B.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 the integrity levels of M1 mitigations, the following need to be considered:

(a) the definition of the ground risk buffer and the resulting ground footprint; and

(b) the evaluation of the people at risk.

the generic criteria to assess the level of integrity (Table B.2) and level of assurance (Table B.3) of the M1 type ground risk mitigations are provided in following paragraph (1).

		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 1:1 rule[1] or for rotary wing UA defined using a ballistic methodology approach acceptable to the competent authority.	The ground risk buffer takes into consideration: (a) improbable[2] single malfunctions or failures (including the projection of high energy parts such as rotors and propellers) which would lead to an operation outside the operational volume; (b) meteorological conditions (e.g. wind); (c) UAS latencies (e.g. latencies that affect the timely manoeuvrability of the UA); (d) UA behaviour when activating a technical containment measure; and (e) UA performance.	Same as medium[3]
		Level of integrity		
		Low	**Medium**	**High**
	Comments	*[1] If the UA is planned to operate at an altitude of 150 m, the ground risk buffer should be a minimum of 150 m.*	*[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 or appropriate appraisals to justify lowering the density of the people at risk (e.g. a residential area during daytime when some people may not be present or an industrial area at night time for the same reason).	The applicant evaluates the area of operations by use of authoritative density data (e.g. data from the U-space data service provider) relevant for the proposed area and time of operation to substantiate a lower density of people at risk. If the applicant claims a reduction, due to a sheltered operational environment, the applicant: (a) uses a UA of less than 25 kg and not flying above 174 knots[4], and (b) demonstrates that although the operation is conducted in a populated environment, it is reasonable to consider that most of the non-involved persons will be located within a building[5].	Same as medium.
	Comments	*N/A*	*[4] as per MITRE presentation given during the UAS Technical Analysis and Applications Center (TAAC) conference in 2016 titled 'UAS EXCOM Science and Research Panel (SARP) 2016 TAAC Update' - PR 16-3979* *[5] The consideration of this mitigation may vary based on the local conditions.*	*N/A*

Table B.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 that 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*
		Level of assurance		
		Low	**Medium**	**High**
	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 a 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 B.3 — Level of assurance assessment criteria for ground risk of non-tethered M1 mitigations

(2) Specific criteria in case of use of a tether to reduce people at risk (NOT REQUIRED)

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EAMPLE OF HOW TO WRITE M1

M1 Strategic Mitigations for Ground Risk

Level of Integrity: This Integrity has two Criterion 1. Definition of the ground risk buffer & 2. Evaluation of people at risk

Criterion 1. Definition of the ground risk buffer

The Ground Risk Buffer is defined as:

The Flight Geography of the Drone Flight area

The Contingence Area for the use of Contingencies laid out in Section 5

The Ground Buffer Area for the Use of Loss of Control of the Mission

	Minimum distance to be covered by the ground risk buffer for untethered unmanned aircraft	
Maximum height above ground	**with an MTOM up to 10 kg**	**with an MTOM above 10 kg**
30 m	10 m	20 m
60 m	15 m	30 m
90 m	20 m	45 m
120 m	25 m	60 m

NOT TO BE USED

Criterion 2. Evaluation of people at risk

The applicant evaluates the area of operations by use of authoritative density data (e.g. data from the U-space data service provider) relevant for the proposed area and time of operation to substantiate a lower density of people at risk. If the applicant claims a reduction, due to a sheltered operational environment, the applicant:

(a) uses a UA of less than 25 kg and not flying above 174 knots, and

(b) demonstrates that although the operation is conducted in a populated environment, it is reasonable to consider that most of the non-involved persons will be located within a building.

Based on the above:

Level of integrity M1: Medium

Level of assurance: This Assurance has two Criterion 1. Definition of the ground risk buffer & 2. Evaluation of people at risk

Criterion 1. Definition of the ground risk buffer:

The Ground Risk Buffer is defined as:

The Flight Geography of the Drone Flight area

The Contingence Area for the use of Contingencies laid out in Section 5

The Ground Buffer Area for the Use of Loss of Control of the Mission.

Below is all our Operations and how the Ground Risk Model is applied.

1. 2D/3D Mapping, General Photography and Videography
2. Bridge/Structure Inspections
3. Asset Management
4. Monitoring of Traffic
5. Coastal Erosion/Defence/Flooding/Subsidence
6. Quarries/Construction sites
7. National, regional & Local roads
8. Emergency Services Operations

(NB*)

Point to Note:

Here is were you will show the ground risk model for each and every type of operation. Below is just an example of how to apply the Ground risk model. In Criterion 2: Evaluation of people at risk you will have to input in text the information. I have an example that you can use for this type of operation. You will have to do the same for every type of operation. Above are just some of the different types of operations that you maybe involved in.

2D/3D Mapping and General Photography & Videography.

This is a typical Ground Risk Buffer Model for 2D/£d Mapping & General Photography.

