**SORA ANNEX B: Integrity and Assurance Levels for the Mitigations used to reduce the intrinsic Ground Risk Class**

[*1.* *How to use Annex B* 2](#_Toc513097544)

[*2.* *Mitigation M1 - An Emergency Response Plan (ERP) is in place, operator validated and effective* 3](#_Toc513097545)

[*3.* *Mitigation M2 - Effects of ground impact are reduced* 5](#_Toc513097546)

[a) Mitigations reducing the effect of the UA impact dynamics (e.g. parachute) 5](#_Toc513097547)

[b) Mitigations protecting the non-active participants (e.g. shelter) 7](#_Toc513097548)

[*4.* *Mitigations M3 - Technical containment in place and effective* 8](#_Toc513097549)

[a) Generic criteria 8](#_Toc513097550)

[b) Specific criteria in case of use of a tether 10](#_Toc513097551)

# *How to use Annex B*

The following table provides basic principles to be kept in mind when using SORA Annex B.

|  |  |  |
| --- | --- | --- |
|  | **Principle description** | **Additional information** |
| #1 | Annex B provides criteria to assess the levels of integrity and assurance of the mitigations proposed by an applicant to reduce the intrinsic Ground Risk Class (GRC) associated to a given operation. | The identification of the mitigations are under the responsibility of the applicant. |
| #2 | Annex B does not cover the Level of Involvement (LoI) of the Competent Authority since other factors (e.g. the performance of the applicant) could play a role in the determination of this LoI. | Some groups (e.g. JARUS WG-7) might provide foreseen level of involvement for Competent Authorities (but this will not only depend on the level of robustness). |
| #3 | The level of integrity of a mitigation is defined considering whether this mitigation will have a positive effect on reducing the risk on the ground or not.  In the case where a mitigation is available but does not reduce the risk on the ground, its integrity level should be considered equivalent to “None”. |  |
| #4 | The levels of integrity/assurance of a mitigation could rely on more than one criterion, in which case, all applicable criteria need to be met in order to achieve the given level of integrity/assurance. |  |
| #5 | Annex B uses intentionally non-prescriptive terms (e.g. suitable, reasonably practicable) to provide the flexibility for the Competent Authority and the applicant to evaluate what is necessary on a case by case basis. |  |

# *Mitigation M1 - An Emergency Response Plan (ERP) is in place, operator validated and effective*

## 

* *Contributing JARUS WGs: WG1, WG2 and WG3*

An Emergency Response Plan (ERP) should be defined by the applicant to cope with cases of loss of control of the operation, i.e. cases of emergency situations where the operation is in an unrecoverable state.

The ERP is expected to cover:

* The plan proposed by the applicant to limit crash escalating effect (e.g. notify first responders ...), and
* The conditions to alert ATM.

|  | | **LEVEL of INTEGRITY** | | |
| --- | --- | --- | --- | --- |
| **Low/None** | **Medium** | **High** |
| **M1 - An Emergency Response Plan (ERP) is in place, operator validated and effective** | Criterion #1 (Procedures) | No ERP is available or the ERP does not cover the elements identified to meet a “Medium” or “High” level of integrity | The ERP:   * is suitable for the situation; * defines criteria to identify an emergency situation; * reduces the risk to people on the ground (by limiting the escalating effect); * is practical to use; * clearly delineates Remote Crew member(s) duties. | |
| *Comments* | *N/A* | *The modulation of the level of robustness between medium and high is achieved through the level of assurance (see table below).* | |
| Criterion #2 (Training) | The training proposed by the applicant either does not cover an ERP or only partly. | The competency-based theoretical and practical training proposed by the applicant covers the ERP and include related proficiency requirements and training recurrences. | |
| *Comments* | *N/A* | *The modulation of the level of robustness between medium and high is achieved through the level of assurance (see table below).* | |

