Pre Defined Risk Assessment, PDRA-08 for swarm operations:

- OVER CONTROLLED GROUND AREAS
- IN CONTROLLED OR UNCONTROLLED AIRSPACE, WITH A LOW PROBABILITY OF ENCOUNTER WITH MANNED AIRCRAFT
- MAXIMUM HEIGHT OF FLIGHT GEOGRAPHY 120m OR IN RESERVED AIRSPACE
- IN VISUAL RANGE
- USING SEVERAL UNMANNED AIRCRAFT UP TO 1 M DIMENSION FOLLOWING PRE-PROGRAMMED PATHS
- WITH SAFETY CREW MEMBERS
- WITH ENHANCED CONTAINMENT

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Overview of the PDRA

This PDRA addresses operations of swarm with multiple UAs in a mostly automated manner, for example for light shows. Due to the characteristic of swarm operations, SORA cannot apply and fit perfectly (e.g., since multiple UAs are used, the determination of GRC is not straight forward). The consequence is that some conditions are adapted to require different levels of robustness from what SORA would lead to with a single UA.

Proper attention to risks peculiar to swarm operations and the presence of assemblies of people nearby must granted:

- The controlled ground area requirement must be formally enforced, including in the ground buffer area.
- The remote pilot (and safety crew members) must always be able to terminate the flight of the swarm.
- Due to the presence of multiple UAs in flight at the same time, proper attention must be exercised on the air risk and the segregation of the operation with respect to manned aviation.
- The operation of several UAS is pre-programmed and automated, which decreases the risk of collision between UAs and obstacles and assure a reliable and safe control of all the UASs at the same time.
- Light shows are generally made for a large audience considered as assemblies of people. In such a case, UAS design should therefore comply with enhanced containment requirements.
- The SORA is not adapted to several drones flying at the same time. Therefore, the ground risk and the air risk in adjacent areas must be addressed through enhanced containment, with or without assemblies of people in the adjacent area.

For light shows at night, the formal definition of VLOS may not apply as during the night the orientation of the UA may not be visible even though it remains possible to see the UA and monitor its flight path. Hence the PDRA refers to “visual range” instead of VLOS. Light shows being largely automated, the expected safety level is met if crew are able to see the UAs and monitor their flight paths.

When regulation requires night lights, this may be complied with as the regulatory lighting may have an intensity significantly lower than the lights for the show, in such a way that they remain invisible for the public but can be detected by safety crew members at the boundaries of the flight geography. This condition is key as it allows to mitigate the risk of fly-away by visual cues. It is then necessary that each UA remains visible somehow. Applicants may propose other solutions to demonstrate that the safety crew members can observe the position of the UAs, event those whose light is off for the purpose of the show.

Safety crew members refer to the air observers whose responsibilities also include direct or indirect flight termination in addition to the usual scan of the airspace to detect incoming traffic.

Due to the large number of UAs flying at the same time and considering speed/height of the UAs, the 1:1 rule may not be sufficient to guarantee that all the swarm will remain within the buffer. In addition, assemblies of people may be present at the very limit of the ground risk buffer. Hence, **the Ground Risk buffer should be calculated assuming a ballistic trajectory of the UA** at the limit of the contingency volume (geofence) using the following simple formulas:

$$x(t) = v_0 t + \frac{1}{2} a t^2$$

$$y(t) = \frac{1}{2} g t^2$$

With:

- x is the distance flown by the UA when exiting the contingency volume. Its value defines the size of the ground risk buffer.
- v_0 the maximum speed of the UAs when exiting the contingency volume + maximum tail wind allowed of the operation.
- a the acceleration ($a=g$ during the free fall).
- t is the time since exiting the contingency volume.
- y is the height of the UAS when exiting the contingency volume.

Ground buffer calculation is considered a part of operational procedures, covered by OSO #8.

A risk assessment based on SORA is provided in Annex A: Risk assessment for PDRA-08.

PDRA characterisation and conditions

This PDRA is the result of applying the SORA to UAS operations performed in **swarms**:

(1) with UA with maximum characteristic dimensions (e.g., rotor diameter/area or maximum distance between rotors in case of multirotor) of up to 1 m and a kinetic energy up to 700 J.

(2) within a distance at which the UAs can be visible during the day or when lit at night[1] with safety crew members[2] whose number must be adapted to the geometry of the operational volume.

(3) over a controlled ground area.

(4) below 120 m (except when close to obstacles) above ground level (AGL) or, in case of an airspace reserved for the operation , up to the limit of the temporary segregated airspace;

(5) in controlled or uncontrolled airspace, provided that there is a low probability of encountering manned aircraft.

The characterisation and conditions for this PDRA are summarised in **Table PDRA-08** below:

PDRA characterization and conditions				
Topic	**Method of proof**	**Condition**	**Integrity[3]**	**Proof[3]**
1. Operational characterisation (scope and limitations)				
Level of human intervention	Self-declaration[4]	1.1 No autonomous operations: the remote pilot should have the ability to maintain control of the UAS, except in case of a lost command and control (C2) link.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		1.2 The operation of several UAS is pre-programmed and takes place in an automated way.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'

1 For light shows at night, the formal definition of VLOS may not apply as during the night the orientation of the UA may not be visible even though it remains possible to see the UA and monitor its flight path. Hence the PDRA refers to "visual range" instead of VLOS. Light shows being largely automated, the expected safety level is met if crew are able to see the UAs and monitor their flight paths.

2 Safety crew members refer to the air observers whose responsibilities also include flight termination in addition to the usual scan of the airspace to detect incoming traffic.

[3] To be completed by the UAS operator

4 Supporting evidence may be requested by the competent authority wherever a self-declaration is expected

PDRA characterization and conditions				
Topic	**Method of proof**	**Condition**	**Integrity[3]**	**Proof[3]**
		1.3 The remote crew, including safety crew members, should always be able to terminate the flight.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		Flight termination as required by 1.3 designates one or several UAs or the entire swarm.		
		1.4 The remote pilot should not operate from a moving vehicle.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		1.5 One remote pilot should be responsible for the safe conduct of the flight.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
UA range limit	Self-declaration	1.6 All UA operating in the swarm should be within visual range from the remote pilot and/or from safety crew members.	*Please include a reference to the relevant chapter/section of the OM where the procedures for keeping the UA in view of the remote pilot or safety crew members.*	'I declare compliance.'
Areas overflown	Declaration supported by data	1.7 UAS operations should be conducted over controlled ground areas. Note: it is reminded that the ground buffer is included in the controlled ground area. Procedures for establishing and controlling the ground area are included in the OM and/or ConOps. Size and dimensions of the operational volume should reflect the capability of the UAs in the swarm and the control and command unit to keep the position in 4D space (height, latitude, longitude and time) and should be such that it allows to conduct safely operations close to natural or artificial obstacles.	*Please include a reference to the relevant chapter/section of the OM where the procedures for establishing the control ground area is included.*	'I declare compliance.'
UA limitations	Self-declaration	1.8 All UAs should be an aircraft other than a fixed-wing aircraft.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		1.9 Maximum characteristic dimension (e.g., rotor diameter/area or maximum distance between rotors in case of a multirotor): 1 m.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		1.10 Typical kinetic energy (as defined in paragraph 2.3.1(k) of SORA) up to 700 J	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'

PDRA characterization and conditions				
Topic	**Method of proof**	**Condition**	**Integrity[3]**	**Proof[3]**
Flight height limit	Self-declaration	1.11 The remote pilot should maintain the UA within 120 m (unless making use of the option defined in point 1.13) above the overflown surface (or any other altitude reference defined by the state of operation). The measurement of the distances should be adapted according to the geographical characteristics of the terrain, such as plains, hills, and mountains.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		1.12 The flight height may be increased up to 15 m above the highest closest obstacle if that obstacle is higher than 105 m.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		1.13 The operations may be conducted at a higher height if the airspace is segregated. In this case the height of the operational volume will be the vertical limit of the segregated airspace.		
		Note 2: In addition to the vertical limit for the operational volume, an air risk buffer is to be considered (see "Air Risk" under point 3.10 of this table).		
Visibility	Declaration supported by data	1.14 Visibility should be sufficient to ensure that the entire swarm remains in visual range for the entire duration of the flight. In particular, at any given time, each UA's position should be visible by at least one crew member[5]. 1.15 Visibility should be sufficient to ensure that no people are in danger on the ground within the controlled ground area. 1.16 The remote pilot and safety crew members should be able to visualize the boundaries of the operational volume and the relative position of each UA in the swarm in order to be able to trigger emergency procedures including the termination of the	*Please include a reference to the relevant chapter/section of the OM* where procedures for determining visibility are provided.	'I declare compliance and that supporting evidence is included in the OM.'

