

**CAA Decision to adopt Acceptable Means of Compliance and
Guidance Material for UK Regs (EU) 2019/947 pursuant to Article 76(3)
UK Reg (EU) 2018/1139**

DECISION No. 60

Publication date: 3 July 2026

Decision amending and adopting Acceptable Means of Compliance (AMC) and Guidance Material (GM) for UK Regulation (EU) 2019/947

Background

1. This ORS9 Decision 60 adopts new and updated Acceptable Means of Compliance (AMC) and Guidance Material (GM) for UK Regulation (EU) 2019/947 to support consistent implementation of the UK SORA framework. The updates refine AMC1 to Article 11 and strengthen Annexes A, B and E by clarifying evidence expectations, methodology and integrity and assurance requirements. This will improve the quality and traceability of submissions, reduce avoidable findings, and support proportionate, consistent assessment outcomes for operators and the CAA.
2. AMC1 to Article 11 Conducting a UK Specific Operation Risk Assessment (UK SORA) has had some minor amendments and updates made to it, some of which are in response to comments received from the AMC/GM consultation held between September and November 2025 last year, including:
 - Operations out of scope for UK SORA
 - Adjacent area and adjacent airspace definition
 - Determining the UA characteristics
 - Adjacent area calculation
 - Containment requirements for adjacent airspace
3. GM1 Article 11 Annex A – Guidance for the submission of compliance evidence to the CAA annex is intended to serve as guidance to support an applicant with gathering and presenting compliance evidence as part of their UK SORA application. The UK has aligned with JARUS Annex A v2.5 content and wording with the addition of a new section ‘Operations with reduced maximum speed’, enabling an applicant to reduce the Intrinsic Ground Risk Class using software or mechanical enforced operational speed limitations. These updates and amendments to GM1 Article 11 Annex A with the addition of new guidance material include:
 - Added new guidance for what is the declarative approach
 - Updated the guidance for what is an agreed compliance basis approach
 - New guidance explaining what compliance evidence approach is
 - Added a new table summarising declaration of compliance vs agreed compliance basis approach vs compliance evidence approach

- Guidance on collecting and storing evidence
 - How to present compliance evidence
 - New guidance material developed for documenting and presenting the intrinsic ground risk footprint
 - Added new material and data for calculating the flight volume, contingency volume and ground risk buffer
 - New guidance for determining the maximum VLOS and BVLOS distances
 - A new section for operations with reduced maximum operating speed
4. Annex B to Article 11 - Ground risk mitigations – Acceptable means of compliance and guidance material has now been provided for all the ground risk mitigations. The following is a brief summary of the new acceptable means and guidance material
- Added AMC to calculate penetration impact of UA on a structure
 - Provided examples on penetration analysis M1A
 - Added industry standards and AMC for M1C Technical means to detect people
 - Added AMC for M2 mitigation, recognising industry standards for parachutes, flight termination systems (FTS).
 - Provided critical area calculation method for M2 mitigation assessment
 - Provided few examples on applying the AMC
 - Extensive guidance on all the ground risk mitigations
5. Annex E to Article 11- Containment – Acceptable means of compliance and guidance material provided for untethered containment. The new AMC include:
- Recognition of consensus industry standards for technical features such as flight termination systems, geo-caging
 - Recognition of mitigations validity in the adjacent area and providing slightly lower requirements when such mitigations are valid
 - Providing both qualitative and quantitative means to demonstrate compliance
 - Low containment being made declarative and medium containment only requiring an agreed compliance basis
 - Examples provided on the application of the AMC for untethered containment

Decision

6. The CAA, under Article 76(3) of UK Regulation (EU) 2018/1139, has decided to adopt the AMC and GM listed at Schedule 1.
7. The wording of this is provided in Schedule 2.
8. This Decision will remain in force unless revoked or amended by the CAA.

Definitions

9. All references to Regulations are to assimilated law pursuant to the Retained European Union Law (Revocation and Reform) Act 2023.

A handwritten signature in black ink, appearing to read 'Giancarlo Buono', written in a cursive style.

Giancarlo Buono
For the Civil Aviation Authority and the United Kingdom

Date of Decision: 3 July 2026

Date of Decision Coming into force: 01 October 2026

Schedule 1
Acceptable Means of Compliance (AMC) and Guidance Material (GM) Updates

Topic	AMC and GM
Conducting a UK Specific Operation Risk Assessment (UK SORA)	<ul style="list-style-type: none"> • AMC1 to Article 11 Conducting a UK Specific Operation Risk Assessment (UK SORA)
Annex A to Article 11	<ul style="list-style-type: none"> • GM1 Article 11 Annex A – Guidance for the submission of compliance evidence to the CAA
Annex B to Article 11	<ul style="list-style-type: none"> • Annex B – AMC1 Strategic Mitigations for Ground Risk • AMC1 Article 11 Annex B. M1A Strategic mitigation – sheltering • GM1 Article 11 Annex B. M1A Strategic mitigation – sheltering • AMC1 Article 11 Annex B. M1B Strategic mitigation using operational restrictions • GM1 Article 11 Annex B. M1B Strategic mitigation using operational restrictions • AMC1 Article 11 Annex B. M1C Tactical Mitigations – Ground observations • GM1 Article 11 Annex B. M1C Tactical Mitigations – Ground observation • AMC1 Article 11 Annex B. M2 Effects of UA impact dynamics are reduced • GM1 Article 11 Annex B. M2 Effects of UA impact dynamics are reduced
Annex E to article 11	<ul style="list-style-type: none"> • Annex E – AMC 1 Integrity and assurance levels for the Operational Safety Objectives (OSO) • AMC1 Article 11 Annex E. Containment requirements • GM1 Article 11 Annex E. Containment requirements

Schedule 2

Text must be presented in the order in which it appears in the regulation

The text of the amendment is arranged to show deleted text, new or amended text as shown below:

- (a) ~~Text to be deleted is shown struck through;~~
- (b) **New text is highlighted in grey;**
- (c) ~~Text to be deleted is shown struck through~~ **followed by the replacement text which is highlighted in grey.**

AMC1 to Article 11 Conducting a UK Specific Operation Risk Assessment (UK SORA)

(...)

Operations out of scope for UK SORA

1.2

(...)

~~(c) Some operations require additional applications, outside the SORA, or may require the use of policy that has not yet been released. Please contact the CAA via uksora@caa.co.uk before starting an application, if this applies to your operation. This includes;~~

~~(1) Multiple Simultaneous Operations;~~

~~(2) Operations that require an airspace change;~~

~~(3) Operations involving the carriage of Dangerous Goods (where this can be achieved in the Specific Category);-~~

(c) Before starting the UK SORA process the applicant should consider if any of the above criteria in part 1.2 apply to the proposed operation. If the answer is yes, then the UK SORA process may not be used for the application.

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 may not be used for the application.~~

~~Some operations may require additional applications outside the UK SORA.~~

~~Please contact the CAA via uksora@caa.co.uk before starting an application. This includes Operations that require an Airspace Change, or those involving the carriage of Dangerous Goods.~~

1.4 If UK SORA may not be used, the applicant should contact the CAA regarding alternative options via uksora@caa.co.uk. UK SORA may not be entirely appropriate for some

operations. Where the proposed risk assessment approach differs only slightly from the published methodology, it may be possible to carry out the risk assessment using UK SORA with minor alterations. Operators should contact the CAA using uksora@caa.co.uk to discuss their application if they believe their proposal fits in this category. The application will be reviewed by a specialist panel to determine whether the proposed approach can be accepted. This includes situations where policy has not yet been developed to support specific types of operation.

(...)

1.25 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 UK SORA Annex A for JARUS SORA 2.5 Annex A further guidance.

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

The adjacent area represents the area adjacent to the outer edge of the ground risk buffer where it is reasonably expected a UA may crash after a loss of control situation.

(...)

1.28 ~~The size of the adjacent area depends on the UA performance.~~ The lateral outer limit of the adjacent area is calculated using the UA performance as distance flown in 3 minutes at the maximum operating speed of the UA as specified by the designer.

The adjacent airspace

1.29 The adjacent airspace is the airspace, where it is reasonably expected that a UA ~~an unmanned aircraft~~ may fly after a loss of control. The adjacent airspace is the airspace adjacent to the operational volume.

(...)

Containment

1.42 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 ~~resulting in an operational volume excursion~~ the UA entering the adjacent area.

1.46 The applicant **must** provide a compliance basis approach and/or compliance evidence for mitigations and OSOs based on the SAIL level.

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

(...)

Remote Pilot in command and flight crew

- 1.55 The responsibilities of a remote pilot ~~and crew~~ are defined in UK Regulation (EU) 2019/947, UAS.SPEC.060 Responsibilities of the remote pilot. The definition of Remote Pilot can be found in UK Regulation (EU) 2018/1139 (The Basic Regulation) Article 3(31).

(...)

Table 2 - UK SORA Application Phases

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

(...)

Determining the UA characteristics

- 1.61 To establish the characteristics of the UA, the applicant **must** consider the following:
- (i) **Characteristic Dimension:** Define the maximum size of the UA by its wingspan for fixed-wing aircraft, or maximum distance between blade tips for rotorcraft (when rotors are in furthest apart position).
 - (ii) **Maximum operating speed as specified by the designer:** This is defined as the maximum possible airspeed the UA may 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. Any references to maximum speed in UK SORA refer to this term unless specifically stated otherwise. Mitigations that reduce speed during an impact are detailed separately in UK SORA Annex B;
 - (iii) **Maximum operational speed:** This is defined as the maximum speed of the UA set by the operator.
 - (iv) **Maximum operational mass:** This is defined as the maximum operational mass set by the operator. The maximum operational mass **must** be lower than or equal to the maximum take-off mass. This **must** consider the designer defined UA mass and the operational payload mass.
 - (v) **Maximum take-off mass:** This is defined as the maximum possible mass of the UA including all payload, as specified by its designer.

(...)

- 1.64 A UA expected to not penetrate a standard dwelling structure 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.

(...)

Ground risk buffer

- 1.83 The applicant **must** define a ground risk buffer that includes an initial calculation and outcome. Refer to ~~JARUS SORA 2.5 Annex A~~ UK SORA Annex A for further guidance.

(...)

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

- 1.93 Acceptable mitigations may reduce the intrinsic risk of an uninvolved person being struck by a UA during a LOC on the ground (includes persons inside structures) being significantly injured due to the impact of a UA. An applicant that wishes to reduce their iGRC **must** identify and apply suitable ground risk mitigations. Annex B contains further guidance on how to complete this step.

(...)

Table 5 - Strategic Ground Risk Mitigations

		Low Robustness	Medium Robustness	High Robustness
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

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

(...)

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

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

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

Table 6 - SAIL Determination

	Residual ARC a	Residual ARC b	Residual ARC c	Residual ARC d
Final GRC ≤2	SAIL 1	SAIL 2	SAIL 4	SAIL 6
Final GRC 3	SAIL 2	SAIL 2	SAIL 4	SAIL 6
Final GRC 4	SAIL 3	SAIL 3	SAIL 4	SAIL 6
Final GRC 5	SAIL 4	SAIL 4	SAIL 4	SAIL 6
Final GRC 6	SAIL 5	SAIL 5	SAIL 5	SAIL 6
Final GRC 7	SAIL 6	SAIL 6	SAIL 6	SAIL 6
Final GRC >7	Certified category			

(...)

Step 8 - Phase 1 Assessment

- 1.138 The purpose of this step is for the applicant to submit their SAIL calculation, operational details, and agreed compliance basis and/or compliance evidence.
- 1.139 Complete all required assessment 1 steps in the UK SORA application service.
- (...)
- 1.151 If the UA weighs 250g or less, ~~is less than 250g~~, the applicant **must** apply at least Low containment, or higher. In this case there is no requirement to account for the population in the adjacent area.
- 1.152 If the UA weighs more than 250g, the applicant **must** determine the size and population characteristics of the adjacent area. The section below explains how to do this.
- (...)
- 1.153 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~~ operating speed of the UA as specified by the designer:
- (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.
- (...)
- 1.156 Determine a set of operational limits (average population density allowed in the adjacent area and assemblies allowed within 1km of the operational volume) appropriate for intended operation using the Tables 7-11.
- (...)
- 1.158 Use Tables 7-1142 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 8 – Containment requirements 3m UA (< 35 m/s) applicant claims sheltering as a mitigation

Average population density allowed	No Upper Limit	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	Assemblies < 40k
SAIL 1 & 2	Out of scope	High	Medium	Low
SAIL 3	Out of scope	Medium	Low	Low
SAIL 4	Medium	Low	Low	Low
SAIL 5-6	Low	Low	Low	Low

Table 98 - Containment requirements 3m UA (< 35 m/s) applicant does not claim sheltering as a mitigation

Average population density allowed in the adjacent area	No Upper Limit	< 50,000 ppl/km ²	< 5,000 ppl/km ²	< 500 ppl/km ²
Assemblies allowed within 1km of the operational volume	> 400k	Assemblies of 40k to 400k	Assemblies < 40k	Assemblies < 40k
SAIL 1 & 2	Out of scope	High	Medium-Low	Low
SAIL 3	Out of scope	Medium	Low	Low
SAIL 4	Medium	Low	Low	Low
SAIL 5-6	Low	Low	Low	Low

Table 109 - Containment requirements 8m UA (< 75 m/s) applicant does not claim sheltering as a mitigation

(...)

Table 110 - Containment requirements 20m UA (< 125 m/s) applicant does not claim sheltering as a mitigation

(...)

Table 121 - Containment requirements 40m UA (< 200 m/s) applicant does not claim sheltering as a mitigation

(...)

Containment requirements for adjacent airspace

1.168 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. The CAA may apply containment requirements at a higher robustness level for some adjacent airspaces in proportion to the risk. Some examples where a higher robustness level may be applied are where the adjacent airspace is a Control Zone (CTR) such as an aerodrome or where the adjacent airspace has predominately Instrument Flight Rules (IFR) traffic.

(...)

Table 1312 - Operational Safety Objectives (OSO)

(...)

Step 13 - Phase 2 Assessment

- 1.178 The purpose of this step is for the applicant to submit their compliance evidence and/or compliance basis for OSOs, TMPR, and Containment. The CAA will then evaluate the proposed risk assessment and robustness of the mitigating measures, that the applicant proposes to keep the operation safe.
- 1.179 The applicant should then:
- Complete all required assessment 2 steps in the UK SORA application service.
 - Make the required Phase 2 payment when prompted.
- 1.180 The CAA will assess the compliance evidence and/or the compliance basis and other information provided by the applicant to determine whether the proposed mitigation measures are adequate and sufficiently robust to keep the operation safe in view of the identified ground and air risks, in order to decide whether to grant the operational authorisation.

(...)

GM1 Article 11 Annex A – Guidance for the submission of compliance evidence to the CAA

Introduction

- A.1 This annex is intended to serve as guidance to support an applicant with gathering, presenting, and retaining their compliance evidence as part of their UK SORA application. The term compliance evidence is used to emphasise the goal of providing evidence that demonstrates compliance to a regulation, requirement, or standard.
- A.2 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, and so, on its own, would be unlikely to be accepted as compliance with the overall requirement.
- A.3 The CAA has adopted three approaches to the way an applicant may demonstrate compliance as part of their UK SORA application:
- (1) the declarative approach.
 - (2) the agreed compliance basis approach.
 - (3) the compliance evidence approach.
- These are described in more detail below.

What is the declarative approach?

- A.4 Compliance with some UK SORA requirements may be demonstrated by a declaration of compliance (see specific requirements for further details). In this context, a declaration of compliance is meant as a declaration statement provided by the applicant that they comply with the relevant requirements in UK SORA. For any UK SORA requirement that allows a declaration, the applicant **must** only declare to the acceptable means of compliance. Deviations from the acceptable means of compliance are not declarative. It is the responsibility of the applicant to collect the necessary compliance evidence that enables them to declare compliance to the requirement. The CAA will provide a declaration template for use during a UK SORA application.

What is a **an agreed compliance basis approach**?

A.5 In this context, a **an agreed compliance basis approach** is meant as a systematic approach used to ensure an applicant complies with the relevant regulation, requirement or standard. The agreed compliance basis approach is where the applicant and the CAA agree on the relevant means and methods of compliance. Once the CAA has agreed with the compliance basis proposed by the applicant, the applicant **must** collect the necessary evidence in accordance with the agreed compliance basis. Then the applicant may submit a declaration of compliance with the relevant requirements. In the agreed compliance basis approach, the applicant does not need to submit the compliance evidence to the CAA. The CAA may request for the compliance evidence if necessary, during evaluation and/or during oversight. The UK SORA Application Service is designed to support applicants to submit their compliance basis and compliance evidence in a structured format. Some mitigations and containment robustness levels only require the applicant to submit a compliance basis approach document. The CAA will provide a compliance basis template for use in a UK SORA application.

The **means** of compliance are non-binding, pre-accepted standards and means used to demonstrate compliance with the UK SORA requirements.

The **methods** of compliance are established procedures used to prove the achievement of the means of compliance thereby demonstrating compliance with the UK SORA requirements. They may include a specific approach or a set of procedures. Some examples of methods of compliance are flight tests, ground tests, engineering analysis, design and installation appraisal, design documentation. In the compliance basis approach, the applicant **must** determine the method of compliance for each means of compliance they propose, to demonstrate compliance with the requirements. The compliance evidence is a result of implementing the method of compliance. For example, if the method of compliance is a flight test for a requirement, the compliance evidence is the actual flight test and all the data and information associated with it. For requirements where the CAA applies the agreed compliance basis approach, the compliance evidence is not required to be submitted as part of the application.

The compliance basis approach consists of the following steps:

- (i) The applicant **must** submit to CAA the proposed means of compliance they will use to demonstrate compliance with the integrity requirements.
- (ii) The applicant **must** submit to the CAA the proposed methods of compliance they will use to demonstrate compliance with the integrity requirements. The methods of compliance provide details on how the applicant aims to complete a specific means of compliance.
- (iii) The CAA will evaluate both the means and methods of compliance and determine their applicability.
- (iv) If the CAA determines that both the means and methods of compliance are adequate to meet the integrity requirements, the CAA will agree the compliance basis and accept that these requirements have been met, subject

to the applicant collecting the compliance evidence and providing a declaration of compliance.

- (v) Following agreement of the compliance basis, the applicant **must** then implement the methods of compliance, collect the compliance evidence and declare that they have done so and that they comply with the relevant UK SORA requirements. This declaration **must** then be submitted to the CAA as part of the application.

If the applicant identifies any scenario where either the means of compliance or methods of compliance have any deviation (other than editorial) from the agreed compliance basis approach, they **must** restart the process. For example, if an applicant agrees with the CAA to fulfil a means of compliance via a flight test and then decide to modify it to a ground test or design documentation, their compliance basis approach is no longer agreed, and therefore no longer valid. In this case, the applicant will need to agree a new compliance basis approach with the CAA.

What is a compliance evidence approach?

- A.6 In this context, a compliance evidence approach is where the applicant fulfils all the steps in A4 and provides the associated evidence for evaluation by the CAA.

What is compliance evidence?

- A.7 Compliance evidence is the term used to describe a piece of evidence used to demonstrate compliance with a regulation, requirement or standard. Compliance evidence may take several forms such as:

- (i) Flight logs.
- (ii) Technical data sheet.
- (iii) Flight tests.
- (iv) Design information.

- A.8 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.

