



**SMALL REMOTELY PILOTED AIRCRAFT SYSTEM (RPAS)
Best Practices for BVLOS Operations**

DERIVED FROM UAV PROGRAM DESIGN WORKING GROUP
PHASE 1 and 2 REGULATORY RECOMMENDATIONS

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(Provided by Unmanned Systems Canada)

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Version	Date	Change
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1 Foreword

1.1 Background

The Canadian Aviation Regulation Advisory Council (CARAC) Unmanned Air Vehicle Systems Program Design Working Group is an industry and government stakeholder committee formed in June 2010 that has been tasked with developing a suite of proposed recommendations for regulations that will enable routine unmanned air vehicle (UAV) operations in Canada. The working group is divided into sub-groups reflecting airworthiness (equipment), operations, and personnel. The regulations development process has been divided into 4 distinct phases as outlined in the Terms of Reference:

1. UAVs under 25 Kg, operating within visual line of sight (VLOS)
2. UAVs under 25 Kg, operating beyond visual line of sight (BVLOS)
3. UAVs over 25 Kg, but under 150 Kg, operating BVLOS
4. UAVs over 150 Kg operating BVLOS

The working group presented its recommendations for Phase 1 to a special day-long CARAC technical committee in June 2012. Due to the long timelines associated with turning a proposed regulation into aviation law (approximately 7 years) the working group decided to incorporate the proposed regulations into new Staff Instructions for TC Inspectors to expedite the approval of Special Flight Operations Certificates for UAS and operations compliant to the proposed regulations. One year prior to the release of the Staff Instructions (SI-623-001) in November 2013, Unmanned Systems Canada released to its members a set of Best Practices for small UAV operations within visual line of sight based upon the regulatory recommendations of the working group. These Best Practices afforded industry an early opportunity to align with the staff instructions. In May of 2015 Transport Canada announced a Notice of Proposed Amendment (NPA) to the Canadian Air Regulations for UAV's under 25kg operated within VLOS based largely on the Phase 1 work of the UAV Program Design working group.

Note: The NPA published by Transport Canada differed in some respects from the Phase 1 VLOS recommendations and, as the Phase 2 BVLOS recommendations were being developed concurrently with the NPA process, differences in regulatory recommendations for VLOS operations and any follow-on implications to BVLOS operations are not reflected in this document.

The working group's recommendations for Small UAVs operated Beyond Visual Line of Sight (BVLOS) were completed in the Spring of 2015 and are, at the time of writing this report, awaiting final CARAC approval.

Terminology Note: There is a great variety of terminology associated with unmanned aircraft these days, with the popular press favouring the use of 'drone', ICAO and industry moving towards UAS (Unmanned Aircraft System) and RPAS (Remotely Piloted Aircraft System), and the existing Canadian regulations referring to UAV. The rationale for moving towards the UAS and RPAS is sound: it indicates that unmanned aircraft are in fact aircraft and not 'vehicles', and that a certain subset of these aircraft are remotely piloted (i.e. RPAS). Unmanned Air Vehicle, however, is the term that is currently defined within the Canadian Aviation Regulations, and thus it has been used in this background section of the document. For the remainder of the document, the terms UAS, and RPAS are employed, reflecting the global trend, and the anticipated terminology for the forthcoming Canadian regulations.

1.2 Document Purpose

This document presents recommended practices and guidelines for established Small UAS operators who wish to extend their operations from VLOS to BVLOS. These guidelines are based on the Phase 2 BVLOS recommendations described above. It is recommended that any application for BVLOS operations of a Small RPAS in Canada at a minimum address the underlying concepts of all the guidelines provided herein (including by reference those of Staff Instruction 623-001).

At the time of writing, Transport Canada has indicated that any operator of small RPAS who is seeking to operate BVLOS must have a safe track record operating VLOS and be a “Compliant Operator” for VLOS. It is anticipated that Transport Canada will, in future, release further guidance information on BVLOS operations that will include how and where unproven or low reliability systems will be able to conduct their required testing.