|  | | **LEVEL of ASSURANCE** | | |
| --- | --- | --- | --- | --- |
| **Low/None** | **Medium** | **High** |
| **M1 - An Emergency Response Plan (ERP) is in place, operator validated and effective** | Criterion #1 (Procedures) | * Procedures are not required to be validated against a recognized standard. * The adequacy of the procedures and checklists is declarative. | * Procedures are validated against recognized standards. * The adequacy of the procedures is proved through: * Dedicated flight tests, or * Simulation, provided that the representativeness of the simulation means is proven for the intended purpose with positive results. | Same as Medium. In addition:   * Any flight test performed to validate the procedures cover the complete flight envelope or be proven to be conservative. * The procedures, flight tests and simulations are validated by a competent third party. |
| *Comments* | *N/A* | *N/A* | *N/A* |
| Criterion #2 (Training) | Does not meet the “Medium” level criterion | * Training syllabus is available * Competency-based theoretical and practical training organised by the operator | * Training syllabus validated by a competent third party. * Remote crew competencies verified by a competent third party. |
| *Comments* | *N/A* | *N/A* | *N/A* |

# *Mitigation M2 - Effects of ground impact are reduced*

## 

* *Contributing JARUS WGs: WG3*

Mitigations M2 are meant to reduce the effect of ground impact once the control of the operation is lost.

Two categories of measures to reduce the effect of ground impact are identified:

* Measures reducing the effect of the UA impact dynamics (area, energy, impulse, transfer energy …), e.g. a parachute,
* Measures protecting the non-active participants, e.g. a shelter.

Criteria to assess the levels of integrity and assurance of these two categories of measures are proposed respectively in sections a) and b).

## Mitigations reducing the effect of the UA impact dynamics (e.g. 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 | 1. UAS contains all elements required for the activation of the mitigation in case of probable1 UAS malfunctions or failures leading to a loss of control of the UA. 2. Effects of impact dynamics and post impact hazards2 are significantly reduced although it can be assumed that a fatality may still occur. | 1. Same as medium but at least with automatic activation3. 2. Effects of impact dynamics and post impact hazards are reduced to a level where it can be reasonably assumed that a fatality will not occur. |
| *Comments* | *N/A* | 1 *The term “probable” needs to be understood in its qualitative interpretation, i.e. “Anticipated to occur one or more times during the entire system/operational life of an item.”*  2 *Examples of post impact hazards include fires, release of high energy parts.* | *3 The applicant retains the discretion to implement an additional manual activation function.* |
| Criterion #2  (Procedures) | Installation and maintenance of the measures proposed to reduce the effect of the UA impact dynamics are performed according to the manufacturer instructions. | | |
| *Comments / Notes* | *The modulation of the level of robustness is achieved through Criterion #1 and the level of assurance (see table below).* | | |
| Criterion #3  (Training) | The applicant identifies and trains the personal in charge of installing and maintaining the measures proposed to reduce the effect of the UA impact dynamics. | | |
| *Comments / Notes* | *The modulation of the level of robustness is achieved through Criterion #1 and the level of assurance (see table below).* | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **M2 - Effects of UA impact dynamics are reduced (e.g. parachute)** |  | **LEVEL of ASSURANCE** | | |
| **Low/None** | **Medium** | **High** |
| Criterion #1  (Technical design) | The applicant declares that the required level of integrity has been achieved1. | The applicant has supporting evidence that the required level of integrity has been achieved. This is typically done by means of testing, analysis, simulation2, 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, representativeness of targeted environment needs to be justified.* | *N/A* |
| Criterion #2  (Procedures) | * Procedures are not required to be validated against a recognized standard. * The adequacy of the procedures and checklists is declarative. | * Procedures are validated against recognized standards. * The adequacy of the procedures is proved through:   + Dedicated flight tests, or   + Simulation, provided that the representativeness of the simulation means is proven for the intended purpose with positive results. | Same as Medium. In addition:   * Any flight test performed to validate the procedures cover the complete flight envelope or be proven to be conservative. * The procedures, flight tests and simulations are validated by a competent third party. |
| *Comments* | *N/A* | *N/A* | *N/A* |
| Criterion #3  (Training) | Training is self-declared (with evidence available) | * Training syllabus is available * Competency-based theoretical and practical training organised by the operator | * Training syllabus validated by a competent third party. * Remote crew competencies verified by a competent third party. |
| *Comments* | *N/A* | *N/A* | *N/A* |

## Mitigations protecting the non-active participants (e.g. shelter)

Taking credit for this mitigation only applies if non-active participations are located within a building.