Summary of Declaration of compliance vs agreed compliance basis approach vs Compliance evidence approach

Table A.1

Type of approach	Description	What will the evaluators do?	Does the applicant need to collect and store the compliance evidence?	Does the applicant need to submit the compliance evidence to the CAA?
Declaration of compliance	Upload the declaration of compliance to the AMC using the declaration template provided	Accept the declaration	Yes	No
Agreed compliance basis approach	Upload the compliance basis using the template provided and agree it with the CAA & once agreed upload the declaration of compliance upon collection of compliance evidence	Agree on the compliance basis approach if acceptable	Yes	No
Compliance evidence approach	Upload the compliance basis using the template provided and upload the associated evidence	Agree on the compliance basis approach if acceptable and evaluate the associated evidence	Yes	Yes

Collecting, Presenting and Storing Evidence

- A.9 The applicant **must** collect and store all evidence to show compliance with the requirements for all approaches (declaration of compliance, agreed compliance basis and compliance evidence approach).
- A.10 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.~~
- A.11 All documents and supporting evidence should be clearly version controlled, and date stamped, with consistent version/date identifiers shown within the document

itself and reflected in the file names of the submission and any referenced attachments.

- A.12 Compliance evidence **must** be stored for ~~the duration of the authorisation~~ 3 years after the ceasing of an operation under the OA. This evidence **must** and be made available to the CAA assessors upon request. Where compliance evidence contains personal data, it is recommended to follow UK Government advice on General Data Protection Regulation (GDPR).
- 1.8 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:~~
- 1.9 Requirement (CAA): ~~“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%).”~~
- ~~(1) 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~~

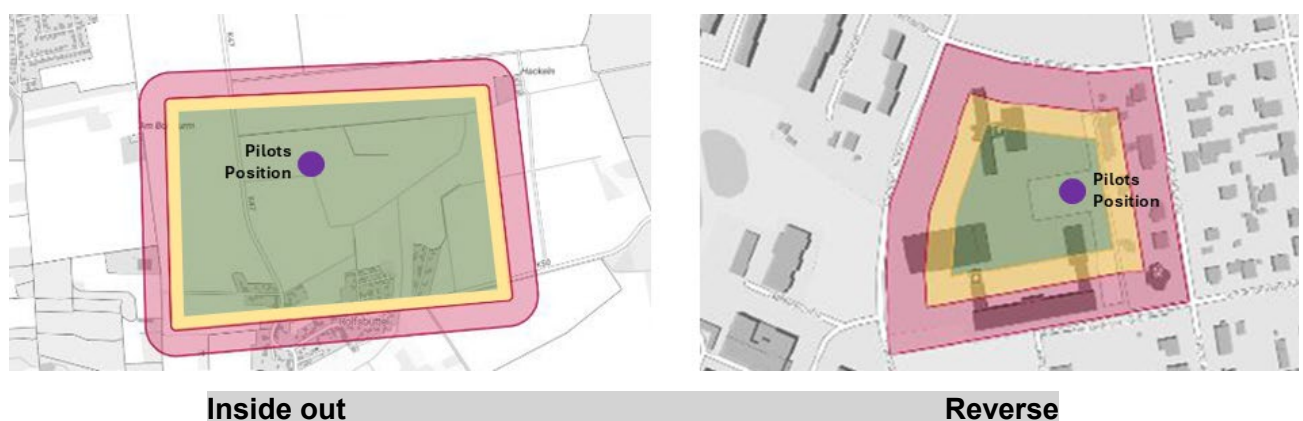
Presenting compliance evidence

- A.13 Any form of compliance evidence submitted to the CAA **must** be in a legible and understandable format.
- A.14 When submitting assessment 1 compliance evidence as part of Phase 1, the applicant should ensure that all the evidence is combined into a single consolidated document. Guidance on how to complete each step of Assessment 1 and the required evidence can be found in [CAP3239A](#).
- A.15 When completing each step of Assessment 1, focus on evidence, not a description of the intended approach. For example, rather than stating “we will use ONS data”, provide the actual population density evidence that is being claimed, or a clear reference to it.

How to document and present the intrinsic ground risk footprint

- A.16 The applicant will need to identify the proposed flight area and provide calculations for determining the minimum dimensions of the operational volume and ground risk buffer.
- A.17 The applicant should present details of the intrinsic ground risk footprint in the form of a .kml file or a similar format suitable for visualisation, accompanied by a description that includes all relevant flight area details.
- A.18 Applicants should provide geographical location data using latitude and longitude coordinates. This may be submitted as a central point with a specified radius, or as a defined multi-point polygon.
- A.19 The graphic representation of the iGRC Footprint below should contain as a minimum:
- An area: Flight Volume in transparent green colour
 - An area: Contingency Volume in transparent yellow colour
 - An area: Ground Risk Buffer in transparent red colour
 - A position: Remote Pilot Position (for VLOS operation)
 - A position: Take Off / Landing Position (optional)
- A.20 The applicant should decide between the following methods to determine the ground area at risk for the specific operation:
- (i) The **'Inside out'** method is used for applications where the flight volume is the constraining factor. The required contingency volume and ground risk buffer are added to the flight volume to determine the total iGRC Footprint.
 - (ii) The **'Reverse'** approach should be used when your operation is constrained by a defined boundary – for example, when operating within a controlled ground area. By subtracting the ground risk buffer and contingency volume will determine the maximum available flight volume.

Figure A.1 – Inside Out vs Reverse computation of the flight area



- A.21 Areas within the flight volume that need to be excluded for any reason (e.g. higher ground risk) should be addressed in the same way as to surround them with a contingency volume and a ground risk buffer.
- A.22 The applicant should provide a graphical representation of the flight area, accompanied by a concise description, all input values, and the calculations for the flight volume, contingency volume and ground risk buffer should be documented.
- A.23 The content should be presented in a manner that is easily comprehensible to all parties involved in the operation, enabling swift access to all pertinent data during routine operations. It is also crucial for the CAA to understand the calculation process.

Calculating the Flight Volume, Contingency Volume and Ground Risk Buffer

- A.24 Tables A.3, A.4, A.5 and A.6 provide sample calculations for determining the minimum dimensions of the flight volume, contingency volume, ground risk buffer and adjacent area calculations. These examples are intended solely as illustrative calculations. Operator specific values should be used in place of these assumptions and will need to be evidenced.
- A.25 The calculation methods have been derived primarily for traditional fixed-wing and quadcopter type multirotor. For alternative aircraft platforms such as VTOL or rotorcraft configurations, the applicant should evidence the applicability of the calculations used.
- A.26 The applicant should use the volume calculation method defined in the tables below. Where an applicant elects to use an alternative method, suitable calculation tools may be sourced and applied to support their assessment.

Table A.2 – Definitions for calculations

Abbreviation	Meaning
AA	Adjacent Area
S _{AA} (m)	Adjacent Area Distance (Horizontally from Contingency Volume)
ALOS (m)	Attitude Line of Sight
Baro	Barometric
C _D	Drag Coefficient
C _L	Lift Coefficient
CD (m)	<p>The "Maximum UA characteristic dimension" or "CD" is the maximum possible length of a straight line that can be spanned from one point on the UA geometry to another point. Propellers and rotors are part of the geometry, whereby their most unfavourable position is considered.</p> <p>Note: Commonly used values for:</p> <p>Fixed-wing aircraft</p>

	<ul style="list-style-type: none"> • Wingspan or • Fuselage length Multicopter <ul style="list-style-type: none"> • Diagonal distance from rotor tip to rotor tip, rotors in unfavourable position
CM	Contingency Manoeuvre
S_{CM} (m)	Contingency Manoeuvre Distance (Horizontally)
H_{CM} (m)	Contingency Manoeuvre Height (Vertically)
CV	Contingency Volume
S_{CV} (m)	Contingency Volume Distance (Horizontally from Flight Volume)
H_{CV} (m)	Contingency Volume Height (Vertically from Ground)
DLOS (m)	Detection Line of Sight
FV	Flight Volume
g (m/s ²)	Gravitational Acceleration, used as 9.81m/s ²
GNSS	Global Navigation Satellite System
GRB	Ground Risk Buffer
S_{GRB} (m)	Ground Risk Buffer Distance (Horizontally from Contingency Volume)
GV (m)	Ground Visibility
H (m)	Height (above ground level)
H_{error} (m)	Height Measurement Error
H_R (m)	Reaction Height (vertically)
H_{BARO} (m)	Barometric Error
S_{fall} (m)	Horizontal displacement attributed to the aircraft's fall trajectory
S_R (m)	Reaction Distance (horizontally)
S_K (m)	Map error
m (kg)	UAS mass
S_{error} (m)	Horizontal Measurement Error
S_{GNSS} (m)	GNSS error (horizontally)
H_{GNSS} (m)	GNSS error (vertically)
S_{POS} (m)	Position Holding error
RTK	Real-time Kinematic system
S_{RTK} (m)	RTK error (horizontally)
H_{RTK} (m)	RTK error (vertically)
t_R (s)	Reaction time
S (m)	Distance
t (s)	Time

t_p (s)	Time to open parachute
V_0 (m/s)	Maximum operational speed that is flown
V_{max} (m/s)	Maximum operating speed of the UA as specified by the designer
V_{climb} (m/s)	Maximum operational climb rate that is flown
V_{wind} (m/s)	Maximum wind speed up to which the UA is designed to be safely operated
V_z (m/s)	Rate of descent with parachute open
Z	Vertical direction
r (m)	Turn radius (can be attributed to banked turn or pitch up/down manoeuvre)
E	Glide ratio
ϵ (deg)	Glide angle
Φ (deg)	Roll angle
Θ (deg)	Pitch angle
Ψ (deg)	Yaw angle
Υ (deg)	Climb angle

Figure A.2 – Schematic diagram of the Flight Volume, Contingency Volume and Ground Risk Buffer

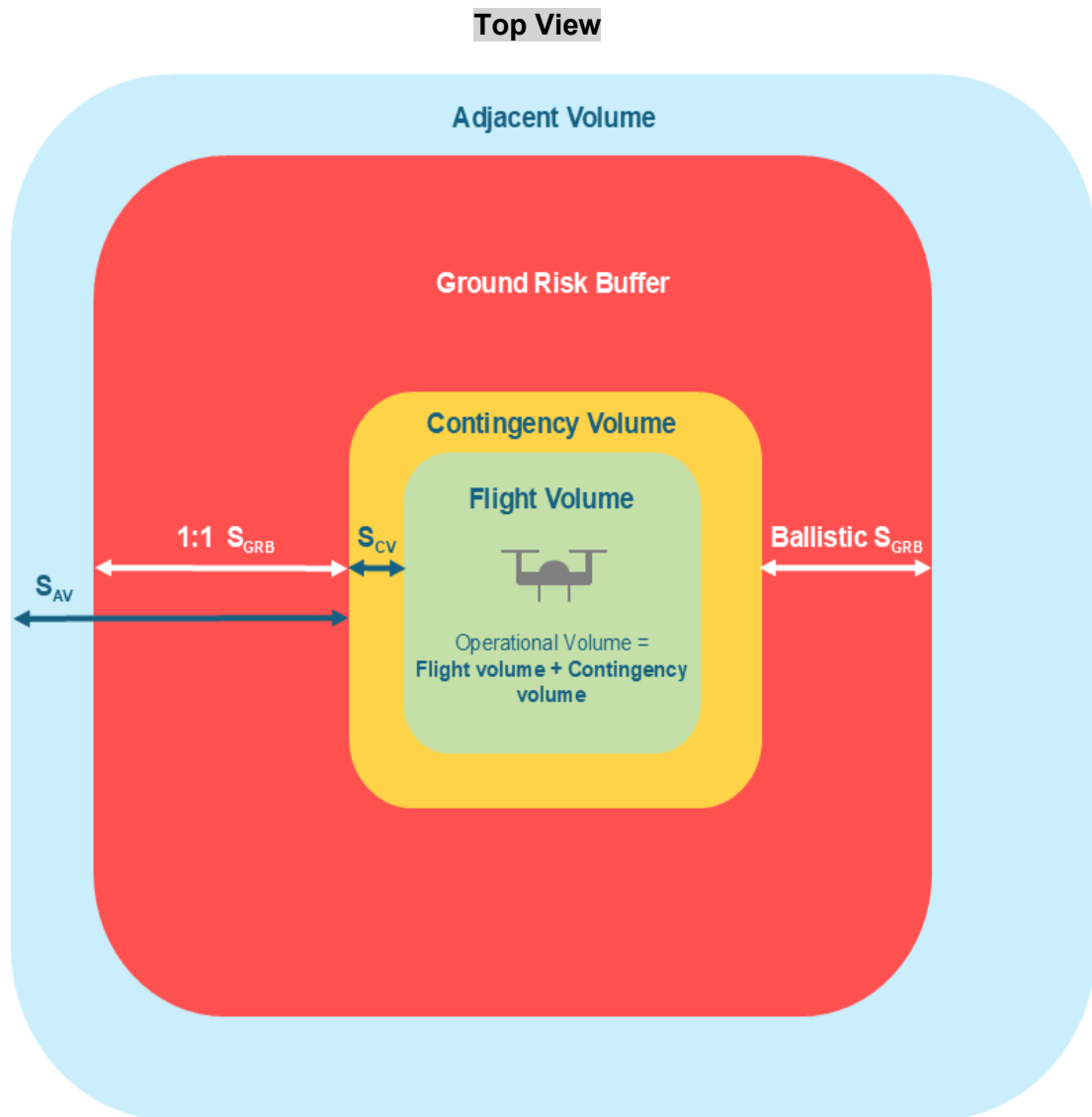
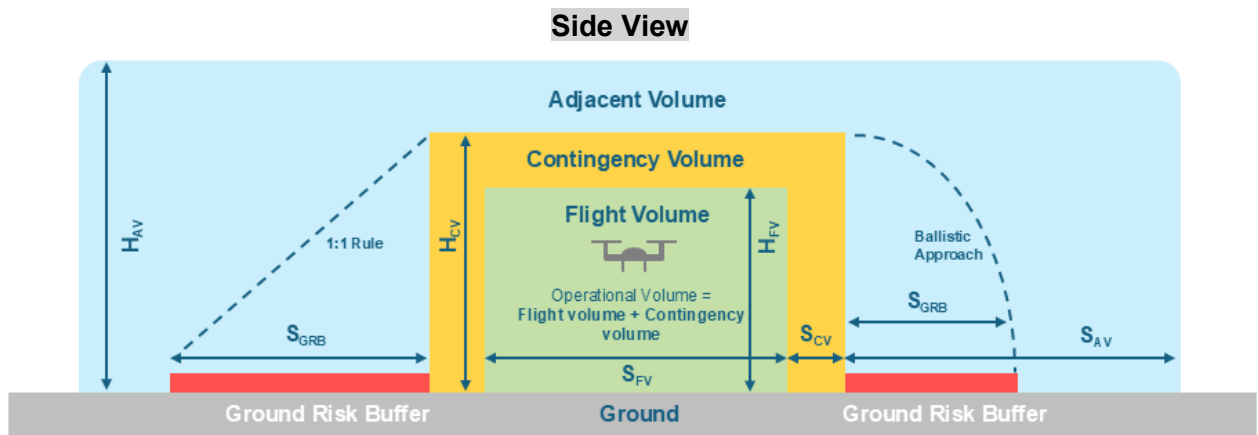


Table A.3 – Flight Volume Calculation

FV horizontal	
Width flight volume: S_{FV}	$S_{FV} \geq 3 CD$
FV vertical	
Height flight volume: H_{FV}	$H_{FV} \geq 3 CD$
<p><i>Note: The flight volume should be sized appropriately to contain the aircraft when operating under standard operating procedures. Smaller values than $H_{FV} = 3 CD$ and $S_{FV} = 3 CD$ are considered unrealistic when considering typical operational complexities and aircraft performance.</i></p>	

Table A.4 – Contingency Volume Calculation

CV horizontal	
Horizontal measurement error: S_{error}	<p>GNSS accuracy: $S_{error} = S_{GNSS} = 3 \text{ m}$</p> <p>RTK accuracy: $S_{error} = S_{RTK} = 0.2 \text{ m}$</p>
Position holding error: S_{POS}	$S_{POS} = 3 \text{ m}$
Map error: S_K	$S_K = 1 \text{ m}$
<p>Reaction distance: S_R</p> <p><i>Note: Values below $V_0 = 3\text{m/s}$ are not considered realistic for this calculation.</i></p>	<p>Initiation of measures $S_R = V_0 t_R$</p> <p>Visual detection: $t_R = 5\text{s}$ <i>Visual detection is applicable to operations where the Remote Pilot is required to dynamically judge distances and aircraft proximity using visual scanning techniques. This includes VLOS and any telemetry.</i></p> <p>Augmented visual detection: $t_R = 1\text{s}$ <i>Augmented detection is applicable to operations where aircraft systems are used to automatically detect abnormal situations and alert the Remote Pilot to manually intervene. This can include clear visual, audio or sensory alert functions.</i></p> <p>Automated detection: $t_R = 0.5\text{s}$</p>

	<p><i>Automated detection is applicable to operations where aircraft systems are used to automatically detect and apply contingency procedures without the Remote Pilot needing to manually intervene. This can include automated functions that return the aircraft to a safe location as a result of flight volume excursion or other abnormal situations.</i></p>
<p>Contingency manoeuvres: S_{CM}</p> <p><i>Note: Values below $V_0 = 3m/s$ are not considered realistic for this calculation.</i></p>	<p>Multirotor – stopping: Based on performing a stopping manoeuvre using the maximum pitch angle, θ_{max}, to counter forward momentum. Typical $\theta_{max} = 25^\circ$ The minimum distance for stopping to hover is: $S_{CM} = \frac{1}{2} \frac{V_0^2}{g \tan(\theta_{max})}$</p> <p>Fixed-wing aircraft - 180° banked turn: Based on performing a steady banked turn, maintaining height, using the maximum bank angle, Φ_{max}, to determine the turn radius. Typical $\Phi_{max} = 45^\circ$ The radius for the turn is: $S_{CM} = \frac{V_0^2}{g \tan(\Phi_{max})}$ <i>Note: For automated responses, ensure that maximum bank angle is in accordance with autopiloted response.</i></p>
<p>Horizontal extension of the contingency volume: S_{CV}</p>	$S_{CV} = S_{error} + S_{POS} + S_K + S_R + S_{CM}$
<p>Examples</p>	<p><i>Note: All calculations are rounded up to the nearest integer.</i></p>
<p>Example multirotor: $V_0 = 10 \frac{m}{s}, \theta = 25^\circ, t_R = 1s$</p>	$S_{CV} = 3m + 3m + 1m + 10m + \frac{1}{2} \cdot \frac{\left(10 \frac{m}{s}\right)^2}{9.81 \frac{m}{s^2} \cdot \tan(25^\circ)} = 28m$
<p>Example fixed-wing aircraft: $V_0 = 30 \frac{m}{s}, \Phi_{max} = 45^\circ, t_R = 1s$</p>	$S_{CV} = 3m + 3m + 1m + 30m + \frac{\left(30 \frac{m}{s}\right)^2}{9.81 \frac{m}{s^2} \cdot \tan(45^\circ)} = 129m$
<p>CV vertical</p>	
<p>Height measurement error: H_{error}</p>	<p>GNSS accuracy: $H_{error} = H_{GNSS} = 4 m$</p> <p>Barometric accuracy: $H_{error} = H_{BARO} = 2 m$</p>

