Pre Defined Risk Assessment, PDRA-04 for Aerial Work operations:

- OVER SPARSELY POPULATED AREAS
- IN ATYPICAL AIRSPACE OR AIRSPACE RESERVED FOR THE OPERATION
- BVLOS
- USING UNMANNED AIRCRAFT UP TO 3M DIMENSION
- WITHIN THE RANGE OF THE DIRECT C2 LINK
- OPERATED FOR INSPECTIONS OF FACILITIES AND INFRASTRUCTURE

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1. Overview of the PDRA

The development of this PDRA was triggered by the request from some states to facilitate operational authorisations of UAS operations for routine and automated surveillance and inspections of facilities and infrastructures, with the UA flying very close to such facilities and infrastructures. The PDRA is based upon SORA version 2.0 and any future changes to this version of SORA may lead to changes of the provision in this PDRA.

Therefore, these types of UAS operations are characterised by the shielding provided by the artificial obstacles of facilities and infrastructures that qualifies the airspace where the UA flies as 'atypical', since no manned aircraft is expected to fly so close to those obstacles. The maximum distance from obstacles or facilities and infrastructures (or from natural obstacles in the area) is established to 30 m, following the criteria discussed within JARUS and already applied in some national standard scenarios[1].

In addition, this 'atypical' airspace is limited to areas within uncontrolled airspace or in controlled airspace which the competent authority defines meet atypical airspace requirements and with relevant coordination as defined by competent authority. Further description of what can be considered atypical airspace for this PDRA is provided in Table PDRA-04.1, section 3.9. Additionally, this PDRA may also be conducted in an 'atypical' airspace consisting in a reserved or segregated airspace.

A maximum height of 30 m above the overflown surface of the earth is considered for the flight geography under the provisions of Table-04-1 section 3.9 (see figure 1). Such a low height ensures that the probability of encounter with manned aircraft is minimal even if overflying an area with no close objects . Furthermore, considering a height of the contingency volume of 20m makes the height of the operational volume limited to 50 m, which is consistent with (and in some cases a bit more conservative) the maximum height in some states for BVLOS operations with UA with a MTOM above 2 kg[2]. In case of proximity (within 30 m distance) to a higher obstacle, the height limitation can be increased up to 15 m above that obstacle, see figure 2, (in line with the rationale given in the 'open' category (category A) and for the 'standard scenarios' (STS) in the 'specific' category (category B)). If the obstacle has a height up to 20m, the height limitation of the operation can be increased up to 30 m so it should never exceed 50m from ground. These restrictions on the airspace allows the operators to use an automated UAS, conducting the UAS operation according to a pre-programmed path uploaded on the flight control system of the UA. The intervention of the remote pilot may be reduced up to only start and interrupt the operation if needed. In this last case the UAS will automatically return to the home position pre-defined by the operator. This provides the ability to perform the BVLOS operation at very low level (below 30 m from ground) or very close to obstacles and in a very small operational volume. As an alternative to conducting the operation using pre-programmed paths defined before take-off, the operation may be performed using pre-planned flexible routes with a UA which through sensors and/or remote pilot intervention is capable during flight of avoiding obstacles while staying within the intended operational volume.

[1] STS-2A-CAA-NL-CONGESTED-CLOSEPROX-V1.4 – https://www.ilent.nl/documenten/publicaties/2019/2/7/standaard-scenarios-sts-2a-caa-nl-congested-closeprox-v1.4.

[2] e.g. French scenario S-2 limits the height to 50 m above the earth surface for operations with UA with MTOM above 2 kg, as there are low level flights of military aircraft across the French territory.

