Transport Canada / Transports Canada

Advisory Circular

Subject:	**Remotely Piloted Aircraft Systems Operational Risk Assessment**		
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1.0 Introduction

(1) This Advisory Circular (AC) is provided for information and guidance purposes. It describes an example of an acceptable means, but not the only means, of demonstrating compliance with regulations and standards. This AC on its own does not change, create, amend or permit deviations from regulatory requirements, nor does it establish minimum standards.

1.1 Purpose

(1) This AC provides information and guidance to manufacturers and operators intending to develop or operate a Remotely Piloted Aircraft System (RPAS) for operations in accordance with the requirements of Part IX, Subpart 3 of the Canadian Aviation Regulations (CARs).

1.2 Applicability

(1) This document applies to manufacturers and operators intending to develop or operate an RPAS for one or more of the operations listed under CAR 903.01 which are identified as requiring a risk assessment during the application process for a Special Flight Operations Certificate (SFOC) – RPAS.

(2) Exclusions. In particular, the guidance provided by this document is not intended to address:

(a) passenger-carrying operations;

(b) risks associated with carriage of dangerous or potentially dangerous payloads;

(c) risks associated with air-to-air collisions between two RPAs;

(d) security risks not confined by the airworthiness of the systems (e.g., C2 link protection from interference is addressed, but protection of the ground control station from external malicious interference is not);

(e) aircraft subject to the aircraft type certification process.

Note: Formal policy defining how RPAS will be accommodated in the type certification process is still under development and will be addressed in future guidance material.

1.3 Description of Changes

(1) Significant changes compared to Issue 01 of this document are described in the following list:

(a) Changes to definitions:

(i) Airport / Heliport Environment was renamed Aerodrome Environment and a 3000 ft (915 m) AGL maximum altitude provision was added.

(ii) The Atypical Airspace infrastructure masking provision was clarified, and a low altitude night provision was added.

(iii) Operating Weight definition was added to support changes to ground risk assessment.

(b) Updated ground risk assessment:

(i) Now uses aircraft Operating Weight instead of Characteristic Dimension and Kinetic Energy.

(ii) Now uses thresholds based on Population Density instead of qualitative descriptions.

(iii) Specific detail for use of VLOS operation as a strategic mitigator of ground risk was added as all ground risk scores now assume BVLOS operation.

(c) Updated air risk assessment:

(i) Clarified that ARC-c airspace resulting from operating underneath controlled airspace starting at 1500 ft AGL or lower is only applicable to Transition Areas and Terminal Control Areas.

(d) Updated Containment Objectives:

(i) Simplified the determination of containment objectives to be based on increased GRC and/or ARC in the adjacent areas compared to the operational volume.

(ii) Additional detail and guidance added to the containment objectives.

(e) Added Appendix B Section 4.0, providing guidance on operational use of visual observer DAA.

(f) Updated many of the OSOs in Appendix C, providing additional detail and guidance on robustness expectations.

(g) Added Standard Scenarios to Appendix D.

(h) Added Appendix F containing guidance on Third Party validation and Organizational Proficiency Checks.

(i) Added Appendix G containing guidance on population density and site surveys.

2.0 References and requirements

2.1 Reference Documents

(1) It is intended that the following reference materials be used in conjunction with this document:

(a) Part IX of the Canadian Aviation Regulations (CARs) — Remotely Piloted Aircraft Systems;

(b) CAR Standard 922 — Remotely Piloted Aircraft System Safety Assurance;

(c) Joint Authorities for Rulemaking of Unmanned Systems (JARUS) JAR-DEL-WG6-D.04, 2019-30-01 — Guidelines on Specific Operations Risk Assessment (SORA).

2.2 Cancelled Documents

(1) Not applicable.

(2) By default, it is understood that the publication of a new issue of a document automatically renders any earlier issues of the same document null and void.

2.3 Definitions and Abbreviations

(1) The following **definitions** are used in this document:

Note: The definitions provided below are strictly for the purposes of conducting an RPAS ORA as described in the remainder of the document. In the case of any conflict between these definitions and definitions from other sources (e.g., the CARs), these definitions shall be used only in the context of the RPAS ORA.

(a) **Adjacent Area / Airspace**: Any ground area or airspace that reachable from the border of the operational volume in T_{ERP} at the maximum performance capability of the RPA (groundspeed, climb rate). Performance capability shall include considerations of:

(i) Groundspeed created by the worst-case combination of wind allowed by the operation and airspeed capabilities of the RPA.

(ii) Maximum Climb Rate capabilities of the RPA.

(b) **Aerodrome Environment**: Aerodrome Environment is defined as at or below 3000 ft (915 m) AGL and within 5 nautical miles (9.3 km) from the centre of an airport, heliport, or aerodrome published in the Canada Flight Supplement or Water Aerodrome Supplement.

(c) **Atypical Airspace**: Atypical Airspace is defined as any of the following:

(i) Restricted Airspace, with authorization from the person specified in the Designated Airspace Handbook TP1820 or in a NOTAM.

(ii) Northern Domestic Airspace as defined in the Designated Airspace Handbook, outside an Aerodrome Environment, at a maximum altitude of 400 ft (122 m) AGL.

(iii) Within 100 feet (30 m) above and within 200 feet (61 m) horizontally from any building or structure which stands out vertically beyond the adjacent surface of surrounding terrain with sufficient size and shape to be noticeable to the pilot of a traditional aircraft in flight.

(iv) Within the hours of legal night, in uncontrolled airspace outside of an Aerodrome Environment, at a maximum altitude of 400 ft (122 m) AGL.

(d) **Beyond Visual Line of Sight (BVLOS)**: BVLOS flight of an RPAS is defined as an operation in which no crew member maintains unaided visual contact with the aircraft sufficient to be able to maintain control of the aircraft and know its location.

(e) **Concept of Operations (CONOPS)**: The clearly defined and detailed purpose of the system/operation intended for the RPAS. This includes a description of the operational aspects of the crew, RPAS system, Processes and Procedures, and the expected Environment.

(f) **Contingency Procedures**: Contingency Procedures describe the planned actions to address undesirable states that, if not addressed, could lead to unsafe situations. While conducting these procedures, the operation is generally still considered to be under control (provided that the RPAS is responding to the contingency procedure such that it is expected to remain inside the contingency volume). These may include procedures such as automatic landing, manual control takeover, or return-to-home.

(g) **Contingency Volume**: The Contingency Volume is the buffer area beyond the Flight Geography in which contingency procedures (e.g., return-to-home, auto-land, manual control) will be used to return the aircraft to the Flight Geography or safely terminate the flight. The Contingency Volume must be defined such that any contingency procedures to be used can be initiated when the RPA leaves the Flight Geography and completed without the RPA leaving the Contingency Volume.

(h) **Controlled Ground Area**: The ground below the intended RPAS Operational Volume (see 2.3(1)(o)), within which persons not involved in the operation are excluded. (Note: exclusion can be accomplished by geographical features, fencing, signage, etc.).

(i) **Detection Volume**: The detection volume is the volume of airspace (temporal and/or spatial measurement) within which traditional aircraft must be detected in order to avoid a near mid-air collision, and remain well clear (if required). It can be thought of as the last point at which an aircraft must be detected, so that the Detect and Avoid (DAA) system can perform all the DAA functions. The detection volume is not tied to the sensor(s) Field of View/Field of Regard. The size of the detection volume depends on the closing speed of traffic that may reasonably be encountered, the time required by the remote pilot to command the avoidance manoeuvre, the time required by the system to respond and the manoeuvrability and performance of the aircraft.

(j) **Emergency Procedures**: Emergency procedures (or Emergency Response Plans) describe the planned actions to limit the escalating effects of an operation that is no longer in control (e.g., uncontrolled flyaway or impact with terrain). These procedures should include contacting relevant external organizations (e.g., Nav Canada, local law enforcement, environmental agencies).

(k) **Flight Geography**: The Flight Geography is the area within which the RPA is intended to fly for a specific operation. To determine the Flight Geography the applicant must consider the position keeping capabilities of the RPAS in 4D space (latitude, longitude, height and time). In particular, the accuracy of the navigation solution, the flight technical error of the RPAS and the path definition error (e.g. map error) and latencies must be considered and addressed in this determination.

(l) **Manufacturer**: A person, group of persons, or organization which builds, maintains, and/or operates facilities that produce, assemble, and/or sell a physical RPAS and the associated technical products (e.g. manuals) holding the intellectual property to substantiate its design and performance.

(m) **Near Mid-Air Collision**: A Near Mid-Air Collision (NMAC) is defined as two aircraft coming within 500 ft (152 m) horizontal and ± 100 ft (30 m) vertical of each other while in flight.

(n) **Operating Weight**: means the weight of a remotely piloted aircraft at any point during a flight, including any payload and any safety equipment that is on board or otherwise connected to the aircraft.

(o) **Operational Volume**: The Operational Volume is composed of the Flight Geography and the Contingency Volume, with an added ground risk buffer of at least 1 to 1 (i.e., if the RPA will be operated at 400 ft (122 m) AGL, the Operational Volume is extended an additional 400 ft (122 m) beyond the Contingency Volume).

(p) **Operator**: A person, group of persons, or organization seeking approval to operate an RPAS under the CAR, Part IX.

(q) **T_{ERP}**: the time required to complete the operational Emergency Response Procedures related to an aircraft fly-away. This shall include the time required to recognize a fly-away, complete any related checklists, contact appropriate airspace/ground users, and allow appropriate time for mitigations.
Note: in absence of a tested value for T_{ERP} it is acceptable to use a value of 3 minutes for the purposes of adjacent area / airspace calculation.

(2) The following **abbreviations** are used in this document:

(a) **AC**: Advisory Circular;

(b) **AGL**: Above Ground Level;

(c) **ARC**: Air Risk Class;

(d) **BVLOS**: Beyond Visual Line of Sight;

(e) **C2 Link**: Command and Control Data Link;

(f) **CAR**: Canadian Aviation Regulation;

(g) **CE**: Conformité européenne;

(h) **CFR**: Code of Federal Regulations;

(i) **CONOPS**: Concept of Operations;

(j) **DAA**: Detect and Avoid;

(k) **DND**: Department of National Defence;

(l) **GCS**: Ground Control Station;

(m) **GRC**: Ground Risk Class;

(n) **EM**: Electromagnetic;

(o) **EMI**: Electromagnetic Interference;

(p) **EU**: European Union;

(q) **ERP**: Emergency Response Plan;

(r) **FAA**: Federal Aviation Administration;

(s) **GNSS**: Global Navigation Satellite System;

(t) **HMI**: Human Machine Interface;

(u) **ISED**: Innovation, Science, and Economic Development Canada;

(v) **JARUS**: Joint Authorities for Rulemaking of Unmanned Systems;

(w) **NMAC**: Near Mid-Air Collision;

(x) **ORA**: Operational Risk Assessment;

(y) **OSO**: Operational Safety Objective;

(z) **PIC**: Pilot-In-Command.

(aa) **RF**: Radio Frequency;

(bb) **RPA**: Remotely Piloted Aircraft;

(cc) **RPAS**: Remotely Piloted Aircraft System;

(dd) **RTH**: Return-To-Home.

(ee) **SAIL**: Specific Assurance and Integrity Level;

(ff) **SFOC**: Special Flight Operations Certificate;

(gg) **SORA**: Specific Operational Risk Assessment;

(hh) **STSC**: Standard Scenario;

(ii) **sRPA**: small Remotely Piloted Aircraft;

(jj) **TMPR**: Tactical Mitigation Performance Requirements;

(kk) **TCCA**: Transport Canada Civil Aviation;

(ll) **TSO**: Technical Standard Order;

(mm) **VLOS**: Visual Line of Sight.

3.0 Background

(1) The first set of regulations governing the operation of RPAS in Canada were published in 2019 in CAR Part IX, initially covering Visual Line of Sight (VLOS) operations with RPA having a

Maximum Take-off Weight (MTOW) of 25 kg or less (under Subpart 1). Other types of operations may be authorized through an SFOC – RPAS issued by the Minister under CAR 903.03. These Special Flight Operations are listed in CAR 903.01, which states:

"No person shall conduct any of the following operations using a remotely piloted aircraft system that includes a remotely piloted aircraft having a maximum take-off weight of 250 g (0.55 pounds) or more unless the person complies with the provisions of a special flight operations certificate — RPAS issued by the Minister under section 903.03:

(a) the operation of a system that includes a remotely piloted aircraft having a maximum take-off weight of more than 25 kg (55 pounds);

(b) the operation of a system beyond visual line-of sight, as referred to in subsection 901.11(2);

(c) the operation of a system by a foreign operator or pilot who has been authorized to operate remotely piloted aircraft systems by the foreign state;

(d) the operation of a remotely piloted aircraft at an altitude greater than those referred to in subsection 901.25(1), unless the operation at a greater altitude is authorized under subsection 901.71(2);

(e) the operation of more than five remotely piloted aircraft at a time from a single control station, as referred to in subsection 901.40(2);

(f) the operation of a system at a special aviation event or at an advertised event, as referred to in section 901.41;

(g) the operation of a system when the aircraft is transporting any of the payloads referred to in subsection 901.43(1);

(h) the operation of a remotely piloted aircraft within three nautical miles of an aerodrome operated under the authority of the Minister of National Defence, as referred to in subsection 901.47(3); and

(i) any other operation of a system for which the Minister determines that a special flight operations certificate — RPAS is necessary to ensure aviation safety or the safety of any person."

(2) In order to be issued an SFOC – RPAS, an operator must submit an application to the Minister as detailed in CAR 903.02. In particular, CAR 903.02 (p) indicates that in addition to the specific information required by 903.02 (a) through (o), the operator must submit "any other information requested by the Minister pertinent to the safe conduct of the operation". For certain complex operations, as determined during the application process, an Operational Risk Assessment (ORA), acceptable to the Minister, is one of the items of "other information" required in support of an application for an SFOC – RPAS.

(3) This document described an ORA methodology based on the JARUS SORA guidelines, adapted for use in the Canadian aviation environment. As indicated in Section 1.0 of this document, this methodology is one means, but not the only means, of meeting the requirement for an ORA under the authority of CAR 903.02 (p).

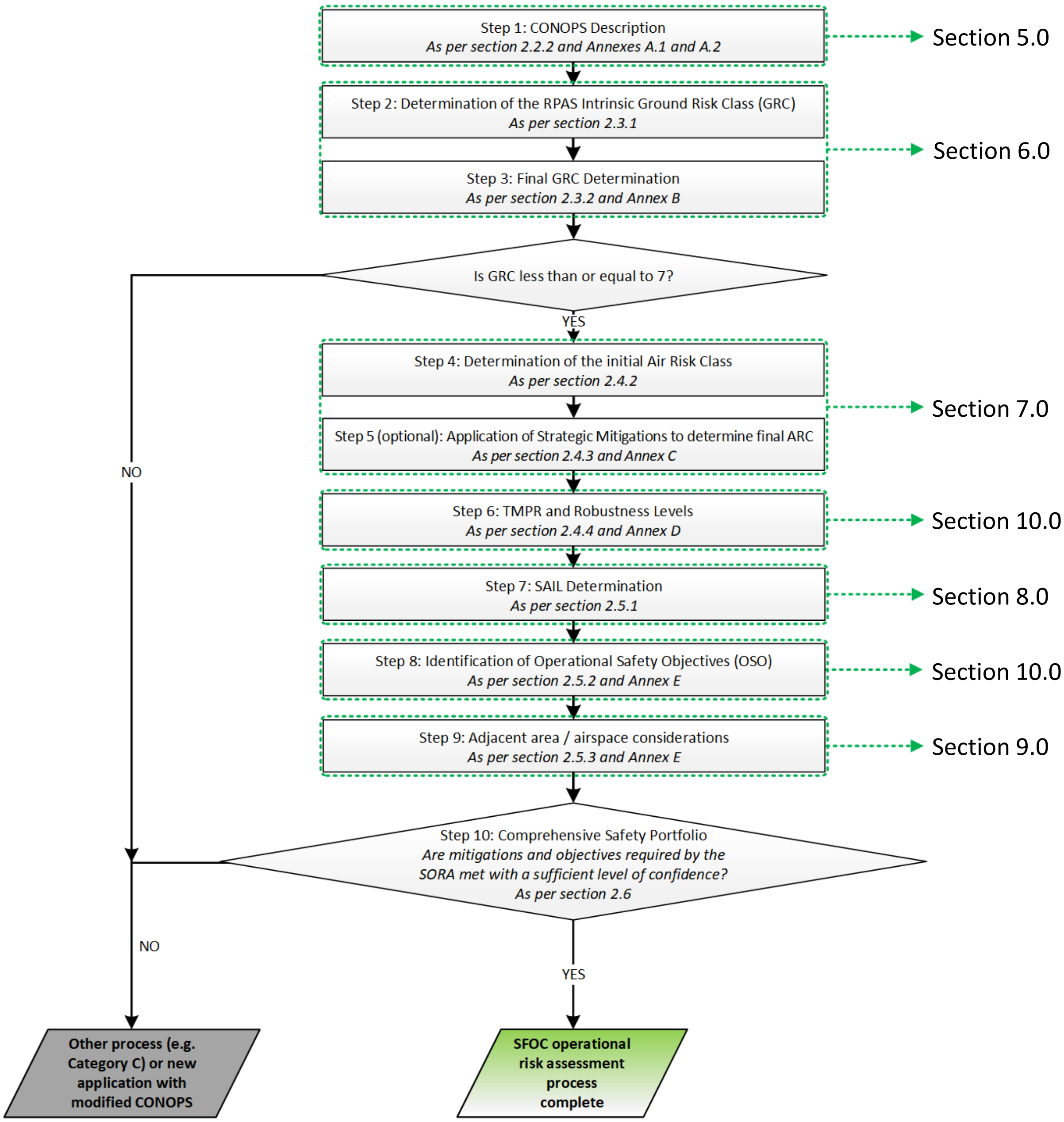
4.0 RPAS ORA Overview

(1) This document describes an ORA based on the JARUS SORA process, which is explained in detail in documents published by JARUS working group 6 – see Reference (d). The remainder of this document describes how the JARUS SORA has been adjusted to accommodate the specificities of the Canadian environment and operational context.

(2) Figure 1, below, illustrates the JARUS SORA process and highlights the areas in which adjustments are necessary. Each of these adjustments are described in detail in the indicated sections of this AC. In general, the RPAS ORA endorses the overall JARUS SORA process steps shown in Figure 1, with adjustments as described in the remainder of this AC.

Note: It is recommended that applicants seek preliminary agreement from TCCA on their approach to Steps 1-5, 7, and 9 (Sections 5.0 to 9.0 of this document) prior to completing the documentation necessary for Steps 6, 8, and 10 (Section 10.0 of this document). This will help to ensure that applicants are developing their substantiation documentation to the appropriate level.

Figure 1 – JARUS SORA Process

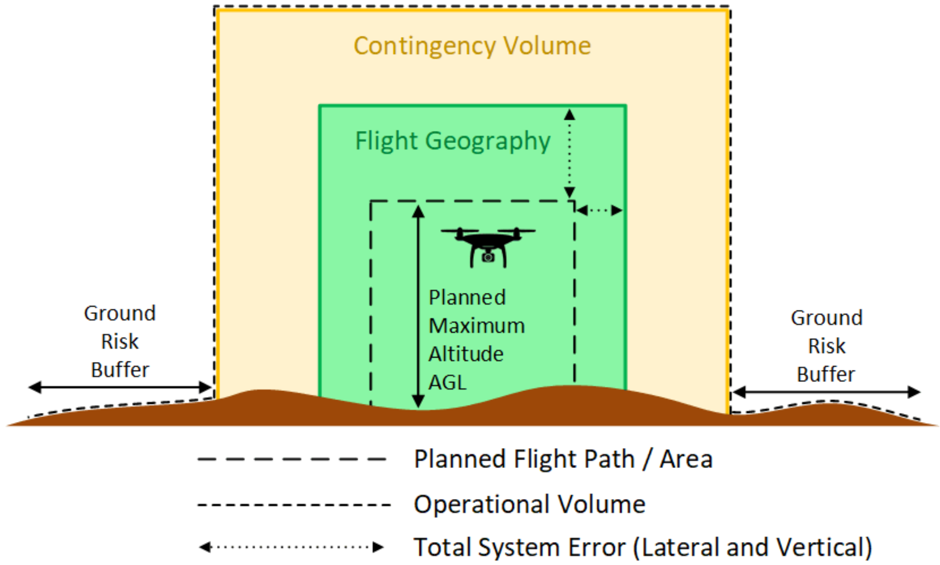


5.0 Concept of Operations and Definition of Operational Volume

(1) Step 1 of the JARUS SORA process involves defining the Concept of Operations (CONOPS) for the intended flight(s). Further explanation of the expected content of a CONOPS description is contained in JARUS SORA Section 2.2.2 and SORA Annex A. However, one of the key concepts that merits further explanation for the purposes of the RPAS ORA is the Operational Volume.

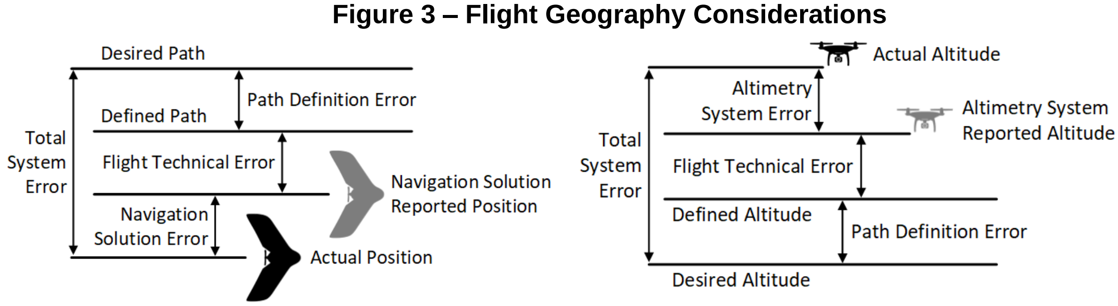
(2) The defined Operational Volume is used for the purposes of Ground Risk Determination (Section 6.0), Air Risk Determination (Section 7.0), and for assessment of Adjacent Area / Airspace Considerations (Section 8.0). As a result, correct definition of this volume is critical for the appropriate application of the RPAS ORA process. As defined in Section 2.3 above, the Operational Volume includes the Flight Geography, the Contingency Volume, and a 1-to-1 ground risk buffer. Refer to Figure 2, below, for an illustration of this concept.

Figure 2 – Operational Volume



(3) **Flight Geography**. As defined in Section 2.3 above, the starting point for the definition of the flight geography is the area or path where the RPA is intended to be flown for the specific operation. However, the definition of this area or path alone is not sufficient to address the intended flight area, as RPA positioning errors must also be considered. The relevant contributors to error are illustrated in Figure 3 and explained in further detail below.

Figure 3 – Flight Geography Considerations



(a) Path Definition Error. Path definition error refers to the difference between the intended path through the environment (laterally and vertically) and the defined path (i.e., what the pilot or autopilot is actually trying to follow). Path definition errors may result from:

(i) Map projection differences. Depending on the type of map or mapping software used to generate the flight plan, distortion resulting from the map projection may result in the actual path over ground being somewhat offset from the intended path plotted over the map features. (Note: A map projection is a systematic transformation of the latitudes and longitudes of locations from the surface of a sphere or an ellipsoid into locations on a plane (2D map), which necessarily results in some distortion of the surface).

(ii) Earth reference model differences. The aviation (and GNSS) standard earth reference model is the WGS-84 system. Planned paths that are created using a different reference model may be subject to error upon conversion into WGS-84 referenced data.

(iii) Altitude considerations. As illustrated in Section 7.0 and Figures 4 and 5, some areas of the RPAS ORA air risk model have a step change in risk level at 400 ft AGL. As a result, the validity of the ORA for operations planned to occur at or below 400 ft AGL in these areas depends on ensuring that the defined path is created to ensure that the aircraft will remain below this altitude ceiling. For example, if the operation is planned to occur in an area with rolling terrain, the 3D path either needs to adjust altitude to follow the terrain, or set a consistent altitude such that the aircraft remains below 400 ft AGL at the lowest terrain elevation that will be overflown.

(iv) Terrain data errors. For areas or paths where the intended altitude is defined in AGL following the terrain, errors in the terrain data used to generate a 3D path will result in altitude deviations relative to the actual terrain.

(b) Flight Technical Error. Flight technical error refers to the accuracy with which the reported aircraft position and altitude are controlled relative to the defined path. This error is dependent on:

(i) The means of control and its associated performance (e.g., manual control vs. autopilot). For example, flight technical error for an autopilot following a 3D path within the performance capabilities of the aircraft is typically quite low. A pilot manually controlling to follow the same 3D path is generally not able to provide the same level of accuracy, leading to a greater flight technical error.

(ii) The means of determining the difference between the reported position and the defined path. Particularly in cases of manual control by a pilot, ability to follow a 3D path is highly dependent on the way the path and path deviation data is displayed (e.g., following a flight director command is much more accurate than trying to maintain path using graphical altitude and course deviation indications, which is again more accurate than trying to maintain path using digital readouts of path deviation).

(c) Navigation Solution and Altimetry System Accuracy. The accuracy of the navigation solution (laterally) and the altimetry system (vertically) must be considered to determine the potential difference between the reported position and the actual position of the aircraft.

(d) Latencies. Any latencies in the C2 link(s), navigation solution computation, or altimetry system may add to the total system error depending on the system architecture. For example, if the system position determination function is on-board the aircraft and the path control function is part of the Ground Control Station (GCS), any C2 link latency will result in flight technical error as the system tries to correct its path based on an out-of-date reported position. (Note that this would be the case in a system where the RPA is being manually controlled by a pilot at the ground control station – i.e., where the pilot is performing the path control function).

(4) **Contingency Volume**. As defined in Section 2.3 above, the contingency volume is intended to provide a buffer area beyond the Flight Geography to allow time and space for contingency procedures to be enacted.

(a) Contingency Procedures. In general, contingency procedures are put in place to support recovery from undesirable states that, if not addressed, could lead to unsafe situations. For example, operation outside of the planned flight path / area is an undesirable state that could be a precursor to a flyaway, and loss of C2 link is an undesirable state that may lead to additional operational risks as a result of a dynamic environment. Samples of typical contingency procedures and related considerations for calculation of the contingency volume are listed below. Note that the procedures listed below are not mandatory, nor is the list intended to be exhaustive; it simply provides examples of the types of considerations to be addressed in defining the contingency volume.

(b) Automatic Return-To-Home (RTH). If an automatic RTH function is used as part of any contingency procedures (e.g. for loss of C2 link), the design of this function should be considered in the definition of the contingency volume. For example, a common RTH function implementation involves the aircraft climbing to a specified altitude and then following a direct path from its current location to the home point. Using this type of RTH function, any planned operation that does not follow a direct linear route will need to include any area between the planned flight path and the home point as part of the contingency volume. The altitude used, if higher than the planned flight path altitude, will also need to be included in the contingency volume.

(c) Automatic Landing. If automatic landing at present position or a specified alternate location is included as part of any contingency procedures, the area surrounding the landing location should be addressed as part of the contingency volume if it may be outside of the flight geography. For example, automatic landing at present position is a common contingency procedure for loss of GNSS navigation; however, loss of GNSS navigation may also result in a loss of position-holding capability. In such cases, the potential position drift resulting from wind during the descent from operating altitude to landing needs to be included in the contingency volume.

(d) Pilot Manual Control Takeover. If a manual control takeover by the pilot is included as a contingency procedure to address departures from the planned flight path / area, the contingency volume needs to provide sufficient time and space to allow the pilot to:

(i) recognize the deviation from the planned path;

(ii) execute the manual control takeover procedure; and

(iii) maneuver the aircraft back to the planned flight path / area.

(5) **Ground Risk Buffer**. The ground risk buffer is added based on the expectation that some mechanism of flight termination may be included as part of the emergency procedure if the aircraft exceeds the contingency volume. Thus, some ground area outside of the contingency volume needs to be considered as part of the ground risk determination. The “1-to-1” concept means that the buffer is defined, at minimum, as a horizontal distance equal to the aircraft’s planned maximum altitude (AGL). Note that:

(a) The planned maximum altitude (and the resulting required buffer distance) may change across flight segments, and the appropriate buffer distance may be applied to the individual segments. For example, if a survey operation is to be flown at 2000 ft AGL, but the transit to the survey area is to be flown at 1000 ft AGL, it is not necessary to apply the 2000 ft buffer to the cruise segments of the flight (1000 ft is sufficient).

(b) The total system error (vertical) is assumed to be small compared to the planned maximum altitude (AGL). If the total system error (vertical) for the proposed operation is a significant percentage of the planned maximum altitude (greater than approx. 10%), the Flight Geography maximum height should be used to define the ground risk buffer.

(6) For an example of the definition of an operational volume, refer to Appendix A.

6.0 Ground Risk Determination

(1) Steps 2 and 3 of the JARUS SORA process involve determining the intrinsic ground risk associated with the operation and applying any strategic mitigations to reduce this risk.

(2) **Intrinsic Ground Risk**. As described in JARUS SORA Section 2.3.1, the intrinsic ground risk class (GRC) is determined from the size / speed of the RPA and the maximum population density contained within the operational volume. For the purposes of the RPAS ORA, the size & speed have been replaced by the RPA Operating Weight and the population density values have been adjusted to reflect the Canadian context as shown in Table 1, below.

Table 1 – RPAS ORA Intrinsic Ground Risk

RPA Operating Weight	Up to 25 kg	Above 25 kg up to 150 kg	Above 150 kg up to 600 kg	Above 600 kg
Maximum Population Density (ppl/km^2)	Intrinsic GRC			
Controlled ground area	1	1	1	1
Up to 5	1	2	3	4
Above 5 up to 25	3	4	5	6
Above 25 up to 400	4	5	6	7
Above 400 up to 1000	5	6	7	8
Above 1000 up to 4000	6	7	8	9
Above 4000 up to 10,000	7	8	9	10
Above 10,000	7	9		

(3) **Application of Operational Volume**. When determining the intrinsic ground risk based on Table 1, all ground within the operational volume as defined in Section 5.0 must be considered. Also note that it is acceptable to break the operation into segments based on changes in risk level, allowing different risk mitigations to be used for different segments of the operation (as illustrated in the example contained in Appendix A).

(4) **Strategic Mitigations for Ground Risk**. As described in JARUS SORA Section 2.3.2 and Annex B, there are a variety of strategic measures that may be put in place in order to reduce the ground risk of an operation. Applicants are encouraged to assess and make use of these strategic mitigations.

(a) **VLOS Operation**. With the adoption of the quantitative, population density-based ground risk listed in Table 1, the implicit “credit” given to VLOS operations in prior versions of the table has been removed. However, it is generally accepted that if an operation is conducted in VLOS and visual surveillance of the ground area in the operational volume is used to ensure that the RPA is kept away from people not involved with the operation, a 1 point reduction in GRC may be assessed.

(b) **Other mitigations**. There is currently no Canadian-specific guidance available regarding the use of other strategic mitigations. As such, these mitigations will be considered on a case-by-case basis and may not result in credit being given in the form of GRC reductions.

Note: Strategic Mitigations will be assessed on an ongoing basis with the intent of setting performance and robustness requirements for GRC reductions in a future revision of this AC.

7.0 Air Risk Determination

(1) Steps 4, 5, and 6 of the JARUS SORA process involve determining the intrinsic air risk associated with the operation and applying any strategic mitigations to reduce this risk. Tactical Mitigation Performance Requirements (TMPR) are also assigned based on the final Air Risk Class (ARC).

(2) **Intrinsic Air Risk**. As described in JARUS SORA Section 2.4.2, the intrinsic ARC is determined from the intended operational environment, by following the provided flow chart / decision tree. For the purposes of the RPAS ORA, the interpretation of the air risk classes has been adjusted based on the definitions contained in Section 2.3. Figure 4, below shows the air risk class decision tree as updated based on these definitions and Figure 5 provides a graphical depiction.