	<p>GNSS accuracy with RTK system: $H_{error} = H_{RTK} = 0.5 \text{ m}$</p> <p><i>Note: Barometric altitude measurements are taken relative to take-off time and position and are therefore susceptible to drift for longer duration operations due to air pressure fluctuations.</i></p>
<p>Reaction distance: H_R</p> <p><i>Note: Values below $V_{climb} = 1\text{m/s}$ are not considered realistic for this calculation.</i></p>	<p>Initiation of measures</p> <p>Vertical reaction distance can be calculated either directly using the maximum climb rate of the aircraft, V_{climb}, or indirectly using the maximum operational speed, V_0, and the maximum climb angle, γ_{max}.</p> $H_R = V_{climb} t_R$ <p>or</p> $H_R = V_0 \sin(\gamma_{max}) t_R$ <p>Typical $\gamma_{max} = 30^\circ$</p> <p>Visual detection: $t_R = 5\text{s}$</p> <p>Augmented visual detection: $t_R = 1\text{s}$</p> <p>Automated detection: $t_R = 0.5\text{s}$</p>
<p>Contingency manoeuvres: H_{CM}</p> <p><i>Note: Values below $V_{climb} = 1\text{m/s}$ are not considered realistic for this calculation.</i></p>	<p>Multirotor – stopping:</p> <p>The vertical kinetic energy is completely converted into potential energy. This can be calculated directly using the maximum climb rate of the aircraft, V_{climb}. If V_{climb} is not known, then V_0 may be used as a more pessimistic approximation.</p> $H_{CM} = \frac{1}{2} \frac{V_{climb}^2}{g}$ <p>OR</p> $H_{CM} = \frac{1}{2} \frac{V_0^2}{g}$ <p>Fixed-wing – pitch down manoeuvre:</p> <p>Exit the FV upwards at the maximum climb angle, γ_{max}, then pitch down to fly on a circular trajectory with V_0 and radius r until level flight is achieved. This assumes a -1G manoeuvre.</p> <p>With</p> $r = \frac{V_0^2}{g}$

	<p>results in the contingency manoeuvre height being approximately:</p> $H_{CM} = \frac{V_0^2}{g} (1 - \cos(\gamma_{max}))$
Contingency volume: H_{CV}	$H_{CV} = H_{FV} + H_{error} + H_R + H_{CM}$
Examples	
Height of flight volume	$H_{FV} = 100m$
<p>Example multirotor:</p> $V_{climb} = 5 \frac{m}{s}, t_R = 1s, H_{error} = 4m$	$H_{CV} = 100m + 4m + 5m + \frac{1}{2} \cdot \frac{\left(5 \frac{m}{s}\right)^2}{9.81 \frac{m}{s^2}} = 111m$
<p>Example fixed-wing:</p> $V_0 = 30 \frac{m}{s}, \gamma_{max} = 20^\circ, t_R = 1s,$ $H_{error} = 4m$	$H_{CV} = 100m + 4m + 30 \frac{m}{s} \cdot \sin(20^\circ) + \frac{\left(30 \frac{m}{s}\right)^2}{9,81 \frac{m}{s^2}} \cdot (1 - \cos(20^\circ)) = 120m$

Table A.5 – Ground Risk Buffer Calculations

GRB horizontal	
<p>Reaction distance: S_R</p> <p><i>Note¹: The reaction distance may be different to the reaction distance used for the contingency volume.</i></p> <p><i>Note²: Values below $V_0 = 3m/s$ are not considered realistic for this calculation.</i></p>	<p>Initiation of measures</p> $S_R = V_0 t_R$ <p>Visual detection: $t_R = 2s$</p> <p>Augmented visual detection: $t_R = 1s$</p> <p>Automated detection: $t_R = 0.5s$</p>
Simplified approach: 1:1 rule: S_{fall}	$S_{fall} = H_{CV} + \frac{1}{2} CD$
<p>Ballistic approach: S_{fall}</p> <p><i>Note¹: Only permitted for rotorcraft and multirotor whose aerodynamic effects during freefall are negligible.</i></p> <p><i>Note²: Values below $V_0 = 3m/s$ are not considered realistic for this calculation.</i></p>	$S_{fall} = V_0 \sqrt{\frac{2H_{CV}}{g}} + \frac{1}{2} CD$

<p>Termination with parachute: S_{fall}</p> <p><i>Note¹: Values below $V_{Wind} = 3m/s$ are not considered realistic for this calculation.</i></p> <p><i>Note²: Only permitted for parachute systems which significantly slow the aircraft.</i></p> <p><i>Note³: Applicable to any type of aircraft platform.</i></p>	<p>Parachute is deployed. Once open, the aircraft is slowed rapidly and freefalls at constant speed, V_Z. The maximum permissible wind speed, V_{Wind} results in a linear glide trajectory. The resulting Ground Risk Buffer is:</p> $S_{fall} = V_0 t_P + V_{Wind} \frac{H_{CV}}{V_Z} + \frac{1}{2} CD$ <p>Where: t_P = Time to open the parachute</p> <p><i>Note: Values for t_P and V_Z are highly platform specific where evidence is required.</i></p>
<p>Termination with fixed-wing aircraft: S_{fall}</p>	<p>Aircraft with glide potential:</p> <p>Power is switched off resulting in the aircraft continuing in a linear glide trajectory: A glide ratio of $E = \frac{180}{\pi \epsilon} = \frac{C_L}{C_D}$ results in</p> $S_{fall} = E \cdot H_{CV} + \frac{1}{2} CD = \frac{H_{CV}}{\epsilon} + \frac{1}{2} CD = H_{CV} \cdot \frac{C_L}{C_D} + \frac{1}{2} CD$ <p>Where: ϵ = Glide angle C_L = Coefficient of lift C_D = Coefficient of drag</p> <p>Aircraft without glide potential:</p> <p>Power is switched off and the flight control surfaces are permanently set in a way that no gliding is possible, initiating a spiral dive manoeuvre, using a robust Flight Termination System (FTS) or passive actuator design.</p> <p>The expected turn radius may be used:</p> $S_{fall} = \frac{V_0^2}{g \tan(\Phi_{max})} + \frac{1}{2} CD$ <p>Typical $\Phi_{max} = 45^\circ$</p>
<p>Total Ground Risk Buffer distance: S_{GRB}</p>	$S_{GRB} = S_R + S_{fall}$
<p>Examples</p>	
<p>Simplified approach – 1:1 rule:</p>	$S_{GRB} = 10m + 111m + \frac{1}{2} \cdot 1.5m = 122m$

$V_{\{0\}} = 10 \frac{m}{s}, CD = 1.5m, H_{\{CV\}} = 111m, t_{\{R\}} = 1s$	
Ballistic approach: $V_0 = 10m/s, CD = 1.5m, H_{CV} = 111m, t_R = 1s$	$S_{GRB} = 10m + 10 \frac{m}{s} \sqrt{\frac{2 \cdot 111m}{9.81 \frac{m}{s^2}}} + \frac{1}{2} \cdot 1.5m = 59m$
Parachute approach: $V_0 = 30m/s, CD = 3m, H_{CV} = 111m, t_R = 1s, t_p = 3s, V_{wind} = 10m/s, V_Z = 5m/s$	$S_{GRB} = 30 \frac{m}{s} \cdot 3s + 10 \frac{m}{s} \cdot \frac{111m}{5 \frac{m}{s}} + \frac{1}{2} \cdot 3m = 314m$
Fixed-wing aircraft with glide potential: $V_0 = 30 \frac{m}{s}, CD = 3m, E = 20, H_{CV} = 120m, t_R = 1s$	$S_{GRB} = 30m + 120m \cdot 20 + \frac{1}{2} \cdot 3m = 2432m$
Fixed-wing aircraft without glide potential: $V_0 = 30 \frac{m}{s}, CD = 3m, \Phi_{max} = 45^\circ, H_{CV} = 120m, t_R = 1s$	$S_{GRB} = 30m + \frac{\left(30 \frac{m}{s}\right)^2}{9.81 \frac{m}{s^2} \cdot \tan(45^\circ)} + \frac{1}{2} \cdot 3m = 124m$

Table A.6 – Adjacent Area Calculations

A.27 The adjacent area begins at the outer limit of the ground risk buffer. Its outer limit results from a three-minute flight of the UA with its maximum operating speed of the UA as specified by the designer (V_{max}), measured from the outer limit of the operating volume (FV+CV). The size is at least 5km, but no more than 35km.

Adjacent area	
Width of the adjacent area: S_{AA}	$S_{AA} = 180 s \cdot V_{max}$
Example	
$V_{max} = 20 \frac{m}{s}$	$180 s \cdot 20 \frac{m}{s} = 3600m$ <p>Since $5000m \leq S_{AA} \leq 35000m$, it follows:</p> $S_{AA} = 5000 m$

Determining the maximum VLOS and BVLOS distances

A.28 When determining the operating range for Visual Line of Sight (VLOS) operations, the remote pilot **must** be able to maintain continuous unaided visual contact with the UA, and be able to detect its position, orientation, and intended flight path. This is to

ensure effective situational awareness and control of the UA, including the ability to take action in response to any potential air or ground risk.

A.29 The maximum VLOS distance is dependent on environmental conditions, UA size, and visibility limitations and **must** be determined during flight planning and verified prior to the operation taking place.

A.30 When an applicant claims VLOS as a tactical mitigation, it **must** deliver the mitigation performance required.

A.31 To determine whether the planned operation is VLOS or BVLOS, refer to the definitions and apply the calculations below.

Table A.7 – Definitions and formulas for calculating maximum VLOS distance

Definitions	
VLOS limit	The maximum possible VLOS distance between remote pilot or observer and UA results from the smaller value of ALOS and DLOS . Anything beyond that is considered BVLOS .
ALOS	<p>Attitude Line of Sight</p> <p>The attitude line of sight defines the maximum distance up to which a remote pilot can detect the position and orientation of the UA. Up to this limit, the remote pilot is able to control the flight path of the UA and is able to determine the attitude and position of the UA.</p> <p>The formula used to calculate the maximum ALOS limit was developed by the Luftfahrt-Bundesamt (LBA) through test and evaluation trials.</p>
DLOS	<p>Detection Line of Sight</p> <p>Detection line of sight defines the maximum distance at which the UA can be operated while the remote pilot can simultaneously detect other aircraft and still has sufficient time to initiate an avoidance manoeuvre. It is not a measure of controllability of the UA, it relates to the ability to detect other aircraft and react in time.</p> <p>DLOS is calculated as approximately one third of the ground visibility (DLOS = 0.3 x GV) allowing the remaining visibility margins for detection of other aircraft and for initiating an avoidance manoeuvre.</p> <p>Note: The detection range may not be the same in all directions due to possible visual obstructions.</p>
GV	<p>Ground Visibility</p> <p>The ground visibility depends on the operational area and the meteorological conditions and should be determined at the time of operation. The procedure for precisely determining ground visibility should be described in the operations submission evidence. The use of ground references or the use of a transmissometer or similar device are possible.</p>

	The maximum ground visibility to be assumed is 5km, analogue to the visibility according to the VFR rules in Class G airspace.
--	--

ALOS limit formula	<p>Example - 1m CD rotorcraft and multirotor:</p> $ALOS_{max} = 327 \cdot CD + 20m$ <p>Example - 1m CD fixed-wing aircraft:</p> $ALOS_{max} = 490 \cdot CD + 30m$
DLOS limit formula	$DLOS_{max} = 0.3 \cdot GV$ <p>GV depends on the actual ground visibility at site and time of operation. However, it always applies:</p> $GV_{max} = 5km$

A.32 To ensure compliance with VLOS requirements:

- (1) the operator **must** verify that the outer limit of the planned operation is within the VLOS boundary;
- (2) the remote pilot **must** always maintain VLOS with the aircraft during the operation.

Figure A.3 – Example VLOS operation that cannot take place

A.33 Figure A.3 illustrates the maximum VLOS boundary distance falls short of the outer edge of the contingency volume. The operation **must** take place in BVLOS.

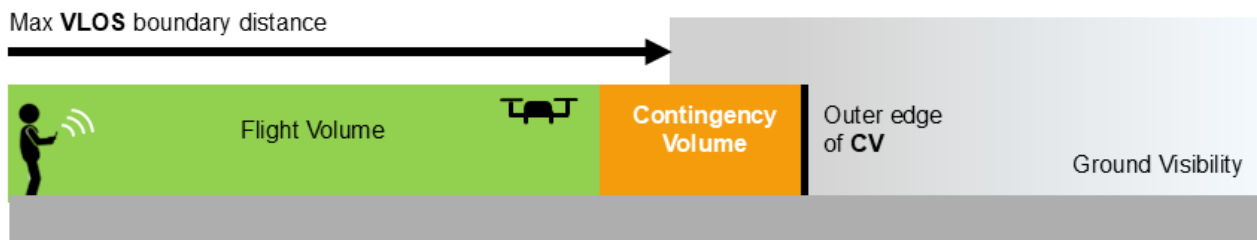


Table A.8 – Example maximum VLOS distances

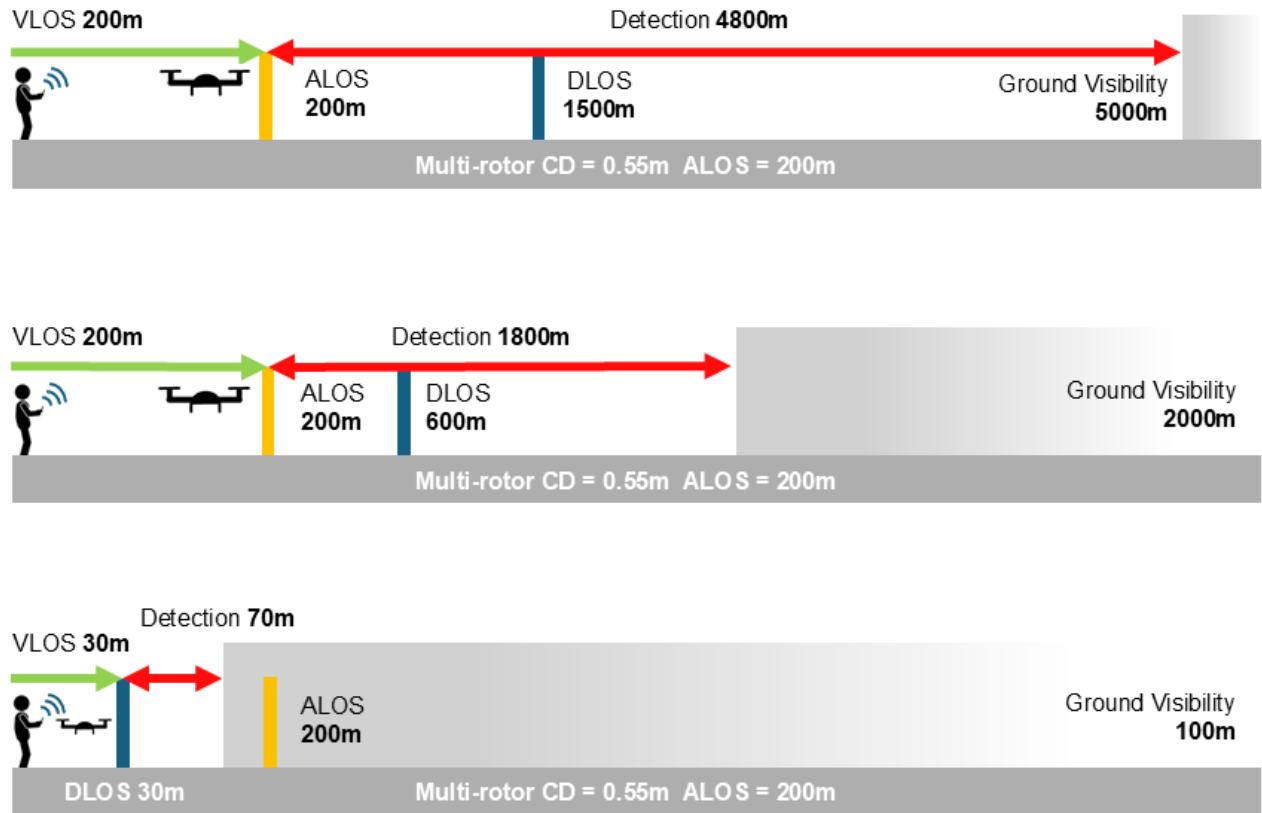
A.34 The following table is valid for a ground visibility of 5km or more.

A.35 The maximum VLOS distance is the lower of the ALOS and DLOS limits. Using a ground visibility of 5km, the 1500m values shown in red represent cases where DLOS ($0.3 \cdot GV$) becomes the limiting factor and therefore sets the maximum VLOS distance.

Maximum VLOS distance calculations		
Maximum UA Characteristic Dimension (CD)	Maximum VLOS distance	
	Multicopter	Fixed-wing
0.5m	183.5m	275m
1m	347m	520m
2m	674m	1010m
3m	1001m	1500m
3.5m	1164.5m	1500m
4 m	1328m	1500m
4.5m	1491.5m	1500m
>4.53m	1500m	1500m
<p><i>Note: ALOS limit formula:</i> <i>Rotorcraft and multicopter: $ALOS_{max} = 327 \cdot CD + 20m$</i> <i>Fixed-wing aircraft: $ALOS_{max} = 490 \cdot CD + 30m$</i></p>		

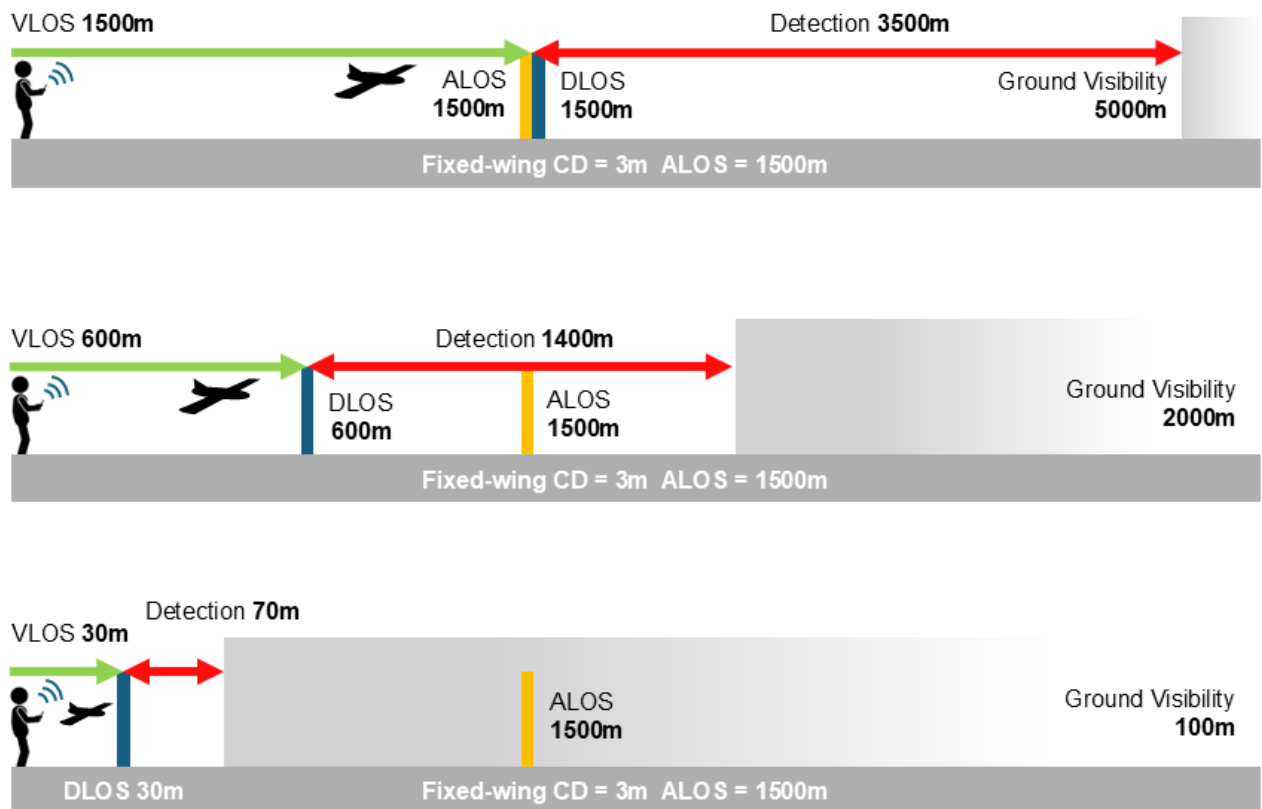
A.36 Figures A.4 and A.5 illustrate how VLOS operational distances for Rotorcraft and Fixed-wing UA are affected by ground visibility, UA size, and the RP's ability to detect and maintain visual contact with the UA. The illustrations are divided into three scenarios, each showing different visibility conditions and the resulting VLOS range.