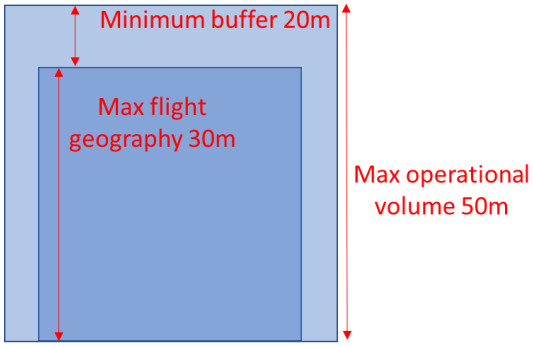

Fig 1 Operational volume and flight geography

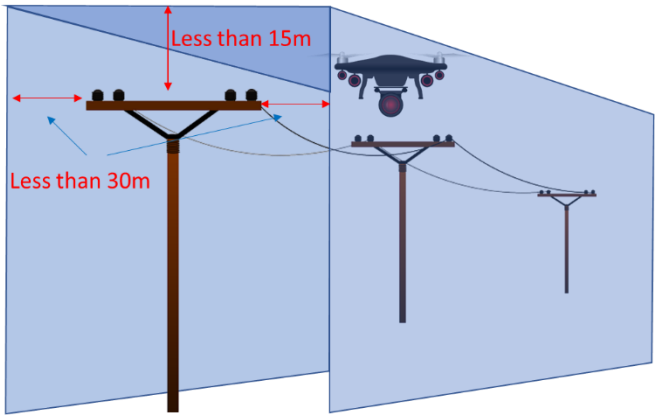

Fig 2 Flight geography in case of inspection of an obstacle higher than 30 m

Given the current lack of relevant experience in the use of communication services to extend the C2 Link coverage through communication networks (e.g. mobile networks) for the type of UAS operations addressed by this PDRA, the scope of the PDRA has been initially limited to the coverage of a direct C2 Link (direct link between the control station and the UA). Once more experience is gained with the use of those services, this PDRA might be revised to encompass their use with the introduction of the appropriate provisions.

Then, to ensure a low SAIL (up to SAIL II, as mentioned before), the ground risk needs also to be kept low by imposing rather restrictive limitations, which for this PDRA are similar to those defined for previous PDRAs for BVLOS operations:

(1) UA with maximum characteristic dimensions[3] up to 3 m and typical kinetic energy up to 34 kJ;

(2) UA operated over sparsely populated areas;

(3) UA operated at very low level;

[3] e.g. wingspan, rotor diameter/area or maximum distance between rotors in case of multirotor.

(4) BVLOS within the range of a direct C2 Link, which limits the area covered and also constitutes a conservative limitation considering the limited experience with communication networks (e.g. mobile networks);

(5) the operation should be limited to pre-programmed or pre-planned flexible routes, which decreases the risk of colliding with obstacles (given the short distance to those), allowing a better protection of third parties on the ground, also due to the knowledge a priori of the routes (thus, avoiding the overflight of people).

In addition to above limitations, the main provisions are:

UA range limit: as in previous PDRAs for BVLOS operations, the launch/recovery should be conducted in VLOS distance from the remote pilot if not operating from a safe prepared area[4]. As mentioned before, the range is limited in flight by the use of a direct C2 link, keeping operations within its coverage so that the safe conduct of the flight is ensured. Given the current lack of relevant experience in the use of communication services to extend the C2 Link coverage through communication networks (e.g. mobile networks) for the type of UAS operations addressed by this PDRA, the scope of the PDRA has been initially limited to the coverage of a direct C2 Link (direct link between the control station and the UA). Once more experience is gained with the use of those services, this PDRA might be revised to encompass their use with the introduction of the appropriate provisions

Ground risk: in addition to provisions included in previous PDRAs, the UAS operator should ensure that the person or entity responsible for the facility or infrastructure indicated has taken the necessary measures to protect the uninvolved persons present within the limits of the facility or infrastructure during the UAS operation.

Air risk: in addition to the limitations previously mentioned to ensure that the airspace can be considered 'atypical' based on the shielding by obstacles, other limitations are also considered to further reduce the likelihood of airspace users in the vicinity, including that UAS operations are away from known or potential areas for take-off & landing, transit or operational areas of other airspace users. Notification in advance of the intended UAS operations to the identified potential airspace users in the vicinity is also part of the proposed method to reinforce a low probability of encounters and to potentially increase the ratio of 'cooperative' aircraft. In case of operations in reserved or segregated airspace, the claim for ARC-a is met if that airspace is established and approved for the purpose of operation under this PDRA, with the operational volume entirely contained in that airspace. In addition, the UAS operator should establish an air risk buffer if there is an adjacent airspace classified as ARC-d (the likelihood of an encounter with another aircraft in that airspace is high) or if the competent authority or the entity responsible for the airspace management considers necessary establishing such buffer. Moreover in addition, prior to flight, the UAS operator should assess the proximity of the planned UAS operation to manned aircraft activity.

Technical provisions: in addition to the provisions in previous PDRAs, specific provisions are included considering that the UA flies close to obstacles: the UAS performance, in particular its position keeping capabilities, should allow flying safely close to those obstacles, and the UAS should be protected against potential electromagnetic interferences from the infrastructure / facilities in the overflown

[4] 'Safe prepared area' means a controlled ground area that is suitable for the safe conduct of the launch/recovery of the UA

area. Besides, provisions for containment related to the adjacent airspace (i.e. SORA step#9 point (c)) are also applied when such airspace can be classified as ARC-c (and not only ARC-d, as per SORA criteria), in order to ensure that the design of the UAS and of any external system supporting the operation can provide enough assurance of containment within the operational volume. Given that BVLOS operations under this PDRA are relying on being conducted in an 'atypical airspace' (based on the limitations indicated above) and, in line with SORA criteria, no tactical mitigations addressing the air risk are being required.

A risk assessment based on SORA is provided in Annex A: Risk assessment for PDRA-04.