Figure 4 – Air Risk Class Decision Tree

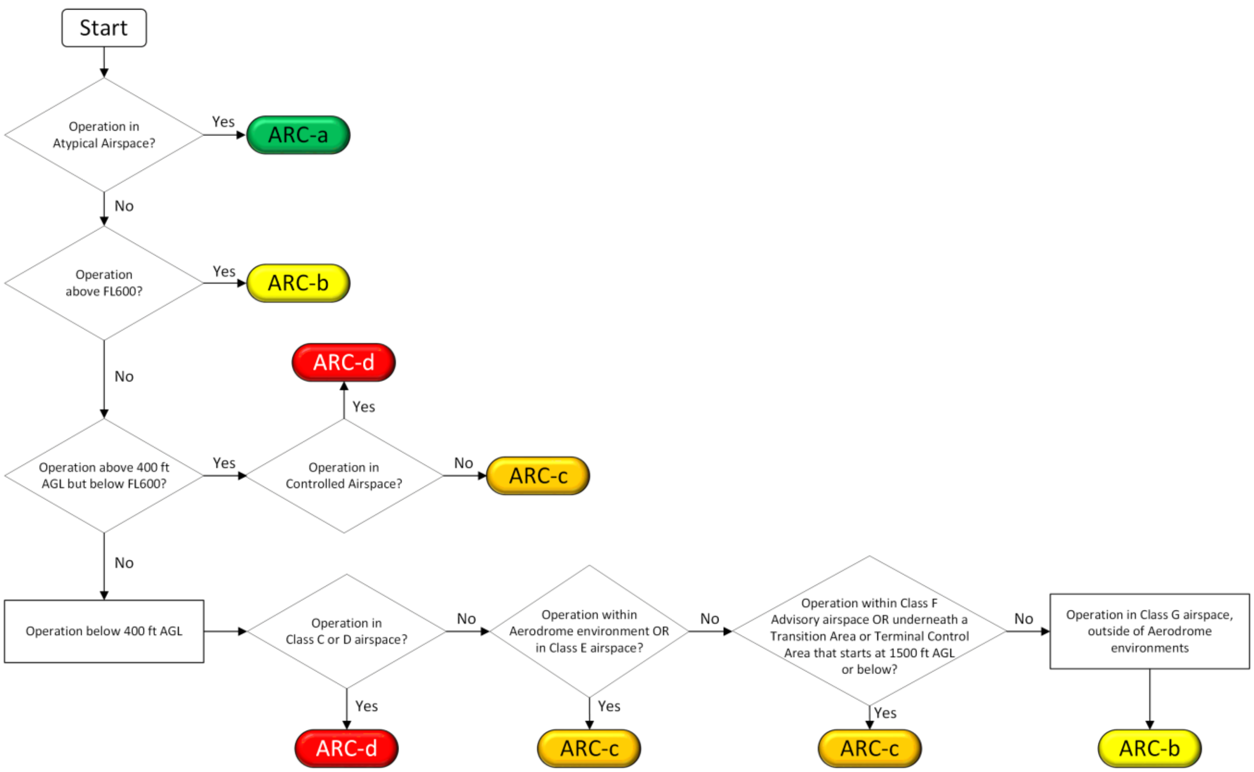
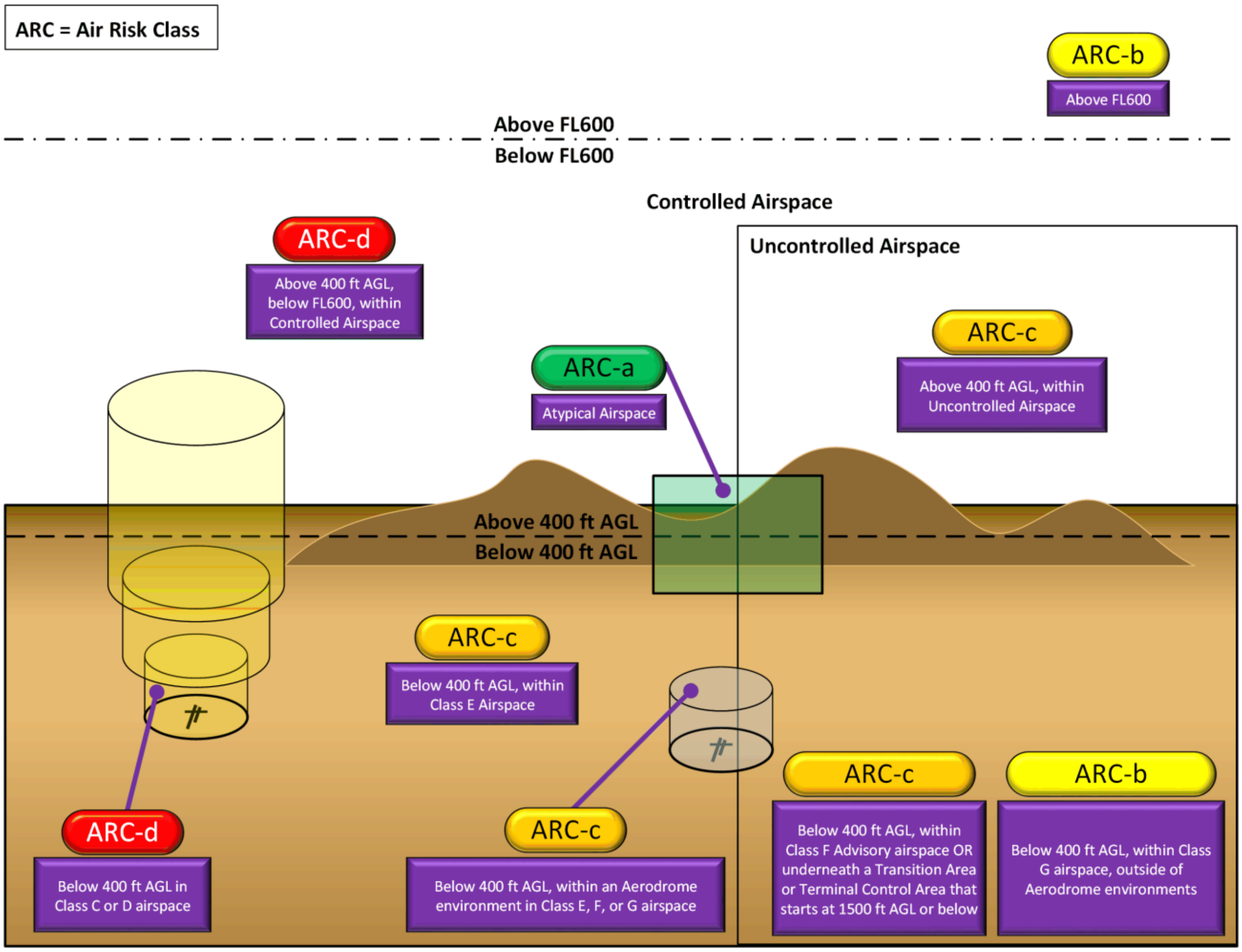


Figure 5 – Graphical Depiction of Air Risk Classes



(3) **Application of Operational Volume**. When determining the ARC based on Figure 4 or Figure 5, all airspace within the operational volume as defined in Section 5.0 must be considered. Also note that it is acceptable to break the operation into segments based on changes in risk level, allowing different risk mitigations to be used for different segments of the operation (as illustrated in the example contained in Appendix A).

(4) **Strategic Mitigations for Air Risk**. As described in JARUS SORA Section 2.4.3 and Annex C, there are a variety of strategic measures that may be put in place in order to reduce the air risk of an operation. Applicants are encouraged to assess and make use of these strategic mitigations; however, there is currently no Canadian-specific guidance available regarding their use. As such, these mitigations will be considered on a case-by-case basis and may not result in credit being given in the form of ARC reductions.

Note: Strategic Mitigations will be assessed on an ongoing basis with the intent of setting performance and robustness requirements for ARC reductions in a future revision of this AC.

(5) **Tactical Mitigation Performance Requirements**. The JARUS SORA TMPR provide the Detect and Avoid (DAA) requirements for the proposed operation, and their performance levels and required robustness levels are assigned based on the final ARC as per JARUS SORA Section 2.4.4. Further detail of the specific performance and robustness requirements for the RPAS ORA are contained in Section 10.1 of this AC.

8.0 SAIL Determination

(1) The determination of the overall risk score of the operation in the form of the Specific Assurance and Integrity Level (SAIL) is carried out as described in JARUS SORA Section 2.5.1 and illustrated in Table 2, below.

Table 2 – RPAS ORA Specific Assurance and Integrity Levels

	Final ARC			
Final GRC	a	b	c	d
1 or 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
>7	RPAS ORA N/A at this time (e.g., may require certified operations / aircraft)			

9.0 Adjacent Area / Airspace Considerations

9.1 Determination of Adjacent Areas and Airspace

(1) The JARUS SORA includes requirements for an assessment of adjacent areas and airspace to determine what hazards may exist in the event of a loss of control of the operation resulting in a fly away. The risk level of these adjacent areas and airspaces are then used to determine an appropriate level of containment objective(s) to be applied to the operation. These containment objectives are expressed in terms of system reliability and design assurance against failure conditions resulting in the aircraft leaving the Operational Volume.

(2) A conservative approach to identifying adjacent areas/airspace would be to consider the maximum performance of the RPA and identify any locations attainable by the RPA under worst-case flyaway conditions. For instance, an RPA with a maximum ceiling of 20,000ft could theoretically reach Class A controlled airspace above FL180. A fixed wing RPA with a range of 200nm could theoretically reach any ground location that is within 200nm of the launch site. Defining the Operational Volume such that it includes adjacent areas and airspace calculated in this manner is acceptable and encouraged, and it will in many cases result in an increase to the resulting SAIL for the operation. However, it is acknowledged for some operations, this strategy may be overly conservative.

(3) The definition of Adjacent Areas and Airspace listed in Section 2.3 involves determining the time required to perform the Emergency Procedures related to an aircraft flyaway and using this time to establish practical limits on what locations the aircraft could reach before risk mitigations can be applied. The intent is to provide a reasonable safety buffer around the operational volume that gives the operator time to implement emergency procedures before the RPA reaches higher risk locations. The emergency procedures could include contacting other users to warn them of the approaching RPA, as well as flight termination assuming that it is shown to have sufficient independence from the primary C2 link.

(4) Alternatively, for some specific operations it may be desirable to calculate the time required to reach the nearest high risk airspace and use this time as a maximum limit when developing Emergency Procedures.

(5) Refer to Appendix A for a demonstration of the application of Adjacent Areas / Airspaces and Containment concepts based on a notional operation.

9.2 Operations not Requiring Containment Objectives

(1) The following operations are specifically excluded from the containment objectives detailed in this section:

(a) Operations performed wholly within the regulations of Part IX, Subpart 1. (VLOS, <25kgs, Basic or Advanced Operations, etc.). The requirements existing in Part IX, Subpart 1 are considered adequate to ensure safety.

(b) Operations at approved Test Ranges. It is assumed that the test range has been designed with adjacent areas/airspace in mind, and that operation there includes procedures required in the event of a fly-away.

9.3 Determination of Required Level of Containment

(1) The required level of containment is determined based on the ground risk in adjacent areas and the air risk in the adjacent airspace.

(2) **Ground risk**. Identify the highest ground risk value in the calculated adjacent area by referring to Section 6.0 and Table 1. The required level of containment based on ground risk is determined as follows:

(a) If the adjacent area maximum GRC is equal to or less than the operational volume final GRC, no additional containment requirement is necessary to address ground risk.

(b) If the adjacent area maximum GRC is one (1) or two (2) points greater than the operational volume final GRC, Low Robustness containment (Section 9.4) is required to address ground risk.

(c) If the adjacent area maximum GRC is three (3) or more points greater than the operational volume final GRC, High Robustness containment (Section 9.5) is required to address ground risk.

(3) **Air risk**. Identify the highest air risk value in the calculated adjacent airspace by referring to Section 7.0 and Figures 4 and 5. The required level of containment based on air risk is determined as follows:

(a) If the adjacent airspace maximum ARC is equal to or one class above the operational volume final ARC, no additional containment requirement is necessary to address air risk.

(b) If the adjacent airspace maximum ARC is two classes above the operational volume final ARC, Low Robustness containment (Section 9.4) is required to address air risk.

(c) If the adjacent airspace maximum ARC is ARC-d and the operational volume final ARC is ARC-a, High Robustness containment (Section 9.5) is required to address ground risk.

(4) **Required Containment Level**. The final required containment level is the greater of the two containment levels identified by the ground and air risk assessments.

9.4 Low Robustness Containment Objectives

(1) The Low Robustness Containment Objectives are:

(a) No single failure of the RPAS or any external system supporting the operation shall result in operation outside of the operational volume.

(b) Any failure of a system or subsystem whose operation is required to meet (a) shall be detectable by the operator.

(2) The supporting information that must be provided to substantiate that the RPAS meets the requirement depends on the operating weight of the aircraft, as follows:

(a) For RPA having an operating weight up to 150 kg, a declaration that the RPAS meets the requirements identified above.

(b) For RPA having an operating weight of more than 150 kg, a declaration as above accompanied by details of the system design, test approach, and testing carried out to validate that the RPAS meets the requirements.

(c) Note that for all sizes of aircraft, the design, test approach, and testing should include consideration of the effects of the following probable failures:

(i) Intermittent or degraded C2 link particularly at or around vertical obstacles or sources of EMI.

(ii) Indications, RPA response and crew procedures / actions in the event of a permanent loss of the C2 link.

(iii) Total or partial failure of the remote pilot station affecting such systems as electronic displays, video feeds, internet, manual control interfaces etc. caused by software, hardware or power failures.

(iv) Navigation system failures including degradation or total loss of GNSS, IMUs, sensors or cameras that may result in a reduction in navigation accuracy and/or a loss of available navigation modes.

(v) Flight planning failures that could result in a loss of containment (i.e. incorrect setting of waypoints / RTH function).

(3) Examples of potentially acceptable containment approaches include (note that this is not intended to be an exhaustive list):

(a) Software-based geographical limits on RPAS operational areas, such as distance or shape-based limits or no-fly zones (commonly referred to using the term “geofencing”).

(b) Flight termination systems, e.g.:

(i) Software-based return-to-home or autoland functions.

(ii) Remote kill switches.

(c) Tethering, either mechanically or as a power source disconnect.

(d) Energy limits (i.e., only carrying sufficient fuel load / battery charge / etc. to reach the edge of the operational volume in a flyaway situation).

9.5 High Robustness Containment Objectives

(1) The High Robustness Containment Objectives are:

(a) No single failure of the RPAS or any external system supporting the operation shall result in operation outside of the operational volume.

(b) The probability that the RPA leaves the operational volume due to any combination of failures of the RPAS and/or any external system supporting the operation shall be shown to be extremely remote.

Note: Quantitative probability values associated with “extremely remote” failure conditions referenced here are intended to be scaled with the kinetic energy of the RPAS as described in Appendix E.

(c) Any failure of a system or subsystem whose operation is required to meet (a) or (b) shall be detectable by the operator.

(d) Software (SW) and Airborne Electronic Hardware (AEH) whose development error(s) could directly lead to operations outside of the operational volume shall be developed to an industry standard or methodology recognized by TCCA (ref. AC 922-001 Appendix A).

(2) The supporting information that must be provided to substantiate that the RPAS meets the requirement depends on the operating weight of the aircraft and distance from people not involved in the operation, as follows:

(a) For RPA having an operating weight up to 25 kg, or RPA having an operating weight of more than 25 kg up to 150 kg and operating at least 500 ft horizontally from people not involved in the operation, a declaration that the RPAS meets the requirements identified above.

(b) For RPA having an operating weight of more than 25 kg up to 150 kg and operating less than 500 ft horizontally from people not involved in the operation, or RPA having an operating weight of more than 150 kg, a declaration as above accompanied by details of the system design, test approach, and testing carried out to validate that the RPAS meets the requirement.

(c) Note that for all sizes of aircraft, the design, test approach, and testing should include consideration of the effects of the following probable failures:

(i) Intermittent or degraded C2 link particularly at or around vertical obstacles or sources of EMI.

(ii) Indications, RPA response and crew procedures / actions in the event of a permanent loss of the C2 link.

(iii) Total or partial failure of the remote pilot station affecting such systems as electronic displays, video feeds, internet, manual control interfaces etc. caused by software, hardware or power failures.

(iv) Navigation system failures including degradation or total loss of GNSS, IMUs, sensors or cameras that may result in a reduction in navigation accuracy and/or a loss of available navigation modes.

(v) Flight planning failures that could result in a loss of containment (i.e. incorrect setting of waypoints / RTH function).

(3) Examples of acceptable containment approaches include (note that this is not intended to be an exhaustive list):

(a) Independent kill switch. To support meeting the above containment requirements, the key aspects of a kill switch design are:

(i) Independence. This requires the kill switch to be separate from the other aircraft systems, particularly those systems whose failures can be precursors to flyaways, including assessment of potential common cause and common mode failure cases.

(ii) Reliability. There are a variety of ways to substantiate reliability for such a system, but likely the simplest is to ensure that the system can be tested pre-flight and, ideally, monitored in-flight. Provided that the system is inspected and tested sufficiently regularly, the exposure time to an undetected failure can be reduced such that the reliability requirement is met. Note that using this approach requires that the inspection/testing of the containment system be integrated into the operational procedures at the appropriate locations.

(b) Tethering. A tether could also be used to address the containment requirements described above. Note that the probability of the tether failing to contain the aircraft would need to be shown to be extremely remote. Potential approaches could include either a tether with sufficient strength that the aircraft structure would be compromised prior to tether breakage, or a tether connected to the aircraft power source such that reaching the limit of the tether guaranteed a disconnection of power and flight termination.

10.0 Performance Objectives

(1) The overall intent of the RPAS ORA process is to set performance objectives for approval of an operation that are commensurate with the risk involved in conducting the operation. The performance requirements applied through the RPAS ORA process can be divided into two categories:

(a) Tactical Mitigation Performance Requirements (TMPR), which are driven purely by the air risk in the form of the ARC, and take the form of either “See and Avoid” (i.e. operations under VLOS) or may require a system which provides an alternate means of achieving the applicable airspace safety objective (i.e., operation using a Detect and Avoid (DAA) system, or multiple DAA systems); and

(b) Operational Safety Objectives (OSOs), which are driven by the overall risk as represented by the SAIL, and describe the performance requirements across a variety of elements that contribute to ensuring the overall safety of the operation.

10.1 DAA Performance Objectives

(1) As described above, the TMPR are driven by the final ARC of the proposed operation; however, VLOS operation is considered an acceptable Tactical Mitigation for collision risk for all ARC levels. When operating VLOS, the operator is advised to consider additional means to increase situational awareness with regard to air traffic operating in the vicinity of the operational volume. When operations will be conducted BVLOS, the DAA performance objectives apply as described in the remainder of this section.

(2) The DAA performance objectives are divided into an overall performance level and related robustness level which are listed in Table 3, below, along with the System Risk Ratio that was used to guide the setting of the lower level performance requirements.

Note: System Risk Ratio refers to the ability of the complete, ‘end-to-end’ DAA system to mitigate potential collisions with conflicting traffic. A potential collision, in the context of a DAA system, is a Near Midair Collision (NMAC) as defined in Section 2.3(1)(m). A lower risk ratio means more NMACs will be mitigated, e.g., a risk ratio of 0.1 indicates that out of 100 potential NMAC situations, the DAA system would mitigate 90.

Table 3 – RPAS ORA Detect and Avoid Objectives

Air Risk Class	DAA Performance Level	DAA Robustness	DAA Risk Ratio
ARC-d	High Performance	High Robustness	≤ 0.1
ARC-c	Medium Performance	Medium Robustness	≤ 0.3
ARC-b	Low Performance	Low Robustness	≤ 0.5

ARC-a	Minimal Performance	Minimal Robustness Requirement	N/A

Note: The risk ratios listed in the above table are applied equally to cooperative and non-cooperative traffic (i.e., a DAA solution that only uses a cooperative sensor such as ADS-B In will not meet the DAA Objectives in any airspace where the corresponding equipment is not mandatory for all aircraft).

(3) To clarify and ease understanding of the high-level DAA performance objectives listed in Table 3, they are broken down into five DAA functions, each of which is further described below.

(4) **Detect**. The detect function deals with the need to determine the location and/or speed of any traditional aircraft operating in the area near the RPAS operation ("intruders"). Note that the calculation of the required detection volume is a key driver of all DAA function objectives; refer to Appendix B for an example detection volume calculation.

Table 4 – DAA Detect Function Objectives

Air Risk Class	Functional Objectives
ARC-d	A system meeting RTCA SC-228 or EUROCAE WG-105 MOPS/MASPS (or similar) and installed in accordance with applicable Requirements.
ARC-c	As per ARC-b, except the detection threshold is 90% of all aircraft in the detection volume. In addition to technologies described in ARC-b, this could also include: • Use of ATC Separation Services • Active communication with ATC and other airspace users. The applicant provides an assessment of the effectiveness of the detection tools/methods chosen.
ARC-b	Everything in ARC-a, plus: The applicant provides an appropriate calculation of the required detection volume. The applicant provides a DAA Plan demonstrating means to detect approximately 70% of all aircraft in the detection volume (in absence of any failures or malfunctions). This could rely on one or more of the following: • Active or passive sensors (RADAR, EO, IR, acoustic, etc.) • Use of Low Cost ADS-B In /UAT/FLARM/Pilot Aware aircraft trackers • Use of (web-based) real time aircraft tracking services • Monitoring aeronautical radio communication (i.e. use of a scanner)
ARC-a	The applicant provides a plan including: • use of visual observer(s) for the launch / recovery area, • monitoring of local radio frequency or frequencies, • advisory radio transmissions before takeoff, at regular intervals during flight operations, and after landing, and • means of increasing conspicuity of the RPA.

Note: The detection percentages listed in the above table are applied equally to cooperative and non-cooperative traffic (i.e., a DAA solution that only uses a cooperative sensor such as ADS-B In will not meet the DAA Detect Function Objectives in any airspace where the corresponding equipment is not mandatory for all aircraft).

Note: The detection thresholds for ARC-b and ARC-c are increased from the minimum amount that would be required to meet the identified risk ratios to account for less than perfect performance of the remaining DAA functions (described below).

(5) **Decide**. The decide function describes the criteria used to determine whether any detected intruder aircraft constitute a threat or potential threat to the RPAS operation (i.e., whether any avoidance action needs to be taken).

Table 5 – DAA Decide Function Objectives

Air Risk Class	Functional Objectives
ARC-d	A system meeting RTCA SC-228 or EUROCAE WG-105 MOPS/MASPS (or similar) and installed in accordance with applicable Requirements.
ARC-c	All requirements of ARC-b and in addition: The operator provides an assessment of the human/machine interface factors that may affect the remote pilot’s ability to make a timely and appropriate decision. The operator provides an assessment of the effectiveness of the tools and methods utilized for the timely detection and avoidance of traffic. In this context timely is defined as enabling the remote pilot to decide within 5 seconds after the indication of incoming traffic is provided. The operator provides an assessment of the failure rate or availability of any tool or service the operator intends to use.
ARC-b	The operator must have a documented de-confliction scheme, in which the operator explains which tools or methods will be used for detection and what the criteria are that will be applied for the decision to avoid incoming traffic. In case the remote pilot relies on detection by someone else, the use of phraseology will have to be described as well. Examples: • The operator will initiate a rapid descent if traffic is crossing an alert boundary and operating at less than 1000ft. • The observer monitoring traffic uses the phrase: ‘DESCEND! DESCEND! DESCEND!’
ARC-a	The operator must have a documented de-confliction scheme, in which the operator explains what actions will be taken if local traffic is detected via radio monitoring.

(6) **Command**. The command function addresses the time required to communicate with the RPA when necessary to initiate an avoidance maneuver.

Table 6 – DAA Command Function Objectives

Air Risk Class	Functional Objectives
ARC-d	A system meeting RTCA SC-228 or EUROCAE WG-105 MOPS/MASPS (or similar) and installed in accordance with applicable Requirements.
ARC-c	The latency of the whole Command and Control (C2) data link, i.e. the time between the moment that the remote pilot gives the command and the airplane executes the comment shall not exceed the time allocated to it in the calculation of the detection volume. Recommendation: the latency of the whole C2 link should not exceed 3 seconds.

Table 6 – DAA Command Function Objectives

Air Risk Class	Functional Objectives
ARC-b	The latency of the whole C2 link shall not exceed the time allocated to it in the calculation of the detection volume. Recommendation: the latency of the whole C2 link should not exceed 5 seconds.
ARC-a	No minimum level of requirement. Recommendation: the latency of the whole C2 link should not exceed 8 seconds.

(7) **Execute**. The execute function includes the details of the avoidance maneuvers to be performed, accounting for the performance of the RPA.

Table 7 – DAA Execute Function Objectives

Air Risk Class	Functional Objectives
ARC-d	A system meeting RTCA SC-228 or EUROCAE WG-105 MOPS/MASPS (or similar) and installed in accordance with applicable Requirements.
ARC-c	The operator’s documented de-confliction scheme must explain the avoidance maneuver(s) to be used, and the time required for the aircraft to execute the maneuver(s) shall be accounted for in the calculation of the detection volume. Avoidance may rely on vertical and horizontal avoidance maneuvering. Where horizontal maneuvering is applied, the aircraft shall be demonstrated to have adequate performance, such as airspeed, acceleration rates, climb/descend rates and turn rates. The following are suggested minimum performance criteria: • Airspeed: ≥ 50 knots • Rate of climb/descend: ≥ 500 ft/min • Turn rate: ≥ 3 degrees per second.
ARC-b	The operator’s documented de-confliction scheme must explain the avoidance maneuver(s) to be used, and the time required for the aircraft to execute the maneuver(s) shall be accounted for in the calculation of the detection volume. RPAS descending to an altitude not higher than the nearest trees, buildings or infrastructure or ≤ 60 feet AGL is considered sufficient. The aircraft should be able to descend from its operating altitude to the ‘safe altitude’ in less than a minute.
ARC-a	The operator’s documented de-confliction scheme must explain the avoidance maneuver(s) to be used.

(8) **Feedback**. The feedback function addresses the fact that the DAA function is a continuously operating system in which data needs to be sufficiently up-to-date to make appropriate decisions with respect to avoidance.

Table 8 – DAA Feedback Function Objectives

Air Risk Class	Functional Objectives
ARC-d	A system meeting RTCA SC-228 or EUROCAE WG-105 MOPS/MASPS (or similar) and installed in accordance with applicable Requirements.

Table 8 – DAA Feedback Function Objectives

Air Risk Class	Functional Objectives
ARC-c	The information is provided to the remote pilot with a latency and update rate that support the decision criteria. The following are suggested minimum criteria: • Intruder and RPA vector data update rates: ≤ 3 seconds.
ARC-b	Where electronic means assist the remote pilot in detecting traffic, the information is provided with a latency and update rate for intruder and RPA data (e.g. position, speed, altitude, track) that support the decision criteria.
ARC-a	Feedback is anticipated to be provided by a combination of visual observer(s) and radio frequency monitoring.

(9) **Integrity and Assurance**. Integrity and assurance describe the required reliability of the DAA system and the level of evidence required to demonstrate compliance with this reliability objective as well as the performance objectives of Tables 4 through 8 above.

Table 9 – DAA System Integrity and Assurance Objectives

Air Risk Class	Integrity	Assurance
ARC-d	Probability of failure: < 1 per 100,000 Flight Hours (10^{-5} loss / FH) Note: A quantitative analysis is required.	The evidence that the DAA System and procedures will reduce the risk of collisions with manned aircraft to an acceptable level is a) reviewed and accepted by Transport Canada or b) validated by an agreed to Third Party and accepted by Transport Canada.
ARC-c	Probability of failure: < 1 per 1,000 Flight Hours (10^{-3} loss / FH) Note: This rate is commensurate with a probable failure condition. These failure conditions are anticipated to occur one or more times during the operational life of each RPAS. No quantitative analysis is required.	The operator provides evidence that the DAA System and procedures will reduce the risk of collisions with manned aircraft to an acceptable level.
ARC-b	Probability of failure: < 1 per 100 Flight Hours (10^{-2} loss / FH) Note: The requirement is considered to be met by commercially available products. No quantitative analysis is required.	The operator provides evidence that the DAA System and procedures will reduce the risk of collisions with manned aircraft to an acceptable level.
ARC-a	Probability of failure: < 1 per 100 Flight Hours (10^{-2} loss / FH) Note: The requirement is considered to be met by commercially available products. No quantitative analysis is required.	The operator's plan as described in the ARC-a DAA requirements is provided as part of their application for operational approval.

10.2 Operational Safety Objectives

(1) While the JARUS SORA suggests Operational Safety Objectives (OSO) and provides suggested robustness levels required for each SAIL level. The list of OSO and robustness levels is provided

here. The reader's attention is drawn to OSO 4, 5, 10 and 12 where the robustness levels required have been changed from what is listed in the published JARUS SORA document.

(2) Refer to Appendix C for additional guidance on each OSO and the means of compliance for each robustness level expected.

(3) For each OSO, it is expected that the applicant demonstrate how the OSO is met to the required level of robustness within their RPAS ORA document. For some OSO and low robustness levels, the demonstration may be completely contained within the RPAS ORA document. For others, an external document reference (e.g., referring to an operational procedures document) may be required.

(4) Applicants are encouraged to document their compliance with Optional OSO requirements as a means to demonstrate the overall robustness level of the operation.

Table 10 – Operational Safety Objectives

OSO Number	OSO Description	SAIL					
		I	II	III	IV	V	VI
1	Ensure the Operator is Competent and/or proven	O	L	M	H	H	H
2	RPAS is manufactured by competent and/or proven entity	O	O	L	M	H	H
3	RPAS is maintained by competent and/or proven entity	L	L	M	M	H	H
4	RPAS is developed to authority recognized design standards	O	O	M[1]	M[1]	H[1]	H
5	RPAS is designed considering system safety and reliability	O	O	M[2]	M	H	H
6	C2 link performance is appropriate for the operation	O	L	L	M	H	H
7	Inspection of the RPAS (product inspection) to ensure consistency to the CONOPS	L	L	M	M	H	H
8, 11, 14, 21[3]	Operational Procedures are defined, validated and adhered to	L	M	H	H	H	H
9, 15, 22[4]	RPAS crew is trained and current and able to control the situation	L	L	M	M	H	H

[1]For Canadian Operations, the robustness levels of OSO #4 have been increased to Medium robustness at SAIL III and IV, and High robustness at SAIL V. Refer to Appendix C for additional information.
[2] For Canadian Operations, the robustness requirement for OSO #5 at SAIL III has been increased to Medium robustness. Refer to Appendix C for additional information.
[3] Operational Safety Objectives related to procedures have been grouped together for clarity. Refer to Appendix C for additional information.
[4] Operational Safety Objectives related to training have been grouped together for clarity. Refer to Appendix C for additional information.

Table 10 – Operational Safety Objectives

OSO Number	OSO Description	SAIL					
		I	II	III	IV	V	VI
10	Safe recovery from technical issue	O[5]	O	L	M	M	H
12	The RPAS is designed to manage the deterioration of external systems supporting the RPAS operation.	O[6]	O	M	M	H	H
13	External Systems supporting the RPAS operations are adequate to the operation	L	L	M	H	H	H
16	Multi-crew coordination	L	L	M	M	H	H
17	RPAS crew is fit to operate	L	L	M	M	H	H
18	Automatic protection of the flight envelope from Human Error	O	O	M[7]	M	H	H
19	Safe recovery from human error	O	O	L	M	M	H
20	A Human Factors evaluation has been performed and the HMI found appropriate for the operation	O	L	L	M	M	H
23	Environmental conditions for safe operations defined, measurable and adhered to	L	L	M	M	H	H
24	RPAS designed and qualified for adverse environmental conditions	O	O	M	M[8]	H	H

11.0 Information management

(1) Not applicable.

12.0 Document history

(1) Not applicable.

[5] Robustness Requirements for OSO #10 were adjusted to match those of OSO #19. Refer to Appendix C for additional information.
[6] Robustness Requirements for OSO #12 were adjusted to match those of OSO #5. Refer to Appendix C for additional information.
[7] For Canadian Operations, the robustness requirement for OSO #18 at SAIL III has been increased to Medium robustness. Refer to Appendix C for additional information.
[8] For Canadian Operations, the robustness requirement for OSO #24 at SAIL IV has been decreased to Medium robustness. Refer to Appendix C for additional information.

13.0 Contact office

For more information, please contact:

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Suggestions for amendment to this document are invited, and should be submitted via the contact information above.

Document approved by

5/15/2024

X Ryan Coates

Ryan Coates
Director Remotely Piloted Aircraft Systems Task...
Signed by: Coates, Ryan

Ryan Coates
Director, Remotely Piloted Aircraft Systems Task Force
Civil Aviation
Transport Canada

APPENDIX A — RPAS ORA Example

(1) **General**. The following example uses notional data for a mission using a fixed-wing RPA in an operational environment selected specifically to demonstrate certain concepts of the RPAS ORA. The data used is not intended to be representative of any specific RPA, operator, or operational environment and should not be interpreted as such. Note that a full CONOPS has not been prepared; only the minimum set of information needed for the purposes of the example is provided below.

(a) **RPA Information**. The notional RPA has the following characteristics:

(i) wingspan of 2.8 m (9.2 ft),

(ii) Operating Weight of 22 kg,

(iii) Cruise speed of 90 km/h (48.6 kts),

(iv) Maximum speed in level flight 110 km/h (59 kts),

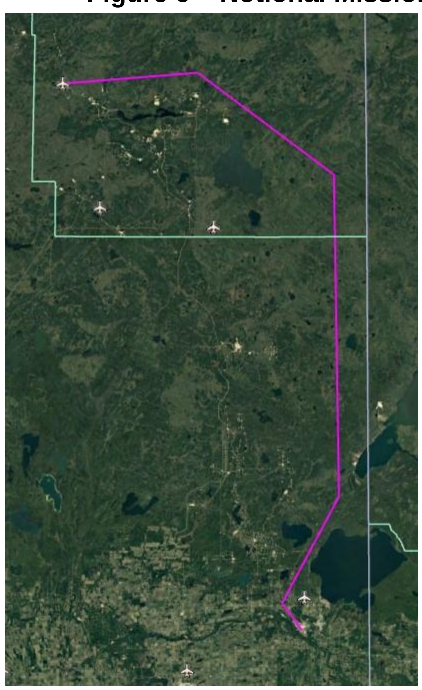
(v) Maximum operating altitude of 19,500 ft MSL, and

(vi) Maximum climb rate of 1500 ft/min.

(b) **Mission Information**. The notional mission is a point-to-point transit from Cold Lake Airport (CYOD) to Conklin (Leismer) (CET2). Planned cruising altitude is 300 ft AGL. Visual observers will be stationed at CYOD and CET2 such that takeoff and landing (and flight within approx. 1.5 km of takeoff and landing) will be conducted VLOS, with the remainder of the flight BVLOS. Refer to Figure 6, below for the planned course.

Note: For the purposes of this example, it is assumed that the operator has obtained permission from the Department of National Defence (DND) to operate from CYOD and within the Cold Lake Air Weapons Range (CYR204).

Figure 6 – Notional Mission



(2) **Definition of Operational Volume**. As described in Section 5.0, the Operational Volume needs to address Flight Geography considerations as well as Contingency Procedures. See below for examples.

(a) **Flight Geography**. The expected total system errors for the RPAS in the horizontal and vertical directions are ± 10 m and ± 30 m (100 ft) respectively. The contributors to this total system error are described below. For a conservative assessment, the flight geography is defined as ± 100 m horizontally and ± 30 m (100 ft) vertically from the planned path, illustrated as a green buffer in Figure 7.