Figure A.4 – Rotorcraft & Multi-rotor VLOS range



Note: Distances are not to scale

A.37 With a ground visibility of only 100m, the VLOS boundary is limited by DLOS to 30m as the ALOS value of 200m is not achievable under these visibility conditions for a multirotor aircraft.

Figure A.5 – Fixed-wing VLOS range

Note: Distances are not to scale

- A.38 With a ground visibility of only 100m, the VLOS boundary is limited by DLOS to 30m as the ALOS value of 1500m is not achievable under these visibility conditions for a fixed-wing aircraft.

Operations with reduced maximum operating speed

- A.39 UK SORA defines **Maximum Operating Speed** as the maximum possible airspeed the UA may achieve, as specified by its Designer.
- A.40 An applicant may propose an operational maximum speed to reduce the intrinsic Ground Risk Class (iGRC) using software-enforced speed limitations or by mechanical restriction.
- A.41 The UAS designer should specify the maximum achievable airspeeds of the UA as described in the designer's technical documentation.
- A.42 The operator may claim a lower operational speed limitation provided that the following process is followed:
- (i) the configuration and procedure to select a reduced maximum speed is clearly stated in the designer's technical manuals and documentation;
 - (ii) the operator has a documented procedure for configuring and verifying the UA's maximum speed limitation for the specific operation;

- (iii) the configuration or mode associated with the lower speed is selected, and controlled prior to take-off;
- (iv) the UA will maintain the selected speed in the relevant configuration throughout the operation;
- (v) the operator has developed relevant procedures in their operations manual in case of failure of the reduced maximum speed restriction.

A.43 Where a reduced maximum speed is claimed, the operator should provide compliance evidence that the limitation is effective, repeatable and robust, such as manufacturer documentation, configuration/flight-controller settings showing the limit is applied, and flight logs or test results demonstrating the aircraft does not exceed the stated speed in representative conditions.

A.44 Evidence should also explain how the speed limit is measured and maintained including any accuracy/uncertainty and how inadvertent override of higher-speed modes is prevented.

A.45 Compliance evidence to verify the robustness of the system and procedures to limit the UA's operational speed should be submitted in Phase 1 of the SORA application process.

Using the UK SORA annexes

A.46 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 A.9 – Example Requirements

Level of integrity

Criterion	Low (SAIL 2)	Medium (SAIL 3)	High (SAIL 4 to 6)
Technical issue with the UAS	OSO1.L.I	OSO1.L.I OSO1.M.I	OSO1.H.I

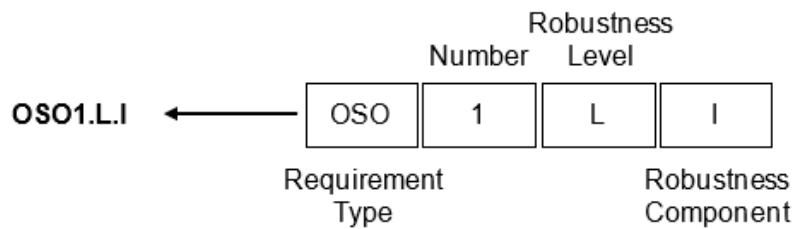
Level of assurance

Criterion	Low (SAIL 2)	Medium (SAIL 3)	High (SAIL 4 to 6)
Technical issue with the UAS	OSO1.L.A	OSO1.M.A OSO1.M.I	OSO1.H.A

Using requirement codes

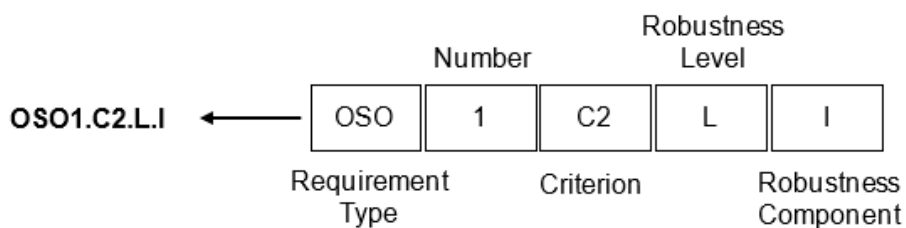
A.47 All UK SORA requirements have a requirement code, which may be used to find AMC and GM. Figure A.6 shows an example of a requirement code for SAIL 2 at low integrity with a single criterion.

Figure A.6 – Requirement codes single criterion



A.48 Some requirements have several criteria, this is displayed after the requirement number, prefixed by the letter C for example C2 shown below in figure A.7.

Figure A.7 – Requirement codes multiple criterion



Using the reference system

Integrity requirements

A.49 Requirement codes ending with the letter I (robustness component) represent integrity requirements and **must** be complied with. Example:

The Applicant **must** meet the following requirements:

- (a) Requirement 1.
- (b) Requirement 2.

Assurance requirements

A.50 Requirement codes ending with the letter A 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.

AMC

A.51 Requirement codes prefixed by the letters AMC may be used to demonstrate compliance with the requirement. **AMC.OSO1.L.I** relates to **Low Integrity**. Where AMC relates to a specific requirement or multiple requirements, the corresponding letter is used. For example:

- (b) The standard 1234 may be used to demonstrate compliance with the requirement.

GM

A.52 Requirement codes prefixed by the letters GM explain how the Applicant may comply and gives general guidance material relating to the overall requirement. **GM.OSO1.L.A** relates to **Low Assurance**. Where GM relates to a specific requirement or multiple requirements the corresponding robustness letter is used.

Additional Requirements

A.53 As the SAIL level increases the robustness level and the corresponding number of requirements may also increase. Using the tables provided, the Applicant may identify additional requirements. In this example, SAIL 3 has medium integrity requirements **OSO1.M.I** in addition to low.

LEVEL of INTEGRITY**Medium (SAIL 3)****OSO1.L.I****OSO1.M.I**

A.54 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:

- **OSO1.L.I**
- **OSO1.L.A**

A.55 Following the low robustness level requirements, additional requirements are listed in the same format as above.

Annex B – AMC1 Strategic Mitigations for Ground Risk

B1. Introduction

- B.1.1** 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.
- B.1.2** 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".
- B.1.3** 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.
- B.1.4** If a criterion is not applicable to a mitigation, e.g. passive mitigations do not require training nor activation, the criterion may be ignored.
- B.1.5** Annex B mitigations are primarily applied to the operational volume and ground risk buffer.
- B.1.6** The GRC **must** may not be lowered to a value less than the corresponding value for a controlled ground area.
- B.1.7** 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. See GM1 to Article 11(6) for further information on RAE-F and SAIL Mark.
- B.1.8** 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 may 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 CAA for an M2 mitigation if the Applicant may 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.~~

AMC1 Article 11 Annex B. M1A Strategic mitigation – sheltering

(...)

M1A Sheltering – Level of assurance

Criterion	Low	Medium	High
Criterion 1 (Evaluation of people at risk)	M1A.C1.L.A	M1A.C1.L.A M1A.C1.M.A	Not applicable

Criterion	Low	Medium	High
Criterion 2 (Evaluation of penetration hazard)	M1A.C2.L.A	M1A.C2.L.A M1A.C2.M.A	Not applicable
Type of Assurance	Declarative only if following the AMC (not declarative if UA found to be penetrating structures and/or UA Kinetic energy $\geq 7000\text{J}$)	Compliance evidence approach	Not applicable

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 which generally consist of structures providing shelter.
- (b) Verify that they reasonably expect uninvolved people will be located under or inside a structure.

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

M1A.C2.L.I

Criterion 2 – Evaluation of penetration hazard

- (a) The applicant **must** use a UA that is not expected to penetrate structures and ~~fatally~~ significantly injure people under the shelter.
- (b) The applicant **must** conduct a penetration analysis.
- (c) If using a SAIL marked UAS to meet the requirements, the applicant **must**:
 - (1) Operate the UA only in operational volumes that have general structures that the UA will not penetrate.

- (2) Ensure the operation of any design features that require functioning for sheltering to be applicable.
- (3) Ensure the operational requirements associated with a design feature that may affect the validity of the applicant's UA penetration analysis are taken into account.

M1A.C1.L.A

Criterion 1 – Evaluation of people at risk

- (a) The Applicant **must** ~~provide evidence~~ submit a declaration 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 hazard

The applicant **must** submit a declaration of compliance that the UA ~~used is under 25 kg~~ MTOM has a kinetic energy at terminal velocity (or a representative velocity) and max operating mass of less than or equal to 175 J.

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.~~

For a UA with a terminal kinetic energy greater than 175 J and less than 7000 J:

- (a) The applicant **must** submit a declaration of compliance that a penetration analysis has been conducted, and the UA cannot penetrate any representative structures in the operational volume.

OR

- (b) If the UA has been determined to penetrate structures in the operational volume, the applicant **must** conduct the same penetration analysis applicable to a UA with a kinetic energy greater than 7000 J.

For a UA with a kinetic energy equal to or greater than 7000 J the applicant **must** submit the following compliance evidence, which will be evaluated by the CAA:

- (a) A penetration analysis report;

AND

(b) Additional evidence to demonstrate compliance with the integrity requirements.

Medium level of robustness

Lower robustness level requirements to be complied with:

- **M1A.C1.L.I**
- **M1A.C2.L.I**
- **M1A.C1.L.A**
- **M1A.C2.L.A**

To avoid double counting, M1(A) medium robustness mitigations **must** not be combined with any M1(B) mitigations.

Additional requirements to be compiled with:

M1A.C1.M.I

Criterion 1 – Evaluation of people at risk

- (a) Same as low. In addition, the applicant **must** restrict operating times and demonstrate that an even higher proportion of uninvolved people are sheltered, compared to the low level of robustness.

M1A.C2.M.I

(...)

M1A.C1.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.~~
- (a) The Applicant **must** submit a declaration of compliance with the integrity requirements.
- (b) 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 **must** not be combined with M1(B) mitigations.

M1A.C2.M.A

Criterion 2 – Evaluation of penetration hazard

No additional requirements.

The Applicant **must** submit a declaration of compliance with the integrity requirements.

AMC.M1A.C2.L.I

(a) An applicant using a UA with a kinetic energy at terminal velocity of less than or equal to 175 J will be deemed to meet the penetration hazard requirement.

OR

(b) For a UA with a kinetic energy at terminal velocity and max operating weight above 175 J the following is applicable:

(i) For a UA over 175 J and below 7000 J, a penetration analysis **must** be conducted. For battery powered UA, the battery should be designed to a consensus industry standard.

(ii) If the penetration analysis determines that a UA will penetrate the structure in their operational volume, they **must** conduct a penetration analysis equivalent to a UA > 7000J. For battery powered UA, the battery should be designed to a consensus industry standard.

(iii) For UA equal to or greater than 7000J a penetration analysis **must** be conducted, and additional evidence **must** be provided. The additional evidence **must** take into consideration secondary fires due to leakage of propulsion fuel. It should evaluate the penetration hazard of automotive vehicles in the operating volume. For battery powered UA, the battery should be designed to a standard acceptable to the CAA. The battery design should take into consideration the effects of collision and the risk of a secondary fire due to battery disintegration from its packaging or assembly should be minimised.

(c) The method to conduct a penetration analysis is described below.

(i) Calculation of the UA Kinetic energy

1. To determine the UA's kinetic energy, the applicant should take into consideration the terminal velocity of the UA. The frontal area of a UA is the cross-sectional area projected on a plane perpendicular to the direction of travel of the UA. The applicant may use table B1 and interpolate where necessary to calculate the frontal area or the applicant may provide the frontal area using appropriate design data.

2. The applicant may use an alternative representative UA velocity for the penetration analysis if they can demonstrate its applicability. An example where a lower velocity may be used is when a parachute is activated prior to collision with a structure.

3. The terminal velocity of a UA may be computed in two ways:

The applicant may determine the terminal velocity using a drop test. A drop test should be conducted from at least 80m from the measurement point and a high-speed camera capable of recording 250 frames per second should be used. The measurement setup should be appropriate with a reference of time and distance. The UA should be configured to its maximum operating weight.

The applicant may calculate the terminal velocity using equation B1.

$$V_{termUA} = \sqrt{\frac{2mg}{C_d \rho A_f}} \quad (B1)$$

Where

$KE_{UA_{term}}$ = Kinetic energy of UA at terminal velocity (J)

V_{termUA} = Terminal velocity of the UA (m/s)

m = Maximum operating weight of UA (kg)

A_f = frontal area of UA (m²) (refer to table B1)

ρ = Density of air at sea level (kg/m³) (assumed to be 1.225 kg/m³)

C_d = Drag coefficient (assumed to be 0.8)

g = acceleration due to gravity (assumed to be 9.8 m/s²)

To calculate the kinetic energy of the UA at its terminal velocity, the equation B2 should be used.

$$KE_{UA_{term}} = \frac{mV_{termUA}^2}{2} \quad (B2)$$

(ii) Penetration analysis: UA with $KE_{UA_{term}} \leq 175$ J

No penetration analysis is required for UA with $KE_{UA_{term}} \leq 175$ J. It will be deemed that the UA cannot penetrate any structure.

(iii) Penetration analysis: UA with 175 J $< KE_{UA_{term}} < 7000$ J

1. The applicant should determine the net kinetic energy of a UA impact into a structure. Each structure has an absorption energy which is listed in the table B4. The resulting kinetic energy is calculated using equation B3.

2. If the net kinetic energy (KE_{net}) is negative, the applicant should conclude that the UA will not penetrate that structure. If the net kinetic energy (KE_{net}) is positive, then the applicant should conclude that the UA will penetrate that structure. If it is identified that the UA will penetrate a structure, then the applicant **must** complete the enhanced penetration analysis that is required for UA with a $KE_{UA_{term}} \geq 7000$ J which will be evaluated by the CAA.

3. The applicant should conduct the penetration analysis for representative structures in their operational volume. It is not necessary to identify every single structure in the operational volume. The general type of structures present in the operational volume may be determined with the help of tools such as google maps or satellite imaging. The analysis should be conducted for both rooftop and side wall penetration unless the applicant can demonstrate (either via simulation or testing or theoretical analysis) that the probability of either collision with a roof or a wall is low that it does not require to be considered. For structures not included in the table, reasonable assumptions for their absorption KE can be made using the existing data. The applicant may also propose

different energy absorption values for the structures in their operational volume with suitable evidence.

$$KE_{net} = KE_{UA_{term}} - KE_{absorbed} \tag{B3}$$

$$KE_{absorbed} = FOA * \frac{A_f}{A_{scalar\ constant}} * \Delta KE_{struct_{abs}} \tag{B4}$$

$$A_{scalar\ constant} = 0.005\ m^2$$

$$FOA = 10$$

KE_{net} = Kinetic energy of UA at terminal velocity (J)

$KE_{absorbed}$ = Kinetic energy absorbed by a structure (J)

$\Delta KE_{struct_{abs}}$ = Transferred energy by a structure (J)

A_f = frontal area of UA (m²) (refer to table B1)

FOA = factor of allowance (no unit)

Table B.1

Characteristic dimension (m)	1	3	8	20	40
Frontal area (m ²) A_f	0.1	0.5	2.5	12.5	25

Table B.2

Roof type	KE absorbed by roof (J) $\Delta KE_{struct_{abs}}$
4 inch Reinforced concrete	13550
14 inch reinforced concrete	271000
Plywood/Wood Joist (2x10 at 16 inch)	68
Gypsum/Steel Joist	34
Plywood Panelized (2x6 at 24 inch)	68
2 inch Lightweight Concrete/Steel Deck and Joists	2710
Medium steel panel (18 gauge)	2033
Light steel panel (22 gauge)	1355
Steel (automobile)	271
No roof	0

Table B.3

Wall Type	KE absorbed by wall (J)
Steel sliding (22 gauge)	1355
8 inch Reinforced CMU	678
8 inch Reinforced Concrete	67750
14 inch Reinforced Concrete	271000

6 inch Reinforced Concrete Tilt up	50813
1/2 in Plywood siding	136
8 inch Unreinforced brick	13550
Steel (automotive doors)	1355
No walls	0

Table B.4

Type of building	Representative Wall	Representative roof
UK residential home: concrete, clay or slate tiled roof, non-flat	8 inch unreinforced brick	Plywood Panelised
Caravan/Trailer/Temporary office trailer	½ inch Plywood siding	Steel Joist
Small commercial buildings and public buildings like hospitals, council buildings	6inch reinforced concrete	2 inch light weight concrete or steel deck
Large apartment complex / large commercial buildings	8inch reinforced concrete	22 gauge steel roof with 3 inch to 14 inch concrete
Warehouses	Steel sliding	Light steel panel
Thatched roof houses	½ inch plywood sliding	Gypsum
Wooden houses	½ inch plywood sliding	Plywood Panelized
Festival and/or concert tents	No walls	Gypsum or lower
Glass roofing (conservatories)	½ inch plywood sliding or lower	Gypsum or lower

(iv) Penetration analysis: UA with a $KE_{UA_{term}} \geq 7000$ J

1. The applicant should conduct the penetration analysis that is applicable for UA with $175 \text{ J} < KE_{UA_{term}} < 7000 \text{ J}$
2. In addition to that penetration analysis, the applicant should ensure that their evaluation of the penetration hazard includes the following:
 - (i) The penetration analysis report considers sheltering due to vehicles in the operational volume i.e. the UA cannot penetrate vehicles and significantly injure people.
 - (ii) A simulation study (example via FEA (Finite Element Analysis) or dynamic modelling) of an impact on the highest KE_{net} structure. Crashworthiness testing on a rigid object using ASTM F3389 and identifying equivalence to a structure may also be accepted.
 - (iii) If the UA is powered by propulsion fuel (other than batteries), an analysis showing that any impact on a structure does not create secondary fires due to the propulsion fuel.
 - (iv) If the UA is powered by a battery, evidence showing that the battery pack is designed to a recognised industry standard (such as IEC62133 or UL1642 or UN

38.3). The applicant should provide evidence to ensure that the battery pack is integrated into the UA in a way that minimises battery fires due to impact on a structure (An example can be that the battery and payload are surrounded by energy absorbing material).

- (v) Any impact on a structure should not result in any additional hazards such as disintegration of battery or payload from UA.
- (vi) If any UA results in penetration of a structure, it should have a maximum probability of 30% of causing an injury of greater than or equal to AIS 3 to uninvolved people. This may be demonstrated either by using one of the methods in AMC1 Article 11 Annex B M2 mitigation or by demonstrating the required probability of a human suffering an injury of AIS3+ in the region where a UA and its elements dissipate after penetrating a structure.
- (d) An applicant may find more information to demonstrate compliance with M1A.C2.L.I (c) by referring to the SAIL mark certificate.