Criterion 2. Evaluation of people at risk:

the applicant:

(a) uses a UA of less than 25 kg and not flying above 174 knots or 89m/s, and

(b) demonstrates that although the operation is conducted in a populated environment, it is reasonable to

consider that most of the non-involved persons will be located within a building.

The UAS types used for all UAS operations within [Company] are below 25Kg and do not fly above 174knots/89m/s. a list of these UAS can be found in section 3.5 Technical Means

The following Operations all have a Ground Risk model where no non-involved person(s) will be unprotected, either they will be located inside a building or vehicle or wearing of PPE which is that of the likes a Hard hat, or Crash Helmet.

2D/3D Mapping, General Photography & Videography

When conducting Drone operations for Mapping, General Photography & Videography, Most sites will be outside of a populated area, when operations are required to be conducted in populated area, the Ground Risk Model will be applied to so no uninvolved persons will be within the Ground Risk Buffer. The flight height will be different for each operation. So, the Ground Risk Buffer will change accordingly, please refer to Table in Level of integrity Criterion 1. Definition of the ground risk buffer.

The Type of UAS will be taken into consideration when flying these locations of populated areas, the use of a lower weight category drone will be utilised in these areas. For general Photography & Videography in a populated area the Mavic 3/Mavic 2/Mavic Air will be used. These are all less than 1kg and the kinetic energy in the unlikely event of loss of control, is less than 46 joules at 10m/s.

When conducting this type of UAS operation the maximum flight speed will be 10m/s. if the UAS operator needs to go faster the Area below the Operation must be fully controlled with on Uninvolved person(s) present.

A Based on the level of assurances of both Criterions above:

Level of assurance for M1: Medium

Based on the above, the overall level of Robustness for M1 is:
Medium with a Correction Factor of -2

B.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. the area, energy, impulse, transfer energy, etc.). One example would be the use of a parachute.e

		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	(a) Effects of impact dynamics and post impact hazards[1] are significantly reduced although it can be assumed that a fatality may still occur. (b) When applicable, in case of malfunctions, failures or any combinations thereof that may lead to a crash, the UAS contains all the elements required for the activation of the mitigation. (c) 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: (a) When applicable, the activation of the mitigation is automated[2]. (b) 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 occur[3].
	Comments	*N/A*	*[1] Examples of post impact hazards include fires and the 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 is installed and maintained in accordance with the manufacturer's 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 B.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 B.7 below).*		

Table B.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 that 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 EASA against a standard considered adequate by EASA and/or in accordance with means of compliance acceptable to EASA (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.*	
	Criterion #2 (Procedures, if applicable)	(a) Procedures do not require validation against either a standard or a means of compliance considered adequate by the competent authority. (b) The adequacy of the procedures and checklists is declared.	(a) Procedures are validated against standards considered adequate by the competent authority and/or in accordance with means of compliance acceptable to that authority. (b) The adequacy of the procedures is proven through: (1) dedicated flight tests; or (2) simulation, provided that the representativeness of the simulation means is proven for the intended purpose with positive results.	Same as medium. In addition: (a) Flight tests performed to validate the procedures cover the complete flight envelope or are proven to be conservative. (b) The procedures, flight tests and simulations are validated by a competent third party.
	Comments	*N/A*		*N/A*
	Criterion #3 (Training, if applicable)	Training is self-declared (with evidence available)	(a) Training syllabus is available. (b) The UAS operator provides competency-based, theoretical and practical training.	(a) Training syllabus is validated by a competent third party. (b) Remote crew competencies are verified by a competent third party.
	Comments	*N/A*	*N/A*	*N/A*

Table B.7 - Level of assurance assessment criteria for M2 mitigations

M2 EFFECTS OF GROUND IMPACT REDUCTION EXAMPLE

M2 Effects of Ground Impact reduction
Level of Integrity: This Integrity has three Criterion 1. Technical Design 2. Procedures, if applicable, 3. Training, If applicable. Criterion 1. Technical design (a) Effects of impact dynamics and post impact hazards are significantly reduced although it can be assumed that a fatality may still occur. (b) When applicable, in case of malfunctions, failures or any combinations thereof that may lead to a crash, the UAS contains all the elements required for the activation of the mitigation. (c) When applicable, any failure or malfunction of the proposed mitigation itself (e.g. inadvertent activation) does not adversely affect the safety of the operation. Criterion 2. Procedures, if applicable Any equipment used to reduce the effect of the UA impact dynamics is installed and maintained in accordance with the manufacturer's instructions 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 Based on the above:
Level of integrity M2: Medium

Level of assurance: This assurance has three Criterion 1. Technical Design 2. Procedures, if applicable, 3. Training, If applicable.

