In order to comply with the integrity requirements of OSO24, the Applicant should determine:

- If credit can be taken for equipment's environmental qualification testing, e.g. by answering the following questions:
  - Is a Declaration of Design and Performance (DDP) available to the Applicant, stating the environmental qualification levels to which the equipment was tested?
  - Did the environmental qualification tests follow a standard considered adequate by the CAA (e.g. RTCA DO-160 "Environmental Conditions and Test Procedures for Airborne Equipment")?
  - Are the environmental qualification tests appropriate and sufficient to cover all environmental conditions expected to be encountered during the operations?
  - If the tests were not performed following a recognised standard, were the tests performed by an organisation or entity qualified or having experience in performing environmental type tests (e.g. RTCA DO-160)?
- Whether the suitability of the equipment to operate in the expected environmental conditions can be determined from either in-service experience or relevant test results?
- Any limitations which may affect the suitability of the equipment to operate in the expected environment conditions.

	The lowest integrity level should be considered where the UAS equipment only has achieved partial environmental qualification and/or a partial demonstration by similarity and/or where parts have no environmental qualification at all.

1844 ## Medium level of robustness (SAIL III)

OSO 24. M.I	The UAS **must** be designed to perform as intended in the environmental conditions defined in the flight manual or equivalent document.
OSO 24. M.A	(a) The Applicant **must** provide evidence of compliance with the Integrity requirements. (b) If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified. (c) If (a), (b) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that the environmental conditions of the intended operation have been considered by the Designer.
OSO 24 FT. M.A	The applicant **must** provide evidence of FTB flight hours proportionate to the risk/SAIL of the operation meeting one of the set of conditions described either in the FTB policy. (a) Within the full operational scope/envelope of the intended operation, and (b) Following the operational procedures and the remote crew training referred to in the OA application.
GM OSO 24. M.I	As an example, if a UAS is proposed to be operated in raining conditions, The UAS design is not required to comply with DO-160 waterproof requirements to demonstrate its suitability to operate in such conditions. The raining conditions can be limited, as long as they are representative of the environmental conditions which the UAS is designed for.
GM OSO 24. M.A	(a) Compliance evidence is typically provided through testing, analysis, simulation, inspection, design review or through operational experience. (c) Designer data is found on the SAIL mark certificate.
GM OSO 24 FT. M.A	The FTB method is an alternative means of compliance with OSO 24 assurance requirements. Compliance with the requirement provides assurance that the operational procedures are adequate at the level corresponding to the SAIL being demonstrated by the FTB approach.

	As an example, if the number of test cycles supporting the FTB flying hours is proportionate to the risk of a SAIL III operation (i.e. 3,000 FH), the assurance level for OSO 24 is satisfied at a low level of robustness.

High level of robustness (SAIL IV, V and VI)

Lower robustness level requirements to be complied with:

OSO 24. M.I	OSO 24. M.A

Additional requirements to be complied with:

OSO 24. H.I	The UAS **must** be developed to a standard or means of compliance acceptable to the CAA.
OSO 24. H.A	No additional requirements.
OSO 24FT. H.A	The Applicant **must** comply with the requirements of OSO24FT.M.A (SAIL IV only).
AMC. OSO 24. H.I	Refer to E5, proposing a standard as an AMC

1850
COR – Containment requirements

1851

		LEVEL of INTEGRITY		
		Low	**Medium**	**High**
Containment requirements	Criterion 1 (Operational volume containment)	CORC1.L.I	CORC1.L.I	CORC1.H.I
	Criterion 2 (End of flight upon exit of the operational volume)	CORC2.L.I	CORC2.L.I	CORC2.L.I
	Criterion 3 (Definition of the ground risk buffer)	CORC3.L.I	CORC3.M.I	CORC3.M.I
	Criterion 4 (Ground risk buffer containment)	N/A	CORC4.M.I	CORC4.M.I
		LEVEL of ASSURANCE		
		Low	**Medium**	**High**
	Criterion 1 (Operational volume containment)	CORC1.L.A	CORC1.L.A	CORC1.L.A
	Criterion 2 (End of flight upon exit of the operational volume)	CORC2.L.A	CORC2.M.A	CORC2.M.A
	Criterion 3 (Definition of the ground risk buffer)	CORC3.L.A	CORC3.L.A	CORC3.L.A
	Criterion 4 (Ground risk buffer containment)	N/A	CORC4.M.A	CORC4.M.A

1852

GM. COR	Determination of containment requirements addresses the risk posed by an operational loss of control that may infringe on areas adjacent to the operational volume and buffers. The level of risk inherent to the adjacent area and adjacent airspace drives the level of containment robustness to be achieved by containment design features and operational procedures. The following section provides the containment requirements for the following 3 levels of robustness: low, medium and high.