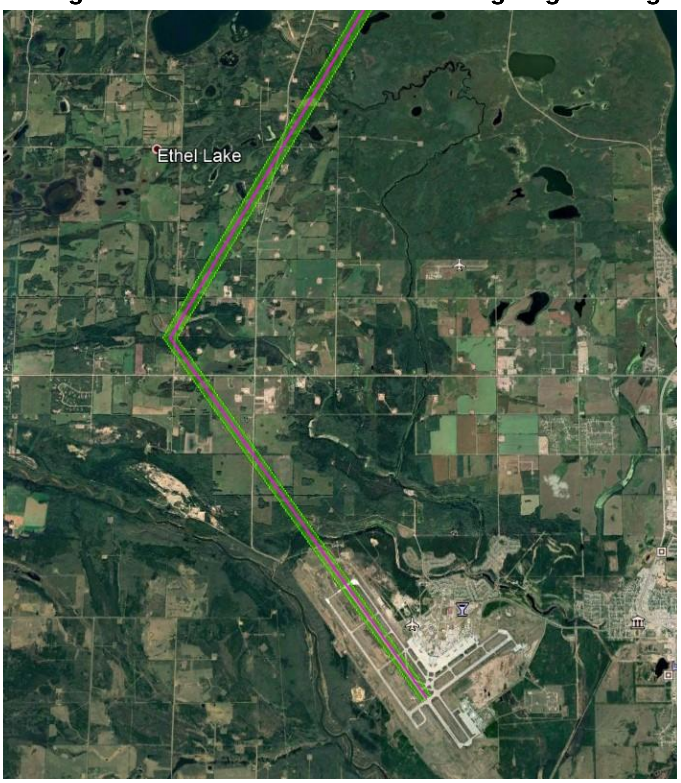
(i) **Path Definition Error**. Horizontal path definition error is expected to be negligible as the flight planning application uses a 3-dimensional projection based on the WGS-84 datum. Vertical path definition error is expected to be within ± 50 ft (15 m) as the flight planning software uses the latest available DTED data to set a vertical profile following the terrain along the planned route.

(ii) **Flight Technical Error**. Flight technical error is expected to be negligible as all path-following is performed by an autopilot and flight control system coupled to the navigation system, all located on board the aircraft. In addition, the flight planning software ensures that the planned path is within the center 50% of the performance envelope of the aircraft.

(iii) **Navigation Solution Accuracy**. The RPA navigation solution has maximum accuracies of ± 8 m horizontal and ± 10 m (33 ft) vertical.

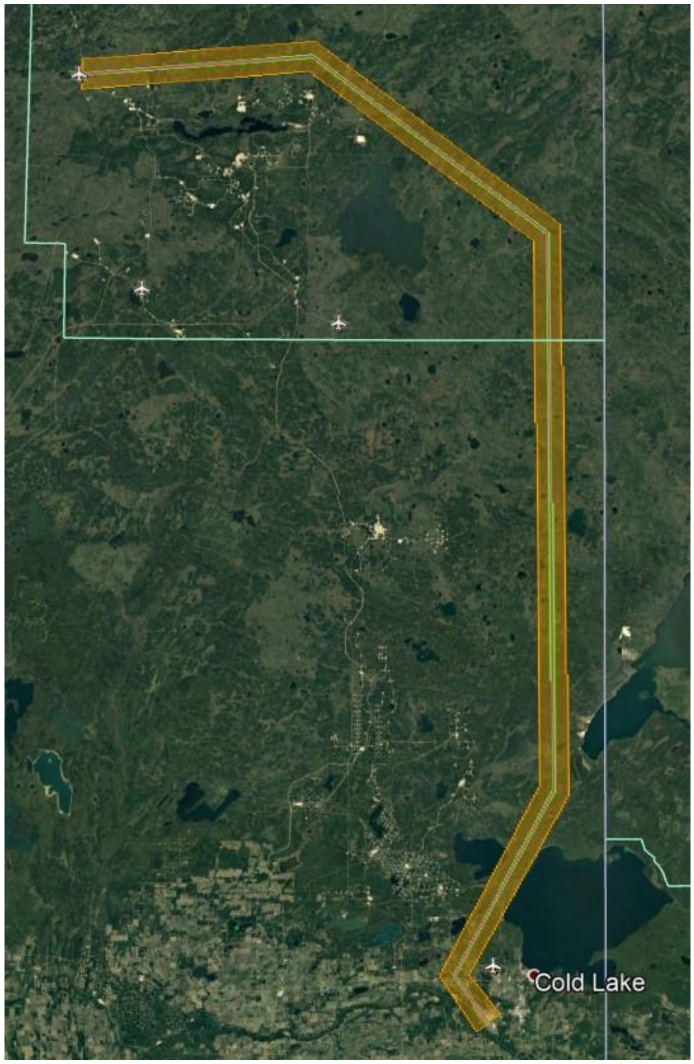
(iv) **Latencies**. Since all path-following is performed on board the aircraft, C2 link latency has no impact on the potential error sources. Latency within the navigation system, autopilot, and flight control system is negligible as these systems operate at 10 Hz or faster.

Figure 7 – Notional Mission showing Flight Geography



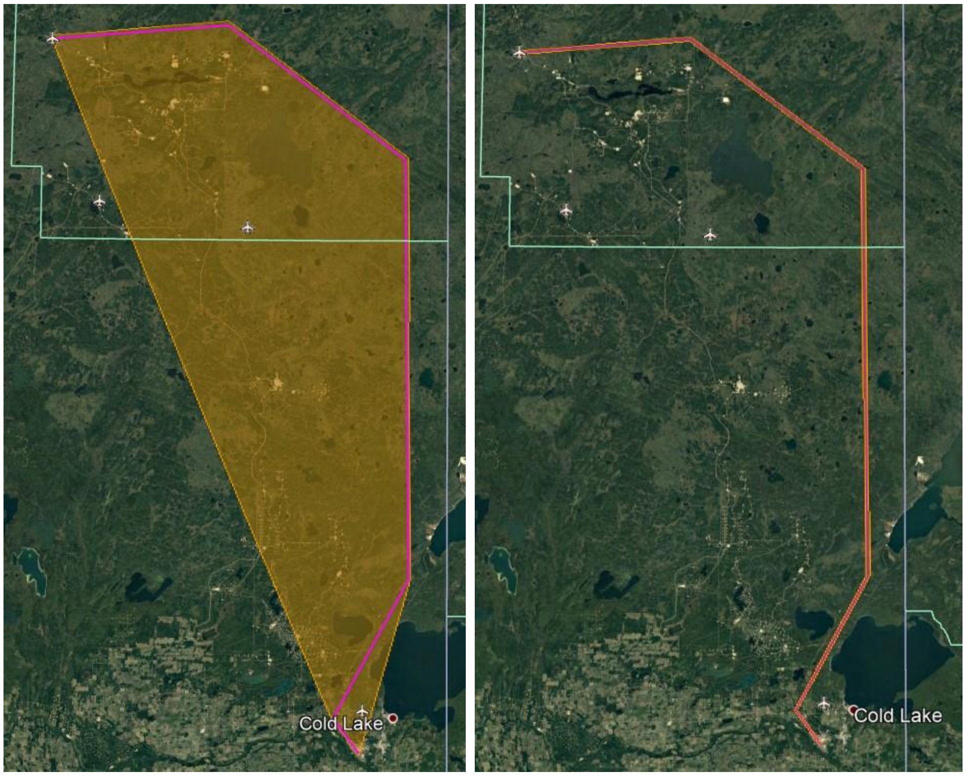
(b) **Contingency Volume**. Contingency procedures addressed in defining the Contingency Volume for this example are Loss of C2, Loss of GNSS, and IMU or Engine Failure. The final contingency volume is illustrated in Figure 8, below.

Figure 8 – Notional Mission showing Contingency Volume



(i) **Loss of C2**. Typical RPAS provide an automatic RTH functionality upon loss of C2 link. These can vary between a simple, direct return to takeoff location up to full automatic route-following to multiple conditional "home" points. To illustrate the potential effects of these implementations on the contingency volume, Figure 9, below, shows a contingency volume based on a direct return to takeoff location (left) and a contingency volume based on automatic route-following along the flight plan to either the takeoff location or the intended destination (right). For the purposes of this example, the route-following implementation will be assumed.

Figure 9 – Notional Mission showing Loss of C2 Contingencies



(ii) **Loss of GNSS**. Loss of GNSS can be addressed in a variety of ways, depending on the design of the navigation system and the capabilities of the platform. For example, a navigation system that does not rely only on GNSS for position may be able to continue as planned during such a loss, or a VTOL platform that relies fully on GNSS may be able to conduct a safe landing at or near its present position in the event of GNSS problems. For a fixed-wing platform that relies on GNSS for navigation, as assumed in this example, a likely contingency procedure is to maintain course for a short period of time (based on IMU or air data) to attempt to regain GNSS, followed by a controlled descent at minimum speed to ground impact. In such a case, the size of the contingency volume is driven by the worst-case potential horizontal drift for the time of flight following GNSS failure, worst-case crosswind, and worst-case IMU/air data positional drift. As an example, consider maintaining course for 2 minutes to attempt regaining GNSS, followed by a 500 ft/min descent (additional 36 seconds), with a worst-case crosswind of 25 kts and a worst-case IMU drift of 2 nm/hr. This results in a 1.17 nm horizontal contingency buffer around the flight geography (156 s = 0.0433 hr * 27 nm/hr = 1.17 nm).

(iii) **IMU or Engine Failure**. In the case of an IMU or engine failure, the flight control system automatically sets full vertical elevator and full left rudder to set the aircraft in a spin down to a low-energy controlled crash. This results in a 1000 ft/min descent, contained within a 200 m circle that drifts horizontally based on the wind conditions. With a worst-case crosswind drift of 25 kts, and a descent time of 18 seconds (300 ft at 1000 ft/min), the resulting horizontal contingency buffer is 0.25 nm. Since this value is smaller than the value calculated for the Loss of GNSS scenario above, the final Contingency Volume shown in Figure 8 is based on the Loss of GNSS scenario.

(3) **Application of Ground Risk**. The notional RPA with 22kg operating weight falls into the up to 25 kg category of RPA. As shown in Figure 10, below, the only areas of population density greater than 5 ppl/km^2 in proximity to the operation are near the Cold Lake airport (shown in green, blue, yellow, and orange for 5-25, 25-400, 400-1000, and 1000-4000 ppl/km^2 respectively). The cyan circles represent the location and VLOS coverage of the Visual Observers (large circles) and the GCS (small circle). Note that a second visual observer was added to cover the contingency volume over the area of higher population density nearest to the airport, allowing for a small decrease in GRC for that segment of the operation. The Ground Risk Classes across the flight can therefore be determined as shown in Table 11, below.

Figure 10 – Notional Mission showing Population Densities greater than 5 ppl/km^2

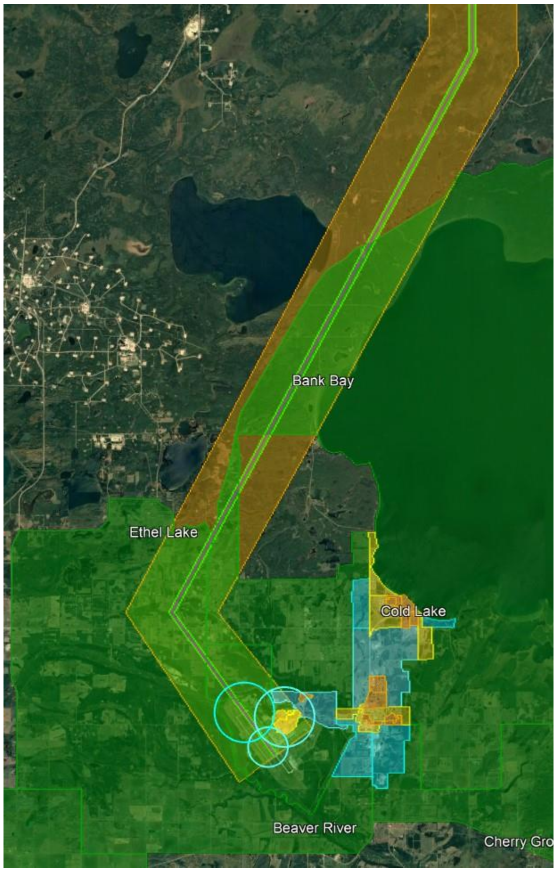


Table 11 – Example Application of Ground Risk

Flight Phase	Maximum Population Density (ppl/km^2)	Final GRC
Takeoff & Initial Climb	Above 400 up to 1000	4 (5 with -1 for VLOS)
Climb & Initial Cruise	Above 5 up to 25	3
Cruise & Initial Descent	Controlled ground area up to 5	1
Approach & Landing	Controlled ground area up to 5	1

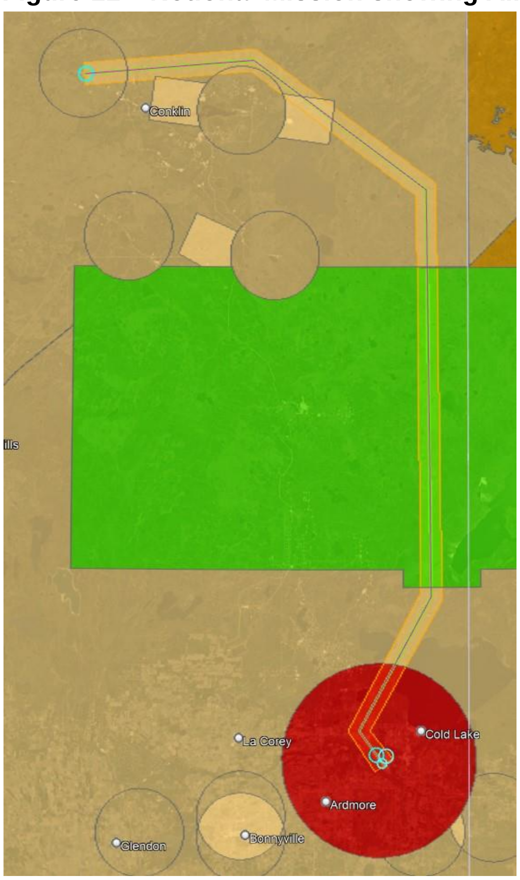
(4) **Application of Air Risk**. As illustrated in the flow chart in Figure 4, identifying the ARC of any given portion of the operation requires 5 pieces of information about that segment – whether the segment is in Atypical Airspace, the planned maximum altitude, whether the segment is in an Aerodrome environment, the class of airspace, and, if the segment is below 400 ft AGL, whether there is controlled airspace above starting at 1500 ft AGL or below. The segments of the proposed mission are illustrated in Table 12, below, and are based on creating a new segment

whenever any one of the six factors changes. Also see Figure 11, below, for an illustration of the notional mission including overlay of the relevant airspaces (light orange overlay is Class E airspace or controlled airspace above, red circle is Class D airspace, green box is CYR204).

Table 12 – Example Application of Air Risk

Flight Segment	Atypical Airspace?	Altitude	Airspace Class	In Aerodrome Environment?	Controlled airspace above?	ARC
Takeoff, Climb, & Transit out of Cold Lake Class D	No	< 400 ft AGL	D	Yes	N/A	d
From Cold Lake Class D to CYR204	No	< 400 ft AGL	G	No	Yes	c
Transit of CYR204	Yes	< 400 ft AGL	F	No	N/A	a
From CYR204 to passing Christina Lake	No	< 400 ft AGL	G	No	Yes	c
Passing Christina Lake	No	< 400 ft AGL	E	Yes	N/A	c
From Christina Lake to Conklin Class E	No	< 400 ft AGL	G	No	Yes	c
Approach & Landing	No	< 400 ft AGL	E	Yes	N/A	c

Figure 11 – Notional Mission showing Airspaces



(5) **SAIL Determination**. Based on Tables 11 and 12, the SAIL for the various mission segments can be determined as shown in Table 13, below.

Table 13 – Example SAIL Determination

<table>
<tr><th>Flight Phase (GRC)</th><th>Flight Segment (ARC)</th><th>GRC</th><th>ARC</th><th>SAIL</th></tr>
<tr><td>Takeoff & Initial Climb</td><td rowspan="3">Takeoff, Climb, & Transit out of Cold Lake Class D</td><td>4</td><td rowspan="3">d</td><td>VI</td></tr>
<tr><td>Climb & Initial Cruise</td><td>3</td><td>VI</td></tr>
<tr><td rowspan="7">Cruise & Initial Descent</td><td rowspan="7">1</td><td>VI</td></tr>
<tr><td>From Cold Lake Class D to CYR204</td><td>c</td><td>IV</td></tr>
<tr><td>Transit of CYR204</td><td>a</td><td>I</td></tr>
<tr><td>From CYR204 to passing Christina Lake</td><td>c</td><td>IV</td></tr>
<tr><td>Passing Christina Lake</td><td>c</td><td>IV</td></tr>
<tr><td>From Christina Lake to Conklin Class E</td><td>c</td><td>IV</td></tr>
<tr><td rowspan="2">Approach & Landing</td><td rowspan="2">c</td><td>IV</td></tr>
<tr><td>Approach & Landing</td><td>1</td><td>IV</td></tr>
</table>

(6) **Discussion**. The above example was selected intentionally to show a wide variation of GRC, ARC, and SAIL levels across a single mission. In such a case, the operator has a number of choices about how to address the resulting requirements.

(a) **SAIL**. As shown in Table 13, the SAIL for the notional mission varies from I in some segments to VI for the departure segment out of CYOD. One way of obtaining approval for such an operation would be to demonstrate performance at the required level to satisfy the requirements described in Section 10.0. Since the requirements for a SAIL VI operation are significantly more stringent than those of a SAIL I or IV, the operator of this mission may want to find a way to reduce the SAIL of the initial segments of the flight so that the complete operation may be conducted at SAIL IV.

(b) **ARC**. In this case, an examination of the GRC and ARC of the initial segments would show that the ARC-d airspace determination was the driver of this segment being SAIL VI, and the ARC-d determination was the result of operating in the Class D control zone of a DND aerodrome (as defined in Section 7.0). To lower this SAIL, the operator could choose to relocate the launch point of the operation to Bonnyville airport (CYBF), which is located outside of the Cold Lake Class D airspace and as a result would be ARC-c and SAIL IV.

(c) **GRC**. An additional benefit of relocating the launch point of the operation to CYBF is that this airport is not in proximity to areas of population density above 25 ppl/km^2, so the associated GRC of this segment of the operation would be reduced from 4 to 3. This would also allow the operation to be conducted with one fewer visual observer since the added observer to cover the portion of increased population density within the contingency volume would no longer be required to maintain the lower GRC.

(d) **DAA**. As the ARC of the notional mission varies across segments, so do the DAA requirements as described in Section 10.1. In this case, the most stringent requirement is for ARC-d as a result of the departure segment out of CYOD (due to the Class D CYOD control zone). Once the RPA is outside the CYOD control zone, the ARC reduces to ARC-c. To satisfy the DAA requirements for this segment, the operator could equip the aircraft with a DAA system meeting ARC-d minimum performance standards or use additional visual observers to maintain VLOS until beyond the ARC-d airspace. If an ARC-d DAA system is used, then the performance standards for the remaining segments of the flight are also met; if visual observers are used for the ARC-d segment, then the operator will need to propose a DAA solution meeting ARC-c requirements. Alternatively, as described above, the operator could choose to relocate the departure point of the mission to CYBF, which would only require an ARC-c DAA solution. The remaining segments of the mission vary between ARC-c and ARC-a, allowing some flexibility in the proposed DAA solution (e.g., a system meeting ARC-c requirements is only necessary for the segments in ARC-c airspace).

(7) **Adjacent Area / Airspace Considerations**. As described in Section 9.0, the areas and airspaces adjacent to the proposed operation must also be considered as part of the RPAS ORA process. The notional mission above is operating primarily within ARC-c airspace, so the adjacent airspace does not require the operator to meet additional containment requirements as per Section 9.3(3)(a). As per Sections 9.3(2)(b) and 9.3(2)(c), additional containment requirements would only be necessary if the operation is adjacent to areas with GRC at least 1 point greater than the final operational GRC. In this example, assuming the launch location of the mission was relocated to CYBF, the final operational GRC would be 3, which means that a GRC in the adjacent area of 4 or more would be required to necessitate low robustness containment, or 6 or more to necessitate high robustness containment. The nearest ground area to the operational volume with a population density above 25 ppl/km^2 or greater (corresponding to GRC 4) would be the outskirts of Bonnyville which are 1.35 nm (2.5 km) from CYBF. The nearest ground area to the operational volume with a population density above 1000 ppl/km^2 or greater (corresponding to GRC 6) would be the more densely populated parts of Bonnyville which are 2 nm (3.7 km) from CYBF. At maximum level flight speed (59 kts) plus worst-case tailwind (25 kts), the aircraft used could have up to 84 kts groundspeed. Therefore, it would take approximately 58 seconds for the aircraft to reach an area with 25 ppl/km^2 or more, and 85 seconds for the aircraft to reach an area with 1000 ppl/km^2 or more in a worst-case flyaway. At this point the operator has several choices for how to proceed:

(a) Increase the robustness of their operation to meet the safety objectives for a GRC of 4 or 6. For GRC 4, no SAIL increase would result, while for GRC 6 this would require an increase the SAIL of the whole operation to V.

(b) Prepare an emergency procedure for dealing with fly-away situations that takes less than 57 seconds to complete. In this case the operator would not be required to meet additional containment requirements.

(c) Prepare an emergency procedure for dealing with fly-away situations that takes less than 85 seconds to complete. In this case the operator would only need to meet the “Low Robustness” Containment Objectives as described in Section 9.4(1).

(d) Meet the “High Robustness” Containment Objectives as described in Section 9.5(1).

(8) **Sample Format for OSO Substantiation**. In order to simplify the process of substantiating and reviewing content related to each OSO, the following format is provided as a sample means of organizing such data. Note that the full details of the OSO substantiation can be provided in the table, or the substantiation can take the form of a reference to the specific content in another document (e.g., an operations manual or flight manual).

Note: For the purposes of this example, it is assumed that operational changes would be made such that the operation could be conducted at SAIL IV. Therefore, the below sample table provides the SAIL IV robustness levels. The appropriate robustness levels for the specific operation should be substituted in when using the sample format.

Table 14 – Sample Format for OSO Substantiation

OSO Number	OSO Description	SAIL	Substantiation of Robustness
		IV	
1	Ensure the Operator is Competent and/or proven	H	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
2	RPAS is manufactured by competent and/or proven entity	M	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
3	RPAS is maintained by competent and/or proven entity	M	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
4	RPAS is developed to authority recognized design standards	L	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
5	RPAS is designed considering system safety and reliability	M	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
6	C2 link performance is appropriate for the operation	M	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
7	Inspection of the RPAS (product inspection) to ensure consistency to the CONOPS	M	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
8, 11, 14, 21	Operational Procedures are defined, validated and adhered to	H	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
9, 15, 22	RPAS crew is trained and current and able to control the situation	M	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
10	Safe recovery from technical issue	M	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
12	The RPAS is designed to manage the deterioration of external systems supporting the RPAS operation.	M	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
13	External Systems supporting the RPAS operations are adequate to the operation	H	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
16	Multi-crew coordination	M	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
17	RPAS crew is fit to operate	M	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.

Table 14 – Sample Format for OSO Substantiation

OSO Number	OSO Description	SAIL	Substantiation of Robustness
		IV	
18	Automatic protection of the flight envelope from Human Error	M	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
19	Safe recovery from human error	M	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
20	A Human Factors evaluation has been performed and the HMI found appropriate for the operation	M	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
23	Environmental conditions for safe operations defined, measurable and adhered to	M	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.
24	RPAS designed and qualified for adverse environmental conditions	H	Refer to AC 903-001 Appendix C for details of OSO Robustness requirements.

APPENDIX B — Detect and Avoid Considerations

1.0 DAA Detection Volume Calculation

(1) **General**. As described in Section 2.3, the detection volume describes the 3D volume within which traditional aircraft must be detected in order for the RPAS to avoid near mid-air collisions and, if possible, remain well clear. At any given point in time, the detection volume can be thought of as a “bubble” around the position of the RPA; however, applying this “bubble” during a mission in which the RPA is not stationary generates a 3D volume representing a buffer around the flight path of the RPA (see illustration in Figure 12, below). The DAA system is not necessarily required to maintain surveillance of the entire mission volume throughout the mission, but the “bubble” around the RPA must be under surveillance at all times. The detection volume “bubble” can be defined based on:

(a) the NMAC boundary dimensions,

(b) the expected maximum closing speed of traffic (horizontal and vertical),

(c) the expected time required for the sensor to establish a track,

(d) the expected accuracy of the sensor track,

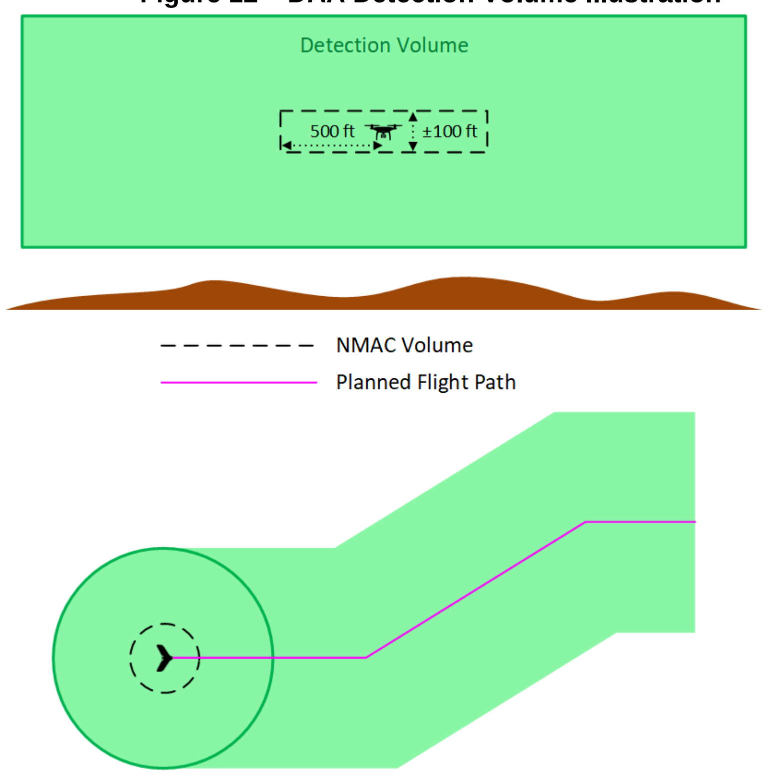
(e) the expected accuracy of the RPA position,

(f) the expected time required for the sensor operator or DAA system to detect and announce a conflict,

(g) the expected time required for the pilot or DAA system to initiate the avoidance maneuver, and

(h) the time required for the aircraft to complete the maneuver after the command is sent.

Figure 12 – DAA Detection Volume Illustration



(2) **Example**. The following example calculation uses notional values to represent RPA, DAA system, and intruder aircraft performance, based on a theoretical fixed-wing RPA, a ground-based radar sensor with a human operator, and a low-level operational environment in uncontrolled airspace. These values are not intended to be representative of any specific RPA or DAA sensor / system, and should be replaced with values appropriate for the RPA, DAA sensor / system, and operational environment under consideration when calculating the detection volume.

(a) **Horizontal Closing Rate**. The cruise speed of the notional RPA is 100 km/h, and the expected maximum closing speed of intruder aircraft is 340 km/h (based on a Cirrus SR22), for a worst-case closing rate of 440 km/h (122 m/s).

(b) **Vertical Closing Rate**. The notional RPA mission is assumed to be flown at a steady altitude, so only the maximum climb/descent rates of intruder aircraft is considered. Based on a Cirrus SR22, the worst-case climb rate is 1300 ft/min, and for the purposes of this example, the worst-case descent rate is also assumed to be 1300 ft/min.

(c) **Time-to-Track**. The maximum expected time required for the notional radar to establish a track once the intruder aircraft is within range is 6.25 seconds (the radar sweeps at 48 rpm and requires a maximum of 5 sweeps to establish a track). The track is updated once every 1.25 seconds thereafter.

(d) **Track Accuracy**. The accuracy of the notional radar is ±1° of bearing and 1% of the range scale in use. For a notional operation, range scales proposed for use are 6 nm, 12 nm, and 24 nm, leading to maximum possible errors of 776 m (1° of bearing error at 24 nm) and 445 m (1% of range error at 24 nm). These are perpendicular components, so the maximum total error in the worst-case direction is 895 m. The notional radar does not provide altitude data, so there is no consideration of vertical track accuracy.

(e) **RPA Position Accuracy**. Refer to Section 5.0(3) for discussion of RPA positioning accuracy; for the purposes of this example, it is assumed that the worst-case RPA position accuracy is ± 10 m laterally and ± 16 m (53 ft) vertically.

(f) **Conflict Assessment**. The maximum expected time required for the radar operator to detect an intruder and announce a conflict once a track is established on the display is 15 seconds.

(g) **Avoidance Initiation**. The maximum expected time required for the pilot to initiate an avoidance maneuver after notification from the radar operator is 10 seconds.

(h) **Maneuver Time**. The maximum expected time required for the aircraft to complete the avoidance maneuver is 24 seconds, consisting of up to 3 seconds for C2 link latency once the command is sent and 21 seconds for the aircraft to descend 350 ft (i.e., to 50 ft AGL) at the notional RPA's maximum descent rate of 1000 ft/min.

(i) **Detection Volume**. Based on the above assumptions, the detection volume must maintain a minimum buffer of 4.21 nm and ± 1353 ft from the current position of the RPA. See below for calculations.

(i) Horizontal Buffer:
Time Components: 6.25 s + 15 s + 10 s + 24 s = 55.25 s
Buffer based on closing rate: 55.25 s at 122 m/s closing rate = 6740 m
Worst-case intruder and RPA positional errors = 895 m + 10 m
NMAC buffer: 152 m (500 ft)
Final buffer: 7797 m = 4.21 nm

(ii) Vertical Buffer.
Time Components: 6.25 s + 15 s + 10 s + 24 s = 55.25 s
Buffer based on closing rate: 55.25 s at 1300 ft/min closing rate = 1200 ft
Worst-case RPA positional error = 16 m = 53 ft

NMAC buffer: 100 ft
Final buffer: 1353 ft

(3) **Discussion**. From the above example, there are several considerations with respect to the choice of RPA and DAA system that merit further discussion.

(a) Buffer size. It is apparent from the calculations that the time-based buffer driven by closing rate is the dominant contributor to the overall size of the “bubble” (approx. 88% of the horizontal buffer and 96% of the vertical). Since the intruder closing rates are not under the control of the RPA operator, the primary means for reducing the buffer required by the closing rate calculation is to reduce the time components in this calculation. This could be done by:

(i) selecting a sensor with a smaller time-to-track,

(ii) reducing the conflict assessment and/or avoidance initiation times through training and/or automation, and/or

(iii) reducing the maneuver time by selecting an RPA with lower C2 link latency and/or higher maneuvering performance.

(b) Ground vs. Airborne sensor. The example above was based on a ground-based sensor, which means that the full mission detection volume would ultimately extend 4.21 nm and ± 1353 ft from the RPA position at its furthest distance from the ground-based sensor. For example, if the ground-based sensor was located at the launch/recovery area, and the RPA was intended to fly up to 15 nm from the launch location, the ground based sensor would need to be capable of detecting intruder targets 19.21 nm from its location at altitudes 1353 ft above and below the RPA. An airborne sensor mounted on the RPA itself would only need to detect intruder aircraft at a distance of 4.21 nm; however, if nothing else in the example setup was adjusted, this would introduce further considerations in the detection volume calculation (e.g., latency of data transmission from the airborne sensor to the ground-based sensor operator).

2.0 DAA Detect Means of Compliance

(1) **Background.** This Section is intended to clarify the tests and validation activities that would be required when demonstrating the performance of a DAA sensor or sensors in support of a BVLOS operation using a technology-based DAA system. They are intended as a proposal of several means, but not necessarily the only means of showing that a DAA system can meet the DAA Detect performance objectives listed in Table 4.

(2) **General.** For both ARC-b and ARC-c airspace, the Detect function performance objective requires a calculation of the required detection volume and a substantiation of a detection rate within that volume. Refer to Appendix B Section 1.0 for an example of a DAA detection volume calculation. Note that, as for the top-level risk ratios, the detection rate requirement is applied equally to cooperative (transponder equipped) and non-cooperative (not transponder equipped) traffic (i.e., if the operational airspace may include non-cooperative traffic, the detection rate must be satisfied for non-cooperative traffic).
Each of the three MoCs below can be applied towards either a validation of Detect performance within a specific detection volume (e.g. demonstration of a detection volume for a specific operation), or a more generalized measurement of detect performance which can be used to identify the full spectrum of detection volumes that could be supported. For example, to validate a ground-based sensor for a linear inspection operation, it may not be necessary to collect data throughout the field of regard of the sensor; a central portion covering the detection volume required for the linear inspection may be sufficient. While a validation within a specific, operationally-driven detection volume may require less effort, it is expected that a generalized

validation approach would provide greater utility for any DAA solution that is intended to be used to support detection in more than one shape of detection volume.

The following considerations are applicable to each of the three MoCs described below:

(a) Source and accuracy of truth data: It should be self-evident that in order to quantify the performance of a system intended to detect aircraft, data recording the true intruder aircraft position and/or kinematics is required. This truth data should be obtained from a source or sources with known and verifiable accuracy (e.g., a TSO-certified GNSS or other independently calibrated and validated data source), and should be recorded at a rate sufficient for comparison to the test sensor data and compatible with the overall DAA problem space (i.e., a truth data source that provides one data point per minute is not appropriate). The truth data source(s) should also provide all appropriate data for comparison to the data from the sensor(s) being tested. For example, if the sensor being tested provides position, altitude, and velocity for intruder aircraft then a truth data source that provides position only is not sufficient for a full characterization of the sensor.

(b) System operational limitations: If any operational limitations are being imposed on the use of the sensor system (e.g., only permitting daytime operations or operations in areas free of precipitation), the performance of the system need not be validated in conditions outside of this defined operational envelope.

(3) **MoC 1: Analysis with Flight Test Validation.** This MoC is a generalized version of the type used to develop and certify traffic collision avoidance systems (TCAS) and other similar systems. It requires significant engineering capability and effort but generates the most robust and transferable dataset. A Detect performance substantiation using this MoC is expected to include, at minimum:

(a) Sensor characterization analysis / modelling: The expected performance of the sensor is analyzed and modeled computationally. This analysis / modeling can be based on first principles (e.g., RF physics for RADAR) or based on developmental test data.

(b) Detect performance simulation: The computational model of the sensor system is exercised through extensive simulation of conflicting traffic orientations & maneuvers (e.g., through use of Monte Carlo simulation with validated encounter models - note that most available encounter models were developed in support of TCAS system development and validation and may not be representative of the intended operational airspace).

(c) Detect performance validation through flight test: The real-world sensor performance is validated through flight test of a specific set of test cases. These test cases should be selected based on the modeling and simulation results to generate data in the center and at the edges of the expected performance envelope. The test data is then used to compare against and validate the simulation data.