[5] This requirement should be understood as the ability for a crew member to check whether any UA remains in the flight geography.

PDRA characterization and conditions					
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		flight, especially in case of incoming traffic outside the operational volume. 1.17 Visibility should be sufficient to ensure that incoming traffic can be detected and avoided by the remote pilot and typically must be at least 5 km.			
Others	Self-declaration	1.18 The UA should not be used to drop dangerous goods, or material that may be harmful to people, goods, or the environment. Dropped material should not contravene any other applicable regulations.		*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
2. Operational risk classification (according to the classification defined in SORA)					
Final GRC	2	**Final ARC**	ARC-b	**SAIL**	II
3. Operational mitigations					
Operational volume (see Figure 2 of SORA)	Self-declaration	3.1 To determine the operational volume, the applicant should consider the position-keeping capabilities of the UAS in 4D space (latitude, longitude, height, and time).		*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		3.2 In particular, the accuracy of the navigation solution, the flight technical error of the UAS, as well as the flight path definition error (e.g., map error) and latencies should be considered and addressed when determining the operational volume.		*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		Note: If provided, a geocage function should be included with a size adapted to the flight geography.			
		3.3 The remote pilot should apply emergency procedures as soon as any UA shows a behavior that may lead to exiting the operational volume.		*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
Ground risk	Declaration supported by data	3.4 The UAS operator should establish a ground risk buffer to protect the crew and third parties on the ground outside the operational volume.		*Please include a reference to the relevant chapter/section of the OM where the procedures for determining the ground risk buffer is defined.*	'I declare compliance and that supporting evidence is included in the OM.'

PDRA characterization and conditions				
Topic	**Method of proof**	**Condition**	**Integrity[3]**	**Proof[3]**
		The applicant should evaluate the area of operations typically by means of an on-site inspection or appraisal to assure that an effective controlled ground area can be settled		
		3.4.1. A ballistic trajectory shall be considered to calculate the ground risk buffer size according to the formula in the 1. Overview.		
		3.4.2 The computation of the ground risk buffer should account for operators' reaction times, technical latencies, and meteorological conditions. Note: This should also include communication latencies between the safety crew members and the remote pilot.		
		3.5 Ground risk buffer should be all contained in a controlled ground area.		
		3.6 The UAS operator should ensure the absence of involved or uninvolved people within the operational volume and the ground risk buffer. Fences, surveillance, or similar systems should be used to ensure the absence of uninvolved people.	*Please include a reference to the relevant chapter/section of the OM where the procedures for establishing the controlled ground area is defined.*	'I declare compliance and that supporting evidence is included in the OM.'
		Note: Involved people like the RP and the safety crew members should be allowed at the boundary of the operational volume, so that they can check that the UAs do not exit the operational volume.		
Air risk	Declaration supported by data	3.7 The operational volume should be:		
		3.7.1 Below 150 m in uncontrolled or controlled airspace with a low risk of encounter with manned aircraft (corresponding to a final air risk that can be classified as not higher than ARC-b);	*Please include a reference to the relevant chapter/section of the OM where the maximum height and the type of airspace are defined.*	'I declare compliance and that supporting evidence is included in the OM.'
		3.7.2 Above 150 m in segregated airspace (corresponding to an air risk that can be classified as not higher than ARC-a)		

PDRA characterization and conditions				
Topic	**Method of proof**	**Condition**	**Integrity[3]**	**Proof[3]**
		3.8 The UAS operator should establish an air risk buffer to protect third parties in the air, outside the operational volume if:	*Please include a reference to the relevant chapter/section of the OM where the procedures for establishing the air risk buffer or write 'N/A'.*	'I declare compliance and that supporting evidence is included in the OM or 'N/A'
		3.8.1 The operational volume has an adjacent airspace classified as ARC-d; or		
		3.8.2 The competent authority or the entity responsible for the airspace management considers it necessary in order to ensure the protection of third parties in the air.		
		3.9 The air risk buffer should be: - 30 m high unless agreed differently with the NAA. - contained in the 'airspace class F or G' (uncontrolled airspace) unless the operation was coordinated with the local ANSP.		
		3.10 Prior to flight, the UAS operator should assess the proximity of the planned UAS operation to manned aircraft activity in the vicinity of the area of operations.	*Please include a reference to the relevant chapter/section of the OM where the procedures for assessing the proximity of aircraft.*	'I declare compliance and that supporting evidence is included in the OM.'
		3.11 The UAS operator should establish a deconfliction scheme that allows the pilot to take efficient and timely decisions in case of incoming traffic.	*Please include a reference to the relevant chapter/section of the OM where the deconfliction scheme is defined.*	'I declare compliance and that supporting evidence is included in the OM.'
Observers	Declaration supported by data	3.12 Observers should include: 3.12.1 Ground observers to guarantee that the controlled ground area remain empty of uninvolved people 3.12.2 Air observers, referred to as safety crew members, to monitor any malfunction or unexpected behavior of a UA and the entire swarm, as well as monitor incoming traffic.	*Please include a reference to the relevant chapter/section of the OM where the deconfliction scheme is the procedures for the observers are defined.*	'I declare compliance and that supporting evidence is included in the OM.'
		Note: Safety crew members should include a remote safety crew member able to identify a vertical fly-away		
4. UAS operator and UAS operations conditions				

PDRA characterization and conditions				
Topic	**Method of proof**	**Condition**	**Integrity[3]**	**Proof[3]**
UAS operator and UAS operations	Declaration supported by data	4.1 The UAS operator should:		
		4.1.1 Develop an operation manual (OM);	*Provide a copy of the OM.*	'I declare compliance and the OM is submitted to the competent authority.'
		4.1.2 Develop procedures to ensure that the security requirements applicable to the area of operations are complied with during the intended operation;	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance and that supporting evidence is included in the OM.'
		4.1.3 Develop measures to protect the UAS against unlawful interference and unauthorized access;	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance and that supporting evidence is included in the OM.'
		4.1.4 Develop procedures to ensure that all operations comply with applicable regulation on the protection of natural persons with regard to the processing of personal data and on the free movement of such data; in particular, the UAS operator should carry out a data protection impact assessment, if applicable.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance and that supporting evidence is included in the OM.'
		4.1.5 Develop guidelines for its remote pilots to plan UAS operations in a manner that minimizes nuisance, including noise and other emissions-related nuisance, to people and animals.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance and that supporting evidence is included in the OM.'
		4.1.6 Develop an emergency response plan (ERP) in accordance with the conditions for 'medium' level of robustness.	*Please include a reference to the relevant chapter/section of the OM.*	*Please include a reference to the relevant chapter/section of the OM.*
		4.1.7 Validate the operational procedures in accordance with the conditions for 'medium' level of robustness.	*Please describe how this condition is met.*	'I declare compliance and that the description for meeting this condition is available to the competent authority for review.'
		4.1.8 Ensure the adequacy of the contingency and emergency procedures and prove them through any of the following: (a) dedicated flight tests; or	*Please describe how this condition is met.*	'I declare compliance and that the description for meeting this condition is available to the competent authority for review.'

PDRA characterization and conditions				
Topic	**Method of proof**	**Condition**	**Integrity[3]**	**Proof[3]**
		(b) simulations, provided that the representativeness of the simulation means is proven for the intended purpose with positive results; or (c) any other means acceptable to the competent authority.		
		4.1.9 Have a policy that defines how the remote pilot and any other personnel in charge of duties essential to the UAS operation can declare themselves fit to operate before conducting any operation.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance and that supporting evidence is included in the OM.'
		4.1.10 If the operation takes place in a reserved or restricted airspace, as part of the procedures that are contained in the OM (point 4.1.1 above), include the description of the following: (a) The method and means of communication with the authority or entity responsible for the management of the airspace during the entire period of the reserved or restricted airspace being active, as mandated by the authorization. Note: The communication method should be published in the notice to airmen (NOTAM), which activates the reserved airspace to also allow coordination with manned aircraft. (b) The member(s) of personnel in charge of duties essential to the UAS operation, who are responsible for establishing that communication;	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance and that supporting evidence is included in the OM.'
		4.1.11 Designate for each flight a remote pilot with adequate competency and other personnel in charge of duties essential to the UAS operation if needed;	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance and that supporting evidence is included in the OM.'
		4.1.12 Ensure that all operations effectively use and support the efficient use	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance and that supporting evidence is included in the OM.'