2. PDRA characterisation and provisions

PDRA-04 is the result of applying the SORA to UAS operations performed in the 'specific' category:

(1) with UA with maximum characteristic dimensions (e.g. wingspan, rotor diameter/area or maximum distance between rotors in case of multirotor) up to 3 m and typical kinetic energies up to 34 kJ;

(2) BVLOS of the remote pilot;

(3) over sparsely populated areas;

(4) within the range of the direct C2 Link in an operational volume under 30 m above the overflown surface (or any other altitude reference defined by the state of operations);

(5) following pre-programmed or pre-planned flexible routes within the operational volume;

(6) in one of the following conditions:

- reserved or segregated airspace for UAS operations;
- operating at a maximum height not exceeding 30 m from ground;
- when operating at no more than 30 m horizontally from an obstacle, operating at a maximum height not exceeding 15 m from the obstacle;
  - if the height of the obstacle does not exceed 20 m, then hight of the operation may be up to 30 m from obstacle (meaning no more than a total of 50m from ground).

(7) operated routinely for regular inspections of facilities and infrastructure, e.g. industrial plants and similar, and operating in the atypical airspace within the shielding of such artificial obstacles as well as the natural obstacles, if any.

Note 1: This PDRA has been tailored for routine automated surveillance operation and inspection of facilities and infrastructures. It may be used as a basis for other purposes and, thus, may require an additional risk assessment.

Note 2: Many UAS operations under this PDRA may be conducted with a high level of automation, which should be considered by competent authorities in terms of the required level of practical skill training and assessment, as it should be proportionate to the lower level of intervention required by the remote pilot.

PDRA characterisation and provisions		
1. **Operational characterisation (scope and limitations)**		
Level of human intervention	1.1	No autonomous operations: the remote pilot should have the ability to maintain control of the UA, except in case of a loss command and control (C2) link.
	1.2	The remote pilot should always be able to terminate the flight.
	1.3	The flight path should be either pre-programmed or flexible routes pre-planned to ensure the UA avoids obstacles in the operational volume.
	1.4	The remote pilot should only operate one UA at a time.

	1.5 The remote pilot should not operate from a moving vehicle. 1.6 The remote pilot should not hand the control of the UA over to another command unit.
UA range limit	1.7 Launch/recovery: at VLOS distance from the remote pilot if not operating from a safe prepared area. *Note: a 'safe prepared area' means a controlled ground area that is suitable for the safe conduct of the launch/recovery of the UA*. 1.8 In flight: The range limit should be within the C2 link direct coverage which ensures the safe conduct of the flight
Overflown areas	1.9 UAS operations should be conducted: 1.9.1 over sparsely populated areas, and 1.9.2 over or up to 15 m horizontal distance from a facility or infrastructure at the request of the person or entity responsible for that facility or infrastructure.
UA limitations	1.10 Maximum characteristic dimension (e.g. wingspan, rotor diameter/area or maximum distance between rotors in the case of a multirotor): 3 m 1.11 Typical kinetic energy up to 34 kJ
Flight height limit	1.12 The maximum height of the operational volume should not be higher than 50 m above the overflown surface (or any other altitude reference defined by the state of operation). 1.13 The maximum height of the flight geography should not be higher than 30 m above the overflown surface (or any other altitude reference defined by the state of operation) 1.14 When flying at a horizontal distance no more than 30 m from an obstacles, the flight height may be increased up to 15 m above the highest closest obstacle and up to 30 m if that obstacle is lower than 20 m. *Note 1: see point 3.9.1 for maximum distance from obstacles.* *Note 2: see point 3.10 defining the air risk buffer.*
Airspace	1.15 The UA should be operated: 1.15.1 in an 'atypical airspace' that is included in uncontrolled airspace, or 1.15.2 In controlled airspace which the competent authority defines meet atypical airspace requirements and with relevant coordination as defined by competent authority, or 1.15.3. in an airspace reserved or segregated for UAS operations. *Note 1: Please refer to para. 3.9*
Visibility	1.16 If take-off and landing are conducted in VLOS of the remote pilot, visibility should be sufficient to ensure that no people are in danger during the take-off /landing phase. The remote pilot should abort the take-off or landing in case people on the ground are in danger.
Others	1.17 The UA should not be used to drop material or carry dangerous goods, except for dropping items in connection with agricultural, horticultural or forestry activities in which the carriage of the items does not contravene any other applicable regulations.