(d) If required, the validated computational model of the sensor system is then re-analyzed / simulated for the specific operational environment, including potential effects from terrain, obstructions, weather, etc.

(e) If any effects of significance are observed in the simulation of environmental effects, additional flight tests are conducted in a representative operational environment to validate the extent of these effects.

(4) **MoC 2: Large Dataset Sensor Validation.** This MoC is expected to require somewhat less engineering capability but potentially more time and/or cost than MoC 1 (depending on the sensor type). Essentially, this MoC replaces the simulation methodology of MoC 1 with an extensive data collection effort. A Detect performance substantiation using this MoC is expected to include, at minimum:

(a) Sensor characterization study: The performance envelope of the sensor is established through the collection of a statistically significant test data set, including sufficient variety of traffic types, orientations, and maneuvers as well as any environmental effects that need to be considered (time of day, weather, terrain, etc.). Depending on the sensor type, this will likely require collection of data from multiple locations across multiple days.

(b) If required, an analysis is developed showing the expected performance of the sensor system in the specific operational environment, including potential effects from terrain, obstructions, weather, etc. This analysis is created based on the data collected in step (a).

(c) A minimum set of flight tests is conducted to validate the expected boundaries of the sensor detection performance in the actual operational environment.

(5) **MoC 3: Operationally-Specific Testing.** This MoC is expected to require the least engineering effort of the three MoCs described here; however, the results are only applicable to a single operational environment (i.e., a single location). A Detect performance substantiation using this MoC is expected to include, at minimum:

(a) In-situ sensor characterization study: The performance envelope of the sensor is established through the collection of a representative, statistically significant test data set in the actual operational environment. This test data set covers the expected variety of traffic types, orientations, and maneuvers specific to the operational environment, as well as any local effects from terrain, obstructions, weather, etc. This MoC may require less data than MoC 2 since the variety of traffic and potential environmental effects that need to be considered are reduced; however, the results may not be generalizable to another operational environment without significant additional data collection.

3.0 Visual Observer DAA

(1) **Background.** In addition to the use of a technology-based DAA system, research shows that in low-to-medium risk airspace it is possible to safely perform BVLOS operation through the use of one or more Visual Observer(s) who are not required to have direct visual contact with the RPA but must know its location and be able to scan the surrounding airspace for conflicting traffic. When conducted in accordance with the operational restrictions and performance objectives described below, BVLOS operations of this type may be considered to address the DAA performance objectives described in Section 10.1.

(2) **Operation with Visual Observer DAA.** The use of visual observers as a DAA solution for low-to-medium risk airspace is subject to a set of requirements and limitations that have been determined to provide an acceptable level of safety. These requirements and limitations are derived from research conducted by regulatory authorities, with margins of safety added in some cases to accommodate the Canadian operational environment and risk tolerance. The requirements and limitations are described in the following four categories.

(3) **Operating Environment.** The operating environment for visual observer DAA operations must meet the following criteria:

(a) Airspace: ARC-b or ARC-c airspace as defined in Section 7.0.

(b) RPA operated at or below 400’ AGL.

(c) Distance from RPA to remote pilot and control station no greater than 4 nm.

(d) Distance from RPA to nearest visual observer no greater than 2 nm.

(e) Distance from RPA to C2 link ground antenna no greater than 50% of the maximum previously demonstrated distance using the same aircraft and C2 link configuration.

(f) Meteorological conditions:

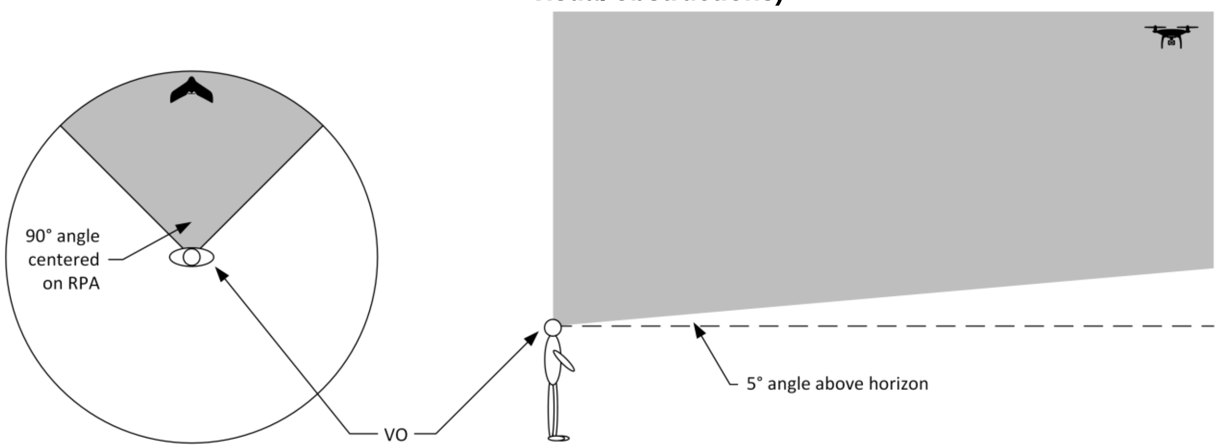
(i) visibility is not less than three miles at all visual observer location(s);

(ii) the cloud ceiling is not less than 1000 feet AGL.

(g) No visual obstructions more than 5 degrees of visual angle upwards from the horizon in the quadrant (90° of azimuth) centered on the RPA location.

Note: A simplified ‘on-site’ means to evaluate this requirement is for the visual observer to stretch out their arm, wrist flexed, palm facing forwards (i.e., looking at the backs of their fingers). The index finger is then placed along the horizon. If any obstructions are visible above the pinky finger then they are considered to be greater than 5 degrees above the horizon.

Figure 13 – Visual Observer must have a clear line of sight throughout the shaded area (no visual obstructions)



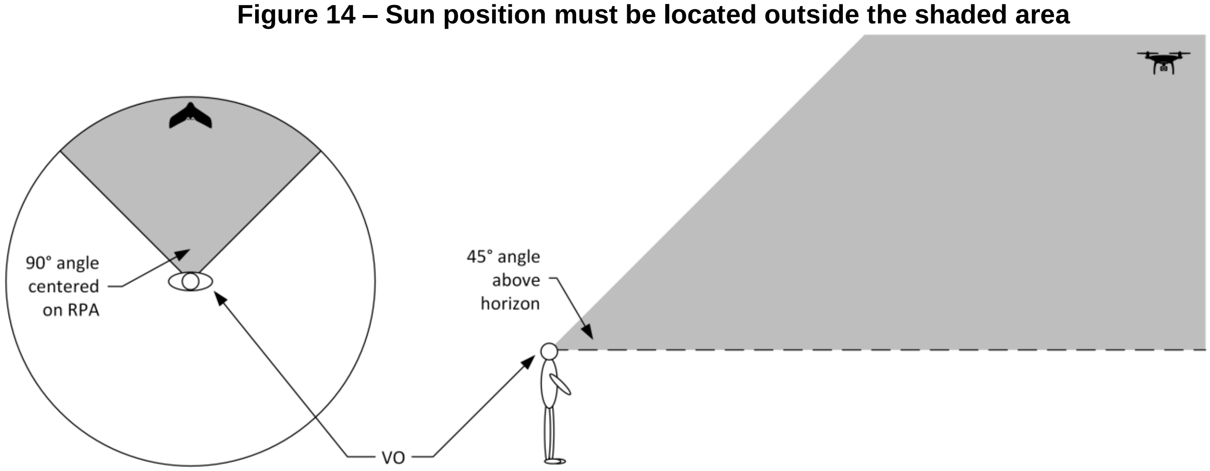
(h) Sun position is:

(i) Outside of the quadrant (90° of azimuth) centered on the RPA location; or

(ii) 45° or greater of elevation above the horizon; or

(iii) Below the horizon (i.e., night operations).

Figure 14 – Sun position must be located outside the shaded area



(i) Location of airspace observer(s) must be free of significant noise pollution (e.g., generators, farm equipment, trucks, etc.).

(4) **Equipment Requirements.** The equipment used for a visual observer DAA operation must meet the following requirements:

(a) RPAS requirements:

(i) Compliant with CAR Standard 922.04.

(ii) Equipped with high intensity flashing anti-collision lighting that:

(A) is white in colour;

(B) for night operations, is visible through NVGs;

(C) flashes at a rate of not less than 40, nor more than 100, cycles per minute;

(D) is visible in all directions within 75° above and below the horizontal plane of the aircraft, except that there may be solid angles of obstructed visibility totalling not more than 0.5 steradians[9];

(E) has a minimum intensity sufficient to be visible to a minimum of 1 nm under operational conditions.

Note: A simplified ‘on-site’ means to evaluate this requirement is for the aircraft to be flown to a distance of 1 nm at the beginning of the mission and the visibility of the lighting confirmed. If the lighting is not visible at 1 nm under operational conditions of the day, the mission cannot be completed.

(iii) C2 link latency (from issuance of command to start of execution by the aircraft) no greater than 2 seconds.

(iv) C2 link must incorporate link strength / link quality monitoring and the link strength/quality must be maintained at or above 50% of maximum throughout the mission.

(b) Other equipment requirements:

(i) The operation must have access to an Aviation-band VHF radio with transmit functionality.

(ii) The remote pilot and the visual observer(s) must have a continuously active and reliable means of communication.

(5) **Crew Qualifications.** The crew conducting a visual observer DAA operation must have the following qualifications:

(a) General qualifications (applies to both PIC and visual observers):

(i) Advanced RPA Pilot Certificate.

(ii) ROC-A.

(iii) Completion of instructor-led TP15263 ground school.

(b) Additional PIC Qualifications:

(i) Minimum of 20 hrs of VLOS operation as an RPA pilot.

(ii) Minimum of 2 hrs “simulated” BVLOS operation where the RPA is not within sight of the pilot but is within sight of one or more visual observers.

[9] The steradian is the SI unit of solid angle. One steradian is the solid angle subtended at the center of a unit sphere by a unit area on its surface. For a general sphere of radius r, any portion of its surface with area $A = r^2$ subtends one steradian at its center.

(iii) Has completed the training specific to the make and model of the RPAS being used for the operation, and has been determined to be competent.

(c) Additional Visual Observer Qualifications:

(i) Minimum of 20 hrs of VLOS operation as a visual observer, including a minimum of 2 hrs where the visual observer communicates with a remotely-located pilot.

(ii) Has completed training on the means used to identify the location of the RPA, and has been determined to be competent using this means.

(6) **Operational Procedures.** Operational procedures for use in a visual observer DAA operation must meet the following:

(a) An airspace deconfliction procedure must be in place, including, at minimum:

(i) advisory position reporting to local air traffic (ongoing during operation, i.e. at regular intervals);

(ii) decision criteria for when an avoidance maneuver is required;

(iii) standardized avoidance maneuvers that allow the operation to give way to manned traffic, up to and including safely ditching the RPA if required;

(iv) standardized phraseology to be used in the communication between the remote pilot and the visual observer(s) – including, at minimum, phraseology for communicating:

(A) the position and orientation of RPA,

(B) the position and orientation of conflicting or potentially conflicting aircraft,

(C) the requirement to conduct an avoidance maneuver,

(D) the selection of the avoidance maneuver to be used (if more than one option is described under (iii) above),

(E) an ‘all clear’ state when the operational area is clear of conflicting traffic and the RPA may continue with the mission.

(b) SOPs must also address (note the below list is not exhaustive):

(i) Safe recovery of the RPA in case of:

(ii) C2 link loss / failure;

(iii) Pilot or visual observer incapacitation;

(iv) Loss of communication between the pilot and any visual observer; or

(v) Change of operational environment conditions that place the operation outside any of the conditions listed in Appendix B Section 3.0 Paragraph (3).

4.0 Visual Observer DAA Operational Guidelines

(1) **Introduction.** This section is intended to provide additional guidance with respect to the operational aspects of the Visual Observer DAA guidance detailed in Appendix B Section 3.0, above. In particular, SFOC-RPAS applicants have identified difficulties in understanding how to comply with item (6) Operational Procedures. The following guidance provides an example of an acceptable means, but not the only means of demonstrating compliance with the expectations of Appendix B Section 3.0 item (6). It should be noted that the below guidance, as well as Appendix B Section 3.0, is primarily focused on seeing airspace and seeing incoming traditional aircraft. However, generally incoming aircraft are likely to be heard before being seen. This will trigger an

individual to look in the direction dictated by the sound and assists in visual acquisition. For this to be most effective, the VO should be in a quiet environment, and not wearing headphones or anything that will detract from their ability to hear the surrounding airspace.

(2) **Definitions.** The following definitions are used in this section:

Note: The definitions provided below are strictly for the purposes of conducting and using VO DAA as described in the remainder of this section. In the case of any conflict between these definitions and definitions from other sources (e.g., the CARs), these definitions shall be used only in the context of VO DAA.

(a) **Aircraft of Concern:** all aircraft that are below 2000 ft AGL[10] and approaching the RPA operational volume, but more than 2 NM from the RPA. They are typically identified by extended VOs, and may be also using VHF radio communications, audible, etc.

(b) **Aircraft not of Concern:** an aircraft is not of concern once communications are established, the position/altitude of both the RPA and the traditional aircraft are confirmed, and a de-conflict procedure for the RPA is completed. The de-conflict procedure for the RPA may be to hold position, descend, terminate flight, etc. Aircraft not of concern may also be within line of sight, but well outside the bubble like an airliner at altitude.

(c) **Altitude Above Ground Level (AGL):** is the absolute altitude of an aircraft above the ground at any point in feet. Note that many RPAS provide their altitude readout based on height above the takeoff point or the ground control station, and with varying terrain, AGL can change significantly in a short distance. Operational altitudes used by RPA (and referenced within this section) will be in AGL unless otherwise noted.

(d) **Altitude Above Sea Level (ASL):** is the absolute altitude of the aircraft or RPA above sea level. Pilots of traditional aircraft will reference their altitude in feet ASL, rounded to the nearest 100 ft. To operate safely, RPAS pilots should always know the altitude ASL of their RPA. For many RPAS operations, this is simply the ASL altitude of the takeoff point or ground control station, plus the altitude of the RPA. As the RPA moves, ASL will not change at a given altitude, but AGL would change with a change in topography.

(e) **De-conflict Solution:** a predetermined and documented procedure to ensure no conflict with an aircraft of concern. This is typically a descent but could be a horizontal maneuver as well. Execution of this procedure must always take less than one minute. The solution is detailed in the Company's SOP manual and is trained for and demonstrated by company operational personnel.

(f) **Evacuate Airspace - for SR BVLOS at less than 400 ft:** The predetermined "De-conflict Procedure" is to descend from altitude of <400 ft to <60 ft in less than 1 minute. This is completed BVLOS to the Pilot and may be VLOS or BVLOS to the VO.

(g) **Evacuate Airspace - for VLOS at greater than 400 ft:** The predetermined "De-conflict Procedure" of descending from the maximum altitude to <400 ft in less than 1 minute. This may be completed in BVLOS or in VLOS to the Pilot but will always be VLOS to the VO.

(h) **Descend:** a predetermined non-emergency best rate descent to a safe altitude. This requires both the RPA and the intruder aircraft to be visual.

(i) **Decision Criteria Summary**:

(i) **For SR BVLOS:** if a VO detects an intruder aircraft and the RPA is within 2NM, the "Evacuate airspace" procedure will be executed.

[10] Within this section all altitudes are Above Ground Level (AGL) unless otherwise specified.

(ii) **For VLOS >400 ft:** if a VO or pilot detects an intruder aircraft, the “Evacuate airspace” procedure will be executed.

(j) **VO DAA:** Using the procedures and equipment in Appendix B Section 3.0, to allow DAA by a means that does not depend on technology.

Note: Under the DAA definition, the detection capability is typically a technology solution. Under VO DAA, the sensing system is a crew member following a set of predetermined procedures.

(k) **Intruder Aircraft:** An aircraft that is entering into the operational volume of the VO, considered to be within 2 NM and below 2000 ft (or unknown altitude). No radio contact has been established with the aircraft.

(l) **Short Range Beyond Visual Line of Sight (SR BVLOS):** Operating BVLOS with the VO DAA Process and equipment as defined Appendix B Section 3.0. In the extreme in ideal conditions, this is 2 NM from the VO to the RPA, and 4 NM from the Pilot to the RPA.

(m) **Sector:** a geometric grid defined by two references, typically a Number and a Letter. This grid is superimposed on the Operational Volume of the intended flight and is common to all crew members of the operation. It serves as a simple means of relaying the location of the RPA and Intruder aircraft as they pertain to the Operation.

Note: Sectors can be divided by any means, and operators tend to default to 1 x 1 km blocks, which is also typically the default unit of measure for the RPA. However, it is suggested to default to 1 x 1 NM blocks, as this is the unit of measure for aviation.

(3) **Normal Operations.** The following applies describes expectations for normal operations, applicable to both SR BVLOS operations at or below 400 ft and to VLOS Operations above 400 ft:

(a) Pilot reports the RPA position (from the predetermined sectors: B4, C5, etc.) to all VOs.

(b) The VO in the applicable VO / 2 NM area looks towards the direction of the RPA.

(i) For SRBVLOS operations below 400 ft, the VO(s) within 2 NM needs to look in the direction of the RPA. The other VOs will look away from the operations as a whole, scanning 270 degrees to the outside of the operational area.

(ii) For VLOS operations >400 ft, the VO or pilot needs to keep the RPA in VLOS at all times.

(c) The pilot reports the position of the RPA as it moves from one quadrant to the next. As RPA position changes, the VOs will adjust their scanning area, towards the RPA or away/outside of the Operational Area. If the RPA is in a location within 2 NM of two VOs, both VOs are to look in the direction of the RPA.

(d) Ongoing (every 5 minutes) a crew member will make calls in the blind on the local VHF channel. These calls will detail the altitude of the RPA ASL, and relative position from a reference known to traditional aviation pilots. The person operating the VHF Radio must hold a valid Restricted Operator Certificate with Aeronautical Qualification (ROC-A). TC AIM COM 1.0 provides additional information on radiotelephony procedures.

(4) **SR BVLOS below 400 ft AGL – Decision Criteria.** The following describes the decision criteria for SR BVLOS below 400 ft AGL:

(a) If a VO who is within 2 NM of the RPA:

(i) Detects an intruder aircraft but does not see the intruder aircraft or the RPA:

(A) The VO shall command “Evacuate Airspace” to the Pilot. The Pilot shall initiate and Reply, “Descending, Descending, Descending” and call altitudes in descent. The VO shall monitor.

(B) Once the intruder aircraft has been visually identified, the VO will continue to monitor the results of the conflict solution and advise the pilot to either continue “Evacuate Airspace” or “No Conflict”.

(ii) Detects an intruder aircraft and sees both the intruder aircraft and the RPA:

(A) The VO shall assess the situation and determine whether there is a potential conflict.

(I) If no potential conflict, the VO shall monitor both aircraft and advise the pilot, “Intruder Sector XX. No Conflict. Monitoring”. The pilot shall acknowledge, the VO will continue to monitor.

(II) If there is a potential conflict, the VO shall monitor both aircraft and advise the pilot, “Intruder Sector XX. Descend”. The Pilot shall initiate and reply, “Descending” and call altitudes in descent. The VO will continue to monitor the results of the conflict solution and advise the pilot to either “Evacuate Airspace” or “No Conflict”.

(iii) Detects an intruder aircraft and sees the intruder aircraft but not the RPA:

(A) The VO shall monitor both aircraft and advise the pilot, “Intruder Sector XX. Descend”. The Pilot shall initiate and reply, “Descending” and call altitudes in descent.

(B) The VO will continue to monitor the results of the conflict solution and advise the pilot to either “Evacuate Airspace” or “No Conflict”.

(iv) Detects an intruder aircraft and sees the RPA but not the intruder aircraft:

(A) The VO shall monitor both aircraft and advise the pilot, “Intruder Sector XX. Descend”. The Pilot shall initiate and reply, “Descending” and call altitudes in descent.

(B) The VO will continue to Monitor the results of the conflict solution and advise the pilot to either “Evacuate Airspace” or “No Conflict”.

(b) If a VO who is greater than 2 NM from the RPA[11]:

(i) Detects but does not see an aircraft of concern:

(A) The VO shall monitor the approximate location and advise the pilot and other VOs, “Aircraft Sector XX. No Visual. Monitoring”. If direction of travel is noted, “Aircraft Sector XX. No Visual. Travelling East”.

(B) The pilot shall acknowledge and the VO will continue to monitor.

(ii) Sees an aircraft of concern:

(A) The VO shall monitor the aircraft and advise the pilot and other VOs, “Aircraft of Concern. Sector XX. Visual, Travelling East at 1000 ft. Monitoring”.

(B) The pilot shall acknowledge and the VO will continue to Monitor.

[11] The intention is that the VO within 2nm is looking in the direction of the RPA, the VOs beyond 2nm are looking in the opposite direction. The intention is to increase detection range.

(5) **VLOS above 400 ft AGL – Decision Criteria.** The following describes the decision criteria for VLOS operations above 400 ft AGL (i.e., at least one VO must have the RPA in sight):

(a) If a VO who is within VLOS of the RPA:

(i) Detects but does not see an intruder aircraft:

(A) The VO shall command the Pilot to “Evacuate Airspace”. The Pilot shall initiate and reply, “Descending, Descending, Descending” and call altitudes in descent. The VO shall monitor.

(B) Once the intruder aircraft has been visually identified, the VO will continue to monitor the results of the conflict solution and advise the pilot to either continue “Evacuate Airspace” or “No Conflict”.

(ii) Sees an intruder aircraft:

(A) The VO shall assess the situation and determine whether there is a potential conflict.

(I) If no conflict, the VO shall monitor both aircraft and advise the pilot, “Intruder Sector XX. No Conflict. Monitoring”. The pilot shall acknowledge and the VO will continue to monitor.

(II) If there is a potential conflict, The VO shall monitor both aircraft and advise the pilot, “Intruder Sector XX. Descend”. The Pilot shall initiate and reply, “Descending” and call altitudes in descent. The VO will continue to monitor the results of the conflict solution and advise the pilot to either “Evacuate Airspace” or “no Conflict”.

(b) If a VO who is BVLOS of the RPA[12]:

(i) Detects but does not see an aircraft of concern:

(A) The VO shall monitor the approximate location and advise the pilot and other VOs, “Aircraft Sector XX. No Visual. Monitoring”. If direction of travel is noted, “Aircraft Sector XX. No Visual. Travelling East”.

(B) The pilot shall acknowledge and the VO will continue to Monitor.

(ii) Sees an aircraft of concern:

(A) The VO shall monitor the aircraft and advise the pilot and other VOs, “Aircraft of Concern. Sector XX. Visual. Travelling East, 1000 ft. Monitoring”.

(B) The pilot shall acknowledge and the VO will continue to monitor.

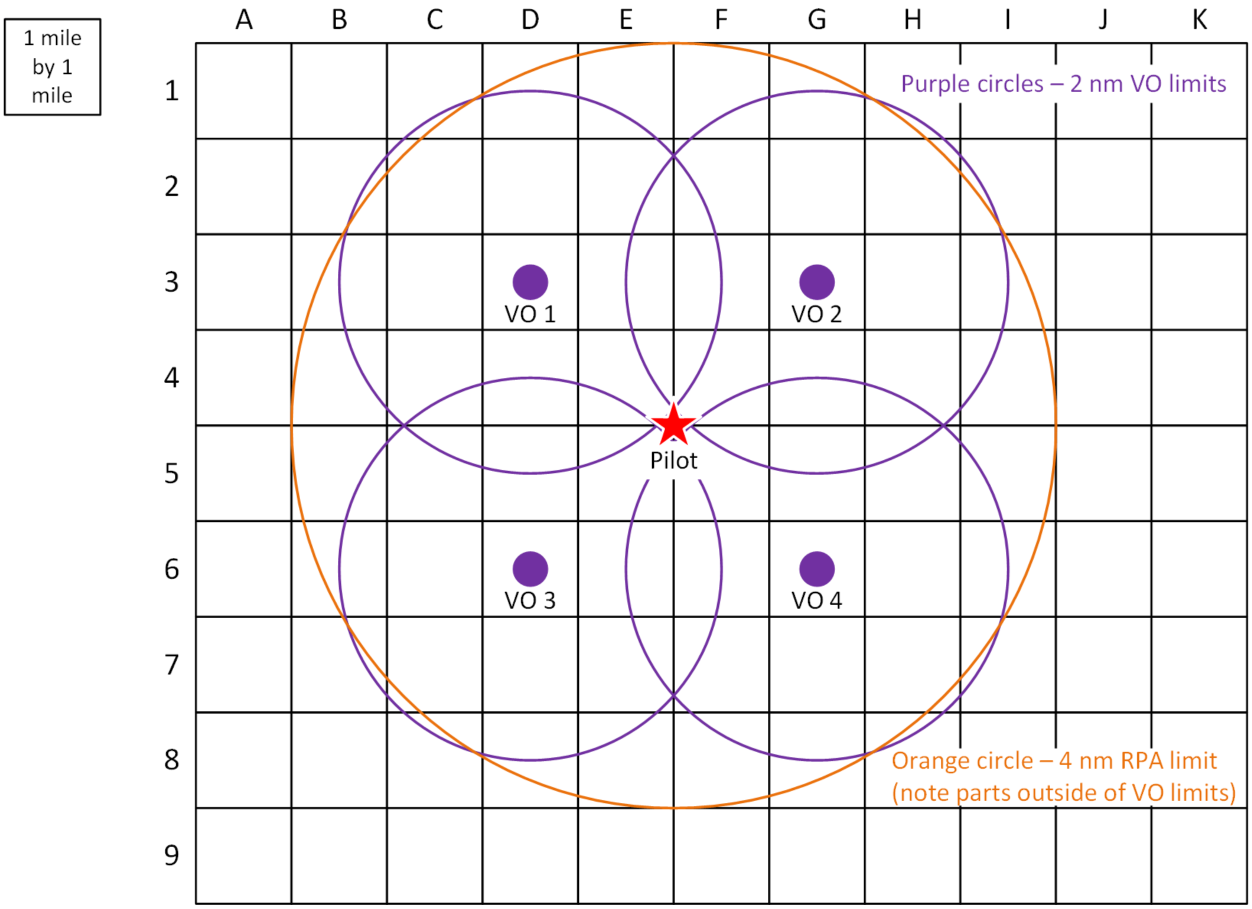
(6) **Examples.** The following examples provide a demonstration of how the above guidance is intended to be implemented.

(a) Example A – Planning. The grid is superposed over the local map and is marked at 1 x 1 NM blocks (see example in Figure 15). The operational area (the Contingency Volume) is 6 x 6 NM total (in ideal conditions, ignoring the Sun’s position, horizon, etc). VO 1, 2, 3, 4 each have a detection range of 2 NM (purple 2 NM circles). The Pilot in the middle has a 4NM max operating distance, and a very short VO range (since they are flying the RPA).

[12] The intention is that the VO within VLOS is looking towards the RPA, the VOs beyond VLOS are looking in the opposite direction. The intention is to increase detection range.

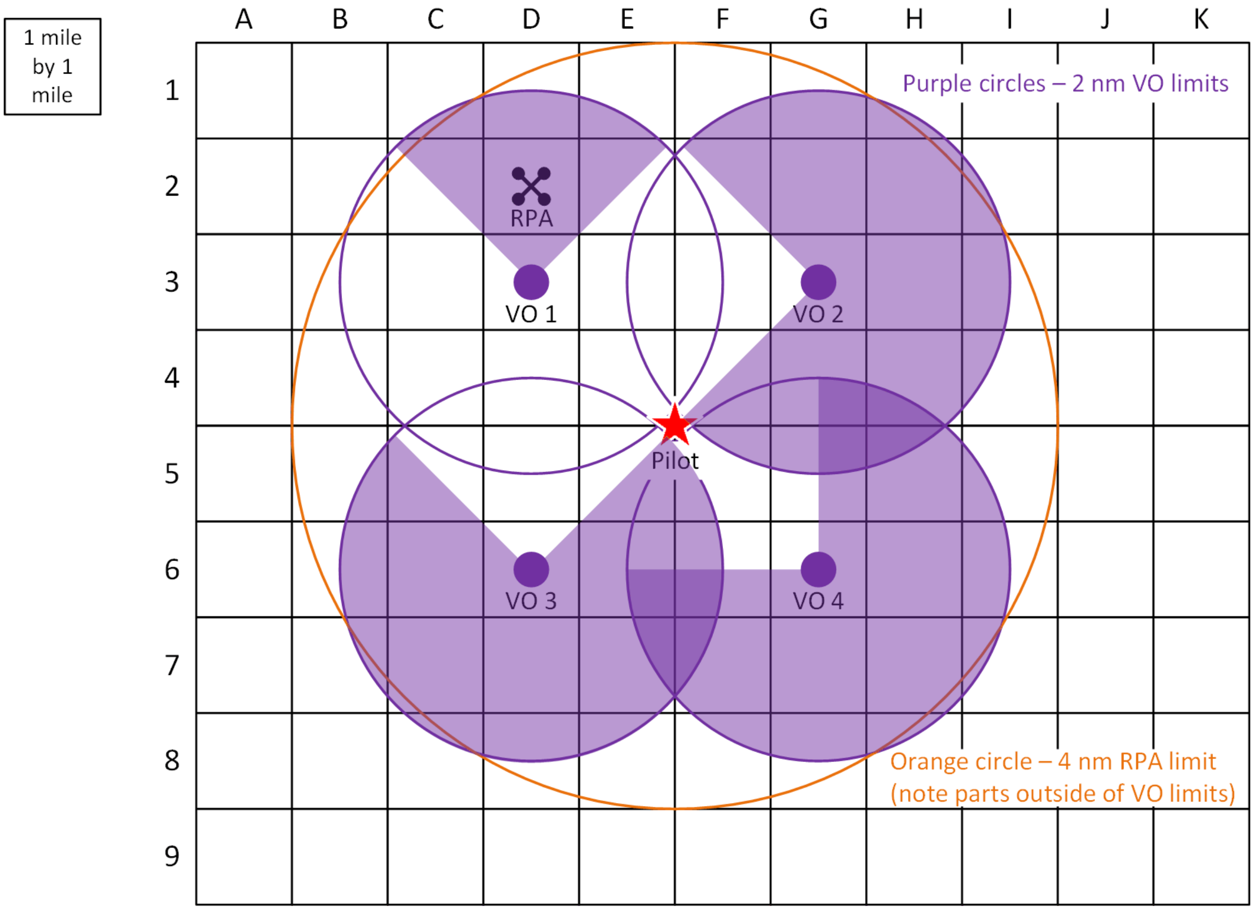
The RPA is always less than 2 NM from a VO, and less than 4 NM from the Pilot as shown.

Figure 15 – VO DAA Operational Guidance, Example A Plan



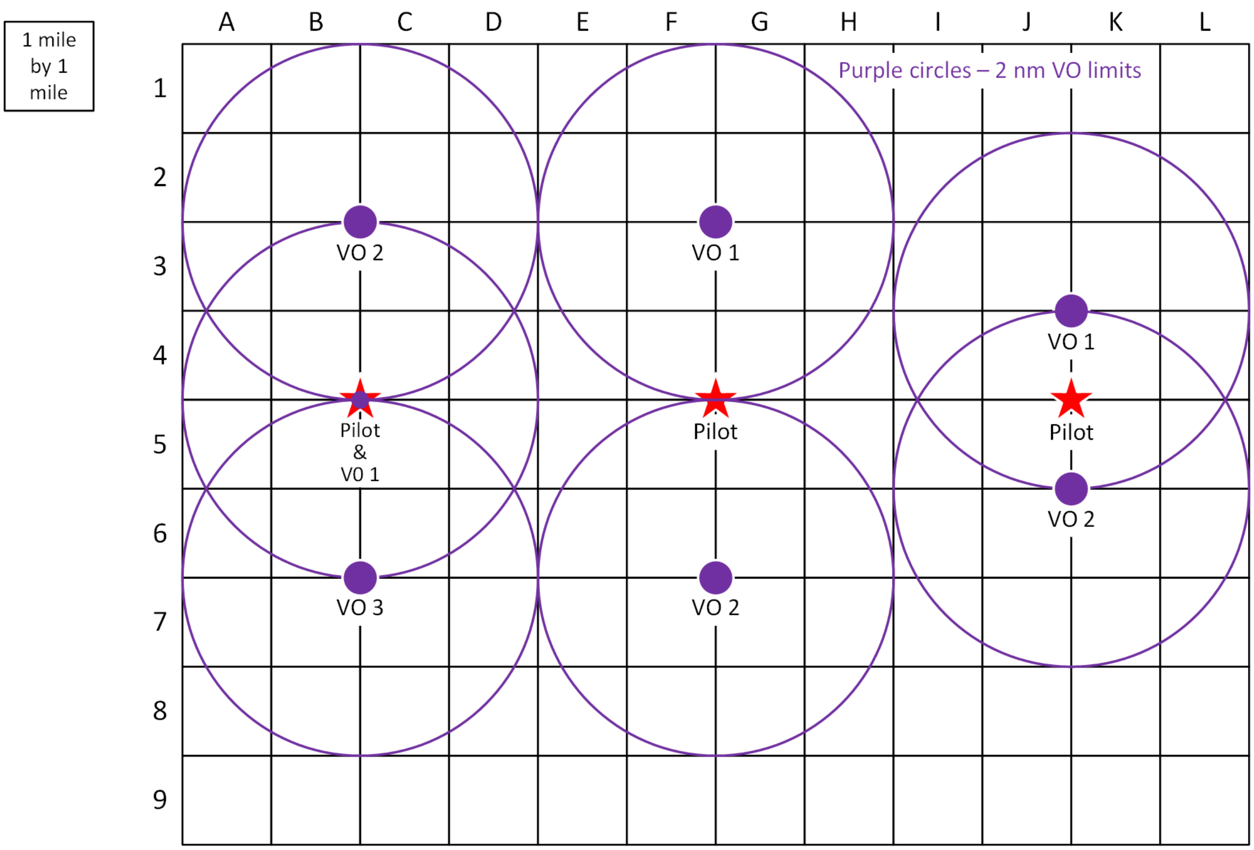
(b) Example A – Intruder Aircraft Example. The pilot reports RPA in sector 2D (black icon, see Figure 16). VO 1 looks to the direction of the RPA, shown by purple VO looking area (shaded triangle in Figure 16). VOs 2, 3, and 4 all look to the outside (shaded area of circle), with their backs to the location of the RPA, looking out and listening through 270 degrees. This model creates holes in the middle but provides the best overall detection distance. Standard operating procedure is: if VO 1 who is looking at the RPA detects an aircraft, it is assumed to be an Intruder Aircraft, Descend/Escape the airspace, while if VO 2, 3, or 4 detect an aircraft, it is an aircraft of concern, and monitor.

