



JARUS guidelines on SORA

Annex B

Integrity and assurance levels for the mitigations used to reduce the intrinsic Ground Risk Class

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1. How to use Annex B

The following table provides the basic principles to consider when using SORA Annex B.

	Principle description	Additional information
#1	Annex B provides assessment criteria for the integrity (i.e. safety gain) and assurance (i.e. method of proof) of the applicant's proposed mitigations. The proposed mitigations are intended to reduce the intrinsic Ground Risk Class (GRC) associated to a given operation.	The identification of mitigations is the responsibility of the applicant.
#2	Annex B does not cover the Level of Involvement (LoI) of the Competent Authority. LoI is based on the Competent Authority assessment of the applicant's ability to perform the given operation.	Some JARUS groups (e.g. WG-7) might provide criteria for level of involvement for use by the Competent Authorities.
#3	A proposed mitigation may or may not have a positive effect on reducing the ground risk associated with a given operation. In the case where a mitigation is available but does not reduce the risk on the ground, its level of integrity should be considered equivalent to "None".	
#4	To achieve a given level of integrity/assurance, when more than one criterion exists for that level of integrity/assurance, all applicable criteria need to be met.	
#5	Annex B intentionally uses non-prescriptive terms (e.g. suitable, reasonably practicable) to provide flexibility to both the applicant and the Competent Authorities. This does not constrain the applicant in proposing mitigations, nor the Competent Authority in evaluating what is needed on a case by case basis.	
#6	This annex in its entirety also applies to single-person organizations.	

Table 1 – Basic Principles

2. M1 – Strategic mitigations for ground risk

M1 mitigations are “strategic mitigations” intended to reduce the number of people at risk on the ground. To assess integrity levels of M1 mitigations the following needs to be considered:

- Definition of the ground risk buffer and resulting ground footprint,
- Evaluation of people at risk.

With the exception of the specific case of “tether” provided in section b, the generic criteria to assess the level of integrity (table 2) and level of assurance (table 3) of M1 type ground risk mitigations are provided in section a.

a) Generic criteria

		LEVEL of INTEGRITY		
		Low	Medium	High
M1 – Strategic Mitigations for Ground Risk	Criterion #1 (Definition of the ground risk buffer)	A ground risk buffer with at least a 1 to 1 rule ¹ .	Ground risk buffer takes into consideration: <ul style="list-style-type: none"> • Improbable² single malfunctions or failures (including the projection of high energy parts such as rotors and propellers) which would lead to an operation outside of the operational volume, • Meteorological conditions (e.g. wind), • UAS latencies (e.g. latencies that affect the timely manoeuvrability of the UA), • UA behaviour when activating a technical containment measure, • UA performance. 	Same as Medium ³
	Comments	¹ If the UA is planned to operate at an altitude of 150m, the ground risk buffer should be a minimum of 150m.	² For the purpose of this assessment, the term “improbable” should be interpreted in a qualitative way as, “Unlikely to occur in each UAS during its total life but which may occur several times when considering the total operational life of a number of UAS of this type”. ³ The distinction between a medium and a high level of robustness for this criterion is achieved through the level of assurance (Table 3 below).	
	Criterion #2 (Evaluation of people at risk)	The applicant evaluates the area of operations by means of on-site inspections/appraisals to justify lowering the density of people at risk (e.g. residential area during daytime	Same as low, however the applicant makes use of authoritative density data (e.g. data from UTM data service provider) relevant for the proposed area and time of operation to substantiate a lower density of people at risk.	Same as medium.

		LEVEL of INTEGRITY		
		Low	Medium	High
		when some people may not be present or an industrial area at night time for the same reason).	<p>AND/OR</p> <p>If the applicant claims a reduction, due to a sheltered operational environment, the applicant:</p> <ul style="list-style-type: none"> • uses a drone below 25 kg and not flying above 174 knots⁴, • demonstrates that although the operation is conducted in a populated environment, it is reasonable to consider that most of the non-active participants will be located within a building⁵. 	
			<p>⁴ These criteria are substantiated in a MITRE technical report to be published by Q1 2019.</p> <p>⁵ The consideration of this mitigation may vary based on local conditions.</p>	