1853

Low level of robustness

COR C1. L.I

<u>Criterion 1 – Operational volume containment</u>

No probable single failure of the UAS or any external system supporting the operation **must** lead to operation outside of the operational volume (qualitative approach), or,

The probability of the failure condition "UA leaving the operational volume" **must** be less than 10^{-3}/FH (quantitative approach).

COR C2. L.I

<u>Criterion 2 – End of flight upon exit of the operational volume</u>

When the UA leaves the operational volume, an immediate end of the flight **must** be initiated through a combination of procedures and/or technical means.

COR C3. L.I

<u>Criterion 3 – Definition of the final ground risk buffer</u>

A ground risk buffer **must** be defined which adheres at least to the 1:1 principle, unless the Applicant is able to demonstrate the applicability of a smaller buffer.

COR C1. L.A

<u>Criterion 1 – Operational volume containment</u>

(a) The compliance evidence **must** at least include a design and installation appraisal which shows that:
  (1) The design and installation features, including independence claims, comply with the low integrity requirements.
  (2) Particular risks relevant to the intended operation have been addressed and do not violate any independence claim.

(b) If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified.

(c) If (a), (b) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that the following aspects considered by the Designer are relevant to the intended operation:
  (1) External systems.
  (2) The operational volume is the same as or contains the operational volume considered by the Designer.
  (3) Particular risks.

(d) The Applicant **must** provide evidence of compliance with Integrity requirements.

COR

<u>Criterion 2 – End of flight upon exit of the operational volume</u>

C2. L.A	(a) The adequacy of the procedures to initiate an immediate end of the flight **must** be tested. (b) If (a) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that the procedures developed by the Designer in (a) are followed by the Operator. (c) The Applicant **must** provide evidence of compliance with Integrity requirements. (d) If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified.
COR C3. L.A	<u>Criterion 3 – Definition of the final ground risk buffer</u> (a) The Applicant **must** provide evidence of compliance with Integrity requirements. (b) If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified. (c) If (a), (b) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that the ground risk buffer is the same as or contains the ground risk buffer defined by the Designer.
AMC. COR C3. L.I	<u>Criterion 3 – Definition of the final ground risk buffer</u> A smaller than 1:1 ground risk buffer value may be demonstrated by the Applicant for a rotary wing UA using a ballistic methodology approach.
AMC. COR C1. L.A	<u>Criterion 1 – Operational volume containment</u> The design and installation appraisal may consist of a written justification which includes functional diagrams, describes how the system works and explains why the Integrity requirement is met.
GM. COR C1. L.I	<u>Criterion 1 – Operational volume containment</u> A probable failure is anticipated to occur one or more times in the entire operational life of the UAS.
GM. COR C3. L.I	<u>Criterion 3 – Definition of the final ground risk buffer</u> The 1:1 principle refers to applying a ground risk buffer that is as wide as the maximum height of the operational volume.

	The 1:1 rule may not be sufficient to meet the target level of safety for some UA configurations (e.g., fixed-wing UA, UA equipped with a parachute). In such cases, the Authority may require defining the ground risk buffer based on a ballistic methodology approach, a glide trajectory, representative flight tests, and/or a combination thereof.
GM. COR C1. L.A	Criterion 1 – Operational volume containment (a) Particular risks are physical risks/hazards which originate from a source external to the UAS. Particular risks are able to effect: - Both UAS structures and systems. - One or more UAS sections, and even the entire UAS. - One or more aircraft functions. - One or more aircraft systems. - One or more aircraft system installations. In other words, a particular risk may violate an independence claim made in the design (e.g. through claiming separation or redundancy of 2 or more systems or functions), which would not be captured by a hazard assessment performed within the boundaries of the UAS. Examples of particular risks are: hail, ice, snow, bird strike, lightning strike, high intensity radiated fields (e.g. electro-magnetic interference). More details on particular risk can be found in SAE ARP4761A. Particular risks originating from system equipment or structural failures, although not expected to be relevant for this requirements, should also be considered by the Applicant. If the design and installation appraisal is developed by the Designer, the Designer should develop a set of assumptions for the particular risks which the UAS is expected to be exposed to in the conditions in which the UAS will be cleared to operate. The Designer should then use these assumptions in their compliance evidence data. (c) Designer data is found on the SAIL mark certificate. (d) Compliance evidence is typically provided through testing, analysis, simulation, inspection, design review or through operational experience.
GM. COR C2. L.A	Criterion 2 – End of flight upon exit of the operational volume (b) Designer data is found on the SAIL mark certificate.