Figure 16 – VO DAA Operational Guidance, Example A Intruder Aircraft



(c) Example B – Planning. As shown in Figure 17, the left grid shows 3 x VOs which allows for an operational area of 3.5 NM x 6 NM and/or 1 NM x 7.8 NM. The centre grid shows 2 x VOs which provides an operational area of 8 NM by very little width (i.e., less than 300 ft). The right grid shows 2 x VOs which allows for an operational area of 2 x 5.5 NM and/or 3.5 x 4 NM. The pilot in the middle has a 4NM max operating distance and a very short VO range (since they are flying the RPA). The RPA is always less than 2 NM from a VO, and less than 4 NM from the pilot as shown. Each VO is at most 2 NM from the pilot.

Figure 17 – VO DAA Operational Guidance, Example B Plan



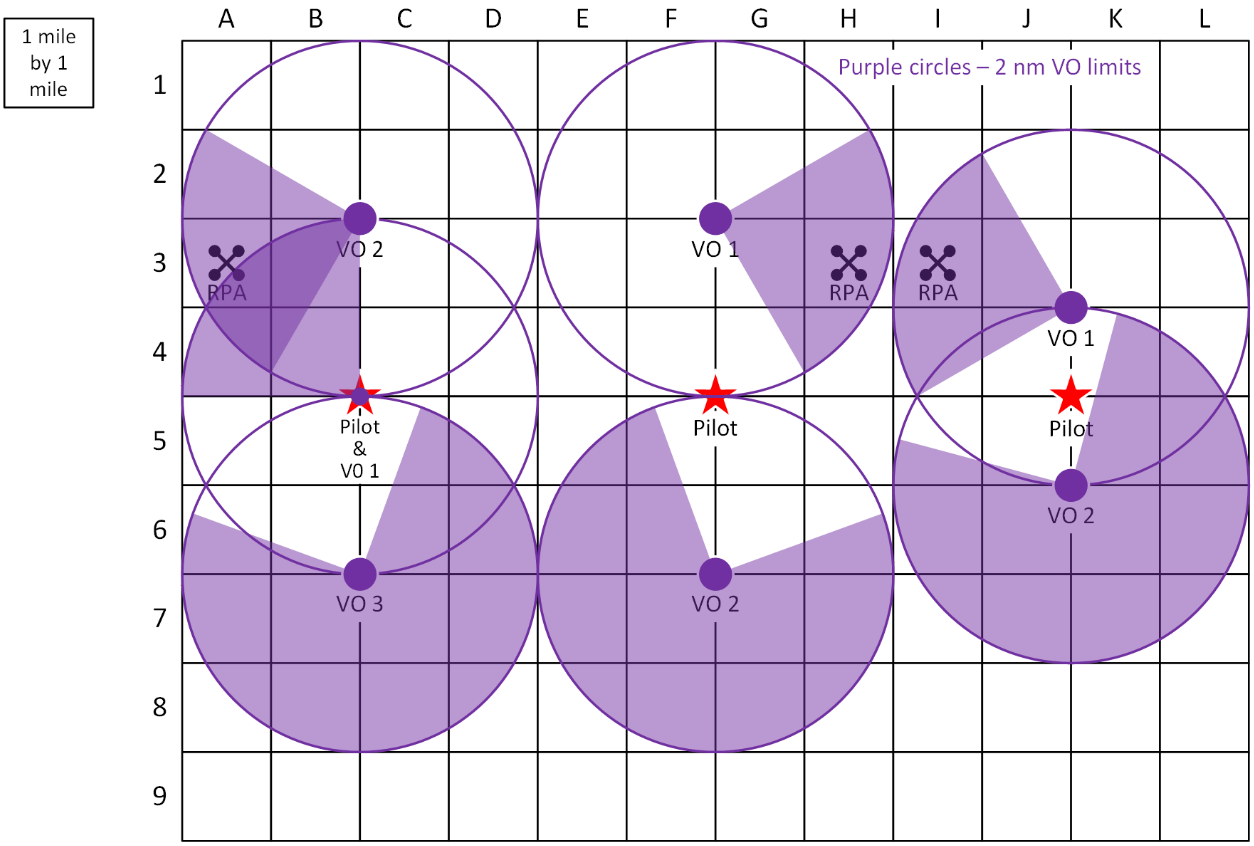
(d) Example B – Intruder Aircraft Example. Refer to Figure 18, below.

(i) Left grid: the pilot reports RPA in sector A3 (black icon). VO 1 and VO 2 look to the direction of the RPA, shown by purple VO looking areas (shaded triangle). VO 3 looks to the outside (shaded area of circle), with their back to the location of the RPA, looking out and listening through 270 degrees. Standard operating procedure is: if VO 1 or 2 who is looking at the RPA detects an aircraft, it is assumed to be an Intruder Aircraft, Descend/Escape the airspace, while if VO 3 detects an aircraft, it is an aircraft of concern, and monitor.

(ii) Centre grid: The pilot reports RPA in sector H3 (black icon). VO 1 looks to the direction of the RPA while VO 2 looks to the southwest with their back to the RPA. Standard operating procedure is: if VO 1 who is looking at the RPA detects an aircraft, it is assumed to be an Intruder Aircraft, Descend/Escape the airspace, while if VO 2 detects an aircraft, it is an aircraft of concern, and monitor.

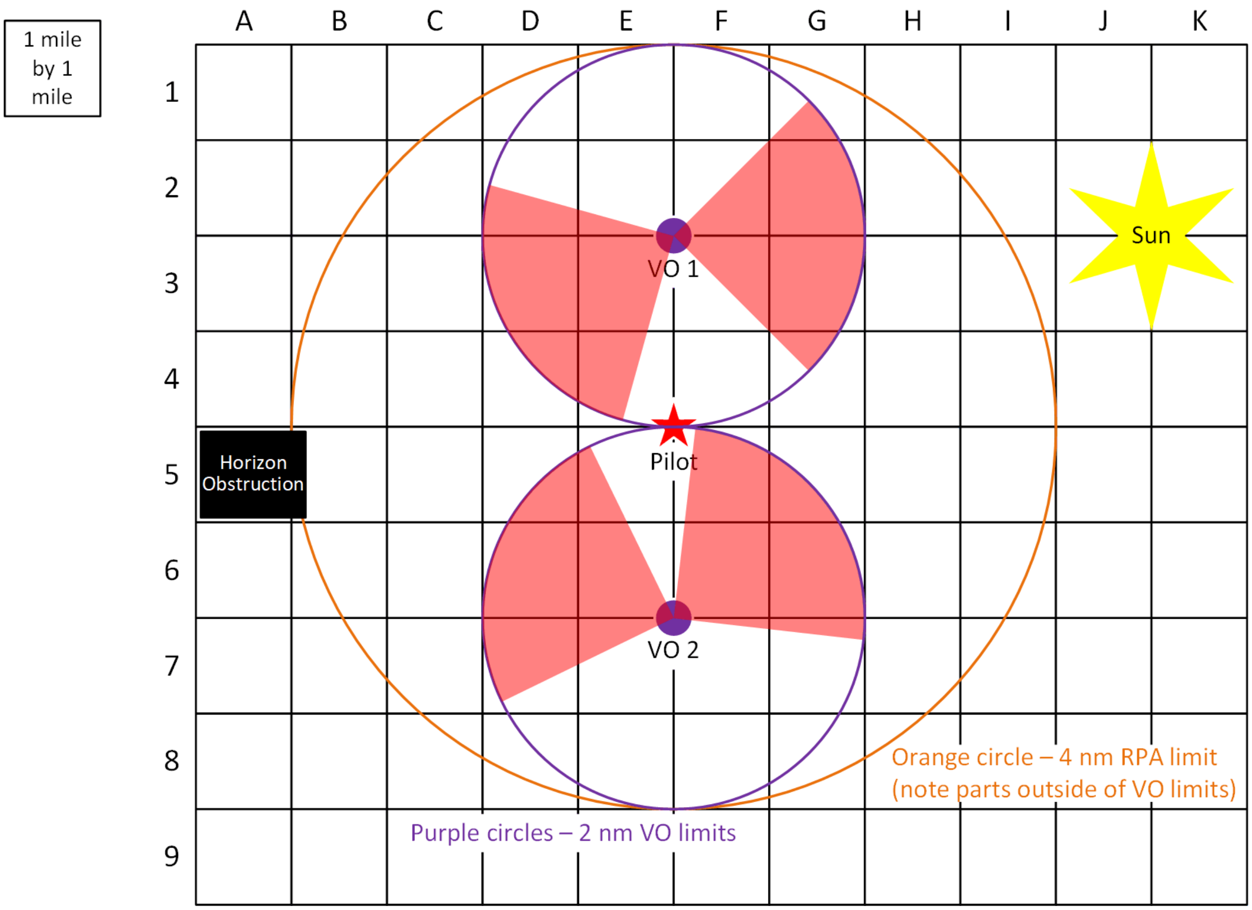
(iii) Right grid: The pilot reports RPA in sector I3 (black icon). VO 1 looks to the direction of the RPA while VO 2 looks to the southeast with their back to the RPA. Standard operating procedure is: if VO 1 who is looking at the RPA detects an aircraft, it is assumed to be an Intruder Aircraft, Descend/Escape the airspace, while if VO 2 detects an aircraft, it is an aircraft of concern, and monitor.

Figure 18 – VO DAA Operational Guidance, Example B Intruder Aircraft



(e) Example C – Planning. The operational area (the Contingency Volume) is 6 x 6 NM total, but VO Range varies from 2nm to very little (as shown in Figure 19). This is due to the position of the sun and an obstruction on the horizon. The pilot in the middle has a 4NM max operating distance, and a very short VO range (since they are flying the RPA). The red shaded areas show the portions of the VO range the RPA cannot be operated within when the restrictions of the limited VO are applied. Note that the VOs could be repositioned as needed to provide better coverage.

Figure 19 – VO DAA Operational Guidance, Example C Plan



APPENDIX C — Operational Safety Objectives

(1) Robustness

As discussed in JARUS SORA Section 1.4.2, Robustness is achieved through a combination of integrity and assurance.

Integrity is a measure of the safety gain that is provided by a risk mitigation. When evaluating Integrity, the question to be asked is “How much will the proposed mitigation improve safety?”

Assurance is an assessment of the confidence that the risk mitigation will supply the claimed integrity. Assurance comes from an assessment of the proof that the safety gain has been achieved. When evaluating assurance, the question to be asked is, “What proof is available that the proposed mitigation will deliver the expected integrity?”

(2) OSO Categories

OSOs can be divided into seven categories. Within each category the OSOs assess specific aspects of the operation. Below is a description of the OSO categories, as well as generalized questions that an applicant should ask themselves when assessing the robustness of risk mitigations.

(f) Technical Issues with the RPAS (OSO #1, 2, 3, 4, 5, 6, 7)

How robust is the operation from a technical standpoint? Think about the technical ability of the crew, the technical quality of the RPAS, and the robustness of the C2 link.

(g) Operational Procedures (OSO # 8, 11, 14, 21)

What operational procedures does the applicant have in place? Assess the quality and completeness of the procedures. Have the procedures been practiced and been shown to work?

Highlight the fact that operational procedures are so important, they’re the only OSOs that require high robustness at SAIL III.

The following procedures must exist as a minimum:

- Flight planning,
- Pre and post-flight inspections,
- Procedures to evaluate environmental conditions before and during the mission (i.e. real-time evaluation),
- Procedures to cope with adverse operating conditions (e.g. what to do in case icing is encountered during the operation, when -the operation is not approved for icing conditions)
- Normal procedures,
- Contingency procedures (to cope with abnormal situations),
- Emergency procedures (to cope with emergency situations), and-
- Occurrence reporting procedures.

(h) Crew Training (OSO #9,15, 22)

What is the quality and completeness of crew training? Is it appropriate to the operation? How does the applicant verify training and ensure currency? Does the training include the entire crew (not just the PIC).

(i) Safe Design (OSO #10, 12)

Intended to complement the technical containment safety requirements (i.e. confidence that RPA will not exit the operational volume). Question to be asked is “If my RPAS does exit my operational volume, what is the risk of a fatality?”. The applicant should demonstrate how their system design minimizes this risk.

(j) Deterioration of External Systems (OSO #13)

If the applicant is relying on an external system for part of their operation, how has the applicant prepared for a deterioration of that system? Examples would be loss of GNSS signal, loss of cell-phone network for C2 link, loss of NAV Canada coordination, etc.

(k) Human Error (OSO #16, 17, 18, 19, 20)

How has the applicant designed their operation to be tolerant to human error? Is the crew trained and do procedures include cross checks of critical items? Can the system recover from human errors? Does the applicant have procedures in place to control crew fatigue?

(l) Adverse Operating Conditions (OSO #23, 24)

Does the applicant have operational limits that respect the manufacturer declared operational limits of the RPAS? Does the RPAS have environmental qualifications that are appropriate for the intended operation?

(3) Technical Declarations

(a) Manufacturers Declarations

A declaration is required from Manufacturers that their RPAS meets applicable technical requirements including –

- Containment Objectives
- Operational Safety Objectives (OSO’s 2, 4, 5, 12, 18, 20, 24)

The applicable OSO’s, their Robustness level and Containment Objectives will be derived from the Operational Risk Assessment and associated SAIL.

(b) Modifier Declarations

A declaration is required from the modifier of an RPAS that the Operational Safety Objectives and Containment Objectives declared by the Manufacturer are still met. This should be accompanied by a description of how this was verified and compliance artifacts when requested.

Note – This declaration is not required for Manufacturer defined modifications performed in accordance with Manufacturer’s instructions.

(4) OSO Detailed Requirements

(a) Technical Issues with the RPAS

(i) OSO 1 – Ensure the operator is competent and/or proven.

(A) General Description and Comments:

The applicant is expected to demonstrate that the crew deployed to perform the operation has the knowledge, and skill required to perform the operation safely. Integrity for this OSO comes from the crew skill and accreditations and these much be consistent with the nature and level of risk for the intended operation. Assurance for this OSO comes from the method by which the applicant demonstrates crew proficiency ranging from an operator self-declaration to external operational proficiency checks (OPC) and recurrent training.

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	O	L	M	H	H	H

(ii) Integrity:

OSO 1 – Ensure the operator is competent and/or proven.		
Low	Medium	High
Operator has an appropriate organizational structure and all operational procedures in place as required under CARs Part IX and OSO #8, 11, 14, 21. RPAS Pilot(s) are qualified in accordance with TCCA IPB 2021-03[13].	Low Integrity criteria plus – Operator has a method to continuously evaluate whether the operations are being conducted according to the terms of the SFOC and to check whether the mitigations proposed as part of the SFOC application are still appropriate.	Same as Medium.

(iii) Assurance:

OSO 1 – Ensure the operator is competent and/or proven.		
Low	Medium	High
Operator self declares procedures and pilot qualifications.	TCCA Organizational Proficiency Check as described in Appendix F.	TCCA Organizational Proficiency Check as described in Appendix F.

[13] Available from the TCCA IMS website at https://tc.canada.ca/en/aviation/reference-centre/civil-aviation-integrated-management-system-ims-documents#ipbs

(ii) OSO 2 – RPAS Manufactured by competent and/or Proven Entity

(A) General Description and Comments:

This OSO is intended to evaluate the qualifications and competency of the RPAS manufacturer rather than the design of the RPAS itself. Robustness relates to the confidence that RPAS produced by the manufacturer will be of consistent quality, meet their technical specifications claimed by the manufacturer. Integrity is arrived by deliverables supplied by the manufacturer. Assurance is modulated by the conformity evidence supplied by the manufacturer, as well as review by Transport Canada (or a third party) when evaluating the manufacturer.

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	O	O	L	M	H	H

(C) Integrity:

<table>
<tr><th colspan="3">OSO 2 – RPAS Manufactured by competent and/or Proven Entity</th></tr>
<tr><th>Low</th><th>Medium</th><th>High</th></tr>
<tr><td>Manufacturer with limited history but quality assurance program and standards in place.</td><td>Low Integrity criteria plus –

Manufacturer has established manufacturing and quality processes. Where external manufacturing is used, they are subject to quality control.

Manufacturer has configuration management processes for all aspects of production.

Operating manual is provided with the system describing the system, how it can be operated as well as its limitations and intended environment.

Where a Manufacturer has defined modifications that the operator can make to the RPAS, instructions for these modifications are provided.</td><td>Medium Integrity criteria plus –

Manufacturer has appointed a person responsible for manufacture.

Manufacturer has a production control system [Note 2.1]

Manufacturer has supply chain management including supplier selection processes and verification of incoming parts and materials.

Manufacturer has procedures in place for the training of production personnel.</td></tr>
<tr><td>Notes</td><td colspan="2">[2.1] A production control system typically includes –
Documented instructions and workmanship criteria
Testing and inspection within the manufacturing process</td></tr>
</table>

	• Identification and control of non-conforming items • Tracking of products including test and inspection results, through the manufacturing process. • Manufacturing equipment requiring calibration performed at regular intervals.

(D) Assurance:

OSO 2 – RPAS Manufactured by competent and/or Proven Entity Note 2.2		
Low	Medium	High
Manufacturer uses internal standards and procedures to control RPAS production and conformity. Manufacturers Declaration that a quality assurance program is in place for the manufacture of the RPAS. Note 2.3	Low Assurance criteria plus – Product under configuration management. This can include a configuration management plan, proof of artifacts (drawings, parts list etc.) under change control. Evidence that a quality control program is in place. This can include a quality manual/plan or industry accreditation Note 2.4. A means to ensure conformity of the manufactured RPAS to the product definition. This can include production acceptance test and final inspection results on the system, first article inspection used to verify the production process. Manufacturer provided manual(s) containing operational procedures (including emergencies), maintenance procedures and limitations (including environmental and loading limits). Any allowable modifications to the RPAS defined by the Manufacturer should have associated instructions on performing them. Note 2.3	Medium Assurance criteria plus – Person responsible for manufacturing identified. Manufacturing capability a) reviewed and accepted by Transport Canada or b) validated by an agreed to Third Party and accepted by Transport Canada Capability will include - • All Medium Assurance criteria • Evidence of a production control system. This can include a manufacturing plan, representative production instructions, test and inspection criteria, representative production travellers, calibration records and any industry manufacturing accreditations. • Evidence of supply chain management. This can include supplier selection and control processes, supplier auditing and incoming inspections. • Qualifications and training records of production personnel are appropriate, current and available.

		• Evidence that the quality assurance program continues to maintain product conformity (e.g. auditing).
Notes	[2.2]Subject to review and acceptance by Transport Canada the processes and procedures referenced by the approvals listed below can meet the Assurance criteria for this OSO. • Transport Canada Civil Aviation Approved Manufacturer • Approved production/manufacturer status granted by international civil/military aviation authorities. [2.3] Refer to Section (3)Technical Declarations [2.4] No specific industry accreditation is currently required by Transport Canada for RPAS manufacturing quality control. The following is provided for guidance only. • SAE AS 9100 Quality Management Systems - Requirements For Aviation, Space And Defense Organizations • ISO 9001 Quality Management Systems	

(iii) OSO 3 - RPAS maintained by competent and/or proven entity

(A) General Description and Comments:

(B) This OSO is intended to evaluate the means by which the RPAS is maintained in an airworthy state. Integrity is arrived at by examining the source of the maintenance procedures, the skills and qualifications of the maintenance crew and the quality of the maintenance program which implements these procedures and manages the personnel. Assurance is arrived at by examining the level of maintenance documentation available, and the qualifications, experience, training and re-currency required of the maintainers.

(C) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	L	L	M	M	H	H

(D) Integrity:

OSO 3 - RPAS maintained by competent and/or proven entity		
Low	Medium	High
Operator has an internal maintenance program in place. Little or no contact with aircraft manufacturer.	Operator has an established maintenance program and maintenance procedures are sourced from RPAS manufacturer instructions. Operator has appointed a person with suitable knowledge and qualifications, responsible for overseeing RPAS maintenance. Process for keeping maintenance records in place.	Medium integrity criteria plus – External verification/review of maintenance program. Maintenance personnel have suitable knowledge and qualifications for their role. This may include AME licensing, technical diplomas/degrees in subjects relevant to RPAS, industry-recognized certification [Note 3.1] Maintenance personnel have suitable skills as well as experience specific to the RPAS being used.

(E) Assurance:

OSO 3 - RPAS maintained by competent and/or proven entity [Note 3.2]		
Low	Medium	High
Minimal maintenance procedure documentation. Maintenance team training self-declarations.	Person responsible for overseeing maintenance and persons responsible for performing maintenance identified. Documented maintenance procedures sourced from manufacturer and validated by the operator. Maintenance Personnel undergo initial training from manufacturer (where	Medium assurance criteria plus – Record of maintenance personnel qualifications. Record of personnel experience maintaining RPAS being utilized on the operation). Maintenance team subject to recurrent training. Maintenance Program assessed through a TCCA

	available) and internally to operator's organisation. Maintenance records available.	Organizational Proficiency Check as described in Appendix F.
Notes	[3.1] No specific industry-recognized certification is currently required by Transport Canada for RPAS maintenance. The following references are provided for guidance only. • ASTM F3600−22 Standard Guide for Unmanned Aircraft System (UAS) Maintenance Technician Qualification • ASTM F3376−19 Standard Guide for Core Competencies for Aviation Maintenance Personnel • Airworthiness Chapter 566 - Aircraft Maintenance Engineer (AME) Licensing and Training - Canadian Aviation Regulations (CARs) [3.2]Subject to review and acceptance by Transport Canada (as appropriate for the RPAS operation) the processes and procedures referenced by the approvals listed below may meet the Assurance criteria for this OSO. • Transport Canada Approved Maintenance Organization • Approved maintenance/repair organization status granted by international civil/military aviation authorities	

(iv) OSO 4 - RPAS developed to authority recognized design standards.

(A) General Description and Comments:

This OSO is intended to evaluate that the RPAS is designed using standards that are appropriate for the operation, and that the means of compliance against those standards are adequate for the level of risk inherent to the operation. At all robustness levels, the applicant should evaluate that the design standards for the RPAS are appropriate for their intended CONOPS to determine Integrity. Assurance is derived from the amount and type of evidence provided.

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	O	O	M	M	H	H

(C) Integrity:

OSO 4 - RPAS developed to authority recognized design standards		
Low	Medium	High
The RPAS is designed to standards that are appropriate for planned CONOPS. Compliance to the standard has been established. Note 4.1		

(D) Assurance:

OSO 4 - RPAS developed to authority recognized design standards		
Low	Medium	High
N/A	Manufacturer Declaration to appropriate design standards (e.g. Standard 922). Means of compliance to the standard identified by Manufacturer and reviewed and accepted by Transport Canada. Note 4.1, 4.2	Medium Assurance plus – Manufacturer rationale for selection of standards appropriate for CONOPS reviewed and accepted by Transport Canada Note 4.3 Compliance evidence a) reviewed and accepted by Transport Canada or b) validated by an agreed to Third Party and accepted by Transport Canada. Note 4.1
Notes	4.1 For manufacturers wanting to conduct flight testing for the purpose of collecting compliance data, a declaration that the RPAS is safe for flight when operated within the defined limitations of the flight test/evaluation program is needed. These limitations will be subject to review and acceptance by Transport Canada. 4.2 No specific design standard is currently required by Transport Canada for SFOC applications. It is up to the applicant to present a rationale showing the design standard	

	selected is appropriate for their CONOPS. The following is provided for guidance only. Design standards can be from industry, standards bodies or regulatory agencies. An abbreviated list is provided below - • Transport Canada Standard 922 • EASA Special Condition Light-UAS • JARUS Certification Specification for Light Unmanned Rotorcraft Systems (LURS) • JARUS Certification Specification for Light Unmanned Aeroplane Systems (LUAS) • ASTM F3298-19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS) • ASTM F3563-22 Design and Construction of Large Fixed Wing Unmanned Aircraft Systems • STANAG 4671, 4702 Design standards can be partially derived from traditional aviation design standards such as Canadian Airworthiness Manual Chapter 523, 523-VLA, 527 or their equivalent standards from regulatory authorities such as FAA, EASA etc. For avionics systems this can also include TSO's and corresponding MOPS. Tailoring of these aviation standards should be explained within the manufacturers rationale for standards used. For RPAS designed to a manufacturer's technical specification, this is expected to cover those areas found within published RPAS standards including flight characteristics, structure, design & construction, powerplant, equipment, crew interfaces and command & control. [4.3] Rationale should clearly show that the design standard is appropriate for the type, size, performance and intended operating environment of the RPAS.

(v) OSO 5 - RPAS is designed considering system safety and reliability

(A) General Description and Comments:

This OSO is intended to ensure that the RPAS has been designed with a level of system safety and reliability that is appropriate for the level of risk of the operation. When assessing Integrity, for all robustness levels, the safety objectives should be selected based on the kinetic energy of the aircraft (refer to Appendix E).

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	O	O	M	M	H	H

(C) Integrity:

<table>
<tr><th colspan="3">OSO 5 - RPAS is designed considering system safety and reliability</th></tr>
<tr><th>Low</th><th>Medium</th><th>High</th></tr>
<tr><td>N/A</td><td>System Safety Assessment demonstrating compliance with the system safety objectives identified in Appendix E. [Note 5.1]

No single failure within the design results in a Catastrophic failure. [Note 5.1, 5.2]

Instructions related to servicing and maintenance of the RPAS are available and a process for reporting service difficulties is in place.

Processes in place to analyse service difficulties and develop a mandatory action plan when these are due to deficiency in design.

Record of Service Difficulties and disposition/resolution maintained.</td><td>Medium Integrity plus –

Software (SW) and Airborne Electronic Hardware (AEH) whose development error(s) may cause or contribute to hazardous or catastrophic failure conditions are developed to an industry-standard or methodology.

Manufacturers design process addresses continued airworthiness of RPAS. This means developing instructions to maintain the system in a condition for safe operation including limitations, inspections, and unscheduled/scheduled maintenance to prevent failures over the course of the system’s intended service life.</td></tr>
<tr><td>Note</td><td colspan="2">[5.1]Operational limitations may be used to constrain the worst-case criticality of failures that must be considered by the system safety assessment.

[5.2]Subject to acceptance by Transport Canada, some mechanical failures may be excluded from the criterion if it can be shown that these mechanical parts are:
• Medium Integrity - Designed to aviation industry best practices.
• High Integrity – Designed and tested to the principles and intent specified in TCCA Airworthiness requirements (e.g. relevant design, construction, strength requirements from TCCA AWM 523, 527).</td></tr>
</table>

	At both Medium and High Integrity pre-flight inspection and scheduled replacement should be used to reduce potential for these mechanical failures.

(D) Assurance:

OSO 5 - RPAS is designed considering system safety and reliability		
Low	Medium	High
N/A	Manufacturer declaration against the system safety objectives (including identifying method used to determine compliance to the objectives) and maintenance and service difficulty reporting requirements.	Medium Assurance plus - Record of Service Difficulties available. System Safety Analysis a) reviewed and accepted by Transport Canada or b) validated by an agreed to Third Party and accepted by Transport Canada. Where Software (SW) and Airborne Electronic Hardware (AEH) Design Assurance is required - [Note 5.3] • Plan for design assurance identifying methodology used a) reviewed and accepted by Transport Canada or b) validated by an agreed to Third Party and accepted by Transport Canada. • Design Assurance documentation available upon request from Transport Canada.
	[5.3] No specific SW/AEH design assurance standard is currently required by Transport Canada for SFOC applications. It is up to the applicant to present a rationale showing the standard selected is appropriate for their system. The following is provided for guidance only - • RTCA DO-178C Software Considerations in Airborne Systems and Equipment Certification. • RTCA DO-254 Design Assurance Guidance for Airborne Electronic Hardware. • RTCA DO–278A Software Integrity Assurance Considerations for Communication, Navigation, Surveillance, and Air Traffic Management (CNS/ATM) Systems. • ASTM F3201 – 16 Standard Practice for Ensuring Dependability of Software Used in Unmanned Aircraft Systems (UAS). • FAA AC 20-115 Airborne Software Design Assurance. • FAA AC 20-152 Development Assurance for Airborne Electronic Hardware. *On a case-by-case basis Transport Canada may consider system level verification approaches such as outlined in FAA PS-AIR-23-09 System Level Verification of Electronic Equipment (Software and Airborne Electronic Hardware) for 14 CFR Part 23 Airplanes.*	

(vi) OSO 6 – C2 link performance is appropriate for the operation

(A) General Description and Comments:

This OSO is intended to examine the C3 link which encompasses:

- The Command and Control (C2) link, and where applicable
- Any Communication link required for the safety of the flight (e.g. VoIP to an onboard VHF radio).
    - *Note – Communication link in this context refers to operational communications transactions (voice or data) by humans.*

and verify that it is appropriate for the level of risk associated with the operation.

There is a great deal of variability in C3 links in terms of technology utilised (SATCOM, Cellular, radio line of sight), supporting architecture (ground and spaced based) and the operational environment (EMI, terrain, weather). In addition, applicants may use multiple technologies to implement the link and may tailor the operational volume to maximise link performance.

As a result of this a prescriptive set of C3 performance requirements is not currently provided for SFOC applications. It is up to the applicant to present a rationale and supporting evidence via the Assurance showing the Integrity of the C3 link selected is appropriate for the operation.

Integrity of the Command and Control (C2) link is derived by assessing the several factors associated with the link used and determining its appropriateness for the intended operation. These factors will include –

- C2 Link Reliability
    - Probability of any combination of failures which result in a loss of control of the RPA.
- C2 Link Loss Behaviour
    - Behaviour during loss of control is predictable, consistent and minimizes the probability the RPAS creates a hazard.
- C2 Link Performance
    - The link performance should support the safe operation of the RPAS. The link performance will be determined by both the technical capability of the C2 system, it’s installation (both onboard and on ground) and the environment (terrain, weather, EMI etc.) in which it is operating.
- C2 Link Performance monitoring
    - The Operator is able to monitor and determine if the link is performing such that it supports safe operation or if alternative procedures must be carried out as mitigation.

Assurance is provided via the applicant’s declaration the link integrity is appropriate for the operation. At higher SAILs Assurance may also require demonstration of link performance, the use of licensed spectrum and review by a Third Party. At all SAILs Transport Canada may request the supporting evidence the applicant used to determine link appropriateness.

Parameters that should be considered when determining link performance requirements can include:

- Transaction time – This is the maximum time an operational communication should take to be transacted. As an example, this could be the maximum time that a pilot-initiated maneuver command should take before the RPA obeys. If this time is exceeded, then operational assumptions such as following a route or staying within a volume may no longer be true. This could result in available bandwidth being a performance requirement to ensure a control message of a certain size can be sent within the transaction time.
- Latency – The time that data takes to pass through the link. This latency contributes to the transaction time.
- Continuity – Measure of whether communications are getting through within the transaction time. This could result in a minimum link latency being a performance requirement or a maximum detected error rate/minimum signal quality.
- Availability – Measure of whether the link will be available when needed. This could be based for example on minimum signal strength and quality for a mobile network or footprint of SATCOM coverage.
- Link Integrity – Measure of whether a communication transaction contains undetected errors. The performance requirement would be determining the level of undetected errors that would not impact the operation. This could be done by showing error detection in the link is sufficient to reduce possibility of undetected errors to this acceptable level.

Integrity and Assurance of any Communication Link will be assessed in a similar fashion to the C2 component in that performance, performance monitoring and reliability must be addressed. For communication involving traditional aviation (e.g. ATM) Required Communication Performance (RCP) concepts can be used to determine the Integrity needed.

The C3 link is also intrinsically tied to the OSO’s related to operational procedures –

- OSO 8, 11, 14, 21 – Operational Procedures.
- OSO 10 - Safe Recovery from Technical Issues.
- OSO 12 – The RPAS is designed to manage the deterioration of external systems supporting RPAS operation.
- OSO 13 - External services supporting RPAS operations are adequate to the operation.

The C3 link performance (e.g. transaction times, latencies etc.) determine the times take to initiate actions by the RPAS and in turn determine procedure times, operational volumes etc. additionally C3 link reliability, lost link behaviour and link monitoring will need to be accounted for in procedures. Therefore, operators should ensure C3 link performance is accounted for when these OSO's related to operational procedures are constructed.

(A) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	O	L	L	M	H	H

(B) Integrity:

OSO 6 - C3 link performance is appropriate for the operation [Note 6.2]		
Low	Medium	High
The applicant determines that – • Link Performance • Link Reliability • Lost Link behaviour are adequate to safely conduct the intended operation. The RPAS operator has the means to continually monitor the Link performance.	Low integrity criteria plus – Link has been demonstrated to be appropriate i.e. measured performance meets or exceeds the performance requirements determined for the intended operation. Evidence of demonstration available. Link design meets an applicable standard which covers Link Reliability and Lost Link behaviour (e.g. TC Standard 922).	Medium integrity criteria plus - Link performance requirements derived from Regulator or Industry Standards. Link uses a licensed Band. Where an external service provider is used as part of the Link solution (e.g. SATCOM or Telco) a Service Level Agreement containing Quality of Service and monitoring/alerting requirements is in place.
Notes	[6.1] Link performance requirements can be derived from - • Regulator or Industry standards. • Analysis using established methodologies e.g. physics based modelling of a radio line of sight link. • Live testing under operationally representative conditions e.g. demonstrating a working link and analysing parameter values to derive the performance needed. At Low Integrity the operator can use analysis or live testing to determine the performance levels needed for their operation. At Medium Integrity is expected that these performance levels will be informed by standards and guidance material specific to the technology being used. At High Integrity the performance requirements should be derived from Regulator or Industry Standards. The intent of deriving these requirements is to show the operator understands when the link is functioning with the required Integrity for the operation. It also provides the	

	parameters that would need to be monitored during each phase of the operation. In certain cases, the RPAS or link equipment manufacturer may have provided data on performance requirements, limitations on usage, and a monitoring capability. In this case the Operator can use analysis and/or demonstration (dependent on the risk level) to show the link will be suitable for the operation. The following materials and standards are provided for guidance – • Transport Canada Standard 922 (with proposed amendments for 922.09 Command and Control Link Reliability and Lost Link Behaviour) • JARUS RPAS “Required C2 Performance” (RLP) concept. • FAA TSO-C213a • RTCA DO-377 Minimum Aviation System Performance Standard for C2 Link Systems Supporting Operations of Unmanned Aircraft Systems in U.S. Airspace. • RTCA DO-362 - Command and Control (C2) Data Link Minimum Operational Performance Standard (MOPS) (Terrestrial). • GSMA Reference Method for assessing Cellular C2 Link Performance and RF Environment Characterization for UAS. • 3GPP TS 22.125 Technical Specification Group Services and System Aspects - Uncrewed Aerial System (UAS) support in 3GPP

(C) Assurance:

OSO 6 - C3 link performance is appropriate for the operation		
Low	Medium	High
Applicant self-declaration that the Link will perform adequately. This can be based on technical specifications from the manufacturer and an analysis performed that is specific to the operation. The analysis shall include applicable environmental conditions (e.g. EMI, signal coverage, terrain shadowing).	Low assurance criteria plus demonstration evidence and standards compliance evidence provided.	Demonstration evidence and standards compliance evidence a) reviewed and accepted by Transport Canada or b) validated by an agreed to Third Party and accepted by Transport Canada. Service Level Agreement details provided to Transport Canada.