Table 2 – Level of Integrity Assessment Criteria for Ground Risk of Non-tethered M1 Mitigations

		LEVEL of ASSURANCE		
		Low	Medium	High
M1 – Strategic Mitigations for Ground Risk	Criterion #1 (Definition of the ground risk buffer)	The applicant declares that the required level of integrity is achieved ¹ .	The applicant has supporting evidence to claim the required level of integrity has been achieved. This is typically done by means of testing, analysis, simulation ² , inspection, design review or through operational experience.	The claimed level of integrity is validated by a competent third party.
	Comments	¹ Supporting evidence may or may not be available	² When simulation is used, the validity of the targeted environment used in the simulation needs to be justified.	N/A
	Criterion #2 (Evaluation of people at risk)	The applicant declares that the required level of integrity has been achieved ³ .	The density data used for the claim of risk reduction is an average density map for the date/time of the operation from a static sourcing (e.g. census data for night time ops). In addition, for localised operations (e.g. intra-city delivery or infrastructure inspection) the applicant submits the proposed route/area of operation to the applicable authority (e.g. city police, office of civil protection, infrastructure owner etc.) to verify the claim of reduced number of people at risk.	Same as medium, however the density data used for the claim of risk reduction is a near-real time density map from a dynamic sourcing (e.g. cellular user data) and applicable for the date/time of the operation.
	Comments	³ Supporting evidence may or may not be available	N/A	N/A

Table 3– Level of Assurance Assessment Criteria for Ground Risk of Non-tethered M1 Mitigations

b) Specific criteria in case of use of a tether

When an applicant wants to take credit for a tether:

- The tether needs to be considered part of the UAS and assessed based on the below criteria, and
- Potential hazards created by the tether itself are addressed through the Operational Safety Objectives (OSO) defined in Annex E.

The Level of Integrity Criteria for a tethered mitigation is found in table 4. The Level of assurance for a tethered mitigation is found in table 5.

		LEVEL of INTEGRITY		
		Low	Medium	High
M1 – Tethered operation	Criterion #1 (Technical design)	Does not meet the “Medium” level criteria	1) The length of the line is adequate to contain the UA in the operational volume. 2) Strength of the line is compatible with the ultimate loads ¹ expected during the operation. 3) Strength of attachment points is compatible with the ultimate loads ¹ expected during the operation. 4) The tether cannot be cut by rotating propellers.	Same as Medium ²
	Comments	N/A	¹ Ultimate loads are identified as the maximum loads to be expected in service, including all possible nominal and failure scenarios multiplied by a 1.5 factor of safety. ² The distinction between a medium and a high level of robustness for this criterion is achieved through the level of assurance (Table 5 below).	
	Criterion #2 (Procedures)	Does not meet the “Medium” level criteria	The applicant has procedures to install and periodically inspect the condition of the tether.	Same as Medium ³
	Comments	N/A	³ The distinction between a medium and a high level of robustness for this criterion is achieved through the level of assurance (Table 5 below).	

Table 4 - Level of Integrity Assessment Criteria for Ground Risk Tethered M1 Mitigations

		LEVEL of ASSURANCE		
		Low	Medium	High
M1 – Tethered operation	Criterion #1 (Technical design)	Does not meet the “Medium” level criteria	<p>The applicant has supporting evidence (including the tether material specifications) to claim the required level of integrity is achieved.</p> <ul style="list-style-type: none"> This is typically achieved through testing or operational experience. Tests can be based on simulations, however the validity of the target environment used in the simulation needs to be justified. 	The claimed level of integrity is validated by a competent third party
	Comments	N/A	N/A	N/A
	Criterion #2 (Procedures)	<ul style="list-style-type: none"> Procedures do not require validation against either a standard or a means of compliance considered adequate by the competent authority. The adequacy of the procedures and checklists is declared. 	<ul style="list-style-type: none"> Procedures are validated against standards considered adequate by the competent authority and/or in accordance with a means of compliance acceptable to that authority¹. Adequacy of the procedures is proven through: <ul style="list-style-type: none"> Dedicated flight tests, or Simulation, provided the simulation is proven valid for the intended purpose with positive results. 	<p>Same as Medium. In addition:</p> <ul style="list-style-type: none"> Flight tests performed to validate the procedures cover the complete flight envelope or are proven to be conservative. The procedures, flight tests and simulations are validated by a competent third party.
	Comments	N/A	¹ National Aviation Authorities (NAAs) may define the standards and/or the means of compliance they consider adequate. The SORA Annex B will be updated at a later point in time with a list of adequate standards based on the feedback provided by the NAAs.	N/A