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		of radio spectrum in order to avoid harmful interference.		
		4.1.13 Keep for a period defined by the Competent Authority and maintain up to date a record of the information on UAS operations, including any unusual technical or operational occurrences and other data as required by the declaration or by the operational authorization.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance and that record-keeping data is available to the competent authority.'
UAS maintenance	Self-declaration	4.2 In addition to the responsibilities that are defined in the conditions for UAS operator in previous points, the UAS operator should ensure that:		
		4.2.1 The UAS maintenance instructions that are defined by the UAS operator should be included in the OM and cover at least the UAS manufacturer's instructions and requirements when applicable.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		4.2.2 The maintenance staff should follow the UAS maintenance instructions when performing maintenance.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		4.2.3 Keep for a period defined by the Competent Authority and maintain up to date a record of the maintenance activities conducted on the UAS;	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		4.2.4 Establish and keep up to date a list of the maintenance staff employed by the operator to carry out maintenance activities;	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		4.2.5 If the UAS uses certified equipment follow the instructions referred to in the equipment certificate	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
External services	Self-declaration	4.3 The UAS operator should ensure that the level of performance for any externally provided service necessary for the safety of the flight is adequate for the intended	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'

PDRA characterization and conditions				
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		operation. The UAS operator should declare that this level of performance is adequately achieved.		
		4.4 The UAS operator should define and allocate the roles and responsibilities between the UAS operator and the external service provider(s), if applicable.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
5. C**onditions** for the personnel in charge of duties essential to the UAS operation				
General	Self-declaration	5.1 The UAS operator should ensure that all personnel in charge of duties essential to the UAS operation are provided with competency-based theoretical and practical training specific to their duties. In addition, the UAS operator should ensure the following. Observers should follow an adequate training to: - Trigger emergency procedures (including flight termination). - Be knowledgeable of the Emergency Response Plan. - Be aware of the just culture concept. - Be able to visualize the boundaries of the operational volume and detect any trespassing of these boundaries.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance. Evidence of training is available for inspection at the request of the competent authority or its authorised representative. The training programme is documented in the OM.'
		5.2 The UAS operator should keep and maintain up to date a record of all the relevant qualifications and training courses completed by the remote pilot and the other personnel in charge of duties essential to the UAS operation and by the maintenance staff for a period defined by the Competent Authority after those persons have ceased to be employed by the organisation or have changed position within the organisation.	*Please describe how this condition is met.*	'I declare compliance. Record-keeping data is available for inspection at the request of the competent authority.'

PDRA characterization and conditions				
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		5.3 The remote pilot and the safety crew should:	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.3.1 Not perform any duties under the influence of psychoactive substances or alcohol, or when they are unfit to perform their tasks due to injury, fatigue, medication, sickness or other causes;	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.3.2 Be familiar with the manufacturer's instructions provided by the manufacturer of the UAS;	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.3.3 Obtain updated information relevant to the intended operation about any restrictions imposed on the airspace; and	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.3.4 Ensure that the UAS is in a safe condition to complete the intended flight safely and, if applicable, check whether the direct remote identification is active and up to date.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
Remote pilot	Self-declaration	5.4 The remote pilot has the authority to cancel or delay any or all flight operations under the following conditions:	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.4.1 The safety of persons is threatened; or	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.4.2 Property on the ground is threatened: or	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.4.3 Other airspace users are in jeopardy: or	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.4.4 There is a violation of the terms of this authorization.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.5 The remote pilot should ensure that the UA remains clear of clouds, and that the ability of the remote pilot to perform unaided visual scanning of the airspace where the UAS is	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'

PDRA characterization and conditions				
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		operating for any potential collision hazard is not hampered by clouds.		
Safety Crew Members	Self-declaration	5.6 The UAS operator should ensure the correct placement and number of safety crew members. Prior to each flight, the UAS operator should verify that:	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.6.1 Visibility and the planned distance of the safety crew members are within acceptable limits that are defined in the operations manual (OM);	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.6.2 There are no potential terrain obstructions for each safety crew member;	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.6.3 That there are no gaps between the zones that are covered by each of the safety crew member.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.6.4 Communication of the remote pilot with each safety crew member is established and effective; and	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.6.5 The safety crew members should be able to determine the position of the UAS and should use visual cues if appropriate.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		Note 1: Instead of safety crew members, the remote pilot may perform the visual scan of the airspace and monitor the position of the UAS, provided that the workload allows the remote pilot to perform their duties and that the position of the remote enables a proper detection of incoming traffic and operations outside the operational volume. *Note 2: The swarm being operated in visual range, the OM must describe the operational procedures to check that the safety crew members are located in such places where they can indeed remain in visual range of the swarm.*		
Multi-crew cooperation (MCC)	Self-declaration	The UAS operator should:		
		5.7 Include procedures to ensure coordination between the remote crew members with robust and effective communication channels. Those procedures should cover as a minimum the:	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'

PDRA characterization and conditions				
Topic	**Method of proof**	**Condition**	**Integrity[3]**	**Proof[3]**
		5.7.1 Assignment of tasks to the remote crew members; and	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.7.2 Establishment of step-by-step communication; and	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.8 Ensure that the training of the remote crew covers MCC	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
Maintenance staff	Self-declaration	5.9 Any staff member authorised by the UAS operator to perform maintenance activities should have been duly trained regarding the documented maintenance procedures.	*Please describe how this condition is met.*	'I declare compliance. Evidence of training is available at the request of the competent authority or its authorised representative.'
Personnel in charge of duties essential to the UAS operation are fit to operate	Self-declaration	5.10 The UAS operator should have a policy defining how the personnel in charge of duties essential to the UAS operation can declare themselves unfit to operate before conducting any operation.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		5.11 The personnel in charge of duties essential to the UAS operation should declare that they are fit to operate before conducting any operation based on the policy defined by the UAS operator.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
6. Technical **conditions**				
General	Self-declaration	6.1 All UAs in the swarm and the control and command unit should be equipped with the means to monitor the critical parameters for a safe flight, in particular the:	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		6.1.1 UAS position, height or altitude, ground speed or airspeed, attitude, and trajectory;		
		6.1.2 UAS energy status (fuel, battery charge of every UAS, etc.); and the		
		6.1.3 Status of critical functions and systems; as a minimum, for services based on RF signals (e.g., C2 Link, GNSS, etc.), means		

PDRA characterization and conditions				
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		should be provided to monitor the adequate performance and trigger an alert if the performance level becomes too low.		
		6.2 The UAS should provide means to program the UAS flight path.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		6.3 The UAS should be protected against potential electromagnetic interferences from the infrastructure / facilities in the overflown area.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
Human-machine interface (HMI)	Self-declaration	6.4 The UAS information and control interfaces should be clearly and succinctly presented and should not confuse, cause unreasonable fatigue, or contribute to causing any disturbance to the personnel in charge of duties essential to the UAS operation such that this could adversely affect the safety of the operation.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		6.5 The UAS operator should conduct an evaluation of the UAS considering and addressing human factors to determine whether the HMI is appropriate for the mission.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
C2 links and communication	Self-declaration	6.6 The UAS should comply with the appropriate requirements for radio equipment and the use of the RF spectrum.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		6.7 Protection mechanisms against interference should be used, especially if unlicensed bands (e.g., ISM) are used for the C2 Link (mechanisms such as FHSS, DSSS or OFDM technologies, or frequency de-confliction by procedure)	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
		6.8 The UAS should be equipped with a C2 Link protected against unauthorized access to the command and control functions.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'