(vii) OSO 7 - Inspection of RPAS (product inspection) to ensure consistency to the CONOPS

(A) General Description and Comments:

This OSO is examining the pre-flight inspections of the RPAS prior to operation. Robustness for this safety objective is arrived at entirely through Assurance. All SAIL levels require some form of pre-flight inspection to determine that the RPAS is airworthy. Increasing assurance is arrived at by investigating the source of the pre-flight procedures as well as the crew training in the use of the pre-flight procedures.

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	L	L	M	M	H	H

(C) Integrity:

OSO 7 - Inspection of RPAS (product inspection) to ensure consistency to the CONOPS		
Low	Medium	High
Integrity level is achieved through assurance level.		

(D) Assurance:

OSO 7 - Inspection of RPAS (product inspection) to ensure consistency to the CONOPS		
Low	Medium	High
Pre-flight procedure is documented. Quality of the procedure and operational implementation is self-declared by the applicant.	Pre-flight procedure uses Manufacturer recommendation as a basis. A crew training syllabus is defined.	TCCA Organizational Proficiency Check as described in Appendix F.

(viii) OSO 8, 11, 14, 21 – Operational Procedures

(A) General Description and Comments:

The Operational Procedures OSOs are each intended to examine a different aspect of the procedures associated with an operation. These are:

- OSO 8 – Ability to resolve technical issues
- OSO 14 – Ability to resolve Human Errors
- OSO 11 – Ability to manage the deterioration of external systems
- OSO 21 – Ability to manage Adverse Operating Conditions

It is expected that an operation will have the following procedures as a minimum:

- Flight planning (see note below),
- Pre and post-flight inspections,
- Procedures to evaluate environmental conditions before and during the mission (i.e. real-time evaluation),
- Procedures to cope with adverse operating conditions (e.g. what to do in case icing is encountered during the operation, when - the operation is not approved for icing conditions)
- Normal procedures,
- Contingency procedures (to cope with abnormal situations),
- Emergency procedures (to cope with emergency situations), and-
- Occurrence reporting procedures.

***Note**:* It is expected that the site survey process included in the flight planning procedure will address identifying and planning for locally-relevant features, including but not limited to:

- Local routes / features where VFR traffic would be expected (e.g., roads, rivers, railways, etc.);
- Local areas commonly used for specific purposes that may not be marked on VFR Sectional charts (e.g., Flight Training Areas, Gliding Areas);
- Other airspace users that may affect the intended RPAS operation (e.g., Crop Dusting, Model Aircraft/Rocketry Clubs); and
- Aerodromes not registered in the CFS/WAS (e.g., “flying farmer” fields or water features typically used by floatplane traffic).

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	L	M	H	H	H	H

(C) Integrity:

OSO – 8, 11, 14, 21 Operational Procedures		
Low	Medium	High
Procedures are present.	Procedures are present, have been developed based on an adequate standard.	Procedures are present, simple, and easy to use by the operator. Ease of use is a judgement call made during Operational Proficiency Check or similar evaluation.

(D) Assurance:

OSO – 8, 11, 14, 21 Operational Procedures		
Low	Medium	High
Procedures have been written by the applicant. Emergency procedures have been tested.	Procedures have been reviewed, practiced and updated where required.	TCCA Organizational Proficiency Check as described in Appendix F.

(ix) OSO 9, 15, 22 – RPAS Crew Training

(A) General Description and Comments:

For all levels, the crew shall be trained in the following topics:

- Application of operational procedures (normal, contingency and emergency procedures, flight planning, pre-flight and post-flight inspections…)
- Communication
- RPA flight path management, automation
- Leadership, teamwork and self-management
- Problem solving and decision-making
- Situational awareness
- Workload management
- Coordination and handover
- CRM

The three OSOs related to Training are intended to each focus on a different aspect of crew training:

- OSO 9 – Technical Issues
- OSO 15 – Human Error
- OSO 22 – Environmental Conditions

Robustness is attained by reviewing the quality of the training syllabus, and the crew competency.

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	L	L	M	M	H	H

(C) Integrity:

OSO 9, 15, 22 – RPAS crew Training		
Low	Medium	High
Training shall cover everything listed above and be appropriate to the intended mission. Low medium or high rating comes from the assessed quality of the training.		

(D) Assurance:

OSO 9, 15, 22 – RPAS crew Training		
Low	Medium	High
Operator Self Declaration	TCCA Organizational Proficiency Check as described in Appendix F.	TCCA Organizational Proficiency Check as described in Appendix F.

(x) OSO 10 - Safe Recovery from Technical Issues

(A) General Description and Comments:

OSO 10 examines the ability of the RPAS to recover from a technical issue. The applicant should examine their system in search of probable failures, single points of failure, and any other technical issues that are expected to arise at least once during the operational life of the RPAS. Note that this failure assessment could be linked to the system safety assessment process conducted under OSO #5. Examples of technical issues would be engine/motor failure, C2 link failure, electrical generation failure, failure of “wear-out” items, etc. When considering probable failures, information from the manufacturer should be consulted as well as any technical issues that are induced by the specific operation planned by the applicant. The consequences of each technical issue should be assessed and either procedural or technical mitigations implemented where required to maintain safety.

For this OSO, Integrity is derived from the level of standards and practices used to develop the technical or procedural mitigations. Assurance is derived from how the mitigation has been demonstrated to be effective. This OSO is not intended to require the applicant to perform their own destructive testing, however, depending on the nature of the mitigation, it may be required for the applicant to conduct their own testing to reach Medium and High Robustness levels. This would be the case if it cannot be demonstrated that the manufacturer has performed representative testing. For example if a flight termination system has been installed to mitigate technical issues resulting in a fly-away, the applicant may be required to demonstrate the operation of this system if it cannot be shown that the manufacturer has not already conducted representative tests.

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	O	O	L	M	M	H

(C) Integrity:

OSO 10 – Safe Recovery from Technical Issues		
Low	Medium	High
Systems and procedures implemented to detect and recover from technical issues are developed to industry best practices.	Systems and procedures implemented to detect and recover from technical issues are developed industry recognized standards.	

(D) Assurance:

OSO 10 – Safe Recovery from Technical Issues		
Low	Medium	High
Operator declaration for procedural mitigations, Manufacturer/modifier declaration for technical solutions.	Demonstration of recovery using operational procedures.	Operational procedures assessed through TCCA Organizational Proficiency Check as described in Appendix F. Evidence for technical systems a) reviewed and accepted by Transport Canada or b) validated by an agreed to Third Party and accepted by Transport Canada.

(xi) OSO 12 – The RPAS is designed to manage the deterioration of external systems supporting RPAS operation.

(A) General Description and Comments:

OSO 12 examines the ability of the RPAS to manage and recover from the deterioration of systems supporting the RPAS operation, but that are not directly under the control of the RPAS operator. Some examples of these systems are:

- satellite navigation systems (GNSS),
- C2 links that are operated by third parties (cell phone, internet, satellite, etc.),
- system power sources (GCS powered by the commercial power grid)
- DAA as a service

The applicant should assess their RPAS for its reliance on external systems and then assess how their RPAS would be affected by degradation and failures of those external systems. Integrity is arrived at by examining the reliability targets of the RPAS. Assurance comes from the manufacturer declaration that the reliability targets have been met. The reliability targets specified in Appendix E may be used to set the reliability level requirements for external systems.

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	O	O	M	M	H	H

(C) Integrity:

<table>
<tr><th colspan="3">OSO 12 - The RPAS is designed to manage the deterioration of external systems supporting RPAS operation</th></tr>
<tr><th>Low</th><th>Medium</th><th>High</th></tr>
<tr><td>N/A</td><td colspan="2">System Safety Assessment demonstrating compliance with the system safety objectives identified in Appendix E.
Note: Operational Limitations may be used to constrain the worst case criticality of failures that must be considered by the system safety assessment.</td></tr>
</table>

(D) Assurance:

OSO 12 - The RPAS is designed to manage the deterioration of external systems supporting RPAS operation		
Low	Medium	High
N/A	Manufacturer declaration against the reliability targets.	System Safety Analysis a) reviewed and accepted by Transport Canada or b) validated by an agreed to Third Party and accepted by Transport Canada.

(xii) OSO 13 - External services supporting RPAS operations are adequate to the operation

(A) General Description and Comments:

OSO 13 examines that any external services used by the operation meet the reliability, integrity, and availability requirements of the operation. Some examples of external systems are:

- satellite navigation systems (GNSS),
- C2 links that are operated by third parties (cell phone, internet, satellite, etc.),
- system power sources (GCS powered by the commercial power grid)
- DAA as a service

The applicant should assess the effect of a failure of each external service on their operation and consider if the level of service provided is commensurate with the hazard created by such a failure. Integrity is arrived at by plans in place to deal with external service providers and the deterioration of their services. Assurance is arrived at by service level agreements with the providers and evidence showing that the service level provided is adequate for the operation.

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	L	L	M	H	H	H

(C) Integrity:

OSO 13 - External services supporting RPAS operations are adequate to the operation		
Low	Medium	High
No interaction with external service providers	Plan in place for dealing with external service providers.	Plan in place and procedures to mitigate deterioration of external services.

(D) Assurance:

OSO 13 - External services supporting RPAS operations are adequate to the operation		
Low	Medium	High
Self-declaration from the operator stating that the external services are adequate for the operation. No interfacing procedures developed. No service level agreements in place.	The operator has evidence to support that the service(s) are adequate for the operation (i.e. Service-Level Agreement(s) in place).	Operator’s evidence that the service(s) and the service level agreement(s) are adequate for the operation a) reviewed and accepted by Transport Canada or b) validated by an agreed to Third Party and accepted by Transport Canada.

(xiii) OSO 16 – Multi-Crew Coordination

(A) General Description and Comments:

OSO 16 is intended to examine the procedures and training that the RPAS crew uses to ensure a safe operation. Integrity is assessed by examining the procedures that are in place as well as the communication channels used by the crew. Increasing integrity is also arrived at by providing Crew Resource Management (CRM) training to the operational crew as well as redundant communication links as required. Assurance is arrived at by examining the level to which the procedures have been validated and any standards used in their development. Higher levels of assurance require that the crew procedures have been operationally tested and reviewed by Transport Canada.

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	L	L	M	M	H	H

(C) Integrity:

OSO 16 – Multi-Crew Coordination		
Low	Medium	High
Procedures in place, but minimal review, and training.	Procedures have been reviewed, and practiced. Operators have minimal training in things like CRM.	Procedures in place, have been extensively practiced. Communication links include redundancy and failures are practiced.

(D) Assurance:

OSO 16 – Multi-Crew Coordination		
Low	Medium	High
Procedures developed by operator and not related to a recognized standard. Operator self declares checklists are adequate.	TCCA Organizational Proficiency Check as described in Appendix F.	TCCA Organizational Proficiency Check as described in Appendix F.

(xiv) OSO 17 – RPAS crew is Fit to Operate

(A) General Description and Comments:

This OSO is intended to evaluate how the operator certifies that the RPAS crew is fit to operate. Evaluation should include the effects of Illness, Stress, Fatigue, Alcohol and other substances, and Emotional well-being. Integrity is arrived at by the level of procedures in place to ensure crew fitness. Assurance is arrived at by the level to which the operator documents aspects of crew fitness, such as policies to enforce rest times and duty-day length.

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	L	L	M	M	H	H

(C) Integrity:

OSO 17 – RPAS crew is Fit to Operate		
Low	Medium	High
Applicant has self-declared policies on crew declaring themselves fit (including rules related to drugs and alcohol).	Rest times are declared and adequate for the operation.	Fatigue Risk Management program is in place.

(D) Assurance:

OSO 17 – RPAS crew is Fit to Operate		
Low	Medium	High
Self-Declaration of RPAS crew.	TCCA Organizational Proficiency Check as described in Appendix F.	TCCA Organizational Proficiency Check as described in Appendix F.

(xv) OSO 18 – Automatic Protection of the flight envelope from Human Error

(A) General Description and Comments:

This OSO is intended to be investigated only if –

- The RPAS in use is manually piloted where erroneous manual input could result in departure from the flight envelope, and;
- A flight envelope protection system is present.

It is not intended to mandate the installation of an Automatic Flight Envelope protection system where the flight envelope is procedurally protected (e.g. by meeting Assurance criteria for Operational and Crew Training OSO's including those related to resolving human errors).

Flight Envelope Protection is defined as any system that limits or interrupts a pilot command in order to maintain operation of the RPAS within its flight envelope. When present the flight envelope protection system is evaluated as to its capabilities to correct pilot error (Integrity) and the standards uses to develop the system (Assurance).

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	O	O	M	M	H	H

(C) Integrity:

OSO 18 – Automatic Protection of the flight envelope from Human Error		
Low	Medium	High
N/A	The RPAS flight control system incorporates automatic protection of the flight envelope to ensure the UA remains within the flight envelope or ensures a timely recovery to the designed operational flight envelope following remote pilot error(s) [Note 18.1].	
Notes	[18.1] The distinction between a Medium and a High level of robustness for this criterion is achieved through the level of assurance.	

(D) Assurance:

OSO 18 – Automatic Protection of the flight envelope from Human Error		
Low	Medium	High
N/A	Flight envelope protection system has been demonstrated to be effective and considers best practices for Human Factors Engineering [Note 18.2]. Demonstration evidence is available. [Note 18.3]	Flight Envelope protection has been developed following a design standard and means of compliance that are acceptable to Transport Canada. [Note 18.2] Compliance evidence a) reviewed and accepted by Transport Canada or b) validated by an agreed to Third Party and accepted by Transport Canada. [Note 18.1]

Notes	[18.2] No specific standard is currently required by Transport Canada. It is up to the applicant to present a rationale showing the design standard selected is appropriate for their RPAS. Design standards can be from industry, standards bodies or regulatory agencies. This OSO will overlap with OSO 4 (*RPAS developed to authority recognized design standards*) as many of the example standards provided within Note[4.2] have sections specific to controllability and stability within the flight envelope. Where such sections exist, Assurance for this OSO could be met via Assurance for OSO 4. For RPAS designed to a manufacturer's technical specification, this is expected to cover those areas found within published RPAS standards. These include determining the RPAS flight envelope and specifying the required controllability, manoeuvrability, and stability within this envelope. System Development and Human Factors standards and guidance include – • RTCA DO-178C Software Considerations in Airborne Systems and Equipment Certification • RTCA DO-254 Design Assurance Guidance for Airborne Electronic Hardware • ISO 9241-210 • MIL-STD-46855A • Aeronautical design standard performance specification handling qualities requirements for military rotorcraft ADS-33E-PRF • Display Guidance: AC23.1311-1C [18.3] Failures of the flight envelope protection should be addressed in OSO 5.

(xvi) OSO 19 – Safe Recovery from Human Error,

(A) General Description and Comments:

Applicants should show both procedural protection (normal checklist) and recovery (emergency checklist) from human error as well as technical solutions (warnings/alerts) to prevent human error where applicable. Integrity is arrived at by review of the procedures and checklists in place to determine if they use industry best practices or standards in their development. Assurance is arrived at by examining the validation of the means to recover from human error.

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	O	O	L	M	M	H

(C) Integrity:

OSO 19 – Safe Recovery from Human Error		
Low	Medium	High
Systems to detect/recover from human errors are developed to industry best practices.	Developed to industry recognized standards.	

(D) Assurance:

OSO 19 – Safe Recovery from Human Error		
Low	Medium	High
Procedures and Checklist have not been validated and technical solutions are developed to industry best practices.	Procedures and checklists are validated and technical solutions are developed to recognized industry standard.	Procedures and checklists are validated to industry standard and tested to ensure adequacy (TCCA Organizational Proficiency Check as described in Appendix F). Evidence for technical systems a) reviewed and accepted by Transport Canada or b) validated by an agreed to Third Party and accepted by Transport Canada.

(xvii) OSO 20 – A Human Factors evaluation has been performed and the HMI found appropriate for the mission

(A) General Description and Comments:

This OSO is intended to evaluate the level to which the operation has been designed with Human Factors in mind. As SAIL increases, the criticality of the Human Machine Interface to the safety of the operation also increases. For all robustness levels, integrity is attained by a review of the RPAS control interfaces to ensure that they follow human factors best practices. Assurance is attained by the level to which the review has been documented, supporting evidence provided and at higher SAIL levels validation by a Third Party.

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	O	L	L	M	M	H

(C) Integrity:

OSO 20 – A Human Factors evaluation has been performed and the HMI found appropriate for the mission		
Low	Medium	High
The RPAS information and control interfaces are clearly and succinctly presented and do not confuse, cause unreasonable fatigue, or contribute to RPAS crew error that could adversely affect the safety of the operation. Evaluation of the above should include (note that the following is not necessarily a comprehensive list): • Controls needed for crew to safely accomplish tasks are present. • Clarity, accessibility, and usability of controls. • Equipment behaviour in response to controls is predictable and unambiguous. • Crew workload in both normal and emergency situations • Efficiency of the emergency procedures • Prioritization of alarms and emergency procedures such that they adapt to criticality of the situation.		

(D) Assurance:

OSO 20 – A Human Factors evaluation has been performed and the HMI found appropriate for the mission		
Low	Medium	High
Applicant self-evaluation of RPAS HMI and declaration that user interface is adequate.	Applicant performs a Human Factors evaluation of the RPAS HMI to show the user interface is adequate. This evaluation is performed in an environment that is representative of the real-world. This can be through the use of real equipment, simulations, controlled flight	Medium Assurance plus – Human Factors evaluation a) reviewed and accepted by Transport Canada or b) validated by an agreed to Third Party and accepted by Transport Canada.

	tests etc. and should include a capability to recreate faults and issues to simulate non-standard or emergency conditions. Human Factor standards and methodologies used in performing the evaluation identified to Transport Canada. [20.1]	
Notes	[20.1] No specific Human Factors evaluation methodology or standard is currently required by Transport Canada. It is up to the applicant to select and present a rationale as to why it's applicable. This OSO will overlap with OSO 4 (*RPAS developed to authority recognized design standards*) as many of the example standards provided within Note[4.2] have sections specific to Human Machine Interfaces. Where such sections exist, Assurance for this OSO could be met by evaluations performed to demonstrate compliance to the standard. Human Factors standards and methodologies include – • Transport Canada Standard 922 (with proposed amendments for 922.11 Control Station Design) • ISO 9241-210 • MIL-STD-46855A • Aeronautical design standard performance specification handling qualities requirements for military rotorcraft ADS-33E-PRF • Display Guidance: AC23.1311-1C • FAA HFDS (HF-STD-001) • AC 25.1302-1	

(xviii) OSO 23 – Environmental conditions for safe operations defined, measurable and adhered to.

(A) General Description and Comments:

This OSO is intended to evaluate the how the operator plans to ensure that the operation remains within the environmental limitations of the RPAS system. Environmental limitations need to be tailored to the operation and the systems proposed for use (i.e. a visual DAA system may require VFR visibility limits). It is expected that the inputs to this OSO are the outputs from OSO 24. Integrity for this OSO is achieved through assurance. Assurance is derived from the examination of the means to which the operation is limited to appropriate environmental conditions.

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	L	L	M	M	H	H

(C) Integrity:

OSO 23 – Environmental conditions for safe operations defined, measurable and adhered to.		
Low	Medium	High
Integrity is achieved through assurance.		

(D) Assurance:

OSO 23 – Environmental conditions for safe operations defined, measurable and adhered to.		
Low	Medium	High
Operating Procedures with respect to environmental conditions are written by the operator and a self-declaration is made that they are adequate.	Procedures are written by operator using a recognized standard. Validation that the limits are less than or equal to the manufacturer limits has been done. Evidence that procedures are adequate is available. Training Syllabus is available	Medium plus TCCA Organizational Proficiency Check as described in Appendix F.

(xix) OSO 24 – RPAS Designed and qualified for Adverse Operating Conditions

(A) General Description and Comments:

This OSO is intended to examine the RPAS specifically to determine its qualification for intended adverse operating conditions. It is expected that the RPAS environmental qualifications will be supplied by the RPAS Manufacturer in documentation such as the Flight Manual or DDP (Declaration of Design and Performance). The environmental qualifications will show the environmental conditions the RPAS can operate under and may also indicate non-operational conditions (e.g. storage conditions or survival low temperatures). It is the responsibility of the operator to show that their specific operation is within the qualification of the RPAS.

(B) SAIL Categories:

SAIL	I	II	III	IV	V	VI
Robustness	O	O	M	M	H	H

(C) Integrity:

OSO 24 – RPAS Designed and qualified for Adverse Operating Conditions[24.2]		
Low	Medium	High
N/A	RPAS designed and tested by manufacturer for the intended environmental conditions.	Medium Integrity plus testing conducted in accordance with industry standards[24.1]
Note	[24.1] No specific testing standards are currently mandated by Transport Canada for SFOC applications. Manufacturers can propose appropriate standards (e.g. DO-160, MIL-STD 810, MIL-STD-461). [24.2] As operating conditions can include RPAS specific environments and conditions it is suggested Manufacturers be familiar with research on this. The following Transport Canada website is included as an example – https://tc.canada.ca/en/aviation/drone-safety/drone-innovation-collaboration/drone-innovation-collaboration-canada#toc1-1	

(D) Assurance:

OSO 24 – RPAS Designed and qualified for Adverse Operating Conditions		
Low	Medium	High
N/A	Manufacturers self-declaration, documentation defining environmental qualification and any associated operational limitations. Supporting evidence available showing testing conducted.	Manufacturer test plans and summary results a) reviewed and accepted by Transport Canada or b) validated by an agreed to Third Party and accepted by Transport Canada.

APPENDIX D — STANDARD SCENARIOS

1.0 Background

(1) **General**. As described in Section 3.0 (3) of AC 903-001, TCCA has created a “Canadianized” version of the JARUS SORA process as one means for conducting operational risk assessments in support of applications for SFOC – RPASs. To date, these SFOC – RPAS applications and their associated ORAs have been considered on an individual, case-by-case basis. With the increasing volume of applications for complex SFOC – RPASs, TCCA has chosen to develop a set of Standard Scenarios, in which a generic ORA is carried out by TCCA specialists to create a simplified application process for specific, commonly observed operational use cases. For each standard scenario, TCCA has developed guidance material for operators to use when submitting an SFOC – RPAS application, including information about how to assess an area, and the mitigations and procedures required to support the application. This is covered in further detail in each specific Standard Scenario (STSC) section of this Appendix. Note that for the specific scenarios addressed, these STSCs are intended to replace the full ORA process described in AC 903-001, and they should be used in their entirety without deviation.

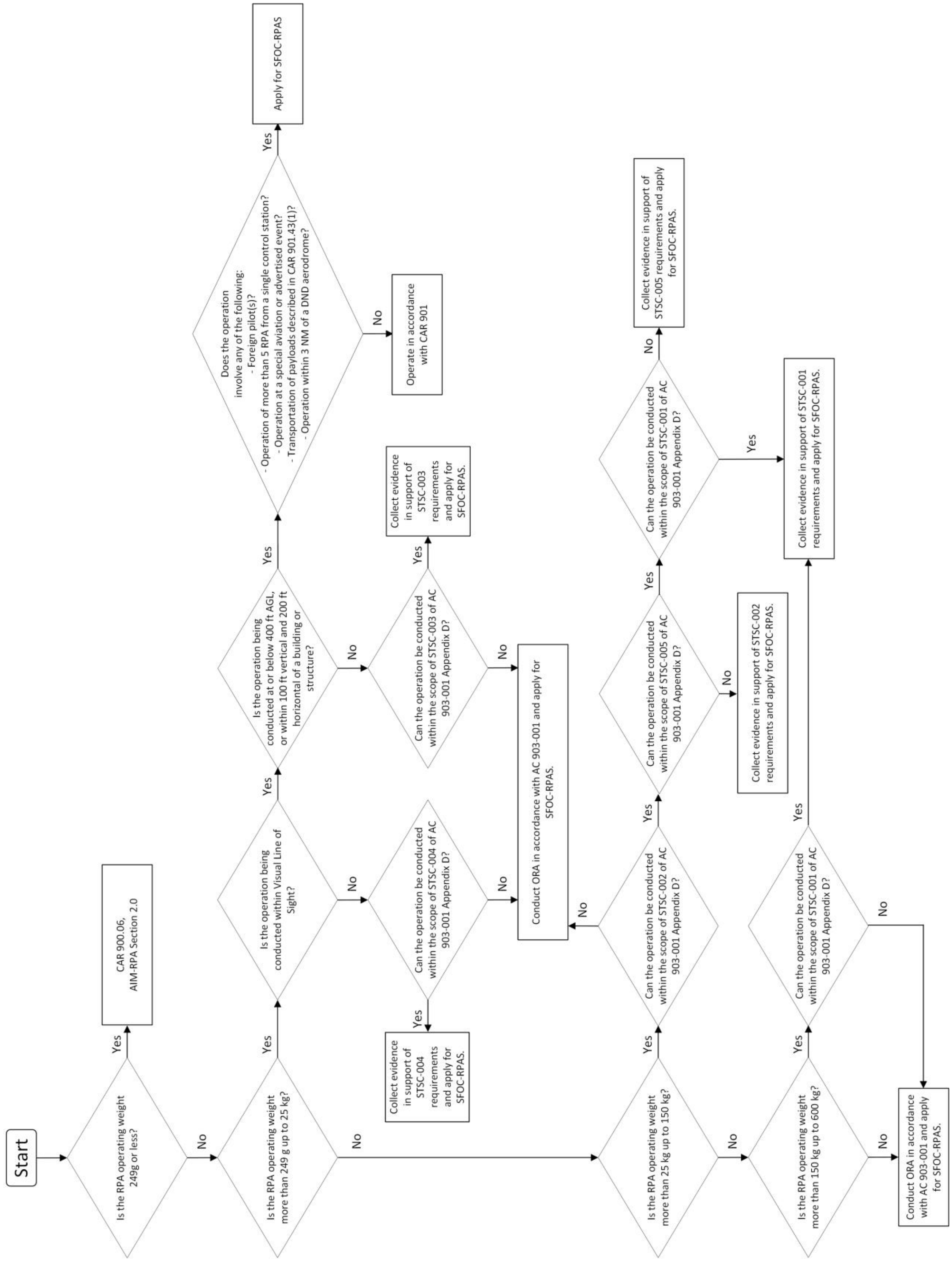
(2) **Usage**. These standard scenarios are provided to assist SFOC – RPAS applicants in preparing their application for an operation that meets the parameters of one of the standard scenarios, and to assist TCCA specialists in reviewing these applications for the issuance of SFOC – RPASs. The standard scenarios (STSCs) currently developed are as follows:

- **(a)** **STSC-001**. Addresses VLOS operation of RPA having an operating weight of more than 25 kg up to 600 kg over controlled ground areas in low risk airspace. (SAIL II)
- **(b)** **STSC-002**. Addresses VLOS operation of RPA having an operating weight of more than 25 kg up to 150 kg over controlled ground areas in any airspace. (SAIL IV)
- **(c)** **STSC-003**. Addresses VLOS operation of small RPA having an operating weight of more than 250 g up to 25 kg in uncontrolled airspace above 400 ft AGL. (SAIL II)
- **(d)** **STSC-004**. Addresses BVLOS operation of small RPA having an operating weight of more than 250 g up to 25 kg over low risk ground areas in low risk airspace using Visual Observer DAA. (SAIL II)
- **(e)** **STSC-005**. Addresses VLOS operation of RPA having an operating weight of more than 25 kg up to 150 kg over controlled ground areas in uncontrolled airspace. (SAIL II)

(3) **Discussion**. These standard scenarios have been developed to simplify SFOC – RPAS application and processing for commonly requested CONOPS with similar characteristics. Thus, over time, the number of standard scenarios may expand to regroup other operations where more regular demand is observed. These scenarios will also provide valuable feed-back to further develop regulations and validate emerging standards and means of compliance (MOC). Therefore, Applicants' feedback will be instrumental in making this endeavor reach its full potential. Such feedback can be forwarded to the contact information provided in AC 903-001 Section 13.0.

(4) **Framework**. The flow chart in Figure 20, below, illustrates the current (as of the date of publication) framework for RPAS operations, including SFOC – RPAS using the standard scenarios in this Appendix. Note that this figure will be updated along with the AC 903-001, but the underlying framework may be updated sooner as lessons are learned from SFOC – RPAS operations. As such, the figure should be considered guidance only and not interpreted as a regulatory statement.

Figure 20 – RPAS Operational Framework



2.0 STSC-001 – 25 - 600 kg RPA, VLOS, Controlled Ground, Low Risk Airspace

(1) **Introduction.** For this standard scenario, TCCA has undertaken an RPAS ORA assessment for a predefined CONOPS involving VLOS operation of RPA having an operating weight of more than 25 kg up to 600 kg over controlled ground areas in low-risk uncontrolled airspace. The primary intended use of this standard scenario is for developmental purposes (for aircraft, technology, training, procedures, etc.); however, commercial operations are also acceptable provided that the conditions and requirements are satisfied (e.g., surveys with large RPA). This standard scenario has not been endorsed by JARUS and is applicable to operations as described in Canadian airspace only.

(2) **Scope.** This standard scenario is intended to be used as part of the application process for an SFOC – RPAS approval. The permissible operational limitations under this scenario are:

(a) RPA having an operating weight of more than 25 kg up to 600 kg.

(b) Ground area:

(i) Must be a minimum[14] of 2 nautical miles outside of any area with a population density greater than 25 ppl/km^2; and

(ii) Must be controlled (ref. AC 903-001 2.3(1)(h)) underneath the entire flight area (i.e., the flight geography per 2.3(1)(k) plus the contingency volume per 2.3(1)(g)), plus a buffer area extending beyond the flight area by 500 feet.

(c) Altitude: No greater than 400 ft AGL.

(d) Airspace can be either:

(i) Uncontrolled airspace, a minimum of 5 nautical miles from the centre of an aerodrome airport or heliport published in the Canada Flight Supplement or Water Aerodrome Supplement AND a minimum[11] of 2 nautical miles horizontally and 1500 ft vertically from any controlled airspace; or

(ii) Class F restricted airspace with permission from the User/Controlling agency.

(3) **Application.** The following sections provide applicants with guidance about the minimum information and evidence required to support an application for operations according to the standard scenario STSC-001. TCCA considers these the minimum requirements for applications under this scenario, and applicants should assess whether higher levels of safety are required based on the complexity of the operation. At minimum, applicants must complete SFOC-RPAS Application Form 26-0835 and associated compliance checklist with all required information and provide attachment(s) with the supporting information described below. More information on SFOC-RPAS application and Compliance Checklist are available from our website.

(4) **Supporting Information.** The following sections provide guidance about the minimum additional supporting information required to demonstrate that an applicant is capable of operating safely within the environment described in this standard scenario. Based on the scope described above, this standard scenario is assigned a SAIL of II and the supporting information is based on requirements at that level. Note that the location of the supporting information / evidence for each of the following points should be identified specifically in the application for this standard scenario.

(a) Operational Considerations. The following table describes the necessary supporting information related to operational considerations (crew qualifications, training, etc.).

[14] Note that these values are minimums, and may be adjusted upwards on a case-by-case basis if aircraft performance and/or emergency procedures dictate that greater values are required.

Topic (SORA OSO #)	Information Required	Guidance
Operator Competency (1)	• Company Operations Manual • Advanced sRPA Pilot Certificates	Note that a document titled “Company Operations Manual” is not specifically required. What is necessary is documentation to demonstrate that operations are conducted in a consistent and standardized manner, along with a process for identifying and addressing any issues identified. Also note that draft documentation could be considered acceptable for this scenario.
Maintenance (3)	• Maintenance Program / Schedule for applicable RPAS(s)	
Pre-Flight Inspection (7)	• Documented Pre-Flight procedure • Evidence that any pre-flight checks required to address Containment requirements as detailed in (c), below, are included	
Operational Procedures (8, 11, 14, 21)	• Evidence that operational procedures have been reviewed, practiced, and updated where required.	For development / testing operations conducted under this scenario, having an ability to review the events of a flight is instrumental to conduct root-cause analysis. For example, videotaping trials allows a vivid and measurable way of conducting a post-event or post-incident analysis, especially when considering factors not otherwise recorded by the RPAS telemetry (e.g.: change in weather; human interactions; etc.).
Crew Training (9, 15, 22)	• Declaration that all crew members have been trained on the topics identified in Appendix C, Section 1.1(4)(a)(ix)(A).	Refer to operational declaration template under item (d), below.
Multi-crew coordination (16)	• Operational Procedures related to crew coordination and communications (can be a reference to a section of the Company Operations Manual).	
Crew Fitness (17)	• Declaration that a crew fitness policy is in place • Crew self-declarations of fitness prior to flight	Refer to operational declaration template under item (d), below.