(NB*)

Point to Note:

Here is were you will add any Flight Termination systems details or parachute for your aircraft. I have an example of how I have completed this with the M300

Criterion 1. Technical design

Above in 3.4.3 Ground Risk is the list of Drones and their Kinetic Energy which is estimated without any reduced Impact System. The highest speed for the drone mapping on any [Company] Construction site will be no more than 10m/s (36kmph), the highest speed for Manual flying will also be 10m/s (36Kmph) for Multi-rotor Drones less than 4KG. Flight Speeds for fixed wing UAS and heavier UAS Operations can vary.

Because the M300 RTK is the heaviest UAS that [Company] have. Here is the kinetic energy of the Matrice 300 RTK which is estimated without any reduced Impact system as follows:

$$E_c = \frac{1}{2}mv^2$$

With m = MTOW = **9Kg** and v = airspeed = **12m/s**, Ec = **648J**. When operating the **M300 RTK** it will have a Parachute System & Flight Termination System installed.

Therefore [Company] feel the need for a Fail-Safe System for the M300 RTK Multi-Rotor Drone. For some operations that are deemed high risk in relation to the amount of unprotected uninvolved persons on or around a site will operate with a Parachute & Flight termination System. For Operations in congested areas the Fail-Safe System will be utilised. The Fail-System [Company] have opted for is the Flyfire OWL system. All Staff members who operated the M300 RTK will receive correct training on this system.

Criterion 2. Procedures, if applicable

Any equipment used to reduce the effect of the UA impact dynamics is installed and maintained in accordance with the manufacturer's instructions safety.

OWL is equipped with Flyfire safety algorithm, and the hazard response time is lowered to 0.5 seconds. In case of emergency, the parachute can also be opened manually. The speed is stabilized at 3.5m per second. (test weight 9 kg). During the forced landing, the high-power buzzer continuously sends out the 110DB warning sound to remind pedestrians on the ground to avoid and protect their safety.

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. Third Party Training Organisation/ DUTO will providing [Company] with the required training on the operation of this system.

Level of assurance for M2: Medium

Based on the above, the overall level of Robustness for M2 is: Medium with a Correction Factor of -1

B.4 M3 — An ERP is in place, UAS operator validated and effective

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

(a) the outcome of the situation relies highly on providence; or

(b) it could not be handled by a contingency procedure; or

(c) when there is a grave and imminent danger of fatalities.

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

(1) a plan to limit the escalating effect of a crash (e.g. to notify first responders), and

(2) 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 ERP is in place, UAS 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: (a) is suitable for the situation; (b) limits the escalating effects; (c) defines criteria to identify an emergency situation; (d) is practical to use; (e) clearly delineates the duties of remote crew member(s).	Same as medium. In addition, in case of a 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 B.8 — Level of integrity assessment criteria for M3 mitigations

		Level of assurance		
		Low/None	**Medium**	**High**
M3 — An ERP is in place, UAS operator validated and effective	Criterion #1 (Procedures)	(a) Procedures do not require validation against either a standard or a means of compliance considered adequate by the competent authority. (b) The adequacy of the procedures and checklists is declared.	(a) The ERP is developed to standards considered adequate by the competent authority and/or in accordance with means of compliance acceptable to that authority. (b) The ERP is validated through a representative tabletop exercise[1] consistent with the ERP training syllabus.	Same as medium. In addition: (a) 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. (b) The applicant has coordinated and agreed the ERP with all third parties identified in the plan. (c) The representativeness of the tabletop exercise is validated by a competent third party.
	Comments	*N/A*	*[1]The tabletop 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	(a) An ERP training syllabus is available. (b) 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 B.9 — Level of assurance assessment criteria for M3 mitigations

M3 AN ERP IS IN PLACE< UAS OPERATOR VALIDATED & EFFECTIVE EXAMPLE

M3 An ERP is in place, UAS operator validated and effective

Level of Integrity: Criteria

The ERP:
(a) is suitable for the situation.
(b) limits the escalating effects.
(c) defines criteria to identify an emergency situation.
(d) is practical to use.
(c) clearly delineates the duties of remote crew member(s).

Level of integrity M3: Medium

Level of assurance: This Assurance has two Criterion 1. Procedures & 2. Training

Criterion 1. Procedures:

The Competent Authority have no guidelines or standards required for the ERP. However "common sense" has been applied in relation to the development of the ERP with the help of our inhouse qualified Health and Safety staff. [Company] Drone Pilots conduct a Tabletop exercise once every six months.

1. the outcome of the situation relies highly on providence; or
2. It could not be handled by a contingency or emergency procedure; or
3. when there is a grave and imminent danger of fatalities.
    a) It is of practical use since it is schematic and simple.
    b) It describes the role of the crew members.

Criterion 2. Training:

The ERP tabletop exercise is recorded and saved. A record of this training is kept up to date.

Level of assurance for M3: Medium

Based on the above, the overall level of Robustness for M3 is: Medium with a Correction Factor of 0