	(c)	Compliance evidence is typically provided through testing, analysis, simulation, inspection, design review or through operational experience.

GM. COR C3. L.A	Criterion 3 – Definition of the final ground risk buffer	
	(a)	Compliance evidence is typically provided through testing, analysis, simulation, inspection, design review or through operational experience.
	(c)	Designer data is found on the SAIL mark certificate.

1854

1855 ## Medium level of robustness

1856 Lower robustness level requirements to be complied with:

COR C1. L.I	COR C1. L.A	COR C2. L.I	COR C3. L.A

Additional requirements to be complied with:

COR C1. M.I

Criterion 1 – Operational volume containment

No additional requirements.

COR C2. M.I

Criterion 2 – End of flight upon exit of the operational volume

No additional requirements.

COR C3. M.I

Criterion 3 – Definition of the final ground risk buffer

The ground risk buffer **must** be developed considering the following aspects:

(a) Probable single failures (including the projection of high energy parts such as rotors and propellers) which may lead to operation outside of the operational volume.

(b) Meteorological conditions.

(c) UA behaviour when activating a technical containment measure.

(d) UA performance.

COR C4. M.I

Criterion 4 – Ground risk buffer containment

(a) No single failure of the UAS or any external system supporting the operation **must** lead to operation outside of the ground risk buffer.

	(b) Software and airborne electronic hardware whose development errors could directly lead to operations outside of the ground risk buffer, **must** be developed to a standard or means of compliance acceptable to the CAA.
COR C1. M.A	Criterion 1 – Operational volume containment No additional requirements.
COR C2. M.A	Criterion 2 – End of flight upon exit of the operational volume (a) The adequacy of the procedures **must** be demonstrated through either of the following methods: (1) Dedicated flight test. (2) Simulation, provided that the simulation is proven valid for the intended purpose with positive results. (b) If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified. If (a), (b) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that the procedures developed by the Designer in (a) are followed by the Operator.
COR C3. M.A	Criterion 3 – Definition of the final ground risk buffer No additional requirements.
COR C4. M.A	Criterion 4 – Ground risk buffer containment (a) The compliance evidence **must** at least include a design and installation appraisal which shows that: (1) The design and installation features, including independence claims, comply with the low integrity requirements. (2) Particular risks relevant to the intended operation have been addressed and do not violate any independence claim. (b) If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified. (c) If (a), (b) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that the following aspects considered by the Designer are relevant to the intended operation: (1) External systems.

	(2) The operational volume is the same as or contains the operational volume considered by the Designer. (3) The ground risk buffer is the same as or contains the ground risk buffer defined by the Designer. (4) Particular risks. (d) The Applicant **must** provide evidence of compliance with Integrity requirements.
AMC. COR C4. M.I	<u>Criterion 4 – Ground risk buffer containment</u> (a) One of the following methods may be used to demonstrate compliance with the requirement: (1) An independent flight termination system which initiates the end of the flight when exiting the operational volume. (2) A secondary independent emergency flight control system which ends the flight in a controlled manner. (3) A tether which prevents the UA from exiting the ground risk buffer. (4) A fail-safe health monitoring system which is triggered in the event of a critical feature failure (e.g. navigation). (b) Refer to E5, proposing a standard as an AMC
AMC. COR C4. M.A	<u>Criterion 4 – Ground risk buffer containment</u> The design and installation appraisal may consist of a written justification which includes functional diagrams, describes how the system works and explains why the Integrity requirement is met.
GM. COR C3. M.I	<u>Criterion 3 – Definition of the final ground risk buffer</u> (a) A probable failure is anticipated to occur one or more times in the entire operational life of the UAS. (b) One example of a meteorological condition is the maximum sustained wind.
GM. COR C2. M.A	<u>Criterion 2 – End of flight upon exit of the operational volume</u> Compliance evidence is typically provided through testing, analysis, simulation, inspection, design review or through operational experience. (c) Designer data is found on the SAIL mark certificate.
GM.	<u>Criterion 4 – Ground risk buffer containment</u>

COR C4. M.A	(a) See GM.CORC1.L.A (a). (c) Designer data is found on the SAIL mark certificate. (d) Compliance evidence is typically provided through testing, analysis, simulation, inspection, design review or through operational experience.