2. Operational risk classification (according to the classification defined in SORA)					
Final GRC	**3**	Final ARC	**ARC-a**	SAIL	**II**

3. Operational mitigations	
Operational volume (see Figure 2 of SORA)	3.1 To determine the operational volume, the UAS operator should consider the position-keeping capabilities of the UAS in 4D space (latitude, longitude, height and time). 3.2 In particular, the accuracy of the navigation solution, the flight technical error of the UAS and the path definition error (e.g. map error) and latencies should be considered and addressed when determining the operational volume. 3.3 The remote pilot should apply the emergency procedures as soon as there is an indication that the UA may exceed the limits of the operational volume.
Ground risk	3.4 The UAS operator should establish a ground risk buffer to protect third parties on the ground outside the operational volume. 3.4.1 The default criterion should be the use of the '1:1 rule' (e.g. if the UA is planned to operate at a height of 25 m, the ground risk buffer should at least be 25 m). 3.4.2 A smaller ground risk buffer value may be proven by the applicant for a rotary wing UA using a ballistic methodology approach acceptable to the competent authority. The 1 to 1 rule may in certain cases not be sufficient to meet the target level of safety. In such a case, the competent authority may ask a refinement of the definition of the ground risk buffer, based on criteria defined in SORA Step #9 depending on the adjacent air and ground risks. 3.4.3 The 1 to 1 rule may in certain cases not be sufficient to meet the target level of safety. In such a case, the competent authority may ask for a refinement of the definition of the ground risk buffer. 3.5 The operational volume and the ground risk buffer should be all contained in a sparsely populated area. 3.6 The UAS operator should evaluate the area of operations, typically by means of an on-site inspection or appraisal, and should be able to justify a significant lower density of people at risk than in sparsely populated areas within the entire operational volume including the ground risk buffer. 3.7 The UAS operator should ensure that the person or entity responsible for the facility or infrastructure has taken the necessary measures to protect the uninvolved persons present within the limits of the facility or infrastructure during UAS operation. 3.8 The UAS operator should include points 3.4 to 3.7 in the Operations Manual (see point 4.1.1) and declare the compliance with those provisions.

Air risk	3.9 The UAS operation should be conducted: 3.9.1 In an 'atypical airspace' which, for the purpose of this PDRA, is as defined by the competent authority or an airspace that is: 3.9.1.1 within the following distances of natural or artificial obstacles (e.g. trees, buildings, towers, cranes, fences, etc.): (i) 30 m horizontal distance; (ii) 15 m vertical distance from the top of the overflown obstacle (or 30 m if the overflown obstacle is less than 20m); and 3.9.2.2 away from all of the following: (i) any known permanent or temporary take-off and landings areas for all types of manned aircraft. This also includes parking lots, parks and other areas where helicopters occasionally operate from as well as sites where police and Helicopter Emergency Medical Services (HEMS), Search and Rescue (SAR) helicopters occasionally operate from in cases of accidents or other emergencies; (iii) known military low flying routes; (iv) any other known low level manned operations in the intended area of operation (e.g. balloon operations authorised en-route below 500 ft); (v) harbour/coastal areas where Search and Rescue (SAR) operations may transit or operate; (vi) any known areas where other unmanned aircraft operate (including areas under model aircraft clubs or association) or 3.9.2. In a reserved or segregated airspace. The claim for ARC-a is met if a reserved or segregated airspace is established and approved for the purpose of operation under this PDRA, with the operational volume should be entirely contained in that reserved or segregated airspace. 3.10 The UAS operator should establish an air risk buffer to protect third parties in the air, outside the operational volume if: 3.10.1 the operational volume has an adjacent airspace classified as ARC-d; or 3.10.2 the competent authority or the entity responsible for the airspace management considers necessary requiring it to ensure the protection of third parties in the air. 3.11 The air risk buffer as per point 3.10 should be contained where the probability of encounter with manned aircraft and other airspace users is low as defined by the competent authority. 3.12 Prior to flight, the UAS operator should assess the proximity of the planned UAS operation to manned aircraft activity.
Observers	N/A

4. Operator and UAS operations provisions	
UAS opeator and UAS operations	4.1 The UAS operator should: 4.1.1 develop an operations manual (OM); 4.1.2 develop an emergency response plan (ERP) in accordance with the provisions for 'medium' level of robustness 4.1.3 validate the operational procedures in accordance with the provisions for 'medium' level of robustness 4.1.4 ensure the adequacy of the contingency and emergency procedures and prove them 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. 4.1.5 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. 4.1.6 If the operation takes place in a reserved or segregated 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 segregated airspace being active, as mandated by the authorisation. *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; 4.1.7 designate for each flight a remote pilot with adequate competency and other personnel in charge of duties essential to the UAS operation if needed; 4.1.8 ensure that all operations effectively use and support the efficient use of radio spectrum in order to avoid harmful interference.
UAS maintenance	4.2 In addition to the responsibilities that are defined in the provisions for UAS operators 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. 4.2.2 The maintenance staff should follow the UAS maintenance instructions when performing maintenance.
External services	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 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.