As with the VLOS best practices document, the information in this document is based on a snap-shot in time and is subject to change as the regulatory process moves forward. It is the authors’ intent to conduct periodic updates to this document as the process evolves, and increased experience is gained through the conduct of BVLOS operations. This version (1.0) of the document builds upon the material published in Staff Instruction 623-001. For traceability, a copy of SI 623-001 as it appeared at the time of writing has been archived on the Unmanned Systems Canada website.

1.3 Document Scope and Organization

This document is, at times, written in a regulatory-type language; however **these guidelines are not regulations**. As stated earlier, they are based on the latest recommendations of the working group, and provided in advance of expected Transport Canada regulations, standards and advice in order to allow the Canadian UAS industry to align itself with future regulation to the extent practical. It is our strong recommendation that companies and individuals submitting SFOC applications for BVLOS operations ensure that their proposed operation will comply with, or at a minimum address the underlying concepts of, all the guidelines provided herein (including by reference those of Staff Instruction 623-001).

It should be noted that the scope of operations that may be considered as BVLOS is extremely vast, ranging from operations that are conducted behind obstructions (e.g. behind a building), to low level cross-country VFR with launch and recovery from an ad-hoc site (e.g. an open field), all the way to cross-country IFR flights through control zones and involving take-off and landing at aerodromes. It should be expected that the level of documentation and justification required to get operating approval is commensurate with the level of complexity of the proposed operation.

It is USC’s recommendation to Transport Canada that this document, and associated feedback received from its release, be considered as the basis for a future Transport Canada Advisory Circular for small RPAS BVLOS operations.

1.3.1 Document Organization

This document consists of 5 sections and 6 Appendices as described below:

Section 1: Provides the necessary background, introduction, purpose and scope of the BVLOS ‘Best Practices’, the guiding philosophy behind the working group recommendations, as well as clarification regarding flight rules and meteorological conditions.

Section 2: Provides guidelines regarding small RPAS pilot qualifications for BVLOS operations.

Section 3: Provides an overview of the proposed design standard for small RPAS operating BVLOS, as well as recommendations regarding maintenance of these systems to ensure that they remain compliant with their design.

Section 4: Provides guidelines for general operation of small RPAS BVLOS that should be considered in conjunction with the guidance material identified in [Appendix 6 of SI 623-001](#). This section contains items such as system capability/equipment requirements, and recommendations for flight planning with respect to lost-link, contingencies, and flight termination.

Section 5: Provides guidelines for recommended “company practices” that should be in place within the organization that seeks to operate an RPAS BVLOS. These practices should be considered in conjunction to those for required for a Compliant Small RPAS Operator for VLOS as described in [Appendix D of SI 623-001](#).

Appendix 1: Provides Terms and Definitions which assist the understanding of this document.

Appendix 2: Provides the proposed small RPAS design standard covering BVLOS and VLOS operations.

Appendix 3: Provides the suggested content for a company operations manual, standard operating procedures, operational flight plan, and additions to the RPAS operations manual for ‘low visibility operations’.

Appendix 4: Replicates the material from Appendix D ‘CRITERIA FOR A COMPLIANT OPERATOR OF SMALL UAV SYSTEMS’ from SI-623-001 at the time of writing of this document, for historical traceability and convenience of reference with Section 5 of this ‘Best Practices’

Appendix 5: Provides a sample mid-air collision risk analysis that may be used in conjunction with local airspace density statistics to build a safety case for sense-and-avoid systems that do not yet meet the reliability requirements identified in the proposed small RPAS design standard of Appendix 2.

1.4 Equivalent Level of Safety, and Integration

The UAV program working group’s regulatory recommendations, and hence the guidelines presented in this document are based on the principle that UAS operations must have an equivalent level of safety to that of manned aviation. This in-turn implies that UAS operations must pose no greater risk of injury or damage to persons or property on the ground, or other airspace users than manned aviation operations.