Operation over a controlled area cannot be considered as a mitigation in the SORA model since when determining the intrinsic Ground Risk Class (GRC), consideration is already given whether the area is controlled (i.e. the operation only involves active participants, if any) or not.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | **LEVEL of INTEGRITY** | | |
| **Low/None** | **Medium** | **High** |
| **M2 - Non-active participants are protected (e.g. shelter)** | Criteria | • Low: does not meet the “Medium” level criteria  • None: there is no possibility for the non-active participants being overflown to take shelter | The applicant:   * uses a drone below 25 kg and not flying above 174 knots1, * 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 building2. | The applicant demonstrates that non-active participants are effectively fully sheltered taking into account the UA mass and speed characteristics. |
| *Comments* | *N/A* | *1 These criteria are substantiated in a MITRE report to be published by September 2018.*  *2 The consideration of this mitigation may vary subject to local conditions.* | *N/A* |

|  | | **LEVEL of ASSURANCE** | | |
| --- | --- | --- | --- | --- |
| **Low/None** | **Medium** | **High** |
| **M2 - Non-active participants are protected (e.g. shelter)** | Criteria | The applicant declares that the required level of integrity has been achieved1. | The applicant has supporting evidence that the required level of integrity has been achieved. This is typically done by means of testing, analysis, simulation2, 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, representativeness of targeted environment needs to be justified.* | *N/A* |

# *Mitigations M3 - Technical containment in place and effective*

## 

* *Contributing JARUS WGs: WG3*

Mitigations M3 are meant to reduce the number of people at risk once the control of the operation is lost.

For this kind of mitigation:

* The applicant is expected to show a minimum level of containment, as per the criteria provided in section a. for a “Low” level of Integrity.
* The integrity level is assessed considering 2 different aspects:
  + The way the applicant derive the intrinsic Ground Risk Class from the flight geography, the containment area and the ground risk buffer;
  + The Emergency Recovery Strategy proposed by the applicant.

Criteria to assess the level of integrity and assurance of M3 type mitigations are provided in section a, except for the specific case of tether for which dedicated criteria have been developed in section b.

## Generic criteria

|  | | **LEVEL of INTEGRITY** | | |
| --- | --- | --- | --- | --- |
| **Low** | **Medium** | **High** |
| **M3 - Technical containment in place and effective (e.g. Emergency Recovery Function)** | Criterion #1 (Definition of the operation volume and the ground risk buffer) | The applicant defines:   1. The operation volume composed of the flight geography and the containment area. 2. A risk ground buffer with at least a 1 to 1 rule1.   In addition, the remote crew performs route planning before each mission with up-to-date data including airspace and obstacles. | Same as low. In addition the definition of the ground risk buffer takes into consideration:   * Probable2 malfunctions or failures (including the projection of high energetic parts such as rotors and propellers), * Meteorological conditions (e.g. wind), * UAS latencies (e.g. latencies that affect the timely manoeuvrability of the UA), * UA behavior in case of activation of the Emergency Recovery Strategy, * UA performance. | Same as Medium |
| *Comments* | *1 If the UA is planned to operate at 150m altitude, the ground risk buffer should at least be 150m.* | *2 The term “probable” needs to be understood in its qualitative interpretation, i.e. “Anticipated to occur one or more times during the entire system/operational life of an item.”*  *The modulation of the level of robustness is achieved through the level of assurance (see table below) and criterion #2 on Emergency Recovery Strategy.* | |
| Criterion #2 (Emergency Recovery Strategy) | The remote crew ensures containment of the operation such that it can be reasonably expected that the UA will stay within the containment area. | 1) The Emergency Recovery Strategy provides for the recovery of the UA in all probable*1* UAS failure modes leading to a breach of the containment area.  2) The remote crew checks before each mission that the parameters used to ensure containment of the UAS are set on the Emergency Recovery Strategy. | Same medium. In addition:  3) There is at least one automatic means to activate the recovery function (i.e. no reliance on datalink).  4) The Emergency Recovery Strategy should not leave the UAS one failure away of breaching the containment area2.  5) The availability3 of the Emergency Recovery Strategy is provided to the remote pilot. |
| *Comments* | *N/A* | *1 The term “probable” needs to be understood in its qualitative interpretation, i.e. “Anticipated to occur one or more times during the entire system/operational life of an item.”* | *2This implies that:*   * *failures of the Emergency Recovery Strategy are all detectable and ;* * *with a non-redundant architecture, the mission should be aborted as soon as a failure of the Emergency Recovery is detected.*   *3The term “availability” needs to be understood as the functioning state of the Emergency Recovery Strategy* |