PDRA characterization and conditions				
Topic	**Method of proof**	**Condition**	**Integrity[3]**	**Proof[3]**
	Declaration supported by data	6.9 In case of a loss of C2 Link, the UAS should have a reliable and predictable method for the UA to recover the command and control link or terminate the flight in a way that reduces the effect on third parties in the air or on the ground;	*Please describe how this condition is met.*	'I declare compliance. A design and installation appraisal is available.'
	Self-declaration	6.10 In the event of an emergency, the remote pilot should have effective means to communicate with the relevant bodies.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
	Self-declaration	6.11 The communication protocol should be appropriate to the number of UAS to be controlled.	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
Tactical mitigation	Self-declaration	6.12 The UAS design must be adequate to ensure that the time required between a command given by the remote pilot and the UA executing it does not exceed 5 seconds	*Please include a reference to the relevant chapter/section of the OM.*	'I declare compliance.'
Containment	Declaration supported by data	6.13 To ensure a safe recovery from a technical issue that involves the UAS or an external system supporting the operation, the UAS operator should ensure that:		
		6.13.1 The probability of the UAS leaving the operational volume should be less than 10–4/FH; and	*Please describe how this condition is met.*	'I declare compliance. Analysis and/or test data with supporting evidence are/is available.'
		6.13.2 No single failure of the UAS or of any external system supporting the operation should lead to operation outside the ground risk buffer	*Please describe how this condition is met.*	
		Notes: *1.The term 'failure' needs to be understood as an occurrence, which affects the operation of a component, part, or element such that it can no longer function as intended. Errors may cause failures but are not considered to be failures. Some structural or mechanical failures may be excluded from the criterion if it can be shown that these mechanical parts were designed according to aviation industry best practices.*		

PDRA characterization and conditions				
Topic	**Method of proof**	**Condition**	**Integrity[3]**	**Proof[3]**
		2. This requirement may be achieved through the use of both automatic containment triggering and operational procedures involving observers who can trigger directly or indirectly a Flight Termination Function *3. Enhanced containment can be achieved through compliance with* Means of Compliance with Light-UAS.2511 MOC Light-UAS.2511-01 which requires a declarative process or similar based on applicable and available regulation.		
		6.14 SW and AEH whose development error(s) could directly lead to operations outside the ground risk buffer should be developed according to an industry standard or methodology that are recognized as adequate by the competent authority.	*Please describe how this condition is met.*	'I declare compliance. Analysis and/or test data with supporting evidence are/is available.'
		Note 1: The proposed additional safety conditions *cover both the integrity and assurance levels.* *Note 2: The proposed additional safety* conditions *do not imply a systematic need to develop the SW and AEH according to an industry standard or methodology recognized as adequate by the competent authority. For instance, if the UA design includes an independent engine shutdown function which systematically prevents the UA from exiting the ground risk buffer due to single failures or a SW/AEH error of the flight controls, the intent of* conditions *6.14 could be considered to be met.*		
		6.15 Compliance with conditions 6.13 and 6.14 above should be substantiated by analysis and/or test data with supporting evidence.	*Please describe how this condition is met.*	'I declare compliance. Analysis and/or test data with supporting evidence are/is available.'

Table JARUS PDRA-08 — Main limitations and provisions for JARUS PDRA-08

Appendix 1 THEORETICAL KNOWLEDGE SUBJECTS FOR THE TRAINING OF THE REMOTE PILOT AND ALL THE PERSONNEL IN CHARGE OF DUTIES ESSENTIAL TO THE UAS OPERATION

(a) The 'specific' category (category B) may cover a wide range of UAS operations with different levels of risk. The UAS operator is therefore required to identify the competency required for the remote pilot according to the outcome of the risk assessment. This appendix 1 to PDRA 8 covers the theoretical knowledge subjects while appendix 2 to PDRA 8 covers the practical knowledge subjects applicable to all operations in the 'specific' category (category B).

(b) The UAS operator should propose to the competent authority, as part of the application, a theoretical knowledge training course for the remote pilot based on the elements defined for operations in the 'open' category (category A), complemented by the following elements. The UAS operator may use the same list of topics to propose also for the other personnel in charge of duties essential to the UAS operation, a theoretical knowledge training course with competency-based theoretical training specific to their duties.

(1) Air safety:

(i) remote pilot records;

(ii) logbooks and associated documentation;

(iii) good airmanship principles;

(iv) aeronautical decision-making;

(v) aviation safety;

(vi) air proximity reporting; and

(vii) advanced airmanship:

(A) manoeuvres and emergency procedures; and

(B) general information on unusual conditions (e.g. stalls, spins, vertical lift limitations, autorotation, vortex ring states);

(2) aviation regulations:

(i) introduction to the UAS regulation with focus on the 'specific' category (category B);

(ii) risk assessment, introduction to SORA; and

(iii) overview of PDRA;

(3) navigation:

(i) navigational aids and their limitations (e.g. GNSS)

(ii) reading maps and aeronautical charts (e.g. 1:500 000 and 1:250 000, interpretation, specialised charts, helicopter routes, U-space service areas, and understanding of basic terms); and

(iii) vertical navigation (e.g. reference altitudes and heights, altimetry);

(4) human performance limitations:

(i) perception (situational awareness in BVLOS operations); and

(ii) fatigue:

(A) flight durations within work hours;

(B) circadian rhythms;

(C) work stress; and

(D) commercial pressures;

(iii) attentiveness:

(A) eliminating distractions; and

(B) scan techniques;

(iv) medical fitness (health precautions, alcohol, drugs, medication etc.); and

(v) environmental factors such as vision changes from orientation to the sun;

(vi) just culture principles;

(5) operational procedures:

(i) airspace classifications and operating principles;

(ii) U-Space/UTM;

(iii) procedures for airspace reservation;

(iv) aeronautical information publications;

(v) NOTAMs; and

(vi) mission planning, airspace considerations and site risk-assessment:

(A) measures to comply with the limitations and conditions applicable to the operational volume and the ground risk buffer for the intended operation; and

(B) BVLOS operations. Use of UA VOs;

(6) UAS general knowledge:

(i) loss of signal and system failure protocols — understanding the condition and planning for programmed responses such as returning to home, loiter, landing immediately;

(ii) flight termination systems; and

(iii) flight control modes;

(7) meteorology:

(i) obtaining and interpreting advanced weather information:

(A) weather reporting resources;

(B) reports;

(C) forecasts and meteorological conventions appropriate for typical UAS flight operations;

(D) local weather assessments;

(E) low-level charts; and

(F) METAR, SPECI, TAF;

(ii) regional weather effects — standard weather patterns in coastal, mountain or desert terrains; and

(iii) weather effects on the UA (wind, storms, mist, variation of wind with altitude, wind shear etc.); and

(8) technical and operational mitigations for air risks.

(i) principles of EVLOS by using airspace observers (AO);

(ii) principles of DAA.

(c) The UAS operator should provide competency-based theoretical training covering the emergency response plan (ERP) that includes the related proficiency requirements and recurrent training.

(d) The UAS operator may define additional aspects from the subjects mentioned in point (b) based on the UAS operations intended to be conducted:

(1) operational procedures;

(i) mission planning, airspace considerations and site risk-assessment — operations over a controlled ground area;

(ii) multi crew cooperation (MCC):

(A) coordination between the remote pilot and other personnel in charge of duties essential to the UAS operation (i.e. AO);

(B) crew resource management (CRM):

(a) effective leadership; and

(b) working with others;

(2) UAS general knowledge — the means supporting BVLOS operations:

(i) the means to monitor the UA (its position, height, speed, C2 Link, systems status, etc.);

(ii) the means of communication with VOs; and

(iii) the means to support air traffic awareness.

(3) Managing data sources regarding:

(i) Where to find the data

(ii) Security of the data

(iii) Quantity of the needed data

(iv) Impact on the storage of data

(e) The training and assessment should be appropriate to the level of automation of the operation

Appendix 2 PRACTICAL SKILL TRAINING OF THE REMOTE PILOT AND ALL THE PERSONNEL IN CHARGE OF DUTIES ESSENTIAL TO THE UAS OPERATION

(a) With regard to the practical skill training and assessment for the remote pilot, the UAS operator should consider the competency defined for the 'open' category (category A) complemented by the following. The UAS operator should adapt the practical skill training based on the characteristics of the operation and the functions available on board of the UAS. The UAS operator may use the same list of topics to propose also for the personnel in charge of duties essential to the UAS operation, other than remote pilot, a practical training.

(1) Preparation of the UAS operation:

(i) implement the necessary measures to comply with the limitations and conditions applicable to the operational volume and ground risk buffer for the intended operation in accordance with the operations manual procedures;

(ii) implement the necessary procedures to operate in controlled airspace, including a protocol to communicate with ATC and obtain clearance and instructions, if necessary;

(iii) confirm that all the necessary documents for the intended operation are on site; and

(iv) brief all participants about the planned operation.

(v) performing airspace scanning;

(vi) adequate placement of AOs, and a deconfliction scheme that includes phraseology,

(2) Preparation for the flight:

(i) make sure that all the safety elements available on UAS, including the height and speed limitation systems, the flight termination system and its triggering system are operational;

(ii) Knowledge of the basic actions to be taken in the event of an emergency situation, including issues with the UAS, or if a mid-air collision hazard arises during the flight.