Many, although not all, of the risks to persons/property on the ground are mitigated by the small size, weight, and speeds associated with the Small UAS category (25 kg). The impact to airspace users, however, is more severe. A collision between a small RPA and an aircraft is likely to be catastrophic, as even bird strikes present a significant hazard to manned aviation. In addition to the risk of collision, consideration needs to be given as to the effects of integrating UAS into the air traffic management system. To this end, the guiding philosophy for the UAV program working group's regulatory recommendations and the guidelines in this document is to 'conform rather than create'. This is accomplished by making the operation of UAS transparent to other airspace users, whether by equipment (e.g. VHF radios, or aircraft lighting standards), or procedures (e.g. filing and following an IFR flight plan).

1.5 Clarification of VLOS, BVLOS, IFR, and VFR

Table 1 below illustrates the difference between IFR, and BVLOS. In particular it presents three rows that are required to describe any RPAS operation; they are:

- 1) The RPAS Operating condition (VLOS, or BVLOS)
- 2) The meteorological minimum conditions (VMC, or IMC)
- 3) The flight rules (VFR, or IFR)

The RPAS operating condition can either be VLOS, or BVLOS depending on how monitoring trajectory and de-confliction with obstacles and air traffic is performed. Visual Line of Sight operations, VLOS, make use of observers and/or the pilot to directly monitor the state of the unmanned aircraft and "sense and avoid" collision with obstacles and/or other aircraft. Beyond Visual Line of Sight operations, BVLOS, do not use direct observation of the aircraft and surrounding airspace for monitoring and sense and avoid, so alternate means must be present.

With respect to meteorological conditions, Visual Meteorological Condition (VMC) is a description of the minimum conditions for being able to fly under Visual Flight Rules (VFR) in a particular airspace. If the weather conditions are below the VMC minimum, then the conditions are considered Instrument Meteorological Conditions (IMC), and it is only possible to fly under Instrument Flight Rules (IFR). It should be noted, however that IFR flight is also often conducted in VMC, thus it is possible for IFR and VFR traffic to be operating in the same airspace.

The flight rules (VFR, or IFR) determine how the aircraft is operated including flight planning, interactions with airspace and air traffic control. There are also increased pilot training/knowledge requirements, and equipment/system capability requirements associated with operations under instrument flight rules.

Table 1: Flight Rules, Met Conditions and RPAS Operating Conditions

1	VFR	Flight Rules	Determines how the aircraft is operated including flight planning, interactions with airspace, ATC, weather minima, etc...
	IFR		
2	VMC	Met Conditions	VMC is a description of the minimum meteorological conditions for applying VFR in a particular airspace. If the conditions are below the VMC minimum, then they are IMC (only IFR flight is allowed)
	IMC		
3	VLOS	RPAS Operating Condition	Determines how monitoring trajectory and deconfliction with obstacles and aircraft is performed (i.e. eyeballs or systems)
	BVLOS		

2 RPAS Flight Crew Qualifications

2.1 Small RPAS Pilot for BVLOS operations

While there are no knowledge requirements/testing approved or accepted for BVLOS RPAS at this time, it is anticipated that these pilots will require VLOS qualifications plus additional knowledge and experience relevant to operating the RPAS in the proposed BVLOS operational scenario. Note that BVLOS operations can range from operation behind a building to full IFR.

An SFOC application should describe this additional knowledge and experience in detail.

As a minimum the following is expected:

(1) Age

The pilot should be a minimum of eighteen years of age.

(2) Medical Fitness

The pilot should sign a Cat 4 declaration which the RPAS Operator must keep on file. A current medical associated with a pilot's licence or permit would suffice, in lieu of the Cat 4 declaration.

(3) Knowledge

An applicant should have:

- (a) completed a course of pilot ground school instruction on the following subjects:
 - (i) air law and procedures relevant to the permit (e.g. general provisions, general operating and flight rules, air traffic control services and procedures, aviation occurrence reporting),
 - (ii) flight instruments (e.g. altimetry, GPS, airspeed and heading indicators),
 - (iii) navigation (e.g. aeronautical charts, pre-flight preparation),
 - (iv) flight operations (e.g. wake turbulence causes, effects and avoidance; data and command links),
 - (v) meteorology (e.g. required for line-of-sight operations),
 - (vi) human factors (e.g. aviation physiology, the operating environment, aviation psychology), and
 - (vii) theory of flight (e.g. basic principles), and

- (b) obtained a passing grade on a written exam administered by a training organization following Transport Canada endorsed RPAS knowledge requirements when possible.