GM1 Article 11 Annex B. M1A Strategic mitigation – sheltering

GM.M1A

~~M1(A) mitigation relies on the fact that people spend on average very little time outdoors without protection from structures. Therefore, operators of sufficiently small UAS may 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 may not be combined with any M1(B) mitigations. In contrast, M1(A) low robustness, which has no operational restrictions, may be combined with M1(B) mitigations.~~

GM.M1A.C1.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%.
- (b) 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.

GM.M1A.C2.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 Centre (TAAC) conference in 2016 titled 'UAS EXCOM Science and Research Panel (SARP) 2016 TAAC Update' PR 16 3979.~~

~~In general, it may 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).~~

- (a) The SAIL mark certificate may provide the following:
 - (i) For example, the SAIL mark certificate may include information that to claim sheltering, the applicant **must** use the UA only in rural environments with structures generally consisting of UK buildings constructed post 1950.
 - (ii) For example, the design may state that a functioning parachute is necessary to claim sheltering for a particular operational volume defined in (i).
 - (iii) For example, the design may state the maximum payload to be used by the operator in order to satisfy the penetration analysis requirement for a given operational volume. The design may state that the maximum payload is limited to a certain value in an operational volume with structures such as wooden houses.
- (b) A structure is anything which can enclose people partially or completely. Structures include but are not limited to concrete or glass buildings, tents, caravans, steel warehouses and automotive vehicles.
- (c) A structure is penetrated by a UA if the UA interacts with the structure in a way results in immediate danger to uninvolved people in or under the structure.
- (d) The objective of the sheltering mitigation is to ensure that any uninvolved people are protected from the operation by being present inside a structure that the UA cannot penetrate. The ASSURE UAS Ground collision severity Evaluation A4 report extensively covers the various methods by which penetration could occur in a structure. It also discusses the potential secondary effects of an impact of a UA on a structure. A significant amount of AMC.M1A.C2.L.I utilises the work done by the A4 and A14 ASSURE report while making assumptions where applicable. A factor of allowance is added to the results from this report to consider the assumptions made by the A14 report. The report conducts these tests using steel balls and evaluates their capability to penetrate roofs. However, a UA is less likely to penetrate a structure to an extent it can cause injury in the same way as a steel ball. Therefore, a factor of allowance of 10 is provided. This factor has been determined from the A14 report along with evaluation experience of the CAA.
- (e) The kinetic energy absorbed by various structures are taken from this report. This report assumes a spherical ball colliding with a structure and the energy required to

penetrate it. A UA colliding with a structure may behave vastly differently to a spherical ball. If the applicant identifies that their UA will penetrate a structure using this method, the M1A is not automatically deemed inapplicable. The applicant is only required to show additional evidence normally reserved for UA with a kinetic energy > 7000 J at terminal velocity. However, if the applicant determines that their UA will penetrate a structure in their operational volume, they cannot use the declaration of compliance method, and the evidence will be evaluated by the CAA irrespective of the kinetic energy of the UA.

- (f) For UA with $175 \text{ J} < KE_{UA_{term}} < 7000 \text{ J}$, a simple penetration analysis report is deemed suitable to claim the penetration hazard requirement of sheltering. To perform the penetration analysis, the applicant should identify the generic structures in their operational volume, take best match values from the tables provided and calculate the resultant kinetic energy due to an impact. If this resultant kinetic energy is negative, then there is a low probability for that UA to penetrate that structure. To identify the various structures in their operational volume, the applicant may use sources such as google street maps and/or satellite imaging to identify the generic type of structures in their operational volume. If the applicant determines that structures in their operational volume are not represented by table B4, they may provide alternate representative values to the structure's $KE_{absorbed}$. For these UA, the applicant needs to demonstrate that their battery is designed to a recognised standard that also tests impact condition of the battery pack.
- (g) For UA with $KE_{UA_{term}} \geq 7000 \text{ J}$, there are additional risks due to the kinetic energy impact of the UA, which have a higher probability of penetrating some structures, and therefore further analysis is required to ensure that any penetration does not result in significant injuries to uninvolved people. For these UA, the applicant needs to demonstrate that their battery is designed to a recognised standard that also tests impact condition of the battery pack. If the UA is using a propulsion fuel other than batteries, then its impact is also to be considered in the penetration analysis.
- (h) In addition, any debris from the penetration injuring uninvolved people is also to be considered. A significant injury is when a UA impact has more than 30% probability of causing an AIS 3 (Abbreviated Injury Scale) and above injury. The ASSURE UAS Ground collision severity Evaluation A4 report defines AIS 3 injuries as any injury that requires hospitalisation or causes loss of consciousness. The table B5 from ASSURE UAS Ground collision severity Evaluation A4 (<https://assureuas.com/wp-content/uploads/2021/06/A4-Final-Report.pdf>) report provides a rough guideline of various human injuries and their equivalent AIS rating. The AIS method of defining an injury is taken from the automotive industry, which uses the study AIS 2005: a contemporary injury scale (<https://pubmed.ncbi.nlm.nih.gov/17092503/>) as its reference.

Table B.5

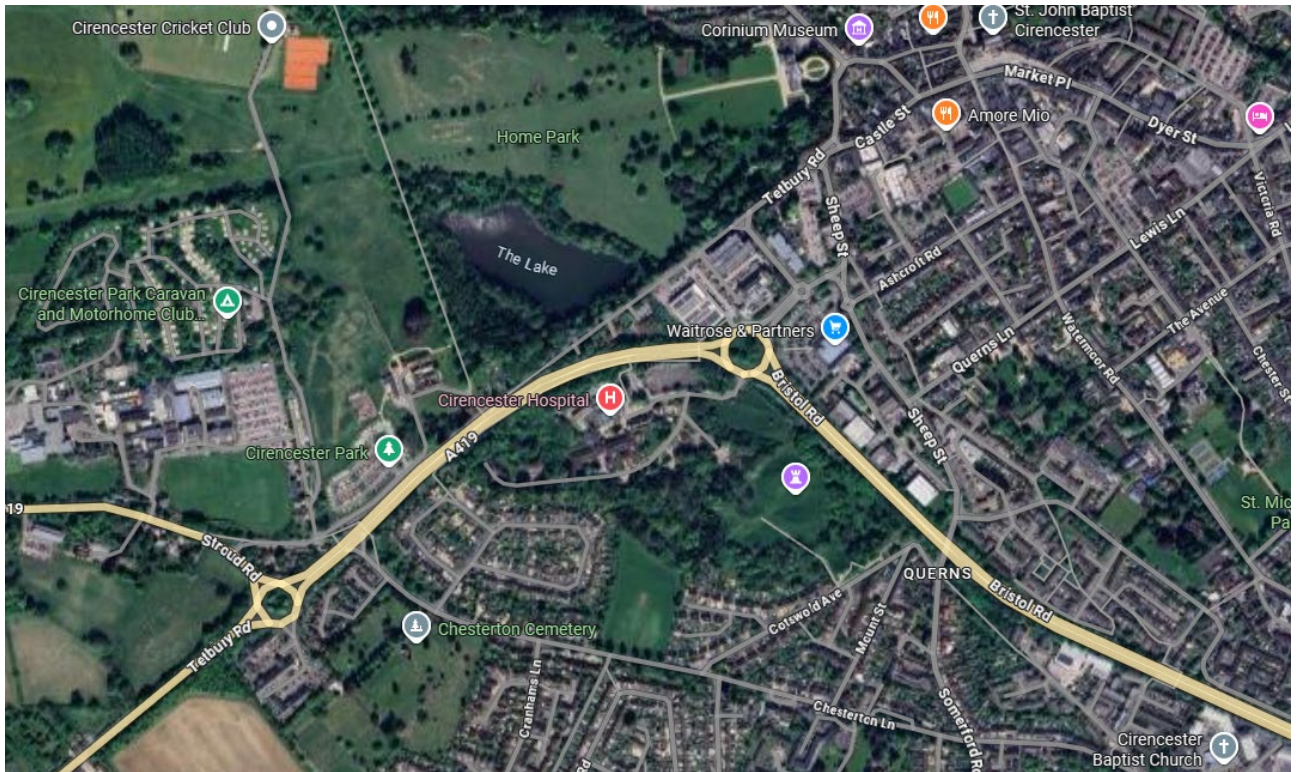
Body Part	Injury	AIS Rating
Head	Penetrating Injury - Superficial; ≤ 2 cm beneath the entrance	AIS 2
	Laceration resulting in blood loss of $> 20\%$ by volume	AIS 3
	Total scalp loss or blood loss of $> 20\%$ by volume	AIS 3
	Severing of the Optic Nerve	AIS 2
	Severing of the Facial Nerve	AIS 3
Brain	Superficial cerebellum contusions ≤ 15 cc; 1-3 cm	$<$ AIS 3
	Concussive Injury Loss of Consciousness 1-6 hours	AIS 3
	All other concussions	AIS 2
Face	Penetrating Injury; with blood loss > 25 cm ²	AIS 2
	Penetrating Injury with blood loss 20% by volume	AIS 3
	Massive destruction of whole face including both eyes	AIS 4
	Complete separation of the facial bones from their cranial attachments or any injury resulting in blood loss $> 20\%$ by volume	AIS 3
Neck	Penetrating Injury with blood loss 20% by volume	AIS 3
	Bilateral laceration of the Carotid Artery	AIS 3
Upper Limbs	Single amputation at the shoulder	AIS 4
	Amputation of a single hand, partial or complete	AIS 2
	Amputation of the thumb	AIS 2
	Amputation of other fingers, single or multiple	AIS 1

Example of a penetration analysis

An applicant has chosen a multi-rotor UA with frontal area of 0.76m² with an operating weight of 16kg. They choose their operational environment to be around Cirencester in the Cotswolds.

They calculate their kinetic energy at terminal velocity to be approximately 20 m/s and kinetic energy of the UA as 3368J. They meet the requirement of a UA < 7000 J.

By using a satellite image of Cirencester, they identify that the town has some new residential buildings, some commercial buildings, leisure clubs, and a hospital.



They proceed to list the type of general structures in their operational volume. For each general structure, they identify from table B4 and approximate to the best matched roof and wall for such structures. The applicant calculates the $\Delta KE_{struct_{abs}}$ for those structures in their operational volume. Using the $\Delta KE_{struct_{abs}}$ for such structures, the applicant proceeds to calculate the KE_{net} . If the KE_{net} for any general structure identified in the Cirencester operational volume is positive, then the applicant **must** meet the additional requirements that are applicable for UA with $KE > 7000J$ to claim sheltering for this operation. They may not qualify for a declaration in case they identify if their UA is found to penetrate any of the general structures in their operational volume.

Below is a non-exhaustive list of buildings in the operational volume and the values used for the KE absorbed by the wall and roof and the net KE for their UA. The penetration analysis in this case demonstrates that the UA cannot penetrate any structures in this operational volume.

Table B.6

Type of building in OV	$\Delta KE_{struct_{abs}}$ absorbed by roof (J)	$\Delta KE_{struct_{abs}}$ absorbed by wall (J)	KE_{net} (J) roof	KE_{net} (J) wall
UK residential home clay tiled roof, non-flat	68	13550	-99991	-20592800
Small commercial buildings including hospitals	2710	50813	-4116000	-77232560

GM.M1A.C1.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~~

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.

AMC1 Article 11 Annex B. M1B Strategic mitigation using operational restrictions

M1B Operational restrictions – Level of integrity

(...)

M1B Operational restrictions – Level of assurance

Criterion	Low	Medium	High
Criterion 1 (Evaluation of people at risk)	Not applicable	M1B.C1.M.A	M1B.C1.H.A
Criterion 2 (Impact on at risk population)	Not applicable	M1B.C2.M.A	M1B.C2.H.A
Type of Assurance	Not applicable	Declarative only if following the AMC	Compliance evidence approach

(...)

M1B.C1.M.A

Criterion 1 – Evaluation of people at risk

The applicant **must** submit a declaration of compliance with the integrity requirements. Compliance evidence of the data sources and processes used to claim lowering the density of population at risk.

Medium robustness M1(B) mitigation **must** not be combined with M1(A) mitigations.

M1B.C2.M.A

Criterion 2 – Impact on at risk population

The applicant **must** provide compliance submit a declaration of compliance evidence that the required level of integrity is achieved. This is typically achieved by means of analysis, simulation, surveys or through operational experience.

AMC.M1B.C1.M.I

- (a) The evidence should be in the form of a report that describes that the operation is in an environment that has a lower number of people at risk on the ground, and the applicant does not fly over large open-air assemblies of people.
- (b) The report should demonstrate that time-based restrictions are in place and ensure a lower proportion of people on the ground at the time of operation.

(...)

M1B.C1.H.A

Criterion 1 – Evaluation of people at risk

No additional requirements

The applicant **must** submit the compliance evidence to demonstrate that the required level of integrity is achieved. The evidence will be evaluated by the CAA.

M1B.C2.H.A

Criterion 2 – Impact on at risk population

No additional requirements

The applicant **must** submit the compliance evidence to demonstrate that the required level of integrity is achieved. The evidence will be evaluated by the CAA.

(...)

AMC1 Article 11 Annex B. M1C Tactical Mitigations – Ground observations

M1C Ground observations – Level of integrity

(...)

M1C Ground observations – Level of assurance

Criterion	Low	Medium	High
Criterion 1 (Procedures)	M1C.C1.L.A	Not applicable	Not applicable
Criterion 2 (Technical means)	M1C.C2.L.A	Not applicable	Not applicable
Type of Assurance	Declarative only if following the AMC	Not applicable	Not applicable

(...)

M1C.C2.L.I

Criterion 2 – Technical means

- (a) 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.
- (b) If using a SAIL marked UAS, the applicant **must** ensure compliance with the associated limitations and operational procedures of all the devices used to achieve the mitigation.

M1C.C1.L.A

Criterion 1 – Procedures

~~(a) The Applicant **must provide evidence** submit a declaration 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

Criterion 2 – Technical means

The Applicant **must provide evidence** submit a declaration of compliance with the integrity requirements.

AMC.M1C.C1.L.I

The procedures should include:

- (a) A clear communication plan, which should use standard phraseology, i.e., a pre-defined set of short, unambiguous words and callouts that everyone involved in the operation uses consistently for routine actions and time-critical events.
- (b) Backup procedures in event of a technical issue.

AMC.M1C.C2.L.I

- (a) If ground observation is achieved using a camera or any other optical image sensor onboard the UA, then such a device should be able to detect people with a certain level of accuracy (example of 25 PPM (pixels per meter)). The applicant may choose a camera designed using principles of BS EN 62676-4:2015 or ISO/TS 19159-4:2022, although the camera does not require to be certified to that standard. The applicant should ensure that the camera is able to detect people at the level of accuracy required from their operating height with suitable safety margin. If any additional algorithms are used to process the data from a camera to perform ground observation, testing evidence of those algorithms should be provided. If observation is done using a camera, the remote pilot may not visually perform the ground observation (such as observing uninvolved people on a screen) while simultaneously flying the UA. However, the pilot may perform the ground observation via algorithms providing them an alert or similar means.
- (b) If ground observation is achieved using a LiDAR sensor onboard the UA, then the LiDAR sensor should be designed using the principles of ISO/TS 19159-4:2022 or IEC 61496-1 or any other equivalent standard. An automotive qualified LiDAR sensor or an equivalent qualified LiDAR sensor may be used if its resolution is suitable to detect people on the ground from the operating height. If any additional algorithms are used to process the data from a camera to perform ground observation, testing evidence of those algorithms should be provided.
- (c) If ground observation is achieved using any other technology, appropriate industry standards for such technology should be used by the applicant. Appropriate industry

standards should be used for testing and calibration of sensors used in the ground observation.

- (d) The applicant should also provide contingency measures to perform ground observation in case of failure or malfunction of a sensor where it is no longer able to detect people at the required level of detail or accuracy. Some reasons for malfunction could be dirt, rain, wind or low light environments. The applicant should also provide any maintenance (such as but not limited to re-calibration, checking of functioning, cleaning) and operational requirements for the sensors used. The applicant should check functioning of the sensor prior to each flight and confirm its working. Any steps that are required to check such functioning should be added to the flight manual.
- (e) If the applicant claims a M1A or M1B mitigation where they restrict operating hours, they should ensure that the sensor device used is suitable to operate at the required accuracy in those operating hours.
- (f) For a SAIL marked UAS, the applicant should:
 - (1) Identify all the technical means as per (a), (b), (c), (d) available in the UAS that allows detection of people;
 - (2) Implement any environmental, operational and other limitations of such technical features;
 - (3) Implement the operational procedures associated with each technical feature. These operational procedures should also include requirements on the operator in case of failure of any such technical means;
 - (4) Implement the maintenance instructions of every technical means used.
- (g) An applicant may find more information to demonstrate compliance with M1C.C2.L.I (b) by referring to the SAIL mark certificate.

GM1 Article 11 Annex B. M1C Tactical Mitigations – Ground observation

GM.M1C

- (a) M1(C) mitigation is a tactical mitigation where the remote crew, UAS, or external system may observe most of the overflowed area(s), allowing the detection of uninvolved people in the operational area and manoeuvring the UA, so that the number of uninvolved people overflowed during the operation is significantly reduced.
- (b) The remote crew or system may use a variety of devices or sensors to detect uninvolved people in the operational volume. Such devices or sensors may be designed to an industry standard with a certain level of accuracy to detect people. If there is any post processing of data and any algorithms used in the detection of people, it is important that such algorithms are shown to be accurate and developed with suitable software development processes in place. Applicants may refer to

ASTM F3201-24 for more guidance on organisational requirements for developing software.

- (c) Environmental conditions play a major role in the efficiency of technical solutions to detect people. Various studies have shown that LiDAR sensors are sensitive to environmental effects such as rain, hail, humidity and dust. Laser signals from LiDAR sensors get absorbed by rain, dust and cause inaccuracies. Applicants are advised to take these into consideration when integrating LiDAR sensors onto the UA. Similar considerations are to be made when using a camera or other optical image sensors.

AMC1 Article 11 Annex B. M2 Effects of UA impact dynamics are reduced

M2 Effects of UA impact dynamics are reduced – Level of integrity

(...)

M2 Effects of UA impact dynamics are reduced – Level of assurance

Criterion	Low	Medium	High
Criterion 1 (Technical Design)	Not applicable	M2.C1.M.A	M2.C1.H.A
Criterion 2 (Procedures)	Not applicable	M2.C2.M.A	M2.C2.M.A M2.C2.H.A
Criterion 3 (Training)	Not applicable	M2.C3.M.A	M2.C3.H.A
Type of Assurance	Not applicable	Declarative only if following the AMC	Compliance evidence approach

M2.C1.M.I

Criterion 1 – Technical design

- (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.
- (d) The technical design requirements may be met by using a SAIL marked UAS. If using a SAIL marked UAS, the applicant **must:**

- (i) Implement the defined limitations in the applicability of (a), (b), (c)
- (ii) ensure that the correct configuration of the UAS is used for which the requirements in (a), (b), (c) are applicable.

M2.C2.M.I

Criterion 2 – Procedures

- (a) Any equipment used to reduce the effect of the UA impact dynamics **must** be installed and maintained in accordance with the Designer's instructions.
- (b) The installation, maintenance and operational procedures for the M2 mitigation **must** be demonstrated as relevant and sufficient through either flight testing, ground testing or simulation methods.
- (c) For procedures using a SAIL marked UA, the relevant installation, maintenance and operational procedures for the mitigation **must** be implemented.

M2.C3.M.I

Criterion 3 – Training

- (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 suitably qualified for the task.
- (c) The applicant **must** have developed a training syllabus which **must** be competency based.
- (d) The operator **must** provide competency-based, theoretical, and practical training for the remote crew.
- (e) Personnel responsible for installation and maintenance of the mitigation measures **must** have completed relevant training.