(3) Flight under abnormal conditions:

(i) manage a partial or complete power shortage of the unmanned aircraft propulsion system while ensuring the safety of third parties on the ground;

(ii) manage a situation of an incursion by a person not involved into the operational volume or the controlled ground area, and take appropriate measures to maintain safety;

(iii) react to, and take the appropriate corrective actions for a situation where the UA is likely to exceed the limit of the flight geography (contingency procedures) and from the operational volume (emergency procedures) as defined during the flight preparation;

(4) Emphasis should be placed on

(i) Normal, abnormal and emergency procedures;

(ii) Remote pilot incapacitation;

(iii) Skill test combined with periodic proficiency check;

(iv) Operating experience (with on the job training counting towards proficiency);

(v) Pre-flight, post-flight and documentation;

(vi) Recurrent training (UAS/FTD).

(b) The practical skill training may be conducted on the actual UAS or a flight training device (FTD). Emphasis should be placed on scenario based training (SBT) using highly structured scripts of real-world experiences for the specific operation to fortify learning in an operational environment and improving situation awareness. SBT should include realistic normal and emergencies scenarios that are written with specific learning objectives in mind.

(c) Practical skill training is checked during the assessment and can be done using the actual UAS or on a flight training device appropriate to the specific operation.

(d) Initial and recurring training:

(1) The UAS operator should ensure that specified minimum requirements with respect to time (e.g. programmed flying hours) for initial and recurrent training (e.g. duration and flying hours) are prescribed and provided in a manner that is acceptable and approved by the competent authority.

(2) Depending on the training course, each of the topics shown in Table 1 below may require an overview or in-depth training. In-depth training should be interactive and include discussions, case study reviews and role-plays, as deemed necessary to enhance learning.

<table>
<tr><th>Topic</th><th>Initial</th><th>Change of UAS</th><th>Change of remote pilot/crew</th><th>Recurrent Training</th></tr>
<tr><td>Situational awareness and error management</td><td rowspan="3">In Depth</td><td>In-depth</td><td>Overview</td><td rowspan="3">Overview</td></tr>
<tr><td>Company safety culture, operational procedures, organisation</td><td rowspan="2">Not Required</td><td rowspan="2">In Depth</td></tr>
<tr><td>Stress management, fatigue and vigilance</td><td></td></tr>
</table>

Decision making		Overview	Not Required	
Automation, philosophy of the use of automation	As Required	In-depth	In Depth	As Required
Specific UAS type-related differences			Not Required (same UAS type)	
Case based studies	In Depth		In Depth	As Required

Table 1 — Level of practical skill training in several topics depending on initial training, recurring training or change of UAS / UAS operator

Risk assessment for PDRA-08

The following risk assessment has been conducted by applying SORA to the PDRA-08.

1.1. Step #1 – CONOPS description

This PDRA is dedicated to operators applying for an operational authorization to conduct drone shows at night. Applicants should elaborate a concept of operations (ConOps) and describe it in the Operations Manual (OM). The OM should address and comply with every condition described in the characterization table above.
As part of the OM, applicants should define the methods used to calculate the size of the contingency volume and buffer area.

1.2. Step #2 — determination of the intrinsic UAS ground risk class

The initial ground risk determination is typically a step which is not straight forward when it comes to operating a large number of UAs at the same time. The swarm cannot be assimilated to a single 'large' UA, nor can it be reduced to a single UA of the swarm because multiple failures could occur, or the entire swarm may be terminated in flight. To get around this obstacle, it is required that operations are conducted above a **controlled ground area,** so that the failure of the swarm remains consequence free for people on the ground.

Intrinsic UAS Ground Risk Class				
Max UAS characteristics dimension	1 m / approx. 3ft	3 m / approx. 10ft	8 m / approx. 25ft	>8 m / approx. 25ft
Typical kinetic energy expected	*< 700 J (approx. 529 Ft Lb)*	*< 34 KJ (approx. 25000 Ft Lb)*	*< 1084 KJ (approx. 800000 Ft Lb)*	*> 1084 KJ (approx. 800000 Ft Lb)*
Operational scenarios				
VLOS/BVLOS over controlled ground area	1	2	3	4
VLOS in sparsely populated environment	2	3	4	5
BVLOS in sparsely populated environment	3	4	5	6
VLOS in populated environment	4	5	6	8
BVLOS in populated environment	5	6	8	10
VLOS over gathering of people	7			
BVLOS over gathering of people	8			

Table A1 Determination of the intrinsic UAS Ground Risk Class (GRC)

The swarm being operated in visual range, the operator must describe the operational procedures to check that the safety crew members are located in such places where they can indeed remain in visual range of the swarm, as required by §1.14 to §1.17 of Section 2.

The limitation of the UA characteristics dimension and the required controlled ground area result in:
iGRC = 1

1.3. Step #3 — final GRC determination

For this PDRA, the following mitigations are considered:

— M1 – Strategic mitigations for ground risk with a "Medium" level of robustness and, consequently:
—
— Due to the large number of UAs flying at the same time and considering speed/height of the UAs, the 1:1 rule may not be sufficient to guarantee that all the swarm will remain within the buffer.
—
— Integrity:
— Criterion #1 (definition of the ground risk buffer)

As per point 3.4.1 of the PDRA, the UAS operator should define a ground risk buffer calculated based on ballistic trajectories of the UAs in case of failure. The following simplified formulas can be used:

(1) $x(t) = v_0 t + \frac{1}{2} a t^2$

(2) $y(t) = \frac{1}{2} g t^2$

Where *t* is obtained from equation (2) where *y* is the maximum height of the flight geography. Other terms are given by the maximum acceleration of the UA and its maximum velocity.

Note: the operator must take into account latencies that may delay the triggering of the flight termination and conditions that may extend the ground buffer (tailwind e.g.). Typically, a reaction time of **3 seconds** must be accounted for in the ground buffer area.

— Criterion #2 (evaluation of people at risk)

Integrity:

— Because it is of foremost importance that no one penetrates the controlled ground area, the operator shall use means to physically protect the ground area. This may require fences, signs and people, including the assistance of law enforcement staff if need be (typically in urban areas). A 'naturally' deserted area like a public park at night or an open field should not be considered as controlled. These measures should be described in the documentation of the applicant.
— Assurance:
— As per point 3.6 of the PDRA, the UAS operator should evaluate the area of operations typically by means of an on-site inspection or appraisal and should be able to demonstrate how the ground area remains controlled at all times.
— The UAS operator should include data to support the claimed level of integrity. Supporting evidence should be available.
—
— M2 – no credit is taken from M2 mitigation

— M3 – the UAS operator should develop en ERP in accordance with the conditions for 'medium' level of robustness,as per point 4.1.6 of the PDRA.

—

		Robustness			Correction
Mitigation Sequence	**Mitigations for ground risk**	**Low / None**	**Medium**	**High**	
1	M1 - Strategic mitigations for ground risk[6]	**0: None -1: Low**	**-2**	**-4**	**0**
2	M2 - Effects of ground impact are reduced[7]	**0**	**-1**	**-2**	**0**
3	M3 - An Emergency Response Plan (ERP) is in place, operator validated and effective	**1**	**0**	**-1**	**0**
Total correction					**0**

Table A2 Mitigations for Final GRC determination (GRC)

—

1.4. Step #4 — Initial air risk assessment

As per point 3.7 of the PDRA, the operational volume should be in uncontrolled airspace below 150 m with a low risk of encounter with manned aircraft (air risk class not higher than ARC-b). Navigation charts should be provided by the applicant to support the claim for the level of ARC assessed.

The operator should check the existence of manned aviation activities in the vicinity of the area of operations.

In case the initial air risk assessment is higher than ARC-b, step #5 is mandatory.

1.5. Step #5 — Application of Strategic Mitigations

If the initial ARC is higher than ARC-b, the operator may use strategic mitigations.

In controlled airspaces, operations must be coordinated with airspace managers and/or airport operators. A protocol may be requested by competent authorities, as per point 3.8.2.

When manned aviation activities can be found in the vicinity of the UAS operation, protocols and agreements with those parties should be obtained before starting operations.

Flying at night or having protocols with interested parties may be accounted for strategic mitigation.

If operations are conducted in a reserved airspace, ARC-a may be claimed with supporting evidence.

1.6. Step #6 — Tactical Mitigation Performance Requirement and Robustness Levels

Operations conducted within visual range are considered as an acceptable tactical mitigation for collision risk, as mentioned in point 3.11 et 3.12 of the PDRA.