5. Provisions for the personnel in charge of duties essential to the UAS operation	
General	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 that consists of theoretical elements from Appendix 1 and practical elements from Appendix 2. 5.2 The training programme should be documented (at least the training syllabus should be available). 5.3 Evidence of training should be presented for inspection upon request from the competent authority or authorised representative.
Remote pilot	5.4 The remote pilot has the authority to cancel or delay any or all flight operations under the following conditions: 5.4.1 the safety of persons is threatened; or 5.4.2 property on the ground is threatened; or 5.4.3 other airspace users are in jeopardy; or 5.4.4 there is a violation of the terms of the authorization issued by the competent authority.
Multi-crew cooperation (MCC)	In applications where Multi-crew cooperation (MCC) might be required, the UAS operator should: 5.5 include procedures to ensure coordination between the remote crew members with robust and effective communication channels. Those procedures should cover as a minimum the: 5.5.1 assignment of tasks to the remote crew members; and 5.5.2 establishment of step-by-step communication; and 5.6 ensure that the training of the remote crew covers MCC.
Maintenance staff	5.7 Any staff member authorised by the UAS operator to perform maintenance activities should have been duly trained regarding the documented maintenance procedures. 5.8 Evidence of training should be presented for inspection upon request from the competent authority or authorised representative. 5.9 The UAS operator may declare that the maintenance team has received training regarding the documented maintenance procedures; however, evidence of this training should be made available upon request from the competent authority or authorised representative.
Personnel in charge of duties essential to the UAS operation is fit to operate	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 fit to operate before conducting any operation. 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.

6. Technical provisions	
General	6.1 The UAS should be equipped with the means to monitor the critical parameters for a safe flight, in particular the: 6.1.1 UA position, height or altitude, ground speed or airspeed, attitude and trajectory; 6.1.2 UAS energy status (fuel, battery charge, 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 should be provided to monitor the adequate performance and trigger an alert if the performance level becomes too low. 6.2 The UAS performance and, in particular, its capability to keep the position in 4D space (latitude, longitude, height and time) should be such that it allows to conduct safely operations close to natural or artificial obstacles. *Note: The UA should be able to fly safely at a horizontal distance closer than 30 m to artificial or natural obstacles.* 6.3 The UAS should provide means to programme the UA flight path prior to take-off or if utilizing flexible routes be equipped with means to avoid obstacles while staying within the intended operational volume 6.3.1. If flexible routes are utilized, the UAS should provide means to prevent the UA from breaching the horizontal and vertical limits of a programmable operational volume 6.4 The UAS should be protected against potential electromagnetic interferences from the infrastructure / facilities in the overflown area.
Human–machine interface (HMI)	6.5 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. 6.6 The UAS operator should conduct a UAS evaluation that considers and addresses human factors to determine whether the HMI is appropriate for the operation.
C2 links and communication	6.7 The UAS should comply with the appropriate requirements for radio equipment and the use of the RF spectrum. 6.8 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) 6.9 The UAS should be equipped with a C2 Link protected against unauthorised access to the command and control functions. 6.10 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; 6.11 In the event of an emergency, the remote pilot should have effective means to communicate with the relevant bodies.
Tactical mitigation	N/A.
Containment	6.12 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:

	6.12.1 no probable failure of the UAS or any external system supporting the operation should lead to operation outside the operational volume; and 6.12.2 it is reasonably expected that a fatality will not occur from any probable failure of the UAS, or any external system supporting the operation. *Note: 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.'* 6.13 A design and installation appraisal should be made available and should include at least: 6.13.1 the design and installation features (independence, separation and redundancy); 6.13.2 the particular risks (e.g. hail, ice, snow, electro-magnetic interference, etc.) relevant to the ConOps. 6.14 The following additional provisions should apply if the adjacent area includes an assembly of people or if the adjacent airspace is classified as ARC-c or ARC-d (in accordance with SORA): 6.14.1 The UAS should be designed to standards that are considered adequate by the competent authority and/or in accordance with a means of compliance that is acceptable to that authority such that: 6.14.1.1 the probability of the UA leaving the operational volume should be less than 10^{-4}/FH; and 6.14.1.2 no single failure of the UAS or of any external system supporting the operation should lead to operation outside the ground risk buffer *Note: 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.* 6.14.2 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 recognised as adequate by the competent authority. *Note 1: The proposed additional safety provisions cover both the integrity and assurance levels.* *Note 2: The proposed additional safety provisions do 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. For instance, if the UA design includes an <u>independent</u> 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 provisions 6.16.2 and 6.16.3 could be considered to be met.* *Note 3: For this PDRA, having adjacent airspace classified as ARC-c like a hospital heliport in uncontrolled airspace is also deemed subject to above additional requirements (in addition to ARC-d, as per SORA Step #9 (c))* 6.15 Compliance with provisions 6.14.1 and 6.14.2 above should be substantiated by analysis and/or test data with supporting evidence.

Table PDRA-04.1 — Main limitations and provisions for PDRA-04

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 4 covers the theoretical knowledge subjects while appendix 2 to PDRA 4 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;

(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) if airspace observers (AOs) are employed: 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 situations 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>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

3. Annex A: Risk assessment for PDRA-04

The following risk assessment has been conducted by applying SORA to the PDRA-04.