M2.C1.M.A

Criterion 1 – Technical design

- (a) The applicant **must** provide evidence submit a declaration of compliance with the Integrity requirements
- (b) If integrity requirements are met by using a SAIL marked UAS, the applicant **must** provide the SAIL mark certificate to demonstrate compliance.
- ~~(b) If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified.~~

M2.C2.M.A

Criterion 2 – Procedures

- ~~(c) (a) The applicant **must provide evidence** submit a declaration of compliance with the Integrity requirements~~
- ~~(d) (b) 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. If Integrity requirements are complied with through a SAIL marked UAS, the applicant **must** provide the SAIL mark certificate.~~
- ~~(a) The installation, 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:
 - ~~(1) Dedicated flight test.~~
 - ~~(2) Simulation, provided that the representativeness of the simulation is proven valid for the intended purpose with positive results.~~~~

M2.C3.M.A

Criterion 3 – Training

- ~~(a) The applicant **must** have developed a training syllabus which must be competency based. submit a declaration of compliance with the Integrity requirements.~~
- ~~(b) The operator **must** provide 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.M2.C1.M.I

Criterion 1 – Technical design

- ~~(a) A UA with a Kinetic energy at terminal velocity ($KE_{UA_{term}}$) or maximum operational velocity (whichever higher) of less than or equal to 175 J will be deemed to comply with M2.C1.M.I.~~
- ~~(b) Any M2 mitigation used to reduce the impact dynamics or post impact hazards should ensure (via simulation and/or testing or operational experience) that it achieves a 90% reduction in lethality when compared to a UAS operation without medium M2 mitigation. (i.e. probability of a fatality should be 10% of the original probability after applying M2 medium).~~

(c) Using the compliance methods in one or more of (i), (ii), or (iii), the applicant may demonstrate that the probability of an uninvolved person suffering an injury equal to or greater than AIS 3 (Abbreviated Injury Scale) is below 30%. To comply with M2.C1.M.I(a), the applicant should use either one or more of the methods below to demonstrate compliance.

(i) If a parachute is used to reduce UA impact dynamics via the reduction of critical area and/or post impact hazards, it should be designed to *ASTM F3322-24a: Standard Specification for Small Unmanned Aircraft System (sUAS) Parachutes* or any other equivalent industry standard. For UA $\leq 25\text{kg}$ and $< 3\text{m}$ wingspan, a parachute designed and tested under ASTM F3322-24a, with a net vector velocity (parachute descent rate velocity plus wind velocity) of $\leq 10\text{ m/s}$ will be deemed to show compliance. For UA $> 25\text{kg}$, the parachute should be designed to ASTM F3322-24a and in addition show compliance to (ii).

(ii) If reduction of critical area of UA is used to show compliance, the critical area after applying M2 mitigation should be calculated using the method below. If the calculated critical area is less than or equal to the target critical area allowed for a particular UA characteristic dimension (CD) as per table B6, it is deemed to show compliance. If the applicant wishes to propose an alternate method to calculate critical area or deviates from the standard values used in the calculation of critical area, they should provide suitable evidence to ensure its accuracy and relevance, which will be evaluated by the CAA...If the applicant has claimed a lower critical area and obtained a reduction in their iGRC in step #2, their critical area should be reduced by 90% from the approved critical area to further claim M2 mitigation medium.

Example 1: For a UA with CD of 3.5m, the applicant should ensure that the critical area after M2 mitigation is less than or equal to 80m^2 . For a UA with WS of 1m, the applicant should ensure that the critical area after M2 mitigation is less than or equal to 0.8m^2 .

Example 2: For a UA with a CD of 3.5m, the applicant successfully claimed that their intrinsic critical area was 15m^2 and obtained a reduction in their iGRC. To obtain a M2 medium mitigation reduction, their reduced critical area after applying mitigation should be 1.5m^2 .

Table B.7

UA characteristic dimension (CD) (m)	CD ≤ 1	$1 < \text{CD} \leq 3$	$3 < \text{CD} \leq 8$	$8 < \text{CD} \leq 20$	$20 < \text{CD} \leq 40$
Target Critical Area (m^2)	0.8	8	80	800	8000

The critical area of a UA should be calculated using the following method.

For UA characteristic dimension (CD) $\text{CD} \leq 1\text{m}$

$$A_c = 2r_D(d_{glide}) + \pi r_D^2$$

$$v_{non_lethal} = \sqrt{\frac{2KE_{non-lethal}}{m}}$$

$$t_{safe} = \frac{v_{nonlethal} - ev_{horizontal}}{-C_g g}$$

$$v_{horizontal} = v \cos \theta$$

$$r_D = r_{person} + \frac{CD}{2}$$

For UA characteristic dimension (CD) $CD > 1m$

$$A_c = 2r_D(d_{glide} + d_{slide_reduced}) + \pi r_D^2$$

$$v_{non_lethal} = \sqrt{\frac{2KE_{non-lethal}}{m}}$$

$$t_{safe} = \frac{v_{non_lethal} - ev_{horizontal}}{-C_g g}$$

$$d_{slide_reduced} = ev_{horizontal}t_{safe} - \frac{1}{2}C_g g t_{safe}^2$$

$$v_{horizontal} = v \cos \theta$$

$$r_D = r_{person} + \frac{CD}{2}$$

$$d_{glide} = \frac{h_{person}}{\tan \theta}$$

Table B.8 - Parameters used in the calculation of Critical area

Variable	Description	Standard values
r_{person}	Radius of a person	0.3 m
h_{person}	Height of a person	1.8 m
e	Coefficient of restitution	0.65
θ	Angle of impact	35 deg
C_g	Coefficient of friction	0.75
g	Gravitational acceleration	9.8 m/s ²
$KE_{non-lethal}$	Non-lethal kinetic energy limit	290 J
π	Pi	3.1415
d_{glide}	Glide distance	2.57 m
v	Max velocity of UA (terminal velocity or max operational velocity)	m/s

<i>m</i>	Maximum take off mass of UA	kg
<i>CD</i>	Characteristic dimension of the UA	m

1. The parameters in table B7 are standard values used in the computation of critical area for a UA. The applicant may propose different values to those parameters but should substantiate with suitable evidence. For example, the applicant may have a stall feature enabled to satisfy M2 mitigation which may create a higher impact angle. They should be able to ensure it by testing and/or simulation. They may then be able to use that impact angle in their critical area calculation.
 2. If the UA contains a propulsion fuel other than batteries, the critical area should consider secondary effects due to the fuel (example: explosion, deflagration). This is because a UA with an alternate propulsion fuel may cause an explosion on impact and result in a critical area larger than the one calculated using the standard critical area calculation method.
 3. An applicant may claim a reduced critical area if they are able to demonstrate any valid reason for that reduction. In case of reduced critical area claims, the applicant should ensure it in their operating environment with the help of testing and/or simulation. If the applicant has claimed either low or medium applicable M1A mitigation, they may apply a sheltering factor of 0.4 to their critical area calculation.
- (iii) Reduction of post impact hazards may be ensured for a UA \leq 25kg MTOM using a solution (example frangible UA) designed and tested to ASTM F3389/F3389M – 21 Standard Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts or any other equivalent industry standard. Method A of ASTM FF3389M-21 is not applicable. The kinetic energy of the UA prior to impact should be equal to or lower than 290 J after applying M2 mitigation.
- (d) To comply with M2.C1.M.I (b), the applicant should use the following methods below to show compliance.
- (i) If a flight termination system (FTS) is used, the applicant should ensure that it is designed to an appropriate industry standard and its reliability to meet the M2 mitigation probability ensured. Applicants should use BS EN 4709-006 or any other equivalent industry standard to design a FTS. A FTS designed to meet low robustness containment COR.L is deemed to show compliance.
 - (ii) If any other system is used in the UAS as part of a M2 mitigation, the applicant should ensure that it is designed to an appropriate industry standard and its reliability to meet the M2 mitigation probability ensured.
- (e) The applicant should use the following methods below to show compliance with M2.C1.M.I (c).
- (i) Mitigated SAIL 1 compliance is deemed to be met without further evidence required.

- (ii) For mitigated SAIL 2 the applicant should perform a simple safety assessment of only the mitigation and its impact on the UAS.
- (iii) For mitigated SAIL 3 and above:
 - 1. A safety assessment of only the M2 mitigation and its impact on the UAS should be conducted using an appropriate industry standard. The applicant may use *F3309/F3309M – 24a Standard Practice for Simplified Safety Assessment of Systems and Equipment in Small Aircraft and/or ED-280 Guidelines for UAS Safety Analysis for the Specific Category*. In addition, the applicant may also use *ED-279 Generic Functional Hazard Assessment (FHA) for UAS* to identify hazards that lead to UAS loss of control in case of failure of M2 mitigation. Applicants may also perform their safety assessment of M2 mitigation as part of OSO 5 for operations equal to or above mitigated SAIL 3.
 - 2. The applicant should ensure that any failure of the M2 mitigation does not reduce the reliability of the UAS ensured in other requirements and OSOs.

AMC.M2.C1.M.A

Criterion 1 – Technical design

- ~~(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.~~
- (a) If the applicant meets the integrity requirements by using a UA with a kinetic energy at max operational velocity or terminal velocity (whichever higher) of $\leq 175\text{J}$, they should submit a declaration stating that their UA is within the kinetic energy requirements. If the applicant meets the integrity requirements by using a parachute, they should submit a declaration that the parachute is designed to the appropriate industry standard.
- (b) If the applicant meets the integrity requirements by reduction of critical area, they should provide a declaration that the critical area calculations have been conducted using AMC.M2.C1.M.I. If the applicant has any deviations from the AMC.M2.C1.M1 and/or wishes to claim a further reduction in critical area, they should provide the associated evidence for the claim of reduction, which will be evaluated by the CAA.
- (c) If the applicant meets the integrity requirements by crashworthiness testing of the UA and demonstrating its reduction in post impact hazards, they should submit a declaration that such testing is conducted to the prescribed industry standard
- (d) If an FTS is used as part of the M2 mitigation, the applicant should provide a declaration that it is designed and tested to the prescribed industry standard
- (e) The applicant should submit a declaration that they conducted their safety assessment and/or functional hazard analysis to the prescribed industry standard.

AMC.M2.C2.M.I

Criterion 2 – Procedures

The applicant should develop steps in the appropriate operations manual and/or flight manual and maintenance manual for the proposed M2 mitigation.

AMC.M2.C2.M.A

Criterion 2 – Procedures

(b) The following standard may be used to demonstrate compliance with the requirement: "Annex E – AMC 1 Integrity and assurance levels for the Operational Safety Objectives (OSO)" on page 316 paragraph 1.5 provides further information about proposing a standard as an AMC.

(...)

M2.C1.H.I

Criterion 1 – Technical design

(...)

- (c) No single failure **must** lead simultaneously to the loss of control of the operation and loss of the effectiveness of the M2 mitigation.
- (d) The technical design requirements may be met by using a SAIL marked UAS. If using a SAIL marked UAS, the applicant **must**:
 - (i) Implement the defined limitations in the applicability of (a), (b), (c).
 - (ii) ensure that the correct configuration of the UAS is used for which the requirements in (a), (b), (c) are applicable.

M2.C2.H.I

Criterion 2 – Procedures

No additional requirements.

- (a) The flight tests performed to validate the procedures **must** cover the entire flight envelope or be ensured to be conservative.
- (b) If using a SAIL marked UAS, 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.
- (c) If using a SAIL marked UAS, the applicant **must** implement adequate procedures that are applicable to the mitigation and the operational limitations associated with it.

(...)

M2.C1.H.A

Criterion 1 – Technical design

The applicant must provide evidence of compliance with the integrity requirements, which will be evaluated by the CAA. ~~The Integrity requirements must be complied with to a standard or means of compliance acceptable to the CAA.~~

M2.C2.H.A

Criterion 2 – Procedures

- ~~(a) The flight tests performed to validate the procedures must cover the entire flight envelope or be demonstrated to be conservative.~~
- (a) The applicant **must** provide evidence of compliance with the integrity requirements, which will be evaluated by the CAA.
- (b) If ~~(a) and~~ Integrity requirements are complied with through a SAIL mark certificate marked UAS, 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** submit the SAIL mark certificate as evidence of compliance.

M2.C3.H.A

Criterion 3 – Training

~~No additional requirement.~~

The applicant must provide evidence of compliance with the integrity requirements, which will be evaluated by the CAA.

AMC.M2.C1.H.I

- (a) The applicant should show compliance with M2.C1.H.I(a) as set out below:
 - (1) The applicant may use methods similar to AMC.M2.C1.M.I but should ensure a 99% reduction in risk to uninvolved persons using those methods.
 - (2) If using the reduction of critical area method, the applicant should ensure that the calculated critical area after applying M2 mitigation is below the target critical area in table B8. If the applicant has claimed a lower critical area and obtained a reduction in their iGRC in step #2, their critical area should be reduced by 99% from the approved critical area to further claim M2 mitigation high.

Example 1: The critical area limit for a UA with characteristic dimension (CD) of 2.5m is 0.65m². The critical area limit for a UA with a CD of 10m is 65m².

Example 2: For a UA with a CD of 3.5m, the applicant successfully claimed that their intrinsic critical area was 15m² and obtained a reduction in their iGRC. To obtain a M2 high mitigation reduction, their reduced critical area after applying mitigation should be 0.15m².

Table B.9

UA characteristic dimension (CD) (m)	CD≤3	3<CD≤8	8<CD≤20	20<CD≤40
Target Critical Area (m ²)	0.65	6.5	65	650

(3) If post impact hazards are reduced using crash testing, the applicant should use method D in ASTM F3389/F3389M-21. The maximum transferred energy to an uninvolved person upon impact should be ≤ 80 J or the kinetic energy of the UA prior to impact should be less than or equal to 175 J after applying M2 mitigation.

(b) To show compliance with M2.C1.H.I (c), the applicant should conduct a safety assessment for the M2 mitigation using the prescribed industry standard and ensure that no single failure causes loss of control to the UA and reduces effectiveness of the M2 mitigation.

AMC.M2.C1.H.A

Criterion 1—Technical design

The following standard may be used to demonstrate compliance with the requirement:

~~{Standard will be added later}~~

- (a) If the applicant meets the integrity requirements by using a UA with a kinetic energy at max operational velocity or terminal velocity (whichever is higher) of ≤175J, they should submit a declaration that their UA is within the kinetic energy requirements. If the applicant meets the integrity requirements by using a parachute, they should submit the compliance basis and associated compliance evidence that the parachute is designed to an appropriate industry standard, which will be evaluated by the CAA.
- (b) If the applicant meets the integrity requirements by reduction of critical area, they should submit the associated compliance basis and compliance evidence for the claim of reduction, which will be evaluated by the CAA
- (c) If the applicant meets the integrity requirements by crashworthiness testing of the UA and demonstrating its reduction in post-impact hazards, they should submit the associated compliance basis and compliance evidence, which will be evaluated by the CAA.
- (d) If an FTS is used as part of the M2 mitigation, the applicant should submit the compliance basis and compliance evidence that it is designed and tested to an appropriate industry standard, which will be evaluated by the CAA.

- (e) The applicant should submit a report of their safety assessment conducted for the M2 mitigation, which will be evaluated by the CAA.
- (f) For an applicant using a SAIL marked UAS, they may find more information to show compliance with M2.C1.H.I (d) by referring to the SAIL mark certificate.

GM1 Article 11 Annex B. M2 Effects of UA impact dynamics are reduced

GM.M2

- (a) M2 mitigation reduces the effect of ground impact in case of a loss of control (LOC) leading to significant injuries to uninvolved and unsheltered people. M2 mitigation does not consider the probability of an occurrence of a loss of control event. M2 mitigation aims to:
 - (1) Lower the probability of significant injuries by reducing the effect of the UA's ground impact (example via lowering the impact energy, lowering the energy transfer dynamics) and/or,
 - (2) Lower the probability of significant injuries by reducing the size of the expected critical area. (Examples include but not limited to the use of parachutes, autorotation, frangibility, stalling the UA)
- (b) The applicant can choose both options to arrive at an overall reduction in the probability of fatality. The probability to demonstrate is a below 30% likelihood of an injury greater than AIS 3.
- (c) If option 2 (reduction of critical area) is used by the applicant to achieve M2, they should demonstrate that the critical area of all their UA is below the critical area limit defined in AMC.M2.C1.M.I. If the applicant has already used a feature to demonstrate reduced critical area in determining their iGRC, they cannot use the same feature to claim any M2 mitigation. As an example, if the applicant has used a maximum operational speed or any other intrinsic feature of the UA that demonstrates reduced critical area and has claimed a reduction in iGRC in Step 2 using that feature, then the applicant cannot use the same feature to claim any M2 mitigation.
- (d) Operational experience may be used to meet the M2 mitigation requirement as an alternative to testing. The applicant should demonstrate that the UAS configuration during operational experience has no differences (that would affect the validity of any of the M2 mitigation requirements) to the one used for satisfying the M2 medium mitigation. This is valid if the applicant has already been operating with the M2 mitigation in other countries. It will be at the discretion of the CAA to accept any relevance of operational experience. The use of operational experience to meet M2 mitigation cannot be declarative.
- (e) Mitigated SAIL is the SAIL after applying all mitigations to reduce the initial SAIL.

- (f) The following section discusses some examples of M2 mitigations. These examples are intended to illustrate how the M2 mitigation may be applied. The very specific examples are intended only as illustration. Applicants should not interpret this as definitively using M2 mitigations which are given as examples here. For every intended M2 mitigation, the applicant should perform the assessment process as set out in the section relating to the mitigation.

Example 1 of using a M2 mitigation: UA using a parachute

An applicant wishes to claim medium M2 mitigation using a parachute. Their mitigated SAIL is aimed at SAIL 1. Their application consists of a UA < 25kg, wingspan of <3m and a parachute designed to ASTM F3322-24a and applicable to their specific UA. They are able to demonstrate that the descend velocity after considering their maximum wind conditions in their operational manual is below 10 m/s. Their parachute is considered applicable for M2 mitigation medium. They should ensure that their maintenance and operational procedures are relevant for the M2 mitigation. They should then submit a declaration to the CAA that they fulfil the integrity requirements.

Example 2 of using a M2 mitigation: UA with a kinetic energy lower than 175J

An applicant wishes to claim medium M2 mitigation with a UA < 175J kinetic energy at its terminal velocity or max operational velocity. If the applicant is able to end their flight prior to impact on the ground, they may use the terminal velocity of the UA. They need to ensure that the velocity and weight used for calculation of the kinetic energy are appropriate. If any system is used to reduce the terminal velocity of the UA, they have collected adequate evidence to demonstrate its applicability and conducted an analysis of the failure of such system does not adversely affect the operation safety. They would then submit a declaration to the CAA that they fulfil the integrity requirements.

Example 3 of using a M2 mitigation: Reduction of critical area

An applicant wishes to claim medium M2 mitigation by the means of a reduced critical area. They use the same parameters as provided in table B7 and calculate their critical area. They have a valid M1A mitigation and therefore apply a factor of 0.4 in calculation of their critical area. The calculated critical area is below the target critical for their UA depending on their UA characteristic dimension as per table B6. They perform a safety analysis of any features used in the reduction of the critical area and ensure that such features have not already been used in Step #2 process when determining their initial ground risk category. They conduct testing or analysis that ensures that failure of such features does not adversely affect the operation safety. They would then submit a declaration to the CAA that they fulfil the integrity requirements.