Note: At the time of writing, the knowledge requirements have not been defined and as such no exams exist. Unmanned Systems Canada is prepared to work with member companies in cooperation with Transport Canada subject matter experts to expand the scope of the current knowledge requirements for pilots of small RPAS operating within VLOS to include the added scope for BVLOS operations.

(4) Experience

Within the 24 months preceding the date of application for the SFOC, the RPAS pilot should have acquired on a small RPAS:

- (a) practical training on small RPAS; and
- (b) the operator, manufacturer or third party that is responsible for the training must be responsible for ensuring that the applicant has reached a satisfactory standard of experience to establish proficiency.

(5) Skill

The applicant should submit a letter, as part the SFOC application, from the person responsible for the training, certifying that the pilot has successfully demonstrated the ability to perform both normal and emergency manoeuvres appropriate to the small RPAS used for the training program, and with a degree of competency appropriate for the proposed BVLOS operation.

(6) Credits

The RPAS operator will determine whether a RPAS pilot can be given credit for previous experience in accordance with the guidance below:

(a) Canadian Civil Licence

An RPAS pilot who holds a Private Pilot Licence or higher shall be considered to have met paragraph 3 (a) of the knowledge requirement.

(b) Foreign Applicants

It is expected that RPAS pilots with foreign credits will be evaluated on a case-by-case basis by Transport Canada.

(c) Canadian Forces Pilot Applicants

Active and retired Canadian Forces personnel who have qualified to pilot aeroplane wings standard or who have successfully completed the Basic Flying Training course of approximately 120 hours as having met paragraph 3 (a) of the knowledge requirement.

Active and retired Canadian Forces personnel who hold current Canadian Forces qualifications on RPAS (or equivalent), as having met knowledge, experience and skill requirements (paragraph 3, 4, and 5).

2.2 Pilot Recency Requirements

- (a) the RPAS pilot should have acted as RPAS pilot within the five years preceding the flight or have met the written examination requirements for the permit within the 12 months preceding the flight; and
- (b) the RPAS pilot has, within the six months preceding the flight, acted as RPAS pilot in day and night operations
 - (i) of an RPAS, or

- (ii) of a flight trainer for an RPAS capable of the full range of flight tasks.

2.3 Qualifications of Flight Instructors

A person who conducts RPAS flight training should meet the following:

- (i) meet the requirements identified in 2.1 and 2.2 and
 - a. Within the 24 months preceding instruction have acquired in a minimum of 50 flights or 6 hours flight time, including a minimum of:
 1. 5 flights or 2 hours of dual instruction flight time,
 2. 5 flights or 2 hours of dual flight time on instructional techniques
 3. 3 hours solo flight time
 4. Competency in night operations

Note: *performance based training requirements may need more data from RPAS operations and training to in order to develop.*

2.4 Additional RPAS Pilot Requirements for BVLOS under Reduced Visibility VFR, Night VFR, and IFR

For night operations, the RPAS pilot must demonstrate night competency to a person holding proficiency on RPAS operations on that type.

For IFR operations the RPAS pilot must maintain a valid manned aircraft pilot licence with an instrument rating and in addition must have flown RPAS IFR within 6 months demonstrating competency or successfully completed an instrument flight in an RPAS under the supervision of a person who holds an IFR rating and the necessary instructor qualifications;

For proposed VFR operations conducted below the standard VFR visibility limits of [CAR 602.115](#), the RPAS pilot must obtain initial training and annual recurrent training in all procedures specified in the RPAS operations manual for low visibility operations.