Topic (SORA OSO #)	Information Required	Guidance
Adherence to RPAS environmental limits (23)	• Declaration that the environmental limits in use for the proposed operation are adequate to ensure safe operation of the RPAS(s).	Refer to operational declaration template under item (d), below. Note that since the primary safety system in this STSC is the containment system described in in (c), below, this declaration can be interpreted as applying to the containment system only (i.e., the environmental limits in use for the proposed operation will ensure that the containment system functions as intended).

(b) Technical Considerations. The following table describes the necessary supporting information related to technical considerations (RPA design, systems performance, etc.).

Topic (SORA OSO #)	Information Required	Guidance
Manufacturer Competency (2)	• N/A	
RPAS Design Standards (4)	• N/A, but refer to Containment requirements as detailed in (c), below.	
RPAS Reliability (5, 12)	• N/A, but refer to Containment requirements as detailed in (c), below.	
C2 Link (6)	• Details of signal strength monitoring and alerting • Evidence of site survey and/or pre-flight assessment plan for local conditions affecting C2 (e.g., terrain, obstacles, EMI sources, etc.)	
Recovery from technical issues (10) and human error (19)	• N/A, but refer to Containment requirements as detailed in (c), below.	
Adequacy of external systems (13)	• Declaration that any external systems or services in use are adequate for the operation.	Refer to operational declaration template under item (d), below.
Flight Envelope Protection (18)	• N/A, but refer to Containment requirements as detailed in (c), below.	
Human Factors evaluation (20)	• Declaration that the RPAS information and control interfaces are clearly and succinctly presented and do not confuse, cause unreasonable fatigue, or contribute to RPAS crew error that could adversely affect the safety of the operation.	Refer to technical declaration template under item (d), below.
RPAS environmental design (24)	• N/A	

(c) Containment Considerations. To ensure safety in the case of failure scenarios that could lead to a flyaway, applicants must demonstrate a robust containment solution for their RPA.

(i) The top level requirements that must be met by this system are (sourced from Section 9.4):

(A) No single failure of the RPAS or any external system supporting the operation shall result in operation outside of the operational volume.

(B) Any failure of a system or subsystem whose operation is required to meet (A) shall be detectable by the operator.

(ii) The supporting information that must be provided to substantiate that the RPAS(s) meets the requirement depends on the operating weight of the aircraft, as follows:

(A) For RPA having an operating weight up to 150 kg, a declaration that the RPAS(s) meet the requirements identified above (refer to technical declaration template under item (d), below).

(B) For RPA having an operating weight of more than 150 kg, a declaration as above accompanied by details of the system design, test approach, and testing carried out to validate that the RPAS(s) meets the requirements.

(C) Note that for all sizes of aircraft, the design, test approach, and testing should include consideration of the effects of the following probable failures:

(I) Intermittent or degraded C2 link particularly at or around vertical obstacles or sources of EMI.

(II) Indications, RPA response and crew procedures / actions in the event of a permanent loss of the C2 link.

(III) Total or partial failure of the remote pilot station affecting such systems as electronic displays, video feeds, internet, manual control interfaces etc. caused by software, hardware or power failures.

(IV) Navigation system failures including degradation or total loss of GNSS, IMUs, sensors or cameras that may result in a reduction in navigation accuracy and/or a loss of available navigation modes.

(V) Flight planning failures that could result in a loss of containment (i.e. incorrect setting of waypoints / RTH function).

(iii) Examples of potentially acceptable containment approaches include (note that this is not intended to be an exhaustive list):

(A) Software-based geographical limits on RPAS operational areas, such as distance or shape-based limits or no-fly zones (commonly referred to using the term “geofencing”).

(B) Flight termination systems, e.g.:

(I) Software-based return-to-home or autoland functions.

(II) Remote kill switches.

(C) Tethering, either mechanically or as a power source disconnect.

(D) Energy limits (i.e., only carrying sufficient fuel load / battery charge / etc. to reach the edge of the controlled area in a flyaway situation).

(d) Declaration templates:

STSC-001 Operational Declaration

I hereby declare that, for the operation described in the attached application package:

- All RPAS crew members have been trained on the topics identified in AC 903-001 Appendix C, Section 1.1(4)(a)(ix)(A).
- A crew fitness policy is in place, and each RPAS crew member self-declares their fitness prior to acting as a member of the flight crew.
- Any external systems or services in use are adequate for the operation.
- The environmental limits in use for the proposed operation are adequate to ensure safe operation of the RPAS(s).

Name of Responsible Person:

Title of Signatory:

Email Address:

Signature:

STSC-001 Technical Declaration

I hereby declare that the RPAS(s) listed below have been developed, constructed, and verified to meet the following technical requirement:

- The RPAS information and control interfaces are clearly and succinctly presented and do not confuse, cause unreasonable fatigue, or contribute to RPAS crew error that could adversely affect the safety of the operation.
- No single failure of the RPAS or any external system supporting the operation will lead to operation outside of the operational volume.
- Any failure of a system or subsystem whose operation is required to meet the above requirement is detectable by the operator.

Make	Model

Name of Responsible Person:

Title of Signatory:

Email Address:

Signature:

3.0 STSC-002 – 25 - 150 kg RPA, VLOS, Controlled Ground, Any Airspace

(1) **Introduction.** For this standard scenario, TCCA has undertaken an RPAS ORA assessment for a predefined CONOPS involving VLOS operation of RPA having an operating weight of more than 25 kg up to 150 kg over controlled ground areas in any airspace. While not an exhaustive list, the use cases that may be addressed by this scenario include filmmaking operations, precision agriculture support, and remote sensing applications with payloads requiring larger RPA. This standard scenario has not been endorsed by JARUS and is applicable to operations as described in Canadian airspace only. Note that this scenario is primarily intended to support operations in controlled airspace, and operations being conducted outside of controlled airspace may be possible with less stringent safety mitigations under STSC-001, STSC-005, or a full AC 903-001 ORA.

(2) **Scope.** This standard scenario is intended to be used as part of the application process for an SFOC – RPAS approval. The permissible operational limitations under this scenario are:

(a) RPA with an operating weight of more than 25 kg up to 150 kg.

(b) Ground area: Must be controlled (ref. AC 903-001 2.3(1)(h)) underneath the entire flight area (i.e., the flight geography per 2.3(1)(k) plus the contingency volume per 2.3(1)(g)), plus a buffer area extending beyond the flight area by 100 feet plus the proposed operational altitude in feet AGL (e.g., if the proposed operational altitude is 100 ft AGL, the controlled buffer area beyond the flight area must be 200 ft laterally).

(i) Note that a controlled ground area is not required in areas or directions where uninvolved persons are sheltered by obstacles that would likely not be penetrated by the RPA at maximum speed (e.g., buildings). The default assumption in this standard scenario is that cars, structures, buildings, etc. **do not** provide shelter, but sheltering can be used if an analysis of RPA kinematics and the sheltering object strength show that sufficient safety is provided.

(ii) Note that operational procedures must also dictate that kinetic energy never be directed towards uninvolved and unsheltered persons less than 500 ft from the RPA. The intent of this requirement is to ensure that the detailed planning of the operation within the operational volume ensures that the flight path and turnaround areas of the RPA are arranged such that in the event of a failure, uninvolved people are protected.

(c) Altitude: No greater than 400 ft AGL. Note that lower altitudes reduce the size of the controlled ground area as per above.

(d) Airspace: Any airspace, with permission & coordination when required with the local air navigation service provider and/or controlling agency.

(3) **Application.** The following sections provide applicants with guidance about the minimum information and evidence required to support an application for operations according to the standard scenario STSC-002. TCCA considers these the minimum requirements for applications under this scenario, and applicants should assess whether higher levels of safety are required based on the complexity of the operation. At minimum, applicants must complete SFOC-RPAS Application Form 26-0835 and associated compliance checklist with all required information and provide attachment(s) with the supporting information described below. More information on SFOC-RPAS application and Compliance Checklist are available from our website.

(4) **Supporting Information.** The following sections provide guidance about the minimum additional supporting information required to demonstrate that an applicant is capable of operating safely within the environment described in this standard scenario. Based on the scope described above, this standard scenario is assigned a SAIL of IV and the supporting information is based on requirements at that level. Note that the location of the supporting information / evidence for each of the following points should be identified specifically in the application for this standard scenario.

(a) Operational Considerations. The following table describes the necessary supporting information related to operational considerations (crew qualifications, training, etc.).

Topic (SORA OSO #)	Information Required	Guidance
Operator Competency (1)	• Company Operations Manual • Advanced sRPA Pilot Certificates	Note that a document titled "Company Operations Manual" is not specifically required. What is necessary is documentation to demonstrate that operations are conducted in a consistent and standardized manner, along with a process for identifying and addressing any issues identified.
Maintenance (3)	• Maintenance Program / Schedule for applicable RPAS(s) • Evidence that maintenance program / schedule is based on manufacturer recommendations and has been validated • Evidence that maintenance personnel have obtained initial training from manufacturer	
Pre-Flight Inspection (7)	• Evidence that the pre-flight procedure is based on manufacturer recommendations • Evidence that any pre-flight checks required to address Containment requirements as detailed in (c), below, are included	
Operational Procedures (8, 11, 14, 21)	• Participation in a TCCA Organizational Proficiency Check as described in Appendix F.	
Crew Training (9, 15, 22)	• Training Program / Syllabus • Evidence that all proposed crew members have received the necessary training	
Multi-crew coordination (16)	• Participation in a TCCA Organizational Proficiency Check as described in Appendix F.	
Crew Fitness (17)	• Organizational crew fitness policy • Evidence of fitness policy being enforced (operational logs, rest times, etc.)	
Adherence to RPAS environmental limits (23)	• Evidence that the environmental limits used in operational procedures are less than or equal to the environmental limits specified by the manufacturer	It is advisable to use limits lower than specified by the manufacturer to allow for some operational buffer when local environmental conditions change during an operation.

(b) Technical Considerations. The following table describes the necessary supporting information related to technical considerations (RPA design, systems performance, etc.).

Topic (SORA OSO #)	Information Required	Guidance
Manufacturer Competency (2)	• Details of any industry certifications (e.g., ISO9001) held by the manufacturer • Details of production & service history for the applicable RPAS(s) • Evidence of production conformity	
RPAS Design Standards (4)	• Declaration that the RPAS(s) meet the applicable design standards for this standard scenario (refer to template in (d) below).	The applicable design standards for this standard scenario are: • Containment requirements as detailed in (c), below; and • CAR Standard 922.04 when the operation is being conducted in controlled airspace.
RPAS Reliability (5, 12)	• Refer to Containment requirements as detailed in (c), below.	The operational limitations described in the scope of this standard scenario ensure that the only failure case with safety implications to the public is that of an uncontrolled flyaway. Hence, the containment requirements address the residual technical risk.
C2 Link (6)	• Details of signal strength monitoring and alerting • Evidence of demonstration of C2 link performance in representative operational conditions • Evidence of site survey and/or pre-flight assessment plan for local EMI conditions	
Recovery from technical issues (10) and human error (19)	• Refer to Containment requirements as detailed in (c), below.	The primary safety mitigation to ensure recovery from technical issues and/or human error in this specific scenario is the combination of the constrained operational environment and the containment requirements described below.
Adequacy of external systems (13)	• Plan in place and procedures to mitigate deterioration of external services.	For any external systems / services being used, operational procedures must address any action required in case of a loss of these systems / services (e.g., GNSS). A third party review is not required for this scenario due to the constrained operational environment.

Topic (SORA OSO #)	Information Required	Guidance
Flight Envelope Protection (18)	• Refer to Containment requirements as detailed in (c), below.	It is expected that essentially all rotary wing RPA will already incorporate a flight envelope protection system, but it is not strictly necessary for this standard scenario as the safety impact of not having such a system is already addressed by the operational limitations and the containment requirements described below.
Human Factors evaluation (20)	• Evidence that the RPAS information and control interfaces are clearly and succinctly presented and do not confuse, cause unreasonable fatigue, or contribute to RPAS crew error that could adversely affect the safety of the operation. • Evidence that the human machine interface has been validated in an environment that is representative of the real world and been shown to be adequate.	This requirement can be met through a formal, documented Human Factors evaluation process or through demonstration of sufficient* operational experience with the human machine interface in similar operational contexts. Note: Sufficient in this case is defined as a minimum of 8 hours of flying time with each of the proposed RPAS types, which may be shared across the proposed operational crew members.
RPAS environmental design (24)	• Declaration that the RPAS(s) can be operated safely throughout the environmental envelope identified in the flight manual (refer to template in (d) below). • Evidence of environmental testing to support the declaration.	The evidence supporting the declaration can be in the form of test reports for specific environmental testing, or records of operational experience in all relevant environmental conditions (e.g., temperature, humidity, wind, EMI).

(c) Containment Considerations. To ensure safety in the case of failure scenarios that could lead to a flyaway, applicants must demonstrate a highly robust containment solution for their RPA.

(i) The top level requirements that must be met by this system are (sourced from Section 9.5):

(A) No single failure of the RPAS or any external system supporting the operation shall result in operation outside of the operational volume.

(B) The probability that the RPA leaves the operational volume due to any combination of failures of the RPAS and/or any external system supporting the operation shall be shown to be extremely remote.

Note: Quantitative probability values associated with “extremely remote” failure conditions referenced here are intended to be scaled with the kinetic energy of the RPAS as described in Appendix E.

(C) Any failure of a system or subsystem whose operation is required to meet (A) or (B) shall be detectable by the operator.

(D) Software (SW) and Airborne Electronic Hardware (AEH) whose development error(s) could directly lead to operations outside of the operational volume shall be developed to an industry standard or methodology recognized by TCCA (ref. AC 922-001 Appendix A).

(ii) The supporting information that must be provided to substantiate that the RPAS meets the requirements is:

(A) A declaration that the RPAS(s) meet the requirements identified above (refer to template in (d) below); and

(B) Details of the system design, test approach, and testing carried out to validate that the RPAS(s) meet the requirements. Note that the design, test approach, and testing should include consideration of the effects of the following probable failures:

(I) Intermittent or degraded C2 link particularly at or around vertical obstacles or sources of EMI.

(II) Indications, RPA response and crew procedures / actions in the event of a permanent loss of the C2 link.

(III) Total or partial failure of the remote pilot station affecting such systems as electronic displays, video feeds, internet, manual control interfaces etc. caused by software, hardware or power failures.

(IV) Navigation system failures including degradation or total loss of GNSS, IMUs, sensors or cameras that may result in a reduction in navigation accuracy and/or a loss of available navigation modes.

(V) Flight planning failures that could result in a loss of containment (i.e. incorrect setting of waypoints / RTH function).

(iii) Examples of acceptable containment approaches include (note that this is not intended to be an exhaustive list):

(A) Independent kill switch. To support meeting the above containment requirements, the key aspects of a kill switch design are:

(I) Independence. This requires the kill switch to be separate from the other aircraft systems, particularly those systems whose failures can be precursors to flyaways, and including assessment of potential common cause and common mode failure cases.

(II) Reliability. There are a variety of ways to substantiate reliability for such a system, but likely the simplest is to ensure that the system can be tested pre-flight and, ideally, monitored in-flight. Provided that the system is inspected and tested sufficiently regularly, the exposure time to an undetected failure can be reduced such that the reliability requirement is met. Note that using this approach requires that the inspection/testing of the containment system be integrated into the operational procedures at the appropriate locations.

(B) Tethering. A tether could also be used to address the containment requirements described above. Note that the probability of the tether failing to contain the aircraft would need to be shown to be remote. Potential approaches could include either a tether with sufficient strength that the aircraft structure would be compromised prior to tether breakage, or a tether connected to the aircraft power source such that reaching the limit of the tether guaranteed a disconnection of power and flight termination.

(d) Declaration template:

STSC-002 Technical Declaration

I hereby declare that the RPAS(s) listed below have been developed, constructed, and verified to meet the technical requirements identified in TCCA STSC-002, found in AC 903-001 Appendix D, to operate in the environment(s) identified in the CONOPS of the attached SFOC – RPAS application. The RPAS Flight Manual, the RPAS Maintenance Procedures, the RPAS Logbook, and the processes for design and manufacturing have been made available to the SFOC – RPAS applicant and are available for inspection or retention by the Minister as required.

Make	Model

Name of Responsible Person:

Title of Signatory:

Email Address:

Signature:

4.0 STSC-003 – Small RPA, VLOS, uncontrolled Airspace above 400 ft AGL

(1) **Introduction.** For this standard scenario, TCCA has undertaken an RPAS ORA assessment for a predefined CONOPS involving VLOS operation of a small RPA having an operating weight of more than 250 g up to 25 kg in uncontrolled airspace above 400 ft AGL. This standard scenario has not been endorsed by JARUS and is applicable to operations as described in Canadian airspace only.

(2) **Scope.** This standard scenario is intended to be used as part of the application process for an SFOC – RPAS approval. The permissible operational limitations under this scenario are:

(a) Small RPA having an operating weight of more than 250 g up to 25 kg.

(b) Ground area: Anywhere in Canada, with limitations on distances from another person as per CAR Part 901 based on the Standard 922 declaration status of the RPA.

(c) Altitude: Limited by the ability for the RPA to remain VLOS, to a maximum that allows the RPA to descend below 400 ft AGL or move into Atypical Airspace (ref. AC 903-001 2.3(1)(c)) in one minute or less.

(d) Airspace: Uncontrolled airspace, a minimum[15] of 2 nautical miles horizontally and 500 ft vertically from any controlled airspace. No limitations on distance from airports, heliports, or aerodromes.

(3) **Application.** The following sections provide applicants with guidance about the minimum information and evidence required to support an application for operations according to the standard scenario STSC-003. TCCA considers these the minimum requirements for applications under this scenario, and applicants should assess whether higher levels of safety are required based on the complexity of the operation. At minimum, applicants must complete SFOC-RPAS Application Form 26-0835 and associated compliance checklist with all required information and provide attachment(s) with the supporting information described below. More information on SFOC-RPAS application and Compliance Checklist are available from our website.

(4) **Supporting Information.** The following sections provide guidance about the minimum additional supporting information required to demonstrate that an applicant is capable of operating safely within the environment described in this standard scenario. Based on the scope described above, this standard scenario is assigned a SAIL of II and the supporting information is based on requirements at that level. Note that the location of the supporting information / evidence for each of the following points should be identified specifically in the application for this standard scenario.

(a) Operational Considerations. The following table describes the necessary supporting information related to operational considerations (crew qualifications, training, etc.).

[15] Note that these values are minimums, and may be adjusted upwards on a case-by-case basis if aircraft performance and/or emergency procedures dictate that greater values are required. Also note that no buffer distance is necessary if the operation has permission from the local ANSP to operate in the adjacent controlled airspace.

Topic (SORA OSO #)	Information Required	Guidance
Operator Competency (1)	• Company Operations Manual • Advanced sRPA Pilot Certificates	Note that a document titled "Company Operations Manual" is not specifically required. What is necessary is documentation to demonstrate that operations are conducted in a consistent and standardized manner, along with a process for identifying and addressing any issues identified. Also note that draft documentation could be considered acceptable for this scenario.
Maintenance (3)	• Maintenance Program / Schedule for applicable RPAS(s)	
Pre-Flight Inspection (7)	• Documented Pre-Flight procedure • Evidence that any pre-flight checks required to address Containment requirements as detailed in (c), below, are included	
Operational Procedures (8, 11, 14, 21)	• Evidence that operational procedures have been reviewed, practiced, and updated where required.	
Crew Training (9, 15, 22)	• Declaration that all crew members have been trained on the topics identified in Appendix C, Section 1.1(4)(a)(ix)(A).	Refer to operational declaration template under item (d), below.
Multi-crew coordination (16)	• Operational Procedures related to crew coordination and communications (can be a reference to a section of the Company Operations Manual).	
Crew Fitness (17)	• Declaration that a crew fitness policy is in place • Crew self-declarations of fitness prior to flight	Refer to operational declaration template under item (d), below.
Adherence to RPAS environmental limits (23)	• Declaration that the environmental limits in use for the proposed operation are adequate to ensure safe operation of the RPAS(s).	Refer to operational declaration template under item (d), below.

(b) Technical Considerations. The following table describes the necessary supporting information related to technical considerations (RPA design, systems performance, etc.).

Topic (SORA OSO #)	Information Required	Guidance
Manufacturer Competency (2)	• N/A	
RPAS Design Standards (4)	• N/A, but refer to Containment requirements as detailed in (c), below.	

Topic (SORA OSO #)	Information Required	Guidance
RPAS Reliability (5, 12)	• N/A, but refer to Containment requirements as detailed in (c), below.	
C2 Link (6)	• Details of signal strength monitoring and alerting • Evidence of site survey and/or pre-flight assessment plan for local conditions affecting C2 (e.g., terrain, obstacles, EMI sources, etc.)	
Recovery from technical issues (10) and human error (19)	• N/A, but refer to Containment requirements as detailed in (c), below.	
Adequacy of external systems (13)	• Declaration that any external systems or services in use are adequate for the operation.	Refer to operational declaration template under item (d), below.
Flight Envelope Protection (18)	• N/A, but refer to Containment requirements as detailed in (c), below.	
Human Factors evaluation (20)	• Declaration that the RPAS information and control interfaces are clearly and succinctly presented and do not confuse, cause unreasonable fatigue, or contribute to RPAS crew error that could adversely affect the safety of the operation.	Refer to technical declaration template under item (d), below. An RPAS that is declared to meet the requirements for “Near People” or “Over People” operations under CAR Standard 922 (922.05 or 922.06 respectively) is considered to meet this requirement and no further declaration is necessary.
RPAS environmental design (24)	• N/A	

(c) Containment Considerations. To ensure safety in the case of failure scenarios that could lead to a flyaway, applicants must demonstrate a robust containment solution for their RPA.

(i) The top level requirements that must be met by this system are (sourced from Section 9.4):

(A) No single failure of the RPAS or any external system supporting the operation shall result in operation outside of the operational volume.

(B) Any failure of a system or subsystem whose operation is required to meet 5.0(4)(d)(i)(A) shall be detectable by the operator.

(ii) The supporting information that must be provided to substantiate that the RPAS(s) meets the requirement is a declaration that the RPAS(s) meet the requirements identified above (see template in (d), below). An RPAS that is declared to meet the requirements for “Near People” or “Over People” operations under CAR Standard 922 (922.05 or 922.06 respectively) is considered to meet this requirement and no further declaration is necessary.

(A) Note that the design, test approach, and testing should include consideration of the effects of the following probable failures:

(I) Intermittent or degraded C2 link particularly at or around vertical obstacles or sources of EMI.

(II) Indications, RPA response and crew procedures / actions in the event of a permanent loss of the C2 link.

(III) Total or partial failure of the remote pilot station affecting such systems as electronic displays, video feeds, internet, manual control interfaces etc. caused by software, hardware or power failures.

(IV) Navigation system failures including degradation or total loss of GNSS, IMUs, sensors or cameras that may result in a reduction in navigation accuracy and/or a loss of available navigation modes.

(V) Flight planning failures that could result in a loss of containment (i.e. incorrect setting of waypoints / RTH function).

(iii) Examples of potentially acceptable containment approaches include (note that this is not intended to be an exhaustive list):

(A) Software-based geographical limits on RPAS operational areas, such as distance or shape-based limits or no-fly zones (commonly referred to using the term “geofencing”).

(B) Flight termination systems, e.g.:

(I) Software-based return-to-home or autoland functions.

(II) Remote kill switches.

(C) Tethering, either mechanically or as a power source disconnect.

(D) Energy limits (i.e., only carrying sufficient fuel load / battery charge / etc. to reach the edge of the operational volume in a flyaway situation).

(d) Declaration templates:

STSC-003 Operational Declaration

I hereby declare that, for the operation described in the attached application package:

- All RPAS crew members have been trained on the topics identified in AC 903-001 Appendix C, Section 1.1(4)(a)(ix)(A).
- A crew fitness policy is in place, and each RPAS crew member self-declares their fitness prior to acting as a member of the flight crew.
- Any external systems or services in use are adequate for the operation.
- The environmental limits in use for the proposed operation are adequate to ensure safe operation of the RPAS(s).

Name of Responsible Person:

Title of Signatory:

Email Address:

Signature:

STSC-003 Technical Declaration

I hereby declare that the RPAS(s) listed below have been developed, constructed, and verified to meet the following technical requirement:

- The RPAS information and control interfaces are clearly and succinctly presented and do not confuse, cause unreasonable fatigue, or contribute to RPAS crew error that could adversely affect the safety of the operation.
- No single failure of the RPAS or any external system supporting the operation will lead to operation outside of the operational volume.
- Any failure of a system or subsystem whose operation is required to meet the above requirement is detectable by the operator.

Make	Model

Name of Responsible Person:

Title of Signatory:

Email Address:

Signature:

5.0 STSC-004 – Small RPA, BVLOS, Low Risk Ground Areas and Low Risk Airspace using Visual Observer DAA

(1) **Introduction.** For this standard scenario, TCCA has undertaken an RPAS ORA assessment for a predefined CONOPS involving BVLOS operation of a small RPA having an operating weight of more than 250 g up to 25 kg over low risk ground areas in low risk airspace, with Visual Observer DAA used as the primary air risk mitigation (as described in Appendix B Section 3.0). This standard scenario has not been endorsed by JARUS and is applicable to operations as described in Canadian airspace only.

(2) **Scope.** This standard scenario is intended to be used as part of the application process for an SFOC – RPAS approval. The permissible operational limitations under this scenario are:

(a) Small RPA having an operating weight of more than 250 g up to 25 kg, declared for "Controlled Airspace" operations under CAR Standard 922 (922.04).

(b) Ground area:

(i) Must be a minimum[16] of 2 nautical miles outside of any area with a population density greater than 25 ppl/km^2; and

(ii) Must be a minimum of 1 km outside of any area with a population density greater than 5 ppl/km^2.

(c) Altitude: No greater than 400 ft AGL.

(d) Airspace can be either:

(i) Uncontrolled airspace, a minimum of 5 nautical miles from the centre of an aerodrome airport or heliport published in the Canada Flight Supplement or Water Aerodrome Supplement AND a minimum[13] of 2 nautical miles horizontally and 1500 ft vertically from any controlled airspace; or

(ii) Class F restricted airspace with permission from the User/Controlling agency.

(3) **Application.** The following sections provide applicants with guidance about the minimum information and evidence required to support an application for operations according to the standard scenario STSC-004. TCCA considers these the minimum requirements for applications under this scenario, and applicants should assess whether higher levels of safety are required based on the complexity of the operation. At minimum, applicants must complete SFOC-RPAS Application Form 26-0835 and associated compliance checklist with all required information and provide attachment(s) with the supporting information described below. More information on SFOC-RPAS application and Compliance Checklist are available from our website.

(4) **Supporting Information.** The following sections provide guidance about the minimum additional supporting information required to demonstrate that an applicant is capable of operating safely within the environment described in this standard scenario. Based on the scope described above, this standard scenario is assigned a SAIL of II and the supporting information is based on requirements at that level. Note that the location of the supporting information / evidence for each of the following points should be identified specifically in the application for this standard scenario.

(a) Operational Considerations. The following table describes the necessary supporting information related to operational considerations (crew qualifications, training, etc.).

[16] Note that these values are minimums, and may be adjusted upwards on a case-by-case basis if aircraft performance and/or emergency procedures dictate that greater values are required.

Topic (SORA OSO #)	Information Required	Guidance
Operator Competency (1)	• Company Operations Manual • Advanced sRPA Pilot Certificates	Note that a document titled "Company Operations Manual" is not specifically required. What is necessary is documentation to demonstrate that operations are conducted in a consistent and standardized manner, along with a process for identifying and addressing any issues identified. Also note that draft documentation could be considered acceptable for this scenario.
Maintenance (3)	• Maintenance Program / Schedule for applicable RPAS(s)	
Pre-Flight Inspection (7)	• Documented Pre-Flight procedure • Evidence that any pre-flight checks required to address Containment requirements as detailed in (d), below, are included	
Operational Procedures (8, 11, 14, 21)	• Evidence that operational procedures have been reviewed, practiced, and updated where required.	Refer to Appendix G, Section 2.0 for guidance on addressing the population density criteria of this standard scenario. Note that a sample site survey for at least one operational location should be provided as part of the application.
Crew Training (9, 15, 22)	• Declaration that all crew members have been trained on the topics identified in Appendix C, Section 1.1(4)(a)(ix)(A).	Refer to operational declaration template under item (e), below.
Multi-crew coordination (16)	• Operational Procedures related to crew coordination and communications (can be a reference to a section of the Company Operations Manual).	
Crew Fitness (17)	• Declaration that a crew fitness policy is in place • Crew self-declarations of fitness prior to flight	Refer to operational declaration template under item (e), below.
Adherence to RPAS environmental limits (23)	• Declaration that the environmental limits in use for the proposed operation are adequate to ensure safe operation of the RPAS(s).	Refer to operational declaration template under item (e), below. Note that since the primary safety system in this STSC is the containment system described in in (d), below, this declaration can be interpreted as applying to the containment system only (i.e., the environmental limits in use for the proposed operation will ensure that the containment system functions as intended).

(b) Detect and Avoid Considerations. The following table describes the necessary supporting information related to Detect and Avoid using the Visual Observer DAA guidance material described in Appendix B, Section 3.0.

Topic (Appendix B Section 3.0 Paragraph)	Information Required	Guidance
(3) (a) and (b)	• None since these conditions are addressed by the scope of this STSC.	
(3) (c) and (d)	• Operational procedure(s) showing how to plan the location(s) of the pilot and VO(s) with reference to the operational flight location(s).	
(3) (e)	• Evidence of C2 link demonstration at a distance at least double the maximum planned operational distance.	
(3) (f)	• Evidence of operational procedure showing how visibility and ceilings will be assessed at operational location(s), with pre-flight GO/NO-GO criteria established.	
(3) (g)	• Evidence of consideration for visual observer sightlines during operational planning, plus evidence of on-site pre-flight assessment of visibility.	
(3) (h)	• Evidence of consideration for sun position during operational planning, plus evidence of on-site pre-flight assessment of sun location.	
(3) (i)	• Evidence of consideration for visual observer noise environment during operational planning, plus evidence of on-site pre-flight assessment of noise.	
(4) (a) (i)	• RPAS Make & Model must be declared for “Controlled Airspace” under CAR Standard 922.	
(4) (a) (ii)	• Specifications of the installed anti-collision lighting to address (A) through (D), plus operational procedures to address (E).	
(4) (a) (iii) and (iv)	• Specifications of C2 link performance and link quality monitoring, and operational procedures showing approach to maintaining quality at or above 50%.	
(4) (b) (i)	• Specifications of Aviation-band VHF radio(s) intended for use in the operation.	
(4) (b) (ii)	• Details of the means of communication between the remote pilot and the visual observer(s).	

Topic (Appendix B Section 3.0 Paragraph)	Information Required	Guidance
(5) (a)	• Evidence of qualifications as specified.	Note that the specified ground school is NOT required to be "in-person".
(5) (b)	• Evidence of qualifications as specified.	
(5) (c)	• Evidence of qualifications as specified.	
(6)	• Reference to the section of the operational procedures that addresses each of the identified items.	

(c) Technical Considerations. The following table describes the necessary supporting information related to technical considerations (RPA design, systems performance, etc.).

Topic (SORA OSO #)	Information Required	Guidance
Manufacturer Competency (2)	• N/A	
RPAS Design Standards (4)	• N/A, but refer to Containment requirements as detailed in (d), below.	
RPAS Reliability (5, 12)	• N/A, but refer to Containment requirements as detailed in (d), below.	
C2 Link (6)	• Details of signal strength monitoring and alerting • Evidence of site survey and/or pre-flight assessment plan for local conditions affecting C2 (e.g., terrain, obstacles, EMI sources, etc.)	
Recovery from technical issues (10) and human error (19)	• N/A, but refer to Containment requirements as detailed in (d), below.	
Adequacy of external systems (13)	• Declaration that any external systems or services in use are adequate for the operation.	Refer to operational declaration template under item (e), below.
Flight Envelope Protection (18)	• N/A, but refer to Containment requirements as detailed in (d), below.	
Human Factors evaluation (20)	• Declaration that the RPAS information and control interfaces are clearly and succinctly presented and do not confuse, cause unreasonable fatigue, or contribute to RPAS crew error that could adversely affect the safety of the operation.	Refer to technical declaration template under item (e), below. An RPAS that is declared to meet the requirements for "Near People" or "Over People" operations under CAR Standard 922 (922.05 or 922.06 respectively) is considered to meet this requirement and no further declaration is necessary.
RPAS environmental design (24)	• N/A	

(d) Containment Considerations. To ensure safety in the case of failure scenarios that could lead to a flyaway, applicants must demonstrate a robust containment solution for their RPA.

(i) The top level requirements that must be met by this system are (sourced from Section 9.4):

(A) No single failure of the RPAS or any external system supporting the operation shall result in operation outside of the operational volume.

(B) Any failure of a system or subsystem whose operation is required to meet (A) shall be detectable by the operator.

(ii) The supporting information that must be provided to substantiate that the RPAS(s) meets the requirement is a declaration that the RPAS(s) meet the requirements identified above (see template in (e), below). An RPAS that is declared to meet the requirements for “Near People” or “Over People” operations under CAR Standard 922 (922.05 or 922.06 respectively) is considered to meet this requirement and no further declaration is necessary.

(A) Note that the design, test approach, and testing should include consideration of the effects of the following probable failures:

(I) Intermittent or degraded C2 link particularly at or around vertical obstacles or sources of EMI.

(II) Indications, RPA response and crew procedures / actions in the event of a permanent loss of the C2 link.

(III) Total or partial failure of the remote pilot station affecting such systems as electronic displays, video feeds, internet, manual control interfaces etc. caused by software, hardware or power failures.

(IV) Navigation system failures including degradation or total loss of GNSS, IMUs, sensors or cameras that may result in a reduction in navigation accuracy and/or a loss of available navigation modes.

(V) Flight planning failures that could result in a loss of containment (i.e. incorrect setting of waypoints / RTH function).

(iii) Examples of potentially acceptable containment approaches include (note that this is not intended to be an exhaustive list):

(A) Software-based geographical limits on RPAS operational areas, such as distance or shape-based limits or no-fly zones (commonly referred to using the term “geofencing”).

(B) Flight termination systems, e.g.:

(I) Software-based return-to-home or autoland functions.

(II) Remote kill switches.