[6] This mitigation is meant as a means to reduce the number of people at risk.
[7] This mitigation is meant as a means to reduce the energy absorbed by the people of the ground upon impact.

In addition, as required by point 1.3 of the PDRA, the remote pilot and the safety crew members should always be able to terminate the flight. Flight termination is considered also a tactical mitigation that can be used.

1.7. Step #7 — SAIL determination

SAIL Determination				
	Final ARC			
Final GRC	a	b	c	d
1	**I**	**II**	**IV**	**VI**
2	**I**	**II**	**IV**	**VI**
3	**II**	**II**	**IV**	**VI**
4	**III**	**III**	**IV**	**VI**
5	**IV**	**IV**	**IV**	**VI**
6	**V**	**V**	**V**	**VI**
7	**VI**	**VI**	**VI**	**VI**

Table A3 SAIL determination

Swarm operations are categorized as SAIL I or II, depending on the final ARC (ARC-a in reserved airspace, ARC-b otherwise).

1.8. Step #8 — identification of Operational Safety Objectives (OSOs)

OSO Number (in line with SORA Annex E)		SAIL					
		I	**II**	**III**	**IV**	**V**	**VI**
	Technical issue with the UAS						
OSO#01	Ensure the operator is competent and/or proven	O	L	M	H	H	H
OSO#02	UAS manufactured by competent and/or proven entity	O	O	L	M	H	H
OSO#03	UAS maintained by competent and/or proven entity	L	L	M	M	H	H
OSO#04	UAS developed to authority recognized design standards[8]	O	O	O	L	M	H
OSO#05	UAS is designed considering system safety and reliability	O	O	L	M	H	H
OSO#06	C3 link performance is appropriate for the operation	O	L	L	M	H	H
OSO#07	Inspection of the UAS (product inspection) to ensure consistency to the ConOps	L	L	M	M	H	H

[8] The robustness level does not apply to mitigations for which credit has been taken to derive the risk classes. This is further detailed in para. 3.2.11(a).

OSO Number (in line with SORA Annex E)		SAIL					
		I	II	III	IV	V	VI
OSO#08	Operational procedures are defined, validated and adhered to	L	M	H	H	H	H
OSO#09	Remote crew trained and current and able to control the abnormal situation	L	L	M	M	H	H
OSO#10	Safe recovery from technical issue	L	L	M	M	H	H
	Deterioration of external systems supporting UAS operation						
OSO#11	Procedures are in-place to handle the deterioration of external systems supporting UAS operation	L	M	H	H	H	H
OSO#12	The UAS is designed to manage the deterioration of external systems supporting UAS operation	L	L	M	M	H	H
OSO#13	External services supporting UAS operations are adequate to the operation	L	L	M	H	H	H
	Human Error						
OSO#14	Operational procedures are defined, validated and adhered to	L	M	H	H	H	H
OSO#15	Remote crew trained and current and able to control the abnormal situation	L	L	M	M	H	H
OSO#16	Multi crew coordination	L	L	M	M	H	H
OSO#17	Remote crew is fit to operate	L	L	M	M	H	H
OSO#18	Automatic protection of the flight envelope from Human Error	O	O	L	M	H	H
OSO#19	Safe recovery from Human Error	O	O	L	M	M	H
OSO#20	A Human Factors evaluation has been performed and the HMI found appropriate for the mission	O	L	L	M	M	H
	Adverse operating conditions						
OSO#21	Operational procedures are defined, validated and adhered to	L	M	H	H	H	H
OSO#22	The remote crew is trained to identify critical environmental conditions and to avoid them	L	L	M	M	M	H
OSO#23	Environmental conditions for safe operations defined, measurable and adhered to	L	L	M	M	H	H
OSO#24	UAS designed and qualified for adverse environmental conditions	O	O	M	H	H	H

361 **Table A4 Recommended operational safety objectives (OSOs)**

1.9. Step #9 — adjacent area/airspace considerations

The SORA is not adapted to several drones flying at the same time. Therefore, the ground risk and the air risk in adjacent areas must be addressed through enhanced containment, with or without assemblies of people in the adjacent area.

It is also possible that adjacent airspaces may include controlled airspace, as per point 6.13 of the PDRA.

Competent authorities should define how to meet the enhanced containment requirements.

1.10. Step #10 — comprehensive safety portfolio

This step addresses the satisfactory substantiation of mitigations and objectives required by the SORA process, ensuring also that any additional requirements to those identified by the SORA process (e.g. security, environmental protection, etc.) as well as the relative stakeholders (e.g. environmental protection agencies, national security bodies, etc.) are adequately addressed.

For the purpose of the assessment of this PDRA, under this step the compliance of proposed provisions for the PDRA against SORA criteria is performed as shown in:

For mitigations used to modify the intrinsic GRC: Table A5 in point 3.9 of this Annex.

For strategic mitigations for the initial ARC: Not applicable.

For tactical mitigations for the final ARC: Not applicable.

For operational safety objectives: see Table A6 in point 3.10 of this Annex.

For adjacent area/airspace consideration: see Table A7 in point 3.11 of this Annex.

384 **3.1 Evaluation of mitigations means**

385

Mitigations for the intrinsic GRC		Level of robustness	Criteria in SORA	Provisions for the PDRA
M3 - An Emergency Response Plan (ERP) is in place, operator validated and effective	LEVEL of INTEGRITY	Medium	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 could result in an unrecoverable state and in which: (a) the outcome of the situation highly relies on providence; or (b) could not be handled by a contingency procedure; or (c) 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) a plan to limit the escalating effect of an eminent crash (e.g. notify first responders), and (b) the conditions to alert ATM — 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 Remote Crew member(s) duties.	An ERP with medium levels of robustness is required as per point 4.1.6 of the PDRA.
	LEVEL of ASSURANCE		Criterion #1 (Procedures) (a) The ERP is developed to standards considered adequate by the competent authority and/or	An ERP with medium levels of robustness is required as per point 4.1.6 of the PDRA.

			in accordance with means of compliance acceptable to that authority. (b) The ERP is validated through a representative tabletop exercise consistent with the ERP training syllabus.	
			Criterion #2 (Training) (a) Training syllabus is available (b) Competency-based theoretical and practical training is organised by the operator	An ERP with medium levels of robustness is required as per point 4.1.6 of the PDRA.

386 **Table A5 Compliance check of PDRA provisions against SORA criteria for mitigations used to modify the intrinsic GRC**
387

388 **3.2 Operational Safety Objectives (OSOs)**

389 Please note that OSOs that are considered as 'optional' for SAIL II have not been addressed in Table A6 below.

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
OSO #01 – Ensure the operator is competent and/or proven	LEVEL of INTEGRITY	Low	The applicant is knowledgeable of the UAS being used and as a minimum has the following relevant operational procedures: checklists, maintenance, training, responsibilities, and associated duties.	The UAS operator should establish procedures and limitations adapted to the type of the intended operation and the risk involved', which implies knowledge on the UAS intended to be used and relevant operational procedures. Furthermore, point 4.1.1 indicates that the UAS operator should develop an Operations Manual (OM).
	LEVEL of ASSURANCE		The elements requested for the level of integrity are addressed in the OPERATIONS MANUAL.	Point 4.1.1 of the PDRA indicates that the UAS operator should develop an Operations Manual (OM).

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
OSO #03 – UAS maintained by competent and/or proven entity (e.g. industry standards)	LEVEL of INTEGRITY	Low	— The UAS maintenance instructions are defined and when applicable cover the UAS designer instructions and requirements. when applicable. — The maintenance staff is competent and has received an authorisation to carry out UAS maintenance. — The maintenance staff use the UAS maintenance instructions while performing maintenance.	— The UAS operator should maintain the UAS in a suitable condition for safe operation by, as a minimum, defining maintenance instructions and employing an adequately trained and qualified maintenance staff. — Besides, point 4.2 of the PDRA indicates that UAS maintenance instructions defined by the UAS operator should cover at least the UAS manufacturer's instructions and requirements when applicable. — Point 4.2 of the PDRA indicates that the maintenance staff should use the UAS maintenance instructions while performing maintenance.