|  | | **LEVEL of ASSURANCE** | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Low** | **Medium** | | **High** | |
| **M3 - Technical containment in place and effective (e.g. Emergency Recovery Function)** | For Criteria #1 and #2 | The applicant declares that the required level of integrity has been achieved1. | | The applicant has supporting evidence that the required level of integrity has been achieved. This is typically done by means of testing2, analysis, simulation3, 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 tests or simulations are used to support the definition of the containment area or the ground risk buffer, the applicant is expected to cover:*   * *a wide scope of containment areas topology, and* * *UA incursion profiles in containment areas.*   *3 When simulation is used, representativeness of targeted environment needs to be justified.* | | *N/A* |

## Specific criteria in case of use of a tether

Tether is a specific example of mitigation falling into the category M3.

If an applicant wants to take credit of a tether:

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

|  | | **LEVEL of INTEGRITY** | | |
| --- | --- | --- | --- | --- |
| **Low** | **Medium** | **High** |
| **M3 – 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 operation volume.  2) Strength of the line is compatible of the limit loads1 expected during the operation.  3) Strength of attachment points is compatible of the limit loads1 expected during the operation.  4) The tether cannot be cut by rotating propellers. | Same as Medium |
| *Comments* | *N/A* | *1Limit loads are the maximum loads expected considering all possible nominal and failure scenarios with a minimum safety factor of 1.5.*  *The modulation of the level of robustness is achieved through the level of assurance (see table 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 |
| *Comments* | *N/A* | *The modulation of the level of robustness is achieved through the level of assurance (see table below).* | |

|  | | **LEVEL of ASSURANCE** | | |
| --- | --- | --- | --- | --- |
| **Low** | **Medium** | **High** |
| **M3 – Tethered operation** | Criterion #1  (Technical design) | Does not meet the “Medium” level criteria | The applicant has supporting evidence (including the tether material specifications) that the required level of integrity has been achieved.   * This is typically achieved by means of testing or through operational experience. * Tests can be based on simulations provided that, representativeness of targeted simulation environment is proven. | The claimed level of integrity is validated by a competent third party |
| *Comments* | *N/A* | *N/A* | *N/A* |
| Criterion #2  (Procedures) | * Procedures are not required to be validated against a recognized standard. * The adequacy of the procedures and checklists is declarative. | * Procedures are validated against recognized standards. * The adequacy of the procedures is proved through:   + Dedicated flight tests, or   + Simulation, provided that the representativeness of the simulation means is proven for the intended purpose with positive results. | Same as Medium. In addition:   * Any flight test performed to validate the procedures cover the complete flight envelope or be proven to be conservative. * The procedures, flight tests and simulations are validated by a competent third party. |
| *Comments* | *N/A* | *N/A* | *N/A* |