Table 5 - Level of Assurance Assessment Criteria for Ground Risk Tethered M1 Mitigations

3. M2 – Effects of ground impact are reduced

M2 Mitigations are intended to reduce the effect of ground impact once the control of the operation is lost. This is done by reducing the effect of the UA impact dynamics (i.e. area, energy, impulse, transfer energy, etc.). One example would be a parachute.

		LEVEL of INTEGRITY		
		Low/None	Medium	High
M2 - Effects of UA impact dynamics are reduced (e.g. parachute)	Criterion #1 (Technical design)	Does not meet the “Medium” level criterion	<ul style="list-style-type: none"> Effects of impact dynamics and post impact hazards¹ are significantly reduced although it can be assumed that a fatality may still occur. When applicable, in case of malfunctions, failures or any combinations thereof that may lead to a crash, the UAS contains all elements required for the activation of the mitigation. When applicable, any failure or malfunction of the proposed mitigation itself (e.g. inadvertent activation) does not adversely affect the safety of the operation. 	Same as medium. In addition: <ul style="list-style-type: none"> When applicable, the activation of the mitigation, is automated². The effects of impact dynamics and post impact hazards are reduced to a level where it can be reasonably assumed that a fatality will not occur³.
	Comments	N/A	¹ Examples of post impact hazards include fires, release of high energy parts.	² The applicant retains the discretion to implement an additional manual activation function. ³ Emerging research and upcoming industry standards will help applicants to substantiate compliance with this integrity criterion.
	Criterion #2 (Procedures, if applicable)	Any equipment used to reduce the effect of the UA impact dynamics are installed and maintained in accordance with manufacturer instructions. ⁴		
	Comments / Notes	⁴ The distinction between a low, a medium and a high level of robustness for this criterion is achieved through the level of assurance (Table 7 below).		
	Criterion #3 (Training, if applicable)	Personnel responsible for the installation and maintenance of the measures proposed to reduce the effect of the UA impact dynamics are identified and trained by the applicant. ⁵		
	Comments / Notes	⁵ The distinction between a low, a medium and a high level of robustness for this criterion is achieved through the level of assurance (Table 7 below).		

Table 6 - Level of Integrity Assessment Criteria for M2 Mitigations

		LEVEL of ASSURANCE		
		Low/None	Medium	High
M2 - Effects of UA impact dynamics are reduced (e.g. parachute)	Criterion #1 (Technical design)	The applicant declares that the required level of integrity has been achieved ¹ .	The applicant has supporting evidence to claim the required level of integrity is achieved. This is typically ² done by means of testing, analysis, simulation ³ , inspection, design review or through operational experience.	The claimed level of integrity is validated by a competent third party against a standard considered adequate by the competent authority and/or in accordance with means of compliance acceptable to that authority ⁴ (when applicable).
	Comments	¹ Supporting evidence may or may not be available	² The use of Industry standards is encouraged when developing mitigations used to reduce the effect of ground impact. ³ When simulation is used, the validity of the targeted environment used in the simulation needs to be justified.	⁴ National Aviation Authorities (NAAs) may define the standards and/or the means of compliance they consider adequate. The SORA Annex B will be updated at a later point in time with a list of adequate standards based on the feedback provided by the NAAs.
	Criterion #2 (Procedures, if applicable)	<ul style="list-style-type: none"> Procedures do not require validation against either a standard or a means of compliance considered adequate by the competent authority. The adequacy of the procedures and checklists is declared. 	<ul style="list-style-type: none"> Procedures are validated against standards considered adequate by the competent authority and/or in accordance with means of compliance acceptable to that authority⁵. The adequacy of the procedures is proved through: <ul style="list-style-type: none"> Dedicated flight tests, or Simulation, provided that the representativeness of the simulation means is proven for the intended purpose with positive results. 	<p>Same as Medium. In addition:</p> <ul style="list-style-type: none"> Flight tests performed to validate the procedures cover the complete flight envelope or are proven to be conservative. The procedures, flight tests and simulations are validated by a competent third party.
	Comments	N/A	⁵ National Aviation Authorities (NAAs) may define the standards and/or the means of compliance they consider adequate. The SORA Annex B will be updated at a later point in time with a list of adequate standards based on the feedback provided by the NAAs.	N/A
	Criterion #3 (Training, if applicable)	Training is self-declared (with evidence available)	<ul style="list-style-type: none"> Training syllabus is available. 	<ul style="list-style-type: none"> Training syllabus is validated by a competent third party.