3 Airworthiness (Compliant RPAS for BVLOS)

3.1 General

During the Phase 2 CARAC work, the subcommittee responsible for airworthiness concerns revised and enhanced the proposed RPAS design standard developed during Phase 1 – VLOS to cover system requirements for Small RPAS engaged in either VLOS or BVLOS operations. These deliberations were presented to and subsequently adopted by the entire CARAC working Group. The result, a proposed new SMALL RPAS DESIGN STANDARD (referred to as Part 5XX), in its entirety, is included in this document as Appendix 3. **This proposed design standard, while not currently approved or adopted by Transport Canada, is the best estimate of appropriate requirements identified by the CARAC UAV Working Group experts. As such, it is considered a “best practice” at this time.**

The rest of this section will provide a summary of the key principles that address the particular requirements of BVLOS operations that are not already covered in previous RPAS design guidance found in the current Transport Canada Staff Instruction.

Similar to the approach for a Compliant Small RPAS for VLOS in the current TC Staff Instruction, compliance with the airworthiness requirements for Small BVLOS RPAS has been proposed as a manufacturer “self-declaration of compliance” process coupled with documentation attesting to the conformity of a particular, individual RPAS to the compliant design. Please refer to the [TC staff instruction section 9.7\(2\) “UAV System Airworthiness”](#) for the current details of this process. In essence, to achieve compliance the manufacturer must keep sufficient documentation to establish how each requirement of the Design Standard has been met, including analysis of specifications, drawings, instructions, any associated ground/flight testing. Two documents must be submitted to the Minister as part of this process: (1) A [“Declaration of Compliance”](#) which is a declaration by the manufacturer that the design of a particular make/model of an RPAS meets the design standard, and (2) A [“Statement of Conformity”](#), which is a declaration that a particular serial number has been manufactured and assembled in accordance with the design as defined in the Declaration of Compliance.

It has also been proposed in both Phase 1 and in Phase 2 that Compliant RPAS should be issued Special Certificates of Airworthiness, although at the time of writing Transport Canada has provided no indications that this will be the case.

3.2 The proposed new SMALL RPAS DESIGN STANDARD

The proposed new SMALL RPAS DESIGN STANDARD has content described by the outline below. As previously mentioned, it is based on the standard that was developed under the Phase 1 CARAC work with the bolded text below representing those sections that are new or that have been significantly revised. It should also be emphasized that while the proposed new SMALL RPAS DESIGN STANDARD specifies performance and reliability requirements for a wide variety of RPAS sub-systems and components, it is the operational requirements for a given type of RPAS, operation and/or airspace (found in section 4.6 of this best practices document) that define which sub-systems and components are required to be embodied in the RPAS for that particular operation. Further, it should be noted that by nature of inclusion, an RPAS compliant with this design standard is also compliant with VLOS RPAS design standard contained in [Appendix C of SI-623-001](#).

Proposed SMALL RPAS DESIGN STANDARD OUTLINE

- 5XX.1. Definitions**
- 5XX.2. General
- 5XX.3. Flight (Performance) etc.
- 5XX.4. RPAS Design and Construction
- 5XX.5. RPA Structure
- 5XX.6. Propulsion System
- 5XX.7. Command and Control**
 - 1. General**
 - 2. Flight and Navigation Information
 - 3. Navigation Systems**
 - 4. Autopilot System**
 - 5. Radiocommunication and Control Links**
- 5XX.8. Sense and Avoid Systems**
- 5XX.9. Lost Link**
- 5XX.10. Flight Termination System**
- 5XX.11. Systems and Equipment
 - 1. General Function and Installation
 - 2. Equipment, Systems and Installations
 - 3. Airspeed System**
 - 4. Pressure Altitude System**
 - 5. Direction Sensing System**
 - 6. Ground/Surface Feature and Cloud Detection Systems**
 - 7. Launch and Recovery Systems
 - 8. High-intensity Radiated Fields (HIRF) Protection
 - 9. Lighting**
 - 10. Systems for IFR Flight**
- 5XX.12. Payloads**
 - 1. All Payloads
 - 2. Payloads used for “Flight Decisions”
 - 3. Interchangeable Payloads
- 5XX.13. Manuals and Documentation

Specific key principles in the new or revised sections of the design standard, that are specifically related to BVLOS include:

3.2.1 - 5XX.7 - Command and Control:

General: The command and control section of the proposed design standard defines the minimum requirements for command and control systems. A specific requirement is also introduced: During pilot handovers, there shall be a means to synchronize and positively transfer control between control stations and/or pilots. The receiving PIC shall be provided with all information required for timely control, response to emergencies and general operating state of the RPA.