High level of robustness

Lower robustness level requirements to be complied with:

COR C1. L.A	COR C2. L.I	COR C2. M.A	COR C3. M.I	COR C3. L.A	COR C4. M.I	COR C4. M.A

Additional requirements to be complied with:

COR C1. H.I	Criterion 1 – Operational volume containment No remote single failure of the UAS or any external system supporting the operation **must** lead to operation outside of the operational volume (qualitative approach), or, The probability of the failure condition “UA leaving the operational volume” **must** be less than 10^{-4}/FH (quantitative approach).
COR C2. H.I	Criterion 2 – End of flight upon exit of the operational volume No additional requirements.
COR C3. H.I	Criterion 3 – Definition of the final ground risk buffer No additional requirements.
COR C4. H.I	Criterion 4 – Ground risk buffer containment No additional requirements.
COR C1. H.A	Criterion 1 – Operational volume containment No additional requirements.
COR	Criterion 2 – End of flight upon exit of the operational volume

C2. H.A	No additional requirements.
COR C3. H.A	Criterion 3 – Definition of the final ground risk buffer No additional requirements.
COR C4. H.A	Criterion 4 – Ground risk buffer containment No additional requirements.
AMC. COR C1. H.I	Criterion 1 – Operational volume containment A tether which prevents the drone from exiting the operational volume may be used to demonstrate compliance with the requirement.
GM. COR C1. H.I	Criterion 1 – Operational volume containment A remote failure is unlikely to occur in the entire operational life of a single UAS but is anticipated to occur several times when considering the total operational life of a number of UAS of that type. The quantitative requirement to achieve a high level of integrity is a reduction by a factor of 10 of the likelihood of exiting the operational volume, when compared with the quantitative requirement to achieve a low or medium level of integrity.

1862

COT – Containment requirements (tether)

1863

		LEVEL of INTEGRITY		
		Low	**Medium**	**High**
Containment requirements (Tethered operations)	Criterion 1 (Technical design)	COTC1.L.I	COTC1.L.I	COTC1.L.I
	Criterion 2 (Procedures)	COTC2.L.I	COTC2.L.I	COTC2.L.I
		LEVEL of ASSURANCE		
		Low	**Medium**	**High**
	Criterion 1 (Technical design)	COTC1.L.A	COTC1.L.A	COTC1.L.A
	Criterion 2 (Procedures)	COTC2.L.A	COTC2.L.A COTC2.M.A	COTC2.L.A COTC2.M.A COTC2.H.A

1864

GM. COT

This section provides the containment requirements which address the specific use of a tether, for the following 3 levels of robustness: low, medium and high.

This section is an alternative to COT – Containment requirements.

1865

1866

Low level of robustness

COT C1. L.I

Criterion 1 – Technical design

(a) The length of the tether **must** be adequate to contain the UA within the operational volume.

(b) The strength of the line **must** be compatible with the ultimate loads during the operation.

(c) The strength of the tether attachment points **must** be compatible with the ultimate loads expected during the operation.

(d) It **must** not be possible for the tether to be cut by a rotating propeller.

COT C2. L.I

Criterion 2 – Procedures

Procedures **must** be developed to install and periodically inspect the condition of the tether.

COT

Criterion 1 – Technical design

C1. L.A	(a) The Applicant **must** provide evidence of compliance with the Integrity requirements. (b) Compliance evidence **must** include the tether material specifications. (c) If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified. (d) If (a), (b), (c) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that: (1) The length of the tether is adequate to contain the UA within the intended operational volume. (2) The ultimate loads considered by the Designer will not be exceeded during the intended operation.
COT C2. L.A	<u>Criterion 2 – Procedures</u> (a) The Applicant **must** provide evidence of compliance with Integrity requirements. (b) If simulation is used to demonstrate the adequacy of the procedures, the simulation **must** be proven valid for the intended purpose with positive results. (c) If (a), (b) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that the procedures provided by the Designer are followed by the Operator.
GM. COT C1. L.I	<u>Criterion 1 – Technical design</u> (b) Ultimate loads are the maximum loads expected to be exerted by the UAS on the tether during the operation, including all possible nominal and failure scenarios, and multiplied by a safety factor of 1.5.
GM. COT C2. L.I	<u>Criterion 2 – Procedures</u> (a) Designer procedures should be followed by the Operator where available.
GM. COT C1. L.A	<u>Criterion 1 – Technical design</u> (a) Compliance evidence is typically provided through testing or operational experience. (d) Designer data is found on the SAIL mark certificate.
GM.	<u>Criterion 2 – Procedures</u>