3.1 Step #1 – CONOPS description

UAS operators that intend to perform a UAS operation under this PDRA should elaborate a concept of operations (ConOps) and describe it in the Operations Manual (see provision 4.1.1, which refers to the OM template, that includes the ConOps as one of the chapters). This ConOps needs to fit the operational limitations defined in this PDRA.

As part of the ConOps, the UAS operator should define the required operational volume and risk buffers (ground and air risk buffers).

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

3.3 Step #3 — final GRC determination

For this PDRA, only the following mitigations for final GRC determination are considered:

M1 – Strategic mitigations for ground risk with a “Low” level of robustness and, consequently:

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 following at least the “1 to 1 rule”. For example, if the UA is planned to operate at a height of 25 m the ground risk buffer should be at least 25 m.

Criterion #2 (evaluation of people at risk)

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 justify a significant lower density of people at risk within the entire operational volume

As per point 3.7 of the PDRA, the UAS operator should ensure that the person or entity responsible for that facility or infrastructure has taken the necessary measures to protect the uninvolved persons present within the limits of the facility or infrastructure.

Note: The control by the facility/infrastructure management is typically done through means like fencing, surveillance systems (e.g. CCTV), ground observers, etc.

Assurance:

The UAS operator should declare that the required level of integrity has been achieved for the above-indicated integrity criteria. Supporting evidence may or may not be available.

M3 – An Emergency Response Plan (ERP) is in place, operator validated and effective with a “medium” level of robustness. As per point 4.1.2, the UAS operator should develop an ERP in accordance with the provisions for ‘medium’ level of robustness.

Consequently, as highlighted in Table A2, the **final GRC is 3**.

		Robustness			Correction
Mitigation Sequence	**Mitigations for ground risk**	**Low / None**	**Medium**	**High**	
1	M1 - Strategic mitigations for ground risk[5]	**0: None -1: Low**	**-2**	**-4**	**-1**
2	M2 - Effects of ground impact are reduced[6]	**0**	**-1**	**-2**	**0**
3	M3 - An Emergency Response Plan (ERP) is in place, operator validated and effective	**1**	**0**	**-1**	**0**
Total correction					**-1**

Table A2 Mitigations for Final GRC determination (GRC)

3.4 Steps #4 to 6 — air risk assessment

This PDRA is intended for UAS operations in airspace where normally manned aircraft cannot operate –thus, considered "atypical" airspace–, or in reserved /segregated airspace

In particular, this PDRA focuses on those UAS operations where the UA flies very close to the facilities or infrastructure targeted by the operation (e.g. surveillance or inspection of an industrial plant), and therefore such artificial obstacles provide the "shielding" that allows the airspace where the UA flies to be considered as "atypical", since no manned aircraft can be expected to fly that close to those obstacles.

Thus, the main issue is establishing how close from obstacles the UA must remain to ensure that the likelihood of encountering a manned aircraft is negligible, while not imposing a too conservative limitation could make this PDRA impractical for most UAS operators.

It is also important to note that this PDRA encompasses routine UAS operations, which drives the need for a rather conservative approach. Indeed, events like a HEMS flying in proximity of a UAS operation at very low level may not be that seldom if that UAS operation is being conducted regularly.

Considering the above, a maximum lateral distance of 30 m from the obstacle and a maximum height of 15 m above the obstacle (or 30 m above the obstacle with a maximum height of 20m) is established in this PDRA based on the following:

JARUS experts contributing to the air risk model in SORA indicated that airspace within 100 ft (30 m) from buildings or structures would be a reasonable example for 'atypical' airspace under the abovementioned criterion of 'airspace where manned aircraft normally cannot go' (this was included in the draft SORA Annex G open for external consultation)

Some countries have already implemented that recommended distance, e.g. Dutch standard scenario STS-2A-CAA-NL-CONGESTED-CLOSEPROX-V1.47.

[5] This mitigation is meant as a means to reduce the number of people at risk.
[6] This mitigation is meant as a means to reduce the energy absorbed by the people of the ground upon impact.
[7] https://www.ilent.nl/documenten/publicaties/2019/2/7/standaard-scenarios-sts-2a-caa-nl-congested-closeprox-v1.4

As indicated in SORA, the competent authority, ANSP, or U-space/UTM service provider, may elect to directly map the airspace collision risks using airspace characterisation studies. These maps would directly show the initial Air Risk Class (ARC) for a particular airspace. If the competent authority, ANSP, or U-space/UTM service provider provides an air collision risk map (static or dynamic), the UAS operator should use that service to plan UAS operations in an airspace that is characterised as 'atypical'.