Navigation Systems – This section of the proposed design standard addresses the minimum standard for primary and secondary navigation systems to ensure that the pilot always has the capability to navigate.

Autopilot System – Any automatic system installed must be able to be overridden or disengaged by the pilot to allow direct control of the RPA trajectory.

Radiocommunication and Control Links – radiocommunication systems installed in an RPAS shall mimic the functions and performance of a manned aircraft radio system i.e. be transparent to other airspace users and ATC.

3.2.2 – 5XX.8 - Sense and Avoid: The sense and avoid section of the proposed design standard defines the minimum performance of an airborne system for detecting other aircraft and providing guidance and control in the avoidance of possible collisions. Some of the requirements for such a system include advance warning to the pilot prior to a potential collision, an automatic function that will perform a collision avoidance maneuver if the pilot does not, or cannot respond to the warning and a 360 degree field of regard capability. In addition, sense and avoid systems will need to be compatible with existing aviation collision avoidance systems (e.g. Airborne Collision Avoidance System (ACAS) or Traffic Alert and Collision Avoidance System (TCAS)), must have the functionality to comply with right-of-way rules and must be compatible with any separation provision services provided by Air traffic Services in a given airspace class.

Note: *The field of regard requirements were debated at length during Working Group deliberations. Some believed that +/- 120 degrees may be sufficient, however, the final consensus (although not unanimous) recommendation is for a field of regard requirement of +/- 180 degrees horizontal coverage. This decision is based largely on the fact that small RPA would likely be overtaken by manned aircraft due to their slow speed and the likelihood that a manned aircraft would be unable to visually acquire the RPA due to its small size.*

3.2.3 - 5XX.9 - Lost Link: The lost command and control link section of the proposed design standard defines the system capability functions that are necessary so the link can be regained or the RPA can be safely recovered. Pre-programmed manoeuvres and procedures must be compliant with the operating and flight rules imposed on the operation.

3.2.4 – 5XX.10 - Flight Termination Systems: The flight termination section of the proposed design standard defines the circumstances under which a flight termination system is required, the characteristics of the system and places responsibility on the manufacturer to document the testing and analysis that demonstrates and verifies the reliability and functionality of the system.

3.2.5 – 5XX.11 - Systems and Equipment:

Airspeed System – The airspeed system must indicate true airspeed, provide drainage of moisture and be capable of operating reliably and accurately in icing conditions or cloud, where such operations are permitted.

Pressure Altitude System – The pressure altitude system must be capable of operating reliably and accurately, including in icing conditions or cloud, where such operations are permitted.

Direction Sensing System – This section sets out the performance requirements for systems that are both reliant, and not reliant, on the earth’s magnetic field.

Ground/Surface Feature and Cloud Detection Systems: This section of the proposed design standard defines the minimum performance standards that these systems must have if they are to be used by the RPAS pilot during flight.

Lighting: This section of the proposed design standard defines performance requirements for RPAS anti-collision and position lights, including field of coverage, flashing characteristics, colour and intensity.

Systems for IFR Flight: This section of the proposed design standard specifies that systems required for IFR flight must be developed, maintained and operated in accordance with any existing TSO or other regulations that are in place for the corresponding manned aviation equivalent equipment.

3.2.6 – 5XX.12 - Payloads: This section of the proposed design standard has been simplified from that proposed in Phase 1 to ensure emphasis is placed on ensuring that payloads do not impede the safe operation of the RPAS.

3.3 Maintaining an RPAS for BVLOS

Any maintenance performed on any Compliant Small RPAS must ensure that the systems remains in conformance to its original design, and thus remains “compliant”. As such, personnel performing such maintenance must have the appropriate training and qualifications. It is expected that in many cases such training will be provided by the original RPAS manufacturer.