			<ul style="list-style-type: none"> The operator provides competency-based, theoretical and practical training. 	<ul style="list-style-type: none"> Remote crew competencies are verified by a competent third party.
	<i>Comments</i>	<i>N/A</i>	<i>N/A</i>	<i>N/A</i>

Table 7 - Level of Assurance Assessment Criteria for M2 Mitigations

4. M3 - An Emergency Response Plan is in place, operator validated and effective

An Emergency Response Plan (ERP) should be defined by the applicant in the event of loss of control of the operation (*). These are emergency situations where the operation is in an unrecoverable state and in which:

- the outcome of the situation highly relies on providence; or
- could not be handled by a contingency procedure; or
- when there is grave and imminent danger of fatalities.

The ERP proposed by an applicant is different from the emergency procedures. The ERP is expected to cover:

- a plan to limit the escalating effect of crash (e.g. notify first responders), and
- the conditions to alert ATM.

(*). Refer to the SORA Semantic Model (Figure 1) in the Main Body

		LEVEL of INTEGRITY		
		Low/None	Medium	High
M3 - An Emergency Response Plan (ERP) is in place, operator validated and effective	Criteria	No ERP is available, or the ERP does not cover the elements identified to meet a “Medium” or “High” level of integrity	The ERP: <ul style="list-style-type: none"> • is suitable for the situation; • limits the escalating effects; • defines criteria to identify an emergency situation; • is practical to use; • clearly delineates Remote Crew member(s) duties. 	Same as Medium. In addition, in case of loss of control of the operation, the ERP is shown to significantly reduce the number of people at risk although it can be assumed that a fatality may still occur.
	Comments	N/A	N/A	N/A

Table 8 - Level of Integrity Assessment Criteria for M3 Mitigations

		LEVEL of ASSURANCE		
		Low/None	Medium	High
M3 - An Emergency Response Plan (ERP) is in place, operator validated and effective	Criterion #1 (Procedures)	<ul style="list-style-type: none"> Procedures do not require validation against either a standard or a means of compliance considered adequate by the competent authority. The adequacy of the procedures and checklists is declared. 	<ul style="list-style-type: none"> The ERP is developed to standards considered adequate by the competent authority and/or in accordance with means of compliance acceptable to that authority¹. The ERP is validated through a representative tabletop exercise² consistent with the ERP training syllabus. 	Same as Medium. In addition: <ul style="list-style-type: none"> The ERP and the effectiveness of the plan with respect to limiting the number of people at risk are validated by a competent third party. The applicant has coordinated and agreed the ERP with all third parties identified in the plan. The representativeness of the tabletop exercise is validated by a competent third party.
	Comments	N/A	¹ National Aviation Authorities (NAAs) may define the standards and/or the means of compliance they consider adequate. The SORA Annex B will be updated at a later point in time with a list of adequate standards based on the feedback provided by the NAAs. ² The table top exercise may or may not involve all third parties identified in the ERP.	N/A
	Criterion #2 (Training)	Does not meet the "Medium" level criterion	<ul style="list-style-type: none"> An ERP training syllabus is available. A record of the ERP training completed by the relevant staff is established and kept up to date. 	Same as Medium. In addition competencies of the relevant staff are verified by a competent third party.
	Comments	N/A	N/A	N/A

Table 9 - Level of Assurance Assessment Criteria for M3 Mitigations