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
	LEVEL of ASSURANCE		— Criterion #1 (Procedure): — The maintenance instructions are documented. — The maintenance conducted on the UAS is recorded in a maintenance log system[1/2]. — A list of maintenance staff authorised to carry out maintenance is established and kept up to date. [1] Objective is to record all the maintenance performed on the aircraft, and why it is performed (defects or malfunctions rectification, modification, scheduled maintenance etc.) [2] The maintenance log may be requested for inspection/audit by the approving authority or an authorised representative. — Criterion #2 (Training): — A record of all relevant qualifications, experience and/or trainings completed by the maintenance staff is established and kept up to date.	— Criterion#1: — Point 4.2 of the PDRA indicates that UAS maintenance instructions defined by the UAS operator should be included in the OM together with the maintenance instructions required to keep the UAS in safe condition. — the UAS operator should keep an up-to-date record of the maintenance activities conducted on the UAS for a minimum of 3 years. — the UAS operator should establish and keep an up-to-date list of the maintenance staff employed by the operator to carry out maintenance activities. — Criterion #2: — The UAS operator should keep and maintain an up-to-date record of all the relevant qualifications training courses completed by the maintenance staff, for at least 3 years after those persons have ceased employment with the organisation or have changed their position in the organisation.

OSO #06 – C3 link performance is appropriate for the operation	LEVEL of INTEGRITY	Low	— The applicant determines that performance, RF spectrum usage[1] and environmental conditions for C3 links are adequate to safely conduct the intended operation. — The UAS remote pilot has the means to continuously monitor the C3 performance and ensure the performance continues to meet the operational requirements[2]. *[1] For a low level of integrity, unlicensed frequency bands might be acceptable under certain conditions, e.g.:* — the applicant demonstrates compliance with other RF spectrum usage requirements (e.g. for EU: Directive 2014/53/EU, for US: CFR Title 47 Part 15 Federal Communication Commission (FCC) rules), by showing the UAS equipment is compliant with these requirements (e.g. FCC marking), and — the use of mechanisms to protect against interference (e.g. FHSS, frequency deconfliction by procedure). *[2] The remote pilot has continual and timely access to the relevant C3 information that could effect the safety of flight. For operations with a low level of integrity for this OSO, this could be achieved by monitoring the C2 link signal strength and receiving an alert from the UAS HMI if the signal becomes too low.*	— The UAS operator should ensure that all operations effectively use and support the efficient use of radio spectrum in order to avoid harmful interference. Besides: — the remote pilot should 'ensure that the operating environment is compatible with the authorised or declared limitations and conditions' — Point 6.6 of the PDRA indicates that the UAS should comply with the appropriate requirements for radio equipment and the use of the RF spectrum. — Point 6.7 of the PDRA indicates that protection mechanisms against interference should be used, especially if unlicensed bands (e.g. ISM) are used for the C2 Link (mechanisms such as such as FHSS, DSSS or OFDM technologies, or frequency de-confliction by procedure) — Point 6.1 of the PDRA indicates that means to monitor critical parameters for a safe flight should be available, and point 6.1.3 includes status of critical functions and systems; as a minimum, for services based on RF signals (e.g. C2 Link, GNSS, etc.) — Point 6.9 of the PDRA indicates that in case of a loss of C2 Link, the UAS should have a reliable and predictable method for the UA to recover the command and control link or terminate the flight in a way that reduces the effect on third parties in the air or on the ground. — Point 6.10 of the PDRA indicates that in the event of an emergency, the remote pilot should have

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
				effective means to communicate with the relevant bodies.
	LEVEL of ASSURANCE		The applicant declares that the required level of integrity has been achieved [(1)] [(1)]*Supporting evidences may or may not be available*	This information should be included in the Operations Manual.
OSO #07 Inspection of the UAS (product inspection) to ensure consistency to the ConOps	LEVEL of INTEGRITY	Low	The remote crew ensures that the UAS is in a condition for safe operation and conforms to the approved Operations Manual.	— The remote pilot should 'ensure that the UAS is in a safe condition to complete the intended flight safely' as per point 5.3.4 of the PDRA. — Pre-flight inspection is included in the Operations Manual.
	LEVEL of ASSURANCE		— Criterion #1 (Procedure): — Product inspection is documented and accounts for the manufacturer's recommendations if available. — Criterion #2 (Training): — The remote crew is trained to perform the product inspection, and that training is self-declared (with evidence available).	— Criterion #1: — The verification that the UAS is in safe condition for the intended operation is included as one of the aspects to be documented in the OM. — Criterion #2: — The training syllabus is prescribed in the PDRA and the training should be self-declared.

Operational procedures (OSO #08, OSO #11, OSO #14 and OSO #21)	LEVEL of INTEGRITY	Medium	— Criterion #1 (Procedure definition): — Operational procedures[1] appropriate for the proposed operation are defined and as a minimum cover the following elements: — Flight planning, — Pre and post-flight inspections, — Normal procedures, — Procedures to evaluate environmental conditions before and during the mission (i.e. real-time evaluation), — Procedures to cope with unintended adverse operating conditions (e.g. when ice is encountered during an operation not approved for icing conditions) — Contingency procedures (to cope with abnormal situations), — Emergency procedures (to cope with emergency situations), and — Occurrence reporting procedures. — Normal, Abnormal, and Emergency procedures are compiled in an Operation Manual. — The limitations of the external systems used to support UAS safe operations are defined in an Operation Manual. — Criterion #2 (Procedure complexity which could jeopardize adherence to): — Operational procedures involve the remote pilot to take manual control when the UAS is usually automatically controlled.	— Criterion #1: – The UAS operator should establish procedures and limitations adapted to the type of the intended operation and the risk involved, including operational procedures to ensure the safety of the operations as per Section 4 of the PDRA. – Point 4.1.1 of the PDRA indicates that the UAS operator should develop an Operations Manual (OM) which should include all the elements indicated in SORA criterion #1. — Criterion #2: — Operational procedures include procedure to terminate to flight but does not allow manual control of the swarm, as per point 1.3 of the PDRA. — Criterion #3: — Operational procedures should be developed to minimise human errors. To that aim it is important that: – each of the tasks and the complete sequence of tasks of a procedure are clearly defined, designing them to be intuitive and unambiguous; – tasks are clearly distributed and assigned to the relevant roles and persons, ensuring a balanced workload; – procedures address adequately fatigue and stress, considering among other aspects: duty times, regular breaks, rest periods, the applicable health and safety requirements on the operational environment,

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
			— Criterion #3 (Consideration of Potential Human Error): — Operational procedures take considerations of human errors. At a minimum, Operational procedures provide: — a clear distribution and assignment of tasks — an internal checklist to ensure staff are performing their assigned tasks.	handover/takeover procedures, responsibilities and workload.
	LEVEL of ASSURANCE		— Operational procedures are validated against recognized standards. — The adequacy of the Contingency and Emergency procedures are proved through: — Dedicated flight tests, or — Simulation provided the simulation is proven valid for the intended purpose with positive results.	— Point 4.1.7 of the PDRA indicates that the UAS operator should validate the operational procedures in accordance with the provisions for 'medium' level of robustness. — Point 4.1.8 of the PDRA indicates that the UAS operator should ensure the adequacy of the contingency and emergency procedures and prove it through any of the following: (a) dedicated flight tests; or (b) simulations, provided that the representativeness of the simulation means is proven for the intended purpose with positive results; or (c) any other means acceptable to the competent authority.

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
Remote crew training (OSO #09, OSO #15 and OSO #22)	LEVEL of INTEGRITY	Low	The competency-based theoretical and practical training ensures knowledge of: a) UAS regulation b) UAS airspace operating principles c) Airmanship and aviation safety d) Human performance limitations e) Meteorology f) Navigation/Charts g) UA knowledge h) Operating procedures and is adequate for the operation.	— Appendices 1 and 2 list the competencies required for remote crew operating UAS in the 'specific' category. — The UAS operator should ensure before conducting operations that the remote crew has the appropriate competencies. —
	LEVEL of ASSURANCE		Training is self-declared (with evidence available)	— The remote pilot should carry a proof of competency while operating the UAS. — The training programme should be documented (at least the training syllabus should be available); and evidence of training should be presented for inspection upon request from the competent authority or authorised representative.