If not mapped, considering the Airspace Encounter Categories (AECs) and the ARCs associated shown in diagram of Figure 4 (ARC assignment process) of SORA, it can be concluded that the airspace where UAS operations under this PDRA must take place can be classified as ARC-a. Therefore, as this is the lowest ARC, the **final ARC is ARC-a.** According to SORA (see Table 4 — TMPRs and TMPR level of robustness assignment, in SORA) no tactical mitigation performance requirement (TMPR) is considered for ARC-a.

Therefore, considering all above, it can be concluded that the proposed provisions for this PDRA comply with the SORA criteria for ARC-a.

3.5 Step #7 — final SAIL determination

Considering that:

Ground risk: final GRC is 3.

Air risk: final ARC is ARC-a

Then, the resulting SAIL for this PDRA is SAIL II, as indicated in Table A3 below:

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

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

The purpose of this step is to evaluate the defences within the UAS operation in the form of OSOs and the associated level of robustness depending on the SAIL. Table A4 provides a qualitative methodology to make this determination. In this table, 'O' means optional, 'L' means recommended with low robustness, 'M' means recommended with medium robustness, and 'H' means recommended with high robustness.

SAIL II corresponding to this PDRA is highlighted in yellow in Table A4 to show the required level of robustness for the different 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
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

[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#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

Table A4 Recommended operational safety objectives (OSOs)

3.7 Step #9 — adjacent area/airspace considerations

In the context of this PDRA, the following provisions derived from SORA apply:

No probable failure of the UAS or any external system supporting the operation should lead to operation outside of the operational volume. Compliance with this should be substantiated by a design and installation appraisal and include at least:

design and installation features (independence, separation and redundancy);

particular risks (e.g. hail, ice, snow, electro-magnetic interference, etc.) relevant to the ConOps.

The following additional provisions should apply if the adjacent area/airspace are gathering of people or ARC-c/d:

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.

Compliance with the requirements above shall be substantiated by analysis and/or test data with supporting evidence.

Software (SW) and Airborne Electronic Hardware (AEH) whose development error(s) could directly lead to operations outside of the ground risk buffer shall be developed to an industry standard or methodology recognized as adequate by the competent authority.

For this PDRA, having adjacent airspace classified as ARC-c is also deemed subject to above additional provisions (in addition to ARC-d, as per SORA Step #9 (c)). This is intended to ensure that if any adjacent airspace has a risk of encounter with manned aircraft higher than low (ARC-b) the design of the UAS and of any external system supporting the operation can provide enough assurance of containment within the operational volume, given that BVLOS operations under this PDRA are relaying on being

conducted in an “atypical airspace” that may be based on the UA flying close to an infrastructure / facility, with no tactical mitigations in place being required.

3.8 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: see 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 3.9 of this Annex.

For adjacent area/airspace consideration: see Table A7 in point 3.9 of this Annex.

3.9 Evaluation of mitigations means

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

Mitigations for the intrinsic GRC		Level of robustness	Criteria in SORA	Provisions for the PDRA
	LEVEL of ASSURANCE		Criterion #1 (Procedures) (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 consistent with the ERP training syllabus.	An ERP with medium levels of robustness is required
			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
M2 - Effects of UA impact dynamics are reduced (e.g. parachute)	LEVEL of INTEGRITY	None	N/A	N/A
	LEVEL of ASSURANCE		N/A	N/A

Mitigations for the intrinsic GRC		Level of robustness	Criteria in SORA	Provisions for the PDRA
M1 - Technical containment in place and effective (e.g. Emergency Recovery Function)	LEVEL of INTEGRITY	Low	Criterion #1 (Definition of the ground risk buffer) The applicant defines a ground risk buffer with at least a 1 to 1 rule.	Point 3.4 of the PDRA: *The UAS operator should establish a ground risk buffer to protect third parties on the ground outside the operational volume.* Point 3.4.1 of the PDRA: *The minimum criterion should be the use of the '1:1 rule' (e.g. if the UA is planned to operate at a height of 25 m, the ground risk buffer should at least be 25 m)*'
			Criterion #2 (Evaluation of people at risk) The applicant evaluates the area of operations by means of on-site inspections/appraisals to justify lowering the density of people at risk (e.g. residential area during daytime when some people may not be present or an industrial area at night time for the same reason). There may be other examples.	Point 3.6 of the PDRA indicates that the UAS operator should evaluate the area of operations typically by means of an on-site inspection or appraisal, and should be able to justify a lower density of people at risk. Point 3.7 of the PDRA indicates that the UAS operator should ensure that the person or entity responsible for the facility or infrastructure has taken the necessary measures to protect the uninvolved persons present within the limits of the facility or infrastructure during UAS operation.
	LEVEL of ASSURANCE		Criterion #1 (Definition of the ground risk buffer) The applicant declares that the required level of integrity has been achieved. Criterion #2 (Evaluation of people at risk) The applicant declares that the required level of integrity has been achieved.	Point 3.8 of the PDRA indicates that the UAS operator should include points 3.4 to 3.7 in the Operations Manual and declare the compliance with those provisions.