3.4 Modifications of a Small RPAS

Given the “self-declaration” and non-type certified nature of a Compliant Small VLOS RPAS which is described in detail in the current TC Staff Instruction, and is expected to also be used for Small BVLOS RPAS, the process to ensure that “after-purchase” modifications made to a particular RPAS do not invalidate the RPAS compliance was reviewed and considered not sufficiently clear. To rectify this shortcoming, the material below was developed to be reflected in any regulatory development for Small RPAS. It is based, in part, on similar regulation for Advanced Ultralights in Canada.

Note: *It must be emphasized that at this time, Transport Canada has not promulgated any regulation, standard or guidance that covers the material in this subsection – it is our hope that this sub-section, like the rest of this entire document, will serve to define “a best practice” which leads to a clear and efficient approach to regulating this aspect of Small RPAS.*

3.4.1 Definition:

Compliant – means satisfying the requirements of proposed SMALL RPAS DESIGN STANDARD (5XX) as recognized by the issuance of a Special C of A.

One of the conditions for a Compliant Small RPAS to remain compliant is that it may not be modified without written approval from the manufacturer. Owners of RPAS must seek manufacturer approval BEFORE they make any modification to their aircraft system.

When considering the modification of a Compliant Small RPAS, the manufacturer and owner are reminded of the following responsibilities:

3.4.2 Manufacturer Responsibilities

The manufacturer of a Compliant Small RPAS is responsible for the "after-market" support for the continuing "fit for flight" condition of their product. They must prepare and provide to all owners of their Compliant Small RPAS the following information:

- Schedule and the maintenance procedures to maintain the RPAS in a "fit for flight" condition; and
- Mandatory Action information issued by themselves or Transport Canada and corrective procedures for potential unsafe flight conditions.

In addition, the manufacturer of a Compliant Small RPAS must

- Maintain a current record of all Mandatory Actions affecting their RPAS.
- Maintain a current record of the owners of their RPAS.

3.4.3 Owner Responsibilities

The owner of a Compliant Small RPAS must:

- Maintain the RPAS in a "fit for flight" condition by adhering to the Manufacturer Specified Maintenance Program.
- Provide the any new owner with documentation to prove the system is "Fit for Flight"
- Complete manufacturer's Mandatory Actions in accordance with the manufacturer's instructions and time frame.
- Maintain appropriate records for the RPAS which must include scheduled maintenance, mandatory action, modifications, and accident repairs.
- Meet the registration requirements found in Part II of the Canadian Aviation Regulations.

3.4.4 RPAS Modifications by Original Manufacturer

If the owner of a compliant small RPAS wants to make a modification to an RPAS, the owner may go to the original equipment manufacturer (OEM) to obtain written approval. The Original Equipment Manufacturer (OEM) can approve the owner modification of the Small RPAS if the owner is deemed to have sufficient expertise to perform the modification and if one of three approaches is taken:

1. The Manufacturer decides that the modified RPAS still conforms to the original type definition for that RPAS model. Therefore, once the owner receives the manufacturer's written approval, the modification may proceed. Unless the specified maintenance program changed, there would also be no need for the manufacturer to submit any information to Transport Canada, as the original Declaration of Compliance (DOC) would still apply; or
2. The Manufacturer deems that the modified RPAS will no longer conform to the original type definition for that RPAS model however, it will conform to the type definition of a different model of Compliant Small RPAS that is manufactured by the OEM, then:
 - a. If the RPAS model is not already on the Listing of Compliant Small RPAS, the OEM must submit a Declaration of Compliance (DOC) and a copy of the Specified Maintenance Program to Transport Canada. The new model of RPAS may then be added to the Listing of Compliant Small RPAS.
 - b. Once the modification is complete, the OEM would provide the owner with a new Statement of Conformity stating that the RPAS conforms to the OEM type definition as stated in the DOC for that new RPAS model.
 - c. The OEM would provide an additional RPAS identification plate (or similar) to the RPAS owner, on which the following information is permanently etched, engraved or stamped:
 - i. Name of OEM;
 - ii. the new model designation;
 - iii. the RPAS serial number (same as original I.D. plate); and
 - iv. where applicable, a modification reference number
 - d. The owner must contact Transport Canada to obtain a new Certificate of Registration to reflect the new RPAS model
3. The Manufacturer deems that the modified Small RPAS would be an entirely different model, and decides to undertake the development of appropriate testing and analyses of the modified Small RPAS to prove that this new model of RPAS is compliant with the Small RPAS Design Standard. Upon completion, the Manufacturer follows the procedures to have a new model of Compliant Small RPAS recognized by Transport Canada, and provides the owner with suitable documentation for this new model of Compliant Small RPAS when it is placed on the Listing of Compliant Small RPAS.