(C) Tethering, either mechanically or as a power source disconnect.

(D) Energy limits (i.e., only carrying sufficient fuel load / battery charge / etc. to reach the edge of the operational volume in a flyaway situation).

(e) Declaration templates:

STSC-004 Operational Declaration

I hereby declare that, for the operation described in the attached application package:

- All RPAS crew members have been trained on the topics identified in AC 903-001 Appendix C, Section 1.1(4)(a)(ix)(A).
- A crew fitness policy is in place, and each RPAS crew member self-declares their fitness prior to acting as a member of the flight crew.
- Any external systems or services in use are adequate for the operation.
- The environmental limits in use for the proposed operation are adequate to ensure safe operation of the RPAS(s).

Name of Responsible Person:

Title of Signatory:

Email Address:

Signature:

STSC-004 Technical Declaration

I hereby declare that the RPAS(s) listed below have been developed, constructed, and verified to meet the following technical requirement:

- The RPAS information and control interfaces are clearly and succinctly presented and do not confuse, cause unreasonable fatigue, or contribute to RPAS crew error that could adversely affect the safety of the operation.
- No single failure of the RPAS or any external system supporting the operation will lead to operation outside of the operational volume.
- Any failure of a system or subsystem whose operation is required to meet the above requirement is detectable by the operator.

Make	Model

Name of Responsible Person:

Title of Signatory:

Email Address:

Signature:

6.0 STSC-005 – 25 - 150 kg RPA, VLOS, Controlled Ground, Uncontrolled Airspace

(1) **Introduction.** For this standard scenario, TCCA has undertaken an RPAS ORA assessment for a predefined CONOPS involving VLOS operation of RPA having an operating weight of more than 25 kg up to 150 kg over controlled ground areas in uncontrolled airspace. While not an exhaustive list, the use cases that may be addressed by this scenario include filmmaking operations, precision agriculture support, remote sensing applications with payloads requiring larger RPA, and operation of model aircraft larger than 25 kg. This standard scenario has not been endorsed by JARUS and is applicable to operations as described in Canadian airspace only.

(2) **Scope.** This standard scenario is intended to be used as part of the application process for an SFOC – RPAS approval. The permissible operational limitations under this scenario are:

(a) RPA: having an operating weight of more than 25 kg up to 150 kg.

(b) Ground area: Must be controlled (ref. AC 903-001 2.3(1)(h)) underneath the entire flight area (i.e., the flight geography per 2.3(1)(k) plus the contingency volume per 2.3(1)(g)), plus a buffer area extending beyond the flight area by 100 feet plus the proposed operational altitude in feet AGL (e.g., if the proposed operational altitude is 100 ft AGL, the controlled buffer area beyond the flight area must be 200 ft laterally).

(i) Note that a controlled ground area is not required in areas or directions where uninvolved persons are sheltered by obstacles that would likely not be penetrated by the RPA at maximum speed (e.g., buildings). The default assumption in this standard scenario is that cars, structures, buildings, etc. **do not** provide shelter, but sheltering can be used if an analysis of RPA kinematics and the sheltering object strength show that sufficient safety is provided.

(ii) Note that operational procedures must also dictate that kinetic energy never be directed towards uninvolved and unsheltered persons less than 500 ft from the RPA. The intent of this requirement is to ensure that the detailed planning of the operation within the operational volume ensures that the flight path and turnaround areas of the RPA are arranged such that in the event of a failure, uninvolved people are protected.

(c) Altitude: No greater than 400 ft AGL. Note that lower altitudes reduce the size of the controlled ground area as per above.

(d) Airspace: Uncontrolled airspace, or Class F restricted airspace with permission from the User/Controlling agency.

(3) **Application.** The following sections provide applicants with guidance about the minimum information and evidence required to support an application for operations according to the standard scenario STSC-005. TCCA considers these the minimum requirements for applications under this scenario, and applicants should assess whether higher levels of safety are required based on the complexity of the operation. At minimum, applicants must complete SFOC-RPAS Application Form 26-0835 and associated compliance checklist with all required information and provide attachment(s) with the supporting information described below. More information on SFOC-RPAS application and Compliance Checklist are available from our website.

(4) **Supporting Information.** The following sections provide guidance about the minimum additional supporting information required to demonstrate that an applicant is capable of operating safely within the environment described in this standard scenario. Based on the scope described above, this standard scenario is assigned a SAIL of II and the supporting information is based on requirements at that level. Note that the location of the supporting information / evidence for each of the following points should be identified specifically in the application for this standard scenario.

(a) Operational Considerations. The following table describes the necessary supporting information related to operational considerations (crew qualifications, training, etc.).

Topic (SORA OSO #)	Information Required	Guidance
Operator Competency (1)	• Company Operations Manual • Advanced sRPA Pilot Certificates	Note that a document titled “Company Operations Manual” is not specifically required. What is necessary is documentation to demonstrate that operations are conducted in a consistent and standardized manner, along with a process for identifying and addressing any issues identified. Also note that draft documentation could be considered acceptable for this scenario.
Maintenance (3)	• Maintenance Program / Schedule for applicable RPAS(s)	
Pre-Flight Inspection (7)	• Documented Pre-Flight procedure • Evidence that any pre-flight checks required to address Containment requirements as detailed in (c), below, are included	
Operational Procedures (8, 11, 14, 21)	• Evidence that operational procedures have been reviewed, practiced, and updated where required.	
Crew Training (9, 15, 22)	• Declaration that all crew members have been trained on the topics identified in Appendix C, Section 1.1(4)(a)(ix)(A).	Refer to operational declaration template under item (d), below.
Multi-crew coordination (16)	• Operational Procedures related to crew coordination and communications (can be a reference to a section of the Company Operations Manual).	
Crew Fitness (17)	• Declaration that a crew fitness policy is in place • Crew self-declarations of fitness prior to flight	Refer to operational declaration template under item (d), below.
Adherence to RPAS environmental limits (23)	• Declaration that the environmental limits in use for the proposed operation are adequate to ensure safe operation of the RPAS(s).	Refer to operational declaration template under item (d), below. Note that since the primary safety system in this STSC is the containment system described in (c), below, this declaration can be interpreted as applying to the containment system only (i.e., the environmental limits in use for the proposed operation will ensure that the containment system functions as intended).

(b) Technical Considerations. The following table describes the necessary supporting information related to technical considerations (RPA design, systems performance, etc.).

Topic (SORA OSO #)	Information Required	Guidance
Manufacturer Competency (2)	• N/A	
RPAS Design Standards (4)	• N/A, but refer to Containment requirements as detailed in (c), below.	
RPAS Reliability (5, 12)	• N/A, but refer to Containment requirements as detailed in (c), below.	
C2 Link (6)	• Details of signal strength monitoring and alerting • Evidence of site survey and/or pre-flight assessment plan for local conditions affecting C2 (e.g., terrain, obstacles, EMI sources, etc.)	
Recovery from technical issues (10) and human error (19)	• N/A, but refer to Containment requirements as detailed in (c), below.	
Adequacy of external systems (13)	• Declaration that any external systems or services in use are adequate for the operation.	Refer to operational declaration template under item (d), below.
Flight Envelope Protection (18)	• N/A, but refer to Containment requirements as detailed in (c), below.	
Human Factors evaluation (20)	• Declaration that the RPAS information and control interfaces are clearly and succinctly presented and do not confuse, cause unreasonable fatigue, or contribute to RPAS crew error that could adversely affect the safety of the operation.	Refer to technical declaration template under item (d), below.
RPAS environmental design (24)	• N/A	

(c) Containment Considerations. To ensure safety in the case of failure scenarios that could lead to a flyaway, applicants must demonstrate a highly robust containment solution for their RPA.

(i) The top level requirements that must be met by this system are (sourced from Section 9.5):

(A) No single failure of the RPAS or any external system supporting the operation shall result in operation outside of the operational volume.

(B) The probability that the RPA leaves the operational volume due to any combination of failures of the RPAS and/or any external system supporting the operation shall be shown to be extremely remote.

Note: Quantitative probability values associated with "extremely remote" failure conditions referenced here are intended to be scaled with the kinetic energy of the RPAS as described in Appendix E.

(C) Any failure of a system or subsystem whose operation is required to meet (A) or (B) shall be detectable by the operator.

(D) Software (SW) and Airborne Electronic Hardware (AEH) whose development error(s) could directly lead to operations outside of the operational volume shall be developed to an industry standard or methodology recognized by TCCA (ref. AC 922-001 Appendix A).

(ii) The supporting information that must be provided to substantiate that the RPAS meets the requirements is:

(A) A declaration that the RPAS(s) meet the requirements identified above (refer to template in (d) below); and

(B) Details of the system design, test approach, and testing carried out to validate that the RPAS(s) meet the requirements. Note that the design, test approach, and testing should include consideration of the effects of the following probable failures:

(I) Intermittent or degraded C2 link particularly at or around vertical obstacles or sources of EMI.

(II) Indications, RPA response and crew procedures / actions in the event of a permanent loss of the C2 link.

(III) Total or partial failure of the remote pilot station affecting such systems as electronic displays, video feeds, internet, manual control interfaces etc. caused by software, hardware or power failures.

(IV) Navigation system failures including degradation or total loss of GNSS, IMUs, sensors or cameras that may result in a reduction in navigation accuracy and/or a loss of available navigation modes.

(V) Flight planning failures that could result in a loss of containment (i.e. incorrect setting of waypoints / RTH function).

(iii) Examples of acceptable containment approaches include (note that this is not intended to be an exhaustive list):

(A) Independent kill switch. To support meeting the above containment requirements, the key aspects of a kill switch design are:

(I) Independence. This requires the kill switch to be separate from the other aircraft systems, particularly those systems whose failures can be precursors to flyaways, and including assessment of potential common cause and common mode failure cases.

(II) Reliability. There are a variety of ways to substantiate reliability for such a system, but likely the simplest is to ensure that the system can be tested pre-flight and, ideally, monitored in-flight. Provided that the system is inspected and tested sufficiently regularly, the exposure time to an undetected failure can be reduced such that the reliability requirement is met. Note that using this approach requires that the inspection/testing of the containment system be integrated into the operational procedures at the appropriate locations.

(B) Tethering. A tether could also be used to address the containment requirements described above. Note that the probability of the tether failing to contain the aircraft would need to be shown to be remote. Potential approaches could include either a tether with sufficient strength that the aircraft structure would be compromised prior to tether breakage, or a tether connected to the aircraft power source such that reaching the limit of the tether guaranteed a disconnection of power and flight termination.

(d) Declaration templates:

STSC-005 Operational Declaration

I hereby declare that, for the operation described in the attached application package:

- All RPAS crew members have been trained on the topics identified in AC 903-001 Appendix C, Section 1.1(4)(a)(ix)(A).
- A crew fitness policy is in place, and each RPAS crew member self-declares their fitness prior to acting as a member of the flight crew.
- Any external systems or services in use are adequate for the operation.
- The environmental limits in use for the proposed operation are adequate to ensure safe operation of the RPAS(s).

Name of Responsible Person:

Title of Signatory:

Email Address:

Signature:

STSC-005 Technical Declaration

I hereby declare that the RPAS(s) listed below have been developed, constructed, and verified to meet the following technical requirement:

- No single failure of the RPAS or any external system supporting the operation will lead to operation outside of the operational volume.
- The probability that the RPA leaves the operational volume due to any combination of failures of the RPAS and/or any external system supporting the operation shall be shown to be extremely remote.
- Any failure of a system or subsystem whose operation is required to meet the above requirements is detectable by the operator.
- Software (SW) and Airborne Electronic Hardware (AEH) whose development error(s) could directly lead to operations outside of the operational volume shall be developed to an industry standard or methodology recognized by TCCA (ref. AC 922-001 Appendix A).
- The RPAS information and control interfaces are clearly and succinctly presented and do not confuse, cause unreasonable fatigue, or contribute to RPAS crew error that could adversely affect the safety of the operation.

Make	Model

Name of Responsible Person:

Title of Signatory:

Email Address:

Signature:

APPENDIX E – RPAS Safety and Reliability Targets

(1) **General**. This appendix sets out the quantitative, probability-based reliability targets for RPAS that must be met when required by an Operational Safety Objective or other performance objective. The reliability targets are scaled based on the kinetic energy of the RPAS as illustrated in Table 15, below.

(2) **Guidance Regarding System Safety Assessment**. For additional guidance on System Safety Assessment processes and practices, refer to Transport Canada AC 922-001, JARUS AMC.RPAS 1309, FAA AC 23-1309E, and SAE ARP 4754A and ARP 4761.

(3) **Guidance Regarding Fatalities and Injuries**. The definitions of the failure categories below use the terms fatality and severe injury when considering catastrophic and hazardous failure cases. Clearly, given that the RPAS addressed by this ORA do not include human occupants, the fatalities and injuries referenced here refer to either people on the ground or aboard other aircraft. When assigning a criticality level to a specific failure, the manufacturer of the RPAS will have to refer to their notional CONOPS for the aircraft. For instance, a failure resulting in an immediate uncontrolled crash may be considered catastrophic for an RPAS operating over an area of dense population, but might only be considered Major or Hazardous for an RPAS operating over a controlled ground area. These decisions regarding failure classification made by the manufacturer during the design stage are expected to result in operational limitations that will be passed onto the operator.

Table 15 – RPAS Reliability Targets

Criticality Classification	Definition applied to RPAS	Safety Objective	Reliability Target by Kinetic Energy, Probability of Failure per Flight Hour		
			< 700 J	< 34 kJ	< 1084 kJ
Catastrophic	Failure conditions that could result in one or more fatalities.	Extremely Improbable	$P(x) < 10^{-4}$	$P(x) < 10^{-5}$	$P(x) < 10^{-6}$
Hazardous	Failure conditions that would reduce the capability of the RPAS or the ability of the pilot to cope with adverse operating conditions to the extent that there would be the following: i. Loss of the RPA where it can be reasonably expected that a fatality will not occur, though people on the ground will sustain severe injuries, or ii. A large reduction in safety margins or functional capabilities, or iii. High workload such that the pilot cannot be relied upon to perform their tasks accurately or completely.	Extremely Remote	$P(x) < 10^{-3}$	$P(x) < 10^{-4}$	$P(x) < 10^{-5}$
Major	Failure conditions that would reduce the capability of the RPAS or the ability of the pilot to cope with adverse operating conditions to the extent that there would be a significant reduction in safety margins, functional capabilities or separation assurance. People on the ground may not sustain severe injuries. In addition, the failure condition has a significant increase in pilot workload or impairs remote pilot efficiency.	Remote	$P(x) < 10^{-2}$	$P(x) < 10^{-3}$	$P(x) < 10^{-4}$
Minor	Failure conditions that would not significantly reduce RPAS safety and that involve crew actions that are within their capabilities. Minor failure conditions may include a slight reduction in safety margins or functional capabilities, a slight increase in pilot workload, such as flight plan changes.	Probable	$P(x) < 10^{-2}$	$P(x) < 10^{-2}$	$P(x) < 10^{-3}$
No Effect in safety	Failure conditions that would have no effect on safety. For example, failure conditions that would not affect the operational capability of the RPAS or increase the pilot workload.	N/A	N/A	N/A	N/A

APPENDIX F — GUIDANCE ON THIRD PARTY VALIDATION AND ORGANIZATIONAL PROFICIENCY CHECKS

1.0 Background

(1) **General**. In some cases, AC 903-001 indicates that an Organizational Proficiency Check conducted by TCCA is required to address certain operational safety objectives. In addition, some operational safety objectives allow for third party validation to be used as a component of demonstrating compliance to the performance requirements associated with specific technical considerations. This Appendix provides guidance on TCCA's expectations with respect to the application and conduct of Organizational Proficiency Checks and technical third party validations.

(2) **Definitions and Abbreviations**.

Note: The definitions provided below are used strictly in the context of either an Organizational Proficiency Check or a technical third party validation as described in the remainder of the Appendix. In the case of any conflict between these definitions and definitions from other sources (e.g., the CARs), these definitions shall be used only in the context described in this Appendix.

(a) **Organizational Proficiency Check (OPC)**: refers to a demonstration of proficiency for the operation being proposed, which may include an assessment of:

(i) the proposed ConOps and associated SORA,

(ii) Compliance with the required robustness levels for each OSO,

(iii) Quality Assurance and Maintenance Control system(s) (for SAIL V and above),

(iv) a demonstrated flight.

All senior members of the organization shall participate, including:

(A) The person responsible for the operation,

(B) the RPAS Pilot responsible for the operation,

(C) the person(s) responsible for RPAS maintenance,

(D) any other crew members required for the operation as per the ConOps.

(b) **RPAS Check Person (RCP)**: an individual capable of conducting an Organizational Proficiency Check as accepted by the Minister. At this time, only qualified Transport Canada flight operations inspectors shall complete these OPCs.

(c) **RPAS Technical Check Person (RTCP)**: an individual capable of conducting an RPAS technical validation as accepted by the Minister. At this time, only qualified Transport Canada engineers and/or airworthiness technical inspectors shall accept technical compliance documentation.

(d) **Third Party**: At minimum, a third party means a person who can demonstrate domain knowledge as well as independence from the document(s), process(es), procedure(s), product(s), or person(s) being reviewed. Any third party to be used in a technical third party evaluation shall be agreed to in advance with TCCA.

2.0 Organizational Proficiency Check

(1) **General**. Organizational Proficiency Check refers to any TCCA validation requested for compliance to OSOs #1, 3, 7, 8/11/14/21, 9/15/22, 16, 17, or 23, and/or the operational components of OSOs #6, 10, or 19.

(2) **Application**. At present, organizational proficiency checks are conducted for any of the OSOs identified in (1) above which require a high robustness level for the operational SAIL level. These organizational proficiency checks consist of a review of the relevant policies, procedures, processes, and competencies through an OPC conducted by an accepted RCP.

3.0 Technical Validation

(1) **General**. Technical third party validation refers to any third party validation requested as a component of demonstrating compliance to OSOs #2, 4, 5, 12, 13, 18, 20, or 24, and/or the technical components of OSOs #6, 10, or 19. These validations are only applicable when identified in the relevant OSO as a means to achieve the required assurance for the operational SAIL level.

(2) **Application**. At present, technical third party validations can take two forms, depending on the approach selected by the applicant:

- **(a)** The applicant may elect to have their technical validation conducted directly by Transport Canada through of a review of the relevant policies, procedures, processes, and competencies by an RTCP.
- **(b)** Alternatively, the applicant may choose to identify an external third party based on the guidance in 1.0(2)(d) above and seek agreement from TCCA that this external third party is acceptable. Once an external third party is agreed upon with TCCA, the technical third party validation consists of a review of the relevant policies, procedures, processes, and competencies by the identified third party, with a final acceptance by a TCCA RTCP. It is expected that this process will significantly reduce the time required for the final TCCA acceptance.

APPENDIX G — GUIDANCE ON POPULATION DENSITY AND SITE SURVEYS

1.0 Background

(1) **General**. In this AC, population density values are used to assess the ground risk portion of the ORA process. In particular, Section 6.0 uses population density values to set the boundaries between different operational ground risk classifications, while Standard Scenario STSC-004 (Appendix D, Section 5.0) uses population density to set boundaries on acceptable locations for the proposed standard operation. This appendix provides additional guidance on where to find these data and how to use them in the context of the ORA or the Standard Scenario.

2.0 Assessment for Unpopulated and Sparsely Populated Areas

(1) **General**. For operations taking place in unpopulated or sparsely populated areas (up to a maximum of 5 or 25 ppl/km^2 respectively), the expectations associated with verifying operational ground risk are generally composed of three items: a “virtual” site survey of population density, an in-person site survey to validate the operational area, and active monitoring of the operational area while the flight operation is in progress. Guidance related to each of these items is provided below. An example of this type of operation can be found in STSC-004 (Appendix D, Section 5.0), under which BVLOS operations are limited to ground areas that are a minimum of 1 km from any area with a population density greater than 5 persons per square km, and a minimum of 2 nautical miles from any area with a population density greater than 25 persons per square km.

(2) **“Virtual” Site Survey**. The primary source of data for the virtual site survey is expected to be the Statistics Canada census data. The data can be downloaded from Statistics Canada for use in separate applications (e.g., Google Earth) or can be accessed directly in graphical format at https://www150.statcan.gc.ca/n1/en/geo. In cases where the main Geography page is unavailable, an alternative link is available at https://www12.statcan.gc.ca/census-recensement/2011/geo/ref/geosearch-georesearche-eng.cfm (note that this link also provides access to archived Census data, and care should be taken to ensure that the most recent available data is being used). Once the Statistics Canada map has been accessed, the display should resemble Figure 21, below. When using population density data for virtual site survey purposes, it is recommended that the lowest granularity of data available be used (Dissemination Areas). To display population density data on the Statistics Canada map, zoom in to the area of interest (Halifax in this example) until the “Displayed boundary” at the lower left of the map shows “Dissemination Areas” as illustrated by the red boarder in Figure 22. The “lock” button can then be pressed (red arrow in Figure 22) to ensure that the Dissemination Area data remains displayed as the map is navigated. The dissemination area(s) near the operational area of interest can then be selected by clicking on the map, which will result in the population information being displayed as shown in Figure 23 (population density highlighted by the red border). As noted above, this virtual site survey provides only an initial assessment for areas of low population density. For example, the population density criteria for STSC-004 is 1km away from areas with 5 persons per square km; thus, if a dissemination area near the intended operation has a population density significantly greater than 5, it is unlikely that the operation will be feasible under STSC-004. However, it may still be possible if the specific geography of the operation and the local population densities permit the 1km from 5 people per square km criteria to be maintained throughout the intended operation. If all dissemination areas within 1km of the operational area have population densities of 5 or less persons per square km, the operation is not automatically acceptable but the operator can proceed to an in-person site survey as described below with reasonable confidence that the operation is feasible. A similar approach can be applied in cases where an operation is planned to be conducted in areas with population densities up to 25 ppl/km^2. An additional layer of virtual site survey may also be conducted using the “Street view” function of Google Maps or Google Earth; Figure 24 provides several examples of areas that are below 5 persons per square km contrasted with areas that are above 5 persons per square km.

Figure 21 – Statistics Canada Geography tool

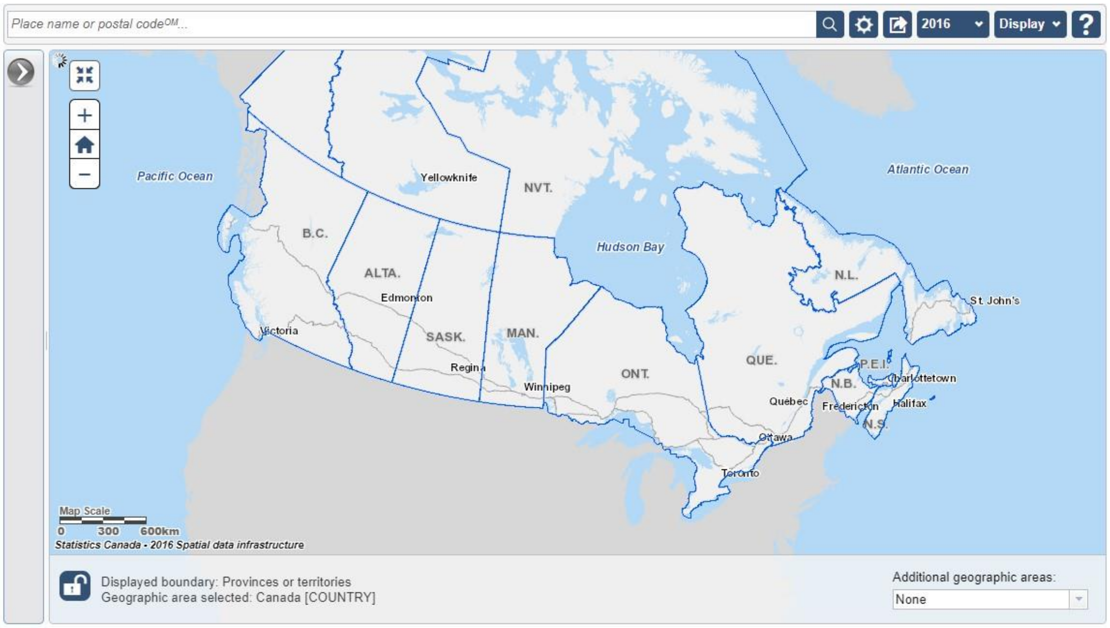


Figure 22 – Map zoomed in to show Dissemination Areas

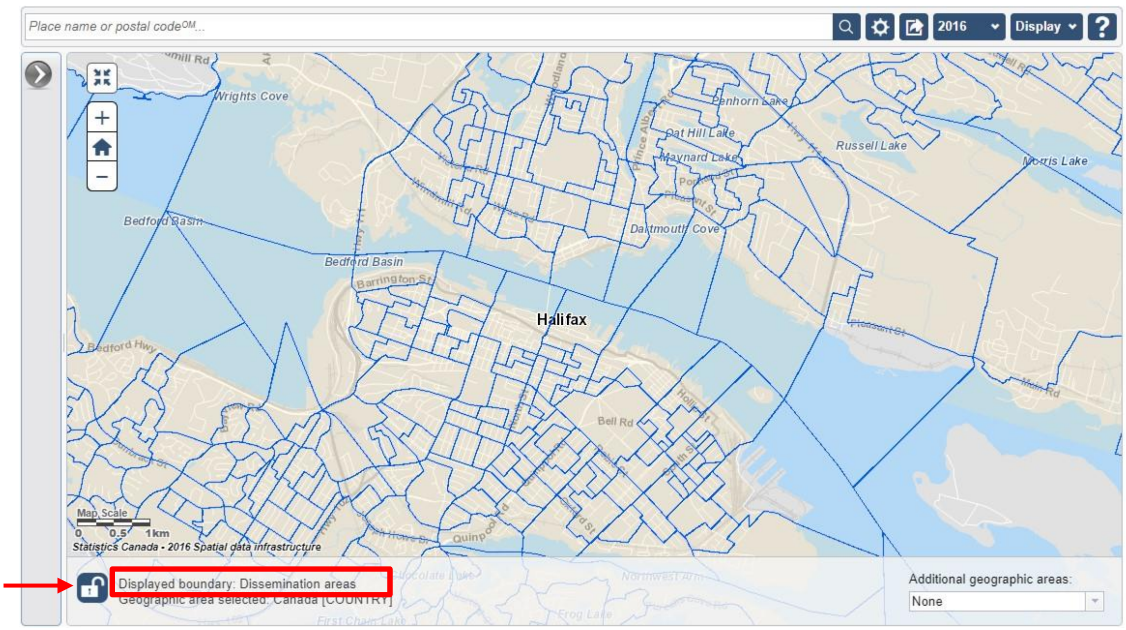


Figure 23 – Display of Population Density Data

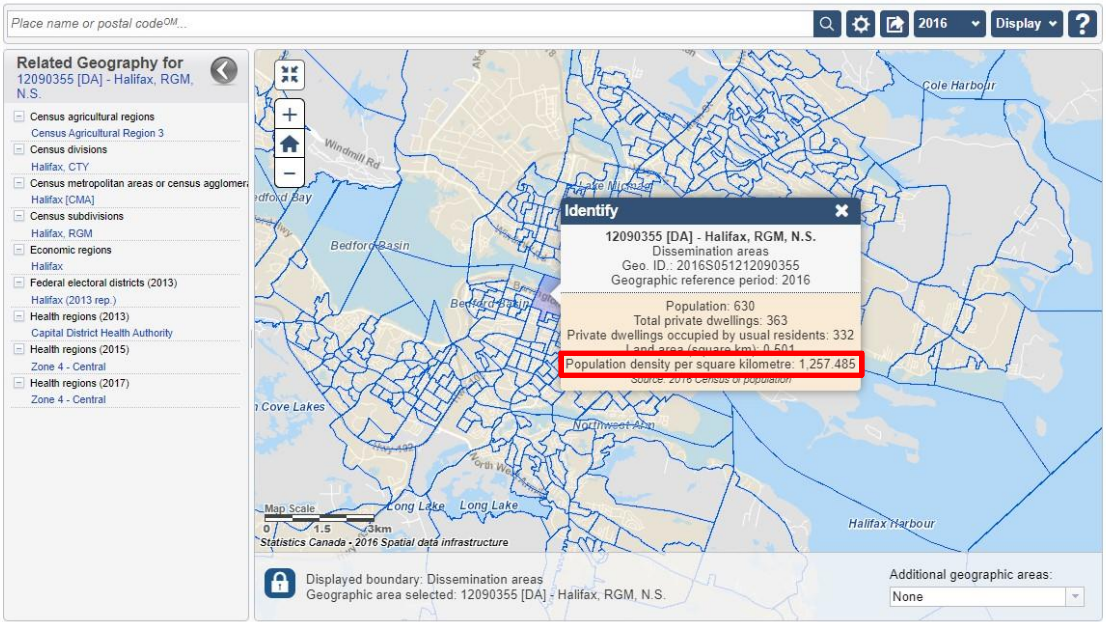


Figure 24 – Sample images of areas with more and less than 5 persons per square km

Less than 5 persons per square km	Between 5 and 25 persons per square km
	
	

Less than 5 persons per square km	Between 5 and 25 persons per square km
	
	

(3) **In-Person Site Survey**. After completing a virtual site survey to assess operational feasibility as described above, the operator must also complete an in-person site survey prior to the operation. For STSC-004, or other operations in areas of low population density, this is required not only to satisfy CAR 901.27, but also to validate that the local population in the operational area satisfies the population density criteria. For example, the site survey should confirm that there are no new built-up areas or changes to city boundaries that would not have been reflected in the most recent census data, and that the operation is planned such that it avoids flight over/near any buildings or areas where people could be expected to be found. This should include assessment of areas that would not be highlighted by the Statistics Canada census (e.g., recreational areas such as campgrounds, beaches, ski hills during wintertime, as well as industrial areas and worksites, etc.).

(4) **Operational Monitoring**. Once the virtual and in-person site surveys have confirmed that the operational area meets the population density criteria, the operation may commence. During the operation, the RPAS operator needs to monitor the area around the aircraft (e.g., using cameras or sensors on the RPA) and adjust operations if evidence is found of sufficient numbers of people on the ground to invalidate the population density criteria. For a case where the site surveys showed an area was clear, but during operations a group of people (e.g., hikers, campers, etc.) were identified in the operational area, the expectation would be for the RPAS operator to handle the situation in the same manner as a traditional aviation pilot who becomes aware of something new creating a hazard to their operation. In the case of STSC-004, the RPAS operator would need to turn around or adjust their flight path to stay 1km away from the group of people.

- **Cases where the Virtual Site Survey indicates more than 5 or 25 people per km^2.** As noted above, there may be cases where the population density indicated by the virtual site survey does not reflect the actual number of people in the operational volume. There could be several reasons for this, and in some cases it may be due to the shape and location of the Dissemination Areas calculated by

Statistics Canada. Dissemination Areas, especially those in rural areas will often contain an area of clustered population and an adjacent larger unpopulated area. In cases like this, an operation may be permissible over the adjacent unpopulated area provided the operator takes reasonable measures to ensure that the operational volume, at the time of the operation, does not exceed the number of people per km^2 allowed by the standard scenario. Operator due diligence to ensure the operational area is clear of people may include:

- Reliance on natural physical barriers. The operation might take place in an area that is difficult to access. Examples could include bodies of water, mountains, or dense forest.
- Reliance on man-made physical barriers. Some operations, for example agricultural spraying, may take place over private property. If the operator, in cooperation with the property owner/manager can take steps to ensure the area is clear of people during the operation, then the operation could be permitted despite the results of the virtual site-survey. In this case, it is expected that the operator would take reasonable precautions to ensure that the area remains clear during the operation. Reasonable precautions could include ensuring that property fencing is intact, and the installation of signage at access points to indicate that the property is private and warning that drone operations might be in progress.
- In addition to determining if the operational area is accessible to people, the in-person site survey should determine how the area will be kept clear of people during the operation. Examples of this might include monitoring of access points to the area before and during the flight, or installation of signage where appropriate. Procedures may also be developed to use on board cameras (or other sensors) on board the RPA to ensure that the area remains sufficiently clear of people during the operation. This might even include the use of a second RPAS that is able to monitor for people in the area, in the even that the primary RPAS is not able to perform this function. (e.g. using a second RPAS equipped with a camera to scan for people while the primary RPAS performs the primary mission with a sensor dedicated to that task.)
- Strategic location of the base of operation and visual observers. While parts of an operation might be BVLOS, STSC-004 operations will generally commence and conclude with a period of VLOS operation. It’s expected that this part of the operation would be conducted in accordance with CAR Part IX VLOS rules, and therefore respect the appropriate distance from people not involved with the operation, maintenance of VLOS, etc. If the operator cannot adequately demonstrate that a small section of the operational volume meets the population density criteria, it may be feasible to design the operation such that flight over those sections is conducted in accordance with Part IX

VLOS rules. This might include locating the launch/recovery site in the problematic area or stationing visual observers at that location so that the operation can transition to VLOS in that area.

3.0 Assessment of More Densely Populated Areas

- **General**. For operations taking place in areas with a population density above 25 ppl/km^2, the expectations associated with verifying operational ground risk are the same as described in Section 2.0 above, with a few exceptions specific to higher population densities. Guidance related to each of these items is as follows:
  - Virtual and In-Person Site Surveys. In the case of higher population density areas, it is expected that the virtual site survey will be the primary source of population density data, as in most cases it is not expected that an in-person survey would be able to demonstrate a population density significantly greater than or less than the expected value. However, an in-person site survey is still required to satisfy CAR 901.27, and attention should still be paid to identifying significantly increased areas of ground risk (e.g., actual or potential outdoor gatherings of people).
  - Operational Monitoring. As in low population density operations, if an area of increased ground risk is identified during an operation, the expectation would be for the RPAS operator to handle the situation in the same manner as a traditional aviation pilot who becomes aware of something new creating a hazard to their operation. For operations being conducted in higher population density areas, the primary difference is determining what constitutes an area of increased ground risk. Since it is generally accepted that operations in areas above 25 ppl/km^2 will involve occasional flight near or over people not involved in the operation, evidence of small numbers of people in the operation is not necessarily problematic. However, it is expected that the operator develop criteria specific to their operational approval for how to identify increased levels of ground risk and when an operation should be suspended or modified as a result.