In another example, they use the critical area method but decide to use a different set of parameters (different to Table B7) to calculate their critical area. In that scenario, they would no longer be able to submit a declaration and will be required to submit full compliance basis and associated compliance evidence. Their evidence of the M2 mitigation will be evaluated by the CAA.

Example 4 of using a M2 mitigation: Reduction of critical area and a parachute

An applicant wishes to claim medium M2 mitigation using a parachute. Their mitigated SAIL is aimed at SAIL 1. Their application consists of a UA > 25kg and/or a wingspan of >3m and a parachute designed to ASTM F3322-24a and applicable to their specific UA. They use the

critical area method on top of deployment of a parachute, use the same parameters as table B7 and conduct the analysis as per example 3. Their critical area calculated is below the target in table B6. They would then submit a declaration to the CAA that they fulfil the integrity requirements.

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

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

(2) ~~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 UK SORA for UAS impact lethality before M2 mitigation is applied is that most impacts are lethal, with the following exceptions:~~

(1) ~~Impacts from a glide of the UA with a characteristic dimension less than or equal to 1 m.~~

(2) ~~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 UK SORA process and is not part of the M2 mitigation process.~~

(c) ~~Critical area for each characteristic dimension:-~~

Maximum characteristic dimension (m)	1	3	8	20	40
Critical area (m²)	6.5s	65	650	6500	65,000

(d) ~~Applicants demonstrating M2 mitigation by reduction of the critical area should use the above values as a baseline for comparison in their proposed mitigation. The Applicant may show a corrected critical area and matching population density, in which case 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.~~

GM.M2.C1.M.1

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.~~

- ~~(d) — This includes inadvertent activation of the mitigation.~~

GM.M2.C1.M.A

Criterion 1 — Technical design

- ~~(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.M2.C1.H.I

Criterion 1 — Technical design

- ~~(a) — 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.

Annex E – AMC 1 Integrity and assurance levels for the Operational Safety Objectives (OSO)

E1. Introduction

- E1.1** 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.
- E1.2** 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.
- E1.3** A number of OSOs propose an alternative Functional Test Based (FTB) approach to complying with the OSO criteria.
- E1.4** 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). There are some instances where this may not be exactly matched. In those instances, the GM will clearly specify which part of the requirement it seeks to address.
- E1.5** 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 unacceptable industry standards.
 - (iii) SHEPHERD D2.2-D3.2 – Identification of satisfactory industry standards and justification for unacceptable industry standards.
- E1.6** The CAA has introduced two new policy concepts; CAP 722J - Recognised Assessment Entity for Flightworthiness (RAE(F)) and CAP 722K - SAIL Mark Policy.
- E1.7** The RAE(F) policy is intended for use by an entity that is, or wishes to be approved, as an RAE(F). An Applicant should use the services of an RAE(F) to demonstrate compliance with several UK SORA requirements. Full details of which UK SORA requirements should be met using an RAE(F) can be found in CAP 722J.
- E1.8** The SAIL Mark policy is intended for use by the Designer of an UAS and a RAE(F) to understand the requirements, administrative processes and guidance to enable the delivery of a Specific Assurance and Integrity Level (SAIL) Mark certificate for a UAS to be operated within the Specific Category in the United Kingdom.

AMC1 Article 11 Annex E. Containment requirements

COR – Containment requirements

Level of integrity

(...)

Level of assurance

Criterion	Low	Medium	High
Criterion 1 (Operational volume containment)	COR.C1.L.A	COR.C1.L.A COR.C1.M.A	COR.C1.L.A COR.C1.M.A COR.C1.H.A
Criterion 2 (End of flight upon exit of the operational volume)	COR.C2.L.A	COR.C2.M.A	COR.C2.M.A COR.C2.H.A
Criterion 3 (Definition of the ground risk buffer)	COR.C3.L.A	COR.C3.L.A COR.C3.M.A	COR.C3.L.A COR.C3.M.A COR.C3.H.A
Criterion 4 (Ground risk buffer containment)	Not applicable	COR.C4.M.A	COR.C4.H.A
Type of Assurance	Declarative only if following the AMC	Agreed Compliance basis approach	Compliance evidence approach

Containment probability targets: Integrity & Assurance summarised

Table E.1 – For SAIL 1 and SAIL 2

Containment level	Adjacent area GRC	Valid M1 or M2 Mitigation	Qualitative approach for OV containment	Quantitative approach for GRB containment	P(OV _{exit}) / FH	P(GRB _{exit}) / FH
Low	<=4	Any	No more than 10 probable single failures	N/A	10 ⁻²	NA
Low	>4	Any	No probable single failure	N/A	10 ⁻³	NA

Medium	Any	No	No probable single failure	No extremely remote single failure	10^{-3}	10^{-5}
Medium	Any	Yes	No probable single failure	No remote single failure	10^{-3}	10^{-4}
High	Any	No	No remote single failure	No extremely improbable single failure	10^{-4}	10^{-6}
High	Any	Yes	No remote single failure	No extremely remote single failure	10^{-4}	10^{-5}

Table E.2 – For SAIL 3 and above

Containment level	Adjacent area GRC	M1 or M2 mitigation	P(OV _{exit}) / FH	P(GRB _{exit}) / FH
Low	Any	Any	10^{-S-1}	N/A
Medium	Any	Any	10^{-S-1}	10^{-S-3}
High	N/A			

Key terms:

S = mitigated SAIL score (calculated at Step #9 of UK SORA)

P(OV_{exit}) / FH = Probability target of the UA exiting the Operational Volume (OV) per flight hour

P(GRB_{exit}) / FH = Probability target of the UA exiting the ground risk buffer (GRB) per flight hour

M1 mitigation = No -> no M1 mitigations or no relevant M1 mitigations (refer to AMC.COR)

M2 mitigation = No -> no M2 mitigations or no relevant M2 mitigations (refer to AMC.COR)

N/A for P(GRB_{exit}) = Not required to meet this requirement

'Any' for adjacent area GRC = Any value of adjacent area GRC (up to and including GRC 8)

>4 for adjacent area GRC = any value of adjacent area GRC greater than GRC 4

Any for mitigations = Mitigations maybe present or absent.

Qualitative approach for Operational Volume (OV) containment = The types of single failure of the UAS and any other external systems supporting the operation that **must** not result in the UA leaving its operational volume. Any single failure which may occur either at the required target level and/or more likely higher than the target level **must** not lead to the UA exiting its operational volume. For example, in low containment for an adjacent area GRC > 4, no 'probable single failure' in the operation may lead to the UA exiting the operational volume. In this case, any single failure which is a 'probable failure' and/or a failure more likely than a

'probable failure' **must** be ensured that it does not result in the UA exiting the operational volume. All such single failures **must** be considered in the containment assessment.

Qualitative approach for ground risk buffer (GRB) containment = The types of single failure of the UAS and any other external systems supporting the operation that **must** not result in the UA leaving its ground risk buffer. Any single failure which may occur either at the required target level and/or more likely higher than the target level **must** not lead to the UA exiting its ground risk buffer. For example, in medium containment without a valid M1 or M2 mitigation, no 'extremely remote single failure' in the operation **must** lead to the UA exiting the ground risk buffer. Any single failures which may be more than 'extremely remote' **must** also be taken into account in ensuring that UA does not exit ground risk buffer. All such single failures **must** be considered in the containment assessment.

Types of failure

- (a) A 'probable failure' is a failure that would not significantly reduce UAS safety and involve remote crew actions that are within their capabilities. It may include a slight reduction in safety margin and increase in crew workload. A probable failure is anticipated to occur one or more times in the entire operational life of the UAS.
- (b) 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 several UAS of that type. A remote failure is a failure that would reduce the capability of the UAS or the ability of the remote crew to cope with adverse operating conditions to the extent that there would a significant reduction in safety margins and functional capabilities. In addition, the failure condition would have a significant increase in remote crew workload or impairs remote crew efficiency.
- (c) An 'extremely remote failure' is a failure that would reduce the capability of the UAS or the ability of the crew to cope with conditions to an extent that loss of control of UA will reasonably result in a fatality and/or a large reduction in safety margins or functional capabilities and/or high workload such that the remote crew cannot be relied upon to perform their tasks accurately or completely.
- (d) An 'extremely improbable failure' is a failure that could result in one or more fatalities.

COR.C1.L.I

Criterion 1 – Operational volume containment

- ~~(a) 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,~~
- (a) Depending on the mitigated SAIL, the applicant **must** refer to table E1 or table E2 for determining the probability target of the failure condition "UA leaving the operational volume" ($P(OV_{exit})$). The applicant may use the qualitative approach and/or the quantitative approach in table E1 and E2.

- (b) ~~The probability of the failure condition “UA leaving the operational volume” must be less than $10^{-3}/FH$ (quantitative approach).~~
- (b) If the applicant fulfils this requirement via technical means, they may use a SAIL marked UAS to meet this requirement. In this case, they **must** ensure:
- (1) They utilise the appropriate design parameters necessary for calculation of the size of the operational volume.
 - (2) adherence to all the relevant limitations (such as external systems, technical, operational, environmental, human factors) of the UAS that impact the dimensions of the operational volume.
 - (3) the applicability of mitigations if applied in the adjacent area.
 - (4) the appropriate configuration of the UAS for which (1), (2), (3) are applicable.

COR.C2.L.I

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

- (a) 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.
- (b) If the applicant fulfils this requirement via technical means, they may use a SAIL marked UAS to meet this requirement. In this case, they **must** ensure:
- (1) adherence to all relevant limitations (such as external systems, technical, environmental, operational, human factors) in the applicability of (a).
 - (2) the appropriate configuration of the UAS for which the requirements in (a) are applicable.

COR.C3.L.I

Criterion 3 – Definition of the final ground risk buffer

- (a) A ground risk buffer **must** be defined which adheres at least to the 1:1 principle, unless the Applicant is able to ensure the applicability of a smaller buffer.
- (b) If the applicant fulfils this requirement using a SAIL marked UAS they **must** ensure:
- (1) They adhere to all relevant limitations (such as external systems, technical, operational, environmental, human factors) in the applicability of (a).
 - (2) The appropriate configuration of the UAS for which the requirements in (a) are applicable.

COR.C1.L.A

Criterion 1 – Operational volume containment

- (a) The applicant **must** provide a declaration of compliance with the Integrity requirements.

- (b) For a qualitative analysis, the compliance evidence to be collected **must** include the following: at least include a design and installation appraisal which shows that:
- (1) The design and installation features appraisal, including independence claims, ~~comply with~~ demonstrate the qualitative probability of achieving the low integrity requirements.
 - (2) A report **must** be prepared listing all UAS and external systems 'probable single failures' and single failures more likely than 'probable'. Their impact on the UA exiting the operational volume **must** be assessed. ~~Particular risks relevant to the intended operation have been addressed and do not violate any independence claim.~~
 - (3) The report **must** contain the impact of environmental conditions, human factors and other external risks which could result in the UA exiting the operational volume and demonstrate that there is no impact of these risks on the independence claims or on the probable failures.
 - (4) If M1 and/or M2 mitigations are claimed in the adjacent area, the applicant **must** include the relevance of them in the report.

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

- (c) For a quantitative analysis:
- (1) A declaration **must** be submitted stating that a report of quantitative functional hazard analysis is developed for all 'probable single failures' and failures more likely than 'probable'.
 - (2) A declaration **must** be submitted stating that evidence to demonstrate achieving the probability requirements of leaving the Operational Volume has been collected.
- (d)(e) ~~If (a), (b) or (c) and Integrity requirements are complied with through a SAIL marked UAS, the Applicant **must** demonstrate that submit the SAIL mark certificate. 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 the integrity requirements, which will be assessed by the CAA.~~

COR.C2.L.A

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

- (a) The applicant **must** submit a declaration of compliance with the integrity requirements. ~~The Applicant **must** provide evidence of compliance with the Integrity requirements, which will be assessed by the CAA.~~
- (b) The adequacy of the procedures to initiate an immediate end of the flight **must** be tested and documented in a report. ~~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) If technical means are used to initiate an immediate end of flight, then such means **must** be tested, and a test report **must** be prepared. If evidence is collected through simulation, the validity of the target environment used in the simulation **must** be justified. ~~The Applicant **must** provide evidence of compliance with the Integrity requirements, which will be assessed by the CAA.~~
- (d) The applicant **must** document in an analysis report of any factors that prevent the end of flight if the UA exists the operational volume. ~~If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified.~~
- (e) If (b), (c), (d) and Integrity requirements are complied with through a SAIL marked UAS, the Applicant **must** submit the SAIL mark certificate.

COR.C3.L.A

Criterion 3 – Definition of the final ground risk buffer

- (a) The applicant **must** submit ~~provide evidence~~ a declaration of compliance with the Integrity requirements. ~~which will be assessed by the CAA.~~
- (b) A report demonstrating the calculation of the final ground risk buffer and adjacent area **must** be prepared. ~~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** submit the SAIL mark certificate. ~~demonstrate that the ground risk buffer is the same as or contains the ground risk buffer defined by the Designer.~~

AMC.COR

The applicant should use Table E1 and E2 in the following way:

- (1) They should determine their mitigated SAIL score in Step #9 of UK SORA.
- (2) They should then pick table E1 or E2 depending on their mitigated SAIL score.
- (3) They should identify their level of containment (Low/Medium/high) using the containment tables in Step #10 of UK SORA.
- (4) They should calculate the average GRC of the adjacent area.

- (5) They should determine if their M1 and M2 mitigations are applicable in the adjacent area.
- (6) They should determine their qualitative or quantitative probability target of the UA exiting operational volume.
- (7) They should then determine their qualitative or quantitative probability target of the UA exiting the ground risk buffer (if applicable).

AMC.COR.C1.L.I

- (a) The applicant should identify all probable single failures of the UAS and any other external systems used in their operation. They should then determine whether any such failure leads to UA operation outside of the operational volume. If they determine such a failure, then appropriate mitigation measures should be presented. In cases where the adjacent area GRC ≤ 4 , there may be up to 10 probable failures that may lead to the UA exiting the operational volume. Applicants may refer to ASTM F3230-21a Standard Practice for Safety Assessment of Systems and Equipment in Small Aircraft, ED-279 Generic functional hazard assessment (FHA) for UAS to conduct such an analysis.
- (b) Operational volume containment may also be met using a geocaging function. Such a function should be designed to an industry standard such as ED-270 Minimum Operational performance standard for geocaging. The applicant may also use BS EN 4709-005 (currently in draft stage) when developing a geocaging system.
- (c) Operational volume containment may also be met using other functions as Return to Home (RTH). The applicant should ensure meeting the probability requirements of leaving the operational volume using any such functions. Failure of any systems that prevent the functioning of RTH or geocaging or any other equivalent system should also be accounted for in the 'probable single failures' of the UAS.

AMC.COR.C2.L.I

- (a) An end of flight may be initiated using a flight termination system (FTS). The FTS should be designed and tested to an industry standard such as BS EN 4709-006 (currently in draft stage). The applicant should ensure reliability of the FTS designed to the above standard by conducting appropriate ground and/or flight testing as per BS EN 4709-006.
- (b) Any FTS should be segregated from the UAS flight control system architecture. It may be manually and/or automatically activated. Any maintenance and operational procedures for the FTS should be defined in the appropriate manuals. Independence of the FTS from all other UAS systems should be ensured. (examples: Use of different sensors for FTS activation, use of different radio frequencies for FTS activation).
- (c) Any other means to end flight upon exit of operational volume should be ensured in the same manner as an FTS.

AMC.COR.C3.L.I

Criterion 3 – Definition of the final ground risk buffer

- (a) A smaller than 1:1 ground risk buffer value may be ensured by the Applicant for a rotary wing UA using a ballistic methodology approach. The applicant may refer to Annex A for further guidance.
- (b) For a fixed wing UA, an alternate approach such as using the glide ratio method may be ensured by the applicant.

AMC.COR.C1.L.A

Criterion 1 – Operational volume containment

- (a) The design and installation appraisal may consists of a written justification which includes functional diagrams, describes how the system works and explains why the how the Integrity requirement is requirements are met.
- (b) If an industry standard is used to conduct a failure analysis, then a declaration should be made by the applicant that the analysis has been conducted following such standard should be provided.

Medium level of robustness

Lower robustness level requirements to be complied with:

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

COR.C1.M.I

Criterion 1 – Operational volume containment

~~No additional requirements.~~

- (a) Depending on the mitigated SAIL, the applicant **must** refer to table E1 or E2 for determining the probability target of the failure condition “UA leaving the operational volume ($P(OV_{exit})$). The applicant may use the qualitative approach and/or the quantitative approach in table E1 and/or E2.
- (b) If the applicant fulfils this requirement via technical means, they may use a SAIL marked UAS to meet this requirement. In this case, they **must** ensure:

- (1) They utilise the appropriate design parameters necessary for calculation of the operational volume.
- (2) They adhere to all the relevant limitations (such as external systems, technical, operational, environmental, human factors) of the UAS that impact the dimensions of the operational volume.
- (3) The applicability of mitigations if applied in the adjacent area.
- (4) The appropriate configuration of the UAS for which (1), (2), and (3) are applicable.

COR.C2.M.I

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

No additional requirements.

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

- (a) Dedicated flight tests.
- (b) Simulation, provided that the simulation is proven valid for the intended purpose with positive results. If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified.

COR.C3.M.I

Criterion 3 – Definition of the final ground risk buffer

(...)

- (b) If the applicant fulfils this requirement using a SAIL marked UAS they **must** ensure:
 - (1) They adhere to all relevant limitations (such as external systems, technical, operational, environmental, human factors) in the applicability of (a).
 - (2) The appropriate configuration of the UAS for which the requirements in (a) are applicable.

~~(c) Meteorological conditions~~

~~(d) UA behaviour when activating a technical containment measure.~~

~~(e) 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.~~

- (a) Depending on the mitigated SAIL, the applicant **must** refer to table E1 or table E2 for determining the probability target of the failure condition “UA leaving the ground risk buffer ($P(\text{GRB}_{\text{exit}})$)”. The applicant may use the qualitative approach and/or the quantitative approach in table E1 and/or E2.
- (...)
- (c) If the applicant uses a SAIL marked UAS to meet this requirement, they **must** ensure:
 - (1) They adhere to all the relevant limitations (such as external systems, technical, operational, environmental, human factors) of the UAS that impact containment of the UA in the ground risk buffer.
 - (2) They determine the applicability of mitigations if applied in the adjacent area.
 - (3) The appropriate configuration of the UAS for which (1) and (2) are applicable.

COR.C1.M.A

Criterion 1 – Operational volume containment

~~The Applicant **must** provide evidence of compliance with the Integrity requirements, which will be assessed by the CAA.~~

The applicant **must** agree a compliance basis with the CAA for meeting the integrity 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.~~
- (a) The Applicant **must** agree a compliance basis with the CAA for meeting the integrity requirements.
- ~~(c) The Applicant must provide evidence of compliance with the Integrity requirements, which will be assessed by the CAA.~~
- (b) If Integrity requirements are complied with a SAIL marked UAS, the applicant **must** provide the SAIL mark certificate.