Safe Design: OSO #10 Safe recovery from technical issue & OSO #12 The UAS is designed to manage the deterioration of external systems supporting UAS operation	LEVEL of INTEGRITY	Low	— The objective of these OSOs is to complement the technical containment safety requirements by addressing the risk of a fatality occurring while operating over populous areas or gatherings of people. — External systems supporting the operation are defined as systems not already part of the UAS but used to: — launch / take-off the UAS, — make pre-flight checks, — keep the UA within its operational volume (e.g. GNSS, Satellite Systems, Air Traffic Management, UTM). External systems activated/used after the loss of control of the operation are excluded from this definition. It is expected when operating over populous areas or gatherings of people, a fatality will not occur from any probable[1] failure[2] of the UAS or any external system supporting the operation. [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] Some structural or mechanical failures may be excluded from the criterion if it can be shown that these mechanical parts were designed to aviation industry best practices.	N/A as operations are planned in controlled ground area
	LEVEL of ASSURANCE		A design and installation appraisal is available. In particular, this appraisal shows that:	N/A as operations are planned in controlled ground area

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
			— the design and installation features (independence, separation and redundancy) satisfy the low integrity criterion; — particular risks relevant to the Operations Manual (e.g. hail, ice, snow, electro-magnetic interference…) do not violate the independence claims, if any.	
OSO #13 External services supporting UAS operations are adequate to the operation	LEVEL of INTEGRITY	Low	The applicant ensures that the level of performance for any externally provided service necessary for the safety of the flight is adequate for the intended operation. Roles and responsibilities between the applicant and the external service provider are defined.	Point 4.3 of the PDRA indicates that the UAS operator should ensure that the level of performance for any externally provided service necessary for the safety of the flight is adequate for the intended operation. The UAS operator should declare that this adequate level of performance is achieved. Point 4.4 of the PDRA indicates that the UAS operator should define the allocation of the roles and responsibilities between the operator and the external service provider(s), if applicable.
	LEVEL of ASSURANCE		The applicant declares that the requested level of performance for any externally provided service necessary for the safety of the flight is achieved (without evidence being necessarily available)	This information should be included in the Operations Manual.

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
OSO #16 Multi crew coordination	LEVEL of INTEGRITY	Low	— Criterion #1 (Procedures): — Procedure(s) to ensure coordination between the crew members and that robust and effective communication channels is (are) available and at a minimum cover: — assignment of tasks to the crew, — establishment of step-by-step communications. — Criterion #2 (Training): — Remote Crew training covers multi crew coordination.	— Criterion #1: — The UAS operator should include procedures to ensure coordination between the remote crew members with robust and effective communication channels as per point 5.7 of the PDRA. — Criterion #2: — According to point 5.8 of the PDRA, the UAS operator should ensure that the training of the remote crew covers MCC.
	LEVEL of ASSURANCE		— Criterion #1 (Procedures): — Procedures are not required to be validated against a recognized standard. — The adequacy of the procedures and checklists is declarative. — Criterion #2 (Training): — Training is self-declared (with evidence available)	— Criterion #1 (Procedures): — See the "level of assurance" for Operational procedures (OSO #08, OSO #11, OSO #14 and OSO #21) — Criterion #2 (Training): — See the "level of assurance" for Remote crew training (OSO #09, OSO #15 and OSO #22)
OSO #17 Remote crew is fit to operate	LEVEL of INTEGRITY	Low	The applicant has a policy defining how the remote crew can declare themselves fit to operate before conducting any operation.	Point 4.1.9 of the PDRA indicates that the UAS operator should have a policy that defines how the remote pilot and any other personnel in charge of duties essential to the UAS operation can declare themselves fit to operate before conducting any operation.
	LEVEL of ASSURANCE		The remote crew declare they are fit to operate before conducting any operation based on the policy defined by the applicant.	The remote crew shall declare that they are fit to operate before conducting any operation based on the policy defined by the UAS operator.

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
OSO #20 **A Human Factors evaluation has been performed and the HMI found appropriate for the mission**	LEVEL of INTEGRITY	Low	The UAS information and control interfaces are clearly and succinctly presented and do not confuse, cause unreasonable fatigue, or contribute to remote crew error that could adversely affect the safety of the operation.	Point 6.4 of the PDRA indicates that the UAS information and control interfaces should be clearly and succinctly presented and should not confuse, cause unreasonable fatigue, or contribute to causing any disturbance to the personnel in charge of duties essential to the UAS operation such that this could adversely affect the safety of the operation.
	LEVEL of ASSURANCE		The applicant conducts an evaluation of the UAS considering and addressing human factors to determine the HMI is appropriate for the mission. The Human-Machine Interface evaluation is based on Engineering Evaluations or Analyses.	Point 6.5 of the PDRA indicates that the UAS operator should conduct an evaluation of the UAS considering and addressing human factors to determine whether the HMI is appropriate for the mission.

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
OSO #23 Environmental conditions for safe operations defined, measurable and adhered to	LEVEL of INTEGRITY	Low	— Criterion #1 (Definition) Environmental conditions for safe operations are defined and reflected in the flight manual or equivalent document. — Criterion #2 (Procedures) Procedures to evaluate environmental conditions before and during the mission (i.e. real-time evaluation) are available and include assessment of meteorological conditions (METAR, TAFOR, etc.) with a simple record system. — Criterion #3 (Training): Training covers assessment of meteorological conditions.	— Criterion #1: — The OM should include a paragraph on the operational environment and geographical area for the intended operations (in general terms, describe the characteristics of the area to be overflown, its topography, obstacles etc., and the characteristics of the airspace to be used, and the environmental conditions (i.e. the weather and electromagnetic environment); the definition of the required operation volume and risk buffers to address the ground and air risks). — Criterion #2: — The OM should contain a point on environmental and weather conditions, including: – environmental and weather conditions adequate to conduct the UAS operation; and – methods of obtaining weather forecasts — Criterion #3: — According to Appendix 1 to this PDRA 'meteorology' as one of the basic competencies from the competency framework that are necessary.

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
	LEVEL of ASSURANCE		• Criterion #1 (Definition): The applicant declares that the required level of integrity has been achieved[(1)]. [(1)] *Supporting evidences may or may not be available* • Criterion #2 (Procedures): See "level of assurance" for Operational procedures (OSO #08, OSO #11, OSO #14 and OSO #21)" • Criterion #3 (Training): see the "level of assurance" for Remote crew training (OSO #09, OSO #15 and OSO #22)"	— Criterion #1 (Definition): — This information should be included in the Operations Manual. — Criterion #2 (Procedures): — See the "level of assurance" for Operational procedures (OSO #08, OSO #11, OSO #14 and OSO #21)" — Criterion #3 (Training): — See the "level of assurance" for Remote crew training (OSO #09, OSO #15 and OSO #22)"

Table A6 Compliance check of PDRA provisions against SORA criteria for Operational Safety Objectives (OSOs)

3.3 Adjacent area/airspace consideration

Mitigations used for containment		Level of robustness	Criteria in SORA	Provisions for the PDRA
	LEVEL of INTEGRITY		— Following requirements shall apply due to the proximity of assembly of people in this PDRA. – The probability of leaving the operational volume shall be less than 10-04/FH. – No single failure of the UAS or any external system supporting the operation shall lead to operation outside of the ground risk buffer.	Point 6.13 of the PDRA indicates that the following additional provisions should apply if the adjacent area includes an assembly of people or if the adjacent airspace is classified as ARC-d (in accordance with SORA): – The probability of leaving the operational volume shall be less than 10^{-04}/FH. – No single failure of the UAS or any external system supporting the operation shall lead to operation outside of the ground risk buffer.

Mitigations used for containment		Level of robustness	Criteria in SORA	Provisions for the PDRA
	LEVEL of ASSURANCE		— Compliance with the requirements above should be substantiated by analysis and/or test data with supporting evidence.	Points 6.13.1 and 6.13.2 of the PDRA indicate that compliance with the provisions in point 6.13 (see above) should be substantiated by analysis and/or test data with supporting evidence.
	LEVEL of INTEGRITY		Software (SW) and airborne electronic hardware (AEH) whose development error(s) could directly[1] lead to operations outside the ground risk buffer should be developed to an industry standard or methodology that is recognised as being adequate by the competent authority. [2]*This does not imply a systematic need to develop the SW and AEH according to an industry standard or methodology recognised as adequate by the competent authority. The use of the term 'directly' means that a development error in a software or an airborne electronic hardware would lead the UA outside the ground risk buffer without the possibility for another system to prevent the UA from exiting the operational volume.*	Point 6.14 of the PDRA indicates that the SW and AEH whose development error(s) could directly lead to operations outside the ground risk buffer should be developed to an industry standard or methodology recognised as adequate by the competent authority (the same note in SORA for 'directly' is also included in this provision).
	LEVEL of ASSURANCE		[*Not explicitly indicated in SORA*] Evidence exists of compliance with an industry standard or methodology that is recognised as being adequate by the competent authority.	Evidence of compliance standard(s) or means of compliance considered adequate by the competent authority

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