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

3.10 Operational Safety Objectives (OSOs)

Please note that OSOs that are considered as 'optional' for SAIL II are 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 CONOPS.	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*	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 6.7 of the PDRA indicates The UAS should comply with the appropriate requirements for radio equipment and the use of the RF spectrum. – Point 6.8 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 6.10 of the PDRA indicates that in case of a loss of C2 Link, the UAS should have a reliable and predictable

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
			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.	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 6.11 of the PDRA indicates that In the event of an emergency, the remote pilot should have 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 ConOps.	the remote pilot should 'ensure that the UAS is in a safe condition to complete the intended flight safely'. Pre-flight inspection is included in the Operations Manual

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): – 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 UAS operator should ensurethat remote pilots 'have been informed about the UAS operator's operations manual' and that personnel in charge of duties essential to the UAS operation, other than the remote pilots, 'have completed the on-the-job-training developed by the operator, and have been informed about the UAS operator's operations manual'. – the training programme should be documented (at least the training syllabus should be available).

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.	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'. – 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: – The UAS operator should reduce the level of complexity avoiding raising the workload and/or the interactions with other entities (e.g. ATM, etc.) of remote pilots and/or other personnel in charge of duties essential to the UAS operation to a level that may jeopardise their ability to perform adequately the procedures. Since taking manual control is still under JARUS discussion, it has not been considered in the assessment.Criterion #3:

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
			– 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 #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.	– 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, handover/takeover procedures, responsibilities and workload..

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
	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 4.1.3 of the PDRA indicates that the UAS operator should validate the operational procedures in accordance with the provisions for 'medium' level of robustness; Point 4.1.4 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 lists the competencies required for remote pilots operating UAS in the 'specific' category. the UAS operator should ensure before conducting operations that the remote pilot has the appropriate competency. the remote pilot should have the appropriate remote pilot competency.
	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	N/A as operations are planned in sparsely populated areas

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
			these mechanical parts were designed to aviation industry best practices.	
	LEVEL of ASSURANCE		A design and installation appraisal is available. In particular, this appraisal shows that: the design and installation features (independence, separation and redundancy) satisfy the low integrity criterion; particular risks relevant to the ConOps (e.g. hail, ice, snow, electro-magnetic interference…) do not violate the independence claims, if any.	N/A as operations are planned in sparsely populated areas
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.

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
	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.
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: According to point 5.5 of the PDRA, in applications where multi-crew cooperation (MCC) might be required, the UAS operator should include procedures to ensure coordination between the remote crew members with robust and effective communication channels. Those procedures should cover as a minimum: – the assignment of tasks to the remote crew members; and – the establishment of step-by-step communication; and Criterion #2: According to point 5.6 of the PDRA, in applications where MCC might be required, the UAS operator should ensure that the training of the remote crew covers MCC.

Operational Safety Objectives (OSOs)		SAIL II level of robustness	Criteria in SORA for SAIL II	Provisions for the PDRA
	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 4.1.5 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 6.5 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 6.6 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)

3.11 Adjacent area/airspace consideration

Mitigations used for containment		Level of robustness	Criteria in SORA	Provisions for the PDRA
	LEVEL of INTEGRITY	Medium	No probable failure of the UAS or any external system supporting the operation shall lead to operation outside of the operational volume.	Point 6.12 of the PDRA indicates that ensure a safe recovery from a technical issue involving the UAS or an external system supporting the operation, the UAS operator should ensure: that no probable failure of the UAS or any external system supporting the operation should lead to operation outside the operational volume, and that it is reasonably expected that a fatality will not occur from any probable failure of the UAS, or any external system supporting the operation.
	LEVEL of ASSURANCE		Compliance with the requirement above shall be substantiated by a design and installation appraisal and shall include at least: design and installation features (independence, separation and redundancy); particular risks (e.g. hail, ice, snow, electro-magnetic interference…) relevant to the ConOps.	Point 6.13 of the PDRA indicates that a design and installation appraisal should be made available and include at least: design and installation features (independence, separation and redundancy); particular risks (e.g. hail, ice, snow, electro-magnetic interference, etc.) relevant to the ConOps.

Mitigations used for containment		Level of robustness	Criteria in SORA	Provisions for the PDRA
	LEVEL of INTEGRITY		Following additional requirements shall apply if adjacent area/airspace are gathering of people or ARC-d: 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 6.14 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-c or 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.
	LEVEL of ASSURANCE		Compliance with the requirements above should be substantiated by analysis and/or test data with supporting evidence.	Point 6.15 of the PDRA indicates that compliance with the provisions in point 6.14 (see above) should be substantiated by analysis and/or test data with supporting evidence.

Mitigations used for containment		Level of robustness	Criteria in SORA	Provisions for the PDRA
	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 6.14.2 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 exist 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

Table A7 Compliance check of PDRA-04 provisions against SORA criteria for mitigations used for containment