COT C2. L.A	(c)	Designer data is found on the SAIL mark certificate.

1867

1868 ## Medium level of robustness

1869 Lower robustness level requirements to be complied with:

COT C1. L.I	COT C1. L.A	COT C2. L.I	COT C2. L.A

Additional requirements to be complied with:

COT C1. M.I

Criterion 1 – Technical design

No additional requirements.

COT C2. M.I

Criterion 2 – Procedures

No additional requirements.

COT C1. M.A

Criterion 1 – Technical design

No additional requirements.

COT C2. M.A

Criterion 2 – Procedures

(a) The procedures **must** be developed to a standard or means of compliance acceptable to the CAA.

(b) The adequacy of the procedures **must** be demonstrated through either of the following methods:

(1) Dedicated flight test.

(2) Simulation, provided that the simulation is proven valid for the intended purpose with positive results.

AMC. COT C2. M.A

Criterion 2 – Procedures

Refer to E5, proposing a standard as an AMC

1870

1871 High level of robustness

1872 Lower robustness level requirements to be complied with:

COT C1. L.I	COT C1. L.A	COT C2. L.I	COT C2. L.A	COT C2. M.A

Additional requirements to be complied with:

COT C1. H.I

<u>Criterion 1 – Technical design</u>

No additional requirements.

COT C2. H.I

<u>Criterion 2 – Procedures</u>

No additional requirements.

COT C1. H.A

<u>Criterion 1 – Technical design</u>

No additional requirements.

COT C2. H.A

<u>Criterion 2 – Procedures</u>

(a) The flight tests performed to validate the procedures **must** cover the entire flight envelope or be demonstrated to be conservative.

(b) If (a) and Integrity requirements are complied with through a SAIL mark certificate, the Applicant **must** demonstrate that the flight envelope of the intended operation is the same as or contained within the flight envelope considered by the Designer.

GM COT C2. H.A

<u>Criterion 2 – Procedures</u>

(b) Designer data is found on the SAIL mark certificate.

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1875 ## Functional test based (FTB) methodology

GM. FTB

(a) The FTB methodology is used in the following situations:

(1) For the **UAS Designer** to conduct an FTB design appraisal, which demonstrates the UAS operational reliability.

(2) For the **UAS Operator** to take credit from the FTB design appraisal conducted by the UAS Designer to show compliance with the relevant OSOs. This has the benefit for the UAS Operator going through the OA process to provide automatic compliance with a number of OSOs, in particular when the Operator does not have a fully established relationship with the Designer or does not have access to the UAS design data.

(3) For the **UAS Operator** to demonstrate safe and successful operations over time in order to expand their operational approval, based on the concept of "reliability growth model".

(4) The FTB methodology is not considered feasible for UAS operations with a SAIL of or above V.

These three approaches are detailed in the following sections b), c) and d).

(b) The UAS Designer may use the FTB methodology to conduct an FTB design appraisal, which demonstrates the UAS operational reliability. The following aspects should be considered in applying the FTB methodology:

(1) Functional testing should be conducted, which may be divided into two types:

(i) 'Functional tests' are operational test cycles that are fully representative of end-state operations, with test points that verify safe operation at the operational limits and corners of the UA envelope.

(ii) 'Induced failure tests', which typically address demand-based systems, i.e. systems that are not continuously active and are triggered only under certain failure conditions. These tests are required where functional tests alone are not sufficient to demonstrate operational reliability, e.g. to cover likely failures.

(c) Although ASTM F3478-20 is not an officially accepted standard, it provides useful guidance for the development and deployment of an FTB campaign. Topics discussed in ASTM F3478-20 include:

(1) Development of operational flight tests, as well as specific (ground) testing to verify underlying system parameters statistically, e.g. component and UA MTBF, operational hazard rates, parachute reliability. Both the UAS Designer and the competent authority need to understand the assumptions made when attributing a distribution type to a system parameter (e.g. exponential, normal, Weibull, gamma distributions).