~~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

~~The Applicant **must** provide evidence of compliance with the Integrity requirements, which will be assessed by the CAA.~~

The Applicant **must** agree a compliance basis with the CAA for meeting the integrity 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.~~
- (a) The applicant **must** agree a compliance basis with the CAA for meeting the integrity requirements.
- (b) The evidence **must** contain a design and installation appraisal which shows that sufficient measures are implemented to meet the probability of UA not exiting the ground risk buffer (GRB).
- (c) In case of UA entering GRB, a report showing evidence of simulation and/or testing to demonstrate that it is contained within the GRB.
- (d) A report **must** be prepared showing any failure modes which may affect containment of the UA within the ground risk buffer identified and suitable mitigations applied.
- (e) If compliance evidence is provided through simulation, the validity of the target environment used in the simulation **must** be justified.
- (f) If ~~(a), (b), and~~ Integrity requirements are complied with by using a SAIL mark certificate marked UAS, the applicant **must** demonstrate that provide the following aspects considered by the Designer are relevant to the intended operation: SAIL mark certificate.
- ~~(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 the Integrity requirements, which will be assessed by the CAA.~~

AMC.COR.C3.M.I

- (a) A 1:1 ground risk buffer may not be applicable when considering other factors as described in COR.C3.M.I. The applicant should ensure that their ground risk buffer calculation method considers all failures that may require a bigger ground risk buffer.
- (b) The applicant should ensure that the maximum glide distance of the UA (at all its possible glide angles) upon activation of FTS should be less than the ground risk buffer. The wind velocity and any other environmental conditions that may increase the glide distance should be considered when defining the ground risk buffer.
- (c) If the applicant identifies that projection of high energy parts such as rotors or propellers is a probable failure, the ground risk buffer should be determined based on the projection distance of such parts. The applicant may ensure this using testing and/or simulation.
- (d) If the activation of an FTS or any other termination system used in COR.C2 may result in the UA having a larger glide distance, then the ground risk buffer should take that into account.
- (e) Any performance degradation or malfunction of the UA should be taken into account in computing the ground risk buffer.
- (f) If any other propulsion fuel is used other than batteries, then the applicant should ensure that the ground risk buffer considers secondary effects of an impact in the ground risk buffer such as detonation and/or deflagration.

AMC.COR.C4.M.I

Criterion 4 – Ground risk buffer containment

- (a) One or more of the following methods may be used to demonstrate ensure compliance with the requirement:
- (1) An independent flight termination system (FTS) which initiates the end of the flight when exiting the operational volume. Compliance with COR.C2.L.I and ensuring that the FTS prevents the UA from leaving the ground risk buffer to the probability target is deemed acceptable.
 - (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.~~

- (3) A geocaged system designed using the principles of an industry standard such as BS EN 4709-005.
- (4) A fail-safe health monitoring system which is triggered in the event of a critical feature failure (e.g. navigation).
- (5) Any other procedural methods which the CAA will determine if appropriate.
- (b) The applicant may use consensus industry standards in development of software and hardware whose development failures may lead to the UA exiting the ground risk buffer. Principles from standards such as ASTM F3201-24 *Ensure dependability of software used in UAS*, RTCA DO-254 *Design Assurance Guidance for Airborne Electronic Hardware*, RTCA DO-178C *Software considerations in Airborne systems and Equipment Certification* (Design assurance levels (DAL) are dependent on $P(OV_{exit}) / FH$) maybe used. The applicant should have configuration control and management of software and hardware. In case of software provided by the manufacturer, the applicant should verify that the software does not affect the validity of their containment measures. This may be verified by the means of flight testing and/or simulation or theoretical analysis of the software update.
- ~~(b) "Annex E – AMC 1 Integrity and assurance levels for the Operational Safety Objectives (OSO)" on page 298 paragraph 1.5 provides further information about proposing a standard as an AMC.~~

AMC.COR.C4.M.A

Criterion 4 – Ground risk buffer containment

~~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.~~

High level of robustness

Lower robustness level requirements to be complied with:

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

Additional requirements to be compiled 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,~~

Depending on the mitigated SAIL, the applicant **must** refer to table E1 or E2 for determining the probability target of the failure condition “UA leaving the operational volume ($P(OV_{exit})$). The applicant **must** use either the qualitative approach and/or the quantitative approach in table E1 and E2.

~~The probability of the failure condition “UA leaving the operational volume” **must** be less than $10^{-4}/FH$ (quantitative approach).~~

(...)

COR.C4.H.I

Criterion 4 – Ground risk buffer containment

~~No additional requirements.~~

Depending on the mitigated SAIL, the applicant **must** refer to table E1 or E2 for determining the probability target of the failure condition “UA leaving the ground risk buffer” ($P(GRB_{exit})$). The applicant may use the qualitative approach and/or the quantitative approach in table E1 and E2.

COR.C1.H.A

Criterion 1 – Operational volume containment

The applicant **must** provide evidence of compliance with the Integrity requirements, which will be assessed by the CAA. ~~The CAA will validate continuing compliance through oversight.~~

COR.C2.H.A

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

The applicant **must** provide evidence of compliance with the Integrity requirements, which will be assessed by the CAA. ~~The CAA will validate continuing compliance through oversight.~~

COR.C3.H.A

Criterion 3 – Definition of the final ground risk buffer

The Applicant **must** provide evidence of compliance with the Integrity requirements, which will be assessed by the CAA. ~~The CAA will validate continuing compliance through oversight.~~

COR.C4.H.A

Criterion 4 – Ground risk buffer containment

The applicant **must** provide evidence of compliance with the Integrity requirements, which will be assessed by the CAA. ~~The CAA will validate continuing compliance through oversight.~~

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.~~

GM1 Article 11 Annex E. Containment requirements

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.~~

- (a) Table E1 and E2 compile the various scenarios in low/medium/high containment an applicant may need to comply.
- (b) Calculating probabilities of UA exiting operational volume and/or ground risk buffer:
 - (i) The applicant should demonstrate qualitatively and/or quantitatively achieving $P(OV_{exit})$ and $P(GRB_{exit})$ (if applicable).
 - (ii) $P(OV_{exit})$ is the probability target that the UA will exit the operational volume. If $P(OV_{exit})$ is $10^{-2}/FH$, this means that only 1 in every 100 flight hours, the UA may exit the operational volume.
 - (iii) $P(GRB_{exit})$ is the probability target that the UA will exit the ground risk buffer. If $P(GRB_{exit})$ is $10^{-2}/FH$, this means that only 1 in every 100 flight hours, the UA may exit the ground risk buffer.
- (c) Validity of mitigations:
 - (i) If mitigations are applied in the operational volume and the applicant can demonstrate that their M1 and/or M2 mitigations are applicable in the adjacent area, they may be used in containment.
 - (ii) M1 mitigations that are inapplicable are any space-based mitigations (such as specific route planning). Such measures are invalid in a loss of control scenario.
 - (iii) M2 mitigations that are inapplicable are any mitigations whose failure may cause the UA to leave the operational volume. As an example, if a parachute failure causes the UA to leave the OV, then such a mitigation cannot be claimed as M2 for containment purposes.

- (d) For SAIL 3 and above:
- (i) For SAIL 3 and above, the probability of leaving the operational volume and/or ground risk buffer (GRB) is only dependent on the residual SAIL level and level of containment of the operation. As an example, for a residual SAIL 4 operation with low containment the probability requirement of exiting operational volume is 10^{-5-1} which is 10^{-5} . Another example, for a residual SAIL 5 operation with medium containment, the probability requirement of exiting operational volume is 10^{-5-1} which is 10^{-6} and the probability requirement of exiting the ground risk buffer is 10^{-5-3} which is 10^{-8} .
- (e) Calculating adjacent area GRC:
- (i) To calculate the ground risk of the adjacent area, the applicant should use the average population density of the adjacent area determined as part of containment.
- (ii) For a given average population density, the adjacent area GRC should be determined using the iGRC in Table 3 of UK SORA.
- (iii) The applicant only needs to determine the average population density in the adjacent area.
- (f) The objective of containment is to ensure that the probability of significant injuries outside the operational volume is suitably addressed. The probability of significant injuries inside the operational volume and ground risk buffer is addressed by the Operational Safety Objectives (OSOs) and mitigations. Containment ensures that in case the UA leaves the operational volume and the ground risk buffer, then the probability of significant injuries are minimised. 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.

For containment to become relevant, the following conditions need to occur:

- (1) The UA should exit the operational volume (OV)
- (2) The UA should exit the ground risk buffer (GRB)
- (3) The UA enters the Adjacent area
- (4) The UA has an event that causes a crash in the adjacent ground area

Using the principles of JARUS Annex F, the probability of significant injuries is defined by equation 15

$$E_{i,Adj} = P(ADJ) P(GI|ADJ) D_{pop,adj} A_c 10^{M_{1adj} + M_{2adj}} \quad (15)$$

Where

$E_{i,Adj}$ = Expected significant injury rate in adjacent area

$P(ADJ)$ = Probability that UAS enters adjacent area

$P(GI|ADJ)$ = Probability of a ground impact when UAS already entered the adjacent area

$D_{pop,adj}$ = Population density in adjacent area (people per m²)

A_c = Unmitigated critical area of UA (m^2)

M_{1adj} = Validity of any M1A, M1B mitigation in adjacent area (1 if true, 0 if false)

M_{2adj} = Validity of any M2 mitigation in adjacent area (1 if true, 0 if false)

The containment requirements summary table (Table E1 and E2) is developed taking the equation 15 into consideration. Applicants who apply M1 or M2 mitigations which are applicable in the adjacent area can meet a slightly lenient probability target to exit the operational volume.

- (g) $P(OV_{exit})$ is defined as the probability that the UA will exit its operational volume. A higher $P(OV_{exit})$ implies a greater probability that the UA will exit its operational volume. As per table E1 or E2, when the applicant applies mitigations which are also applicable in the adjacent area, they only need to ensure a slightly higher probability target of leaving the operational volume (vs a scenario without mitigations). This is because if the UA leaves the OV, it has mitigations employed to reduce its impact to uninvolved persons in the adjacent area.
- (h) 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.
- (i) The examples below are intended to illustrate how the containment process may be applied. The very specific examples are intended only as illustration. Applicants should not interpret these examples as definitively applying the containment process. For every containment application, the applicant should perform the containment process and demonstrate compliance with the integrity requirements.

(i) Low containment example 1:

An applicant who is both the designer and operator and has a multi rotor UA, follows step #10 in the UK SORA and from the containment tables they determine their level of containment to be low. To determine their low containment requirements, they follow the steps set out in AMC.COR. They determine that their adjacent area ground risk category is below 4. They also determine that their residual SAIL level is SAIL 1. They choose to follow the qualitative method to fulfil containment requirements. They will then need to demonstrate that they ensure fewer than 10 'probable single failures' and no other single failure more likely than 'probable' that would lead to the UA exiting the operational volume. They do not need to satisfy any probability requirements for exiting the ground risk buffer.

To perform their qualitative analysis, they should then conduct a design and installation appraisal. A design and installation appraisal is a detailed review of the design, the requirements developed for that design, functional diagrams, description of the working of the UAS, the safety assessment and installation and conformity of such design. It should also include operational related requirements that are specific to the design. With the help of the design and installation appraisal, the applicant **must** determine all the 'probable failures' that can occur in their UAS operation. A probable failure is a failure that would result in a slight reduction in safety margin and increase in crew workload. Once all the 'probable single failures' and any other

failures more likely than 'probable' are determined, the applicant should assess whether any such failure could lead to the UA leaving the operational volume. The applicant should not have more than 10 such failures for this low containment. If they determine that they do not have more than 10 such failures, they can conclude compliance with the operational volume containment. After fulfilling this requirement, they **must** then address a means to terminate flight if leaving the operational volume. In this example, we assume the applicant uses a FTS to meet this requirement. They should then design their FTS to BS EN 4709-006 or any other equivalent standard. They should conduct the testing requirements as per the industry standard. They should ensure that maintenance, operational and pre-flight checks for the working of the FTS are followed. They should ensure that their FTS is independent from all other UAS systems. Once they have completed these tasks, they can conclude compliance with the end of flight requirement. They should then look to ensure compliance to the definition of ground risk buffer requirement. They can use a 1:1 ground risk buffer to meet this requirement. If they wish to use a smaller ground risk buffer, they should ensure its applicability. Upon completion of these, the applicant should then submit a declaration to the CAA that they comply with the integrity requirements.

(ii) Low containment example 2:

An applicant who is an operator with a UK 5 class marked multi rotor UA follows step #10 in the UK SORA, and from the containment tables they determine their level of containment to be low. For determining their low containment requirements, they follow the steps provided in AMC.COR. They determine that their adjacent area ground risk category is greater than 4. They also determine that their residual SAIL level is SAIL 2. In this example, the UK 5 class mark has a type examination certificate issued by a UK approved conformity assessment board (CAB). In this case, the UK 5 UA has a flight termination system which is designed to BS EN 4709-006. The applicant has chosen to do a qualitative assessment. When referring to table E1, they identify that their target is 'no probable single failures' **must** lead to the UA exiting the operational volume. To perform their qualitative analysis, they should then conduct a design and installation appraisal. A design and installation appraisal is a detailed review of the design, the requirements developed for that design, functional diagrams, description of the working of the UAS, the safety assessment and installation and conformity of such design. It should also include operational related requirements that are specific to the design. With the help of the design and installation appraisal, the applicant **must** determine all the 'probable failures' and any other single failures more likely than a 'probable failure' that can occur in their UAS operation. A 'probable failure' is a failure that would result in a slight reduction in safety margin and increase in crew workload. Once all these failures are determined, the applicant should assess whether any such failure could lead to the UA leaving the operational volume. The applicant cannot have any 'probable single failures' leading to exiting the operational volume for this low containment. If they determine that they meet this requirement, they can conclude that they comply with the relevant integrity requirement. They should then look to ensure compliance to the definition of ground risk buffer requirement. They can use a 1:1 ground risk buffer to meet this requirement. If they wish to use a smaller ground risk buffer, they should ensure its applicability. Upon completion of these, the

applicant should then provide a declaration to the CAA that they show compliance with the integrity requirements.

In the same example, if the applicant does not have a type examination certificate for their UK 5 UA, they will, in addition to the above process, need to obtain the compliance evidence from the designer to demonstrate meeting COR.C2.L.I. If the UA used by the applicant is a UK 3 with a C5 accessory kit attached to it but does not have a type examination certificate for it, they will still need to obtain the compliance evidence from the designer to demonstrate meeting COR.C2.L.I in addition to the steps above.

(iii) Medium containment example:

An applicant who is an operator with a fixed wing UA follows step #10 in the UK SORA and from the containment tables they determine their level of containment to be medium. For determining their medium containment requirements, they follow the steps provided in AMC.COR. They determine that their adjacent area ground risk category is greater than 4. They also determine that their residual SAIL level is SAIL 2. They have approved M2 mitigation in their operational volume. They have made the assessment and determined that their M2 mitigation is still valid at the same robustness in the adjacent area. From table E1, they determine that the level of assurance is deemed as a compliance basis. The applicant should follow the compliance basis approach stated in Annex A. In this example, they have decided to use the quantitative method to fulfil the containment requirements. They have decided that they will perform a quantitative functional hazard analysis using the industry standards recommended in AMC.COR.C1.L.I which is also applicable in the medium containment. To show compliance with COR.C2.M.I they have decided to use a FTS designed to BS EN 4709-006 standard. To show compliance with COR.C3.M.I, they **must** define their ground risk buffer taking into account all applicable factors and will not be able to use the 1:1 method. To show compliance with COR.C4.M.I, they have decided to use the quantitative method for functional hazard analysis. Now that they have decided on their means of compliance for each of the integrity criteria in medium containment, they will now have to propose a method of compliance for each of the criteria. Methods of compliance may include but not limited to flight testing, subsystem testing, simulation, analysis, ground testing, design compliance, operational experience, process methodologies. If the CAA determines that both the means and methods of compliance are adequate to meet the integrity requirements, the CAA will accept these requirements have been met, subject to a further declaration. The applicant **must** then complete the methods of compliance, gather the compliance evidence and provide a declaration of compliance. This declaration **must** then be submitted to the CAA as part of the application.

GM.COR.C1.L.I

Criterion 1—Operational volume containment

~~A probable failure is anticipated to occur one or more times in the entire operational life of the UAS.~~

- (a) ~~The applicant may use multiple methods to ensure UA is contained within the operational volume in case of a loss of control.~~
- (b) ~~A template of FHA is provided in ED-279 or ASTM F3230-21a, either of which may be used by the applicant in their FHA report.~~
- (c) ~~It is important that the applicant considers all external systems whose failure may result in the UA exiting the operational volume.~~
- (d) ~~The BS EN 4709-005 is currently in draft stage and expected to be finalised in 2026. Once finalised the applicant should use the published version. Until that time, the applicant may use the latest draft version.~~

GM.COR.C2.L.I

- (a) ~~The BS EN 4709-006 is currently in draft stage and expected to be finalised in 2026. Once finalised the applicant should use the published version. Until that time, the applicant may use the latest draft version.~~
- (b) ~~To demonstrate the end of flight upon exit of operational volume using a flight test for a FTS solution, the applicant may refer to BS EN 4709-006 which lists testing requirements for FTS.~~

GM.COR.C3.L.I

~~To calculate the ground risk buffer, applicants may refer to Annex A Table A.4.~~

~~Criterion 3 — Definition of the final ground risk buffer~~

~~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 CAA 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:~~
 - (1) ~~Both UAS structures and systems.~~
 - (2) ~~One or more UAS sections, and even the entire UAS.~~

- ~~(3) — One or more aircraft functions.~~
- ~~(4) — One or more aircraft systems.~~
- ~~(5) — One or more aircraft system installations.~~
- ~~(b) — 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.~~
- ~~(c) — 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 may be found in SAE ARP4761A.~~
- ~~(d) — 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.~~
- ~~(e) — Designer data is found on the SAIL mark certificate.~~
- ~~(f) — Compliance evidence is typically provided through testing, analysis, simulation, inspection, design review or through operational experience.~~
- (a) Some of the environmental conditions that affect the probability of leaving the operational volume are temperature, high intensity radiation field, density of air, wind velocity and wind gusts, rain, nighttime operation.
- (b) Some of the human factor's conditions are pilot error, operational errors, maintenance errors and design of systems related to human factors (such as haptic touch, positioning of buttons/levers).
- (c) Some of the external risks are GNSS failure, loss of communication, cyber security breaches.

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

GM.COR.C3.M.I

- (a) Some of the meteorological conditions that may affect the ground risk buffer are wind velocity, wind gusts, rain, light (day or night) and radiation.
- (b) UA behaviour when activating a technical containment measure means any changes to UA system functions that increase its probability of a loss of control event or invalidates the existing ground risk buffer calculation methods. In these cases, the ground risk buffer may need to be larger than the 1:1 method. An example may be where a deployment of a containment feature may vary the glide ratio for a fixed wing UA, which may increase the GRB from the calculated value.
- (c) UA performance may mean any degradation in any of UA systems performance during operation or over a prolonged period that may require a larger ground risk buffer.
- (d) Designer data is found on the SAIL mark certificate.

Criterion 3 – Definition of the final ground risk buffer

- ~~(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

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

~~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.COR.C4.M.I

- (a) The objective of COR.C4 is to ensure that the UA does not leave the ground risk buffer. Tables E1, E2 provide the probability targets that the applicant would need to meet for leaving the ground risk buffer. This is to ensure that for medium and high containment operations, the UA is contained within the ground risk buffer.
- (b) The applicant may use ASTM F3201-24 to help develop organisational requirements when developing software and/or electronic hardware for medium and high containment applications. The applicant is recommended to use Tier 2 or Tier 3 when using ASTM F3201-24. They may also refer to low DAL levels in RTCA DO-254 and RTCA DO-178 for some guidance on processes, configuration control, independency in development and testing and other areas.
- (c) Designer data is found on the SAIL mark certificate.

Criterion 4 – Ground risk buffer containment

- ~~(a) See GM.CORC1.L.A (a).~~
- ~~(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.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.~~