(i) Any infringement or loss of control occurring during the test campaign will require a root cause analysis. If design modifications are necessary following the investigation, an analysis is performed to assess whether the FTB flying hours performed prior to the modification can still be considered valid. Some tests or the entire FTB campaign might have to be reconducted.

(ii) UAS Designers and competent authorities should be cognisant of the systems, such as software or airborne electronic hardware-based systems that do not allow accurate analysis under operational time or demand-based testing. These systems should use system-specific analyses (e.g. multiple condition/decision coverage, model checking, development assurance, design and analysis) appropriate to the SAIL level.

(d) The CAA may grant a specific flight test authorisation to conduct the functional and induced failure tests needed to complete the FTB campaign.

(e) The UAS Operator may take credit from the FTB design appraisal conducted by the UAS Designer to show compliance with the relevant OSOs. To do so, the following conditions need to be met:

(1) The functional tests performed by the Designer cover the full operational scope/envelope intended by the Operator.

(2) The functional tests performed by the Designer have been executed following the operational procedures and the remote crew training referred to in the operational authorisation, which meet the integrity assurance of the associated OSOs.

(3) The Operator’s maintenance instructions are established based on the Designer’s instructions and requirements which were used for maintenance, repair, or replacement of UAS sub-systems during the functional tests performed by the Designer.

(4) Any deviation in the UAS configuration from the configuration used by the Designer during the FTB campaign are confirmed by the Designer to not impair the validity of the FTB design appraisal.

(5) The minimum number of test cycles has been achieved for the corresponding SAIL, with no failure occurrence:

(i) 30 hours for SAIL I;

(ii) 300 hours for SAIL II;

(iii) 3000 hours for SAIL III; and

(iv) 30000 hours for SAIL IV

Note: this allows achieving a factor of 95% confidence in the reliability of the operation per a binomial/Poisson distribution.

(6) The functional tests performed by the Designer have been executed by the Designer according to principles or standards considered adequate by the CAA, including the following:

(i) The functional tests have been executed using an acceptable sample size of UAS.

(ii) Safe life limits for UAS sub-systems sensitive to wear-out conditions based on the maximum cycles and hours demonstrated by one or more fleet leader UAS (i.e. the UAS with the longest time and/or cycles compared to other UAS used during the FTB campaign) have been derived by the Designer and captured in the FTB design appraisal limitations.

Note: induced failure tests may also help demonstrate compliance with the following OSOs:

(iii) OSO 5 and Containment requirements: safety and reliability / safe design (e.g. induced failure tests with no loss of control or containment as path-fail criteria).

(iv) OSO 6: C3 link performance appropriate for the operation (e.g. if the distance from a C2 radio transmitter/receiver is a critical factor, then the demonstration of the maximum allowable range from the transmitter/receiver in the most likely worst-case conditions is needed).

(v) OSO 18: Automatic protection of the flight envelope from human errors.

(f) The UAS Operator may use the FTB methodology to demonstrate safe and successful operations over time in order to expand their operational approval, based on the concept of "reliability growth model", as follows:

(1) The UAS Operator should operate with a low SAIL approval and then, through operational experience, gather sufficient operational data to justify an increase in the SAIL based upon the increase in operational reliability demonstrated. This approach is only valid under representative operating conditions, without requesting additional strategic or tactical mitigations.

(i) The CAA may accept accumulation of FTB hours between Operators if the UAS configuration, operational procedures, training, etc. are demonstrated to be equivalent.

(ii) This method does not cover expanded operating conditions, which would require additional testing and/or analysis to be performed by the UAS Designer.

(iii) As an example, the Operator may start operating with a SAIL II operational approval to fly over a population density of up to 500 people per km². As they demonstrate 3,000 hours of operation with no loss of control, they may be approved by the Authority to operate at SAIL III under the exact same operating conditions, with an allowable maximum population density increased to 5,000 people per km².

(iv) The UAS Operator should demonstrate that:

(1) the next population band does not introduce new hazards. If new hazards are introduced, they should be mitigated through test or analysis.

(2) The conditions listed in (c) have been met, in particular the minimum number of test cycles required for the desired SAIL per (c)(ii)(5).

(3) any UAS configuration differences compared to the initial configuration do not impair the validity of the argument.