NOTE: *While the manufacturer is under no legal obligation to provide a new Statement of Conformity (SOC) after the modification has been completed, the owner may wish to obtain one for their records. The owner and the manufacturer should discuss this issue prior to the owner beginning work on the aircraft.*

3.4.5 RPAS Modifications not made by the Original Manufacturer

If the OEM chooses not to approve the modification, or is no longer in operation, and the owner chooses to make the modification anyway, the owner may go to any other manufacturer of compliant small RPAS or suitably qualified aircraft organization to obtain written approval from them for the modification. In this case, the new organization essentially takes over the modified RPAS design and must determine what aspects of the design are affected by the modification. To do so, this new organization must develop sufficient understanding of the original Small

RPAS design to be capable to make judgments on how the modification may affect the OEM's original finding of compliance.

NOTE: The owner may decide to be the “suitably qualified aircraft organization” – if this is the path chosen, the owner must demonstrate that he has the appropriate qualifications and expertise to fully understand all aspects of the specific Small RPAS type design and demonstrate this knowledge and capability to the satisfaction of Transport Canada – This is not a recommended approach for most Small RPAS owner/operators!

The selected Manufacturer or Aircraft Organization must undertake the development of appropriate testing and analyses of the modified small RPAS to prove that this modified RPAS remains compliant with the Small RPAS Design Standard. The tests and analyses performed must be chosen with respect to the scope of the modification and the systems that are involved. To complete this process, the selected Manufacturer or Aircraft Organization must document both the modification and the tests and analyses performed. Submission of this documentation, in the form of a Compliant Small RPAS Modification Declaration of Compliance Form must be submitted to TC.

Commercial operation of any Small RPAS that has been modified without proper approval is a violation of the Canadian Aviation Regulations.

Note: If the OEM or other organization choose not to approve the modification, then the modified RPAS is no longer considered in compliance with the conditions for registration as a “Compliant Small RPAS”. The owner must therefore contact Transport Canada to have the RPAS taken off the Canadian Civil Aircraft Register and take other steps to regain operating approval, as specified elsewhere in the Transport Canada Staff Instructions and guidance material for obtaining SFOCs.

4 General RPAS Operation

For general operational guidance material for RPAS VLOS operations, the reader is directed to [Section 6 of Transport Canada's Staff Instruction 623-001](#). As these SI's are subject to change at Transport Canada's discretion, SFOC applicants should always consult the most recent versions from Transport Canada's website.

This section presents a collection of best practices for BVLOS operations that should be considered in addition to the requirements of section 6 of SI 623-001 when designing a BVLOS operation.

It is anticipated that most operations of small RPAS BVLOS will be conducted under Visual Flight Rules (VFR), from launch and recovery areas that are not traditional aerodromes. Conducting flight under Instrument Flight Rules (IFR) may be attractive for some operations as it can provide additional separation from traffic in controlled airspace, however it requires that the RPAS integrate predictably into the existing IFR structure. To this end, this requires additional pilot training/qualification (i.e. a pilot license with an IFR rating), and equipment that meets the standard employed by other IFR aircraft (i.e. TSO'd systems where they exist).

One notable difference expected between conventional manned IFR flights and small RPAS IFR is that the RPAS will most likely launch and recover to/from a site that is not an aerodrome, and may be able to conduct these phases of flight safely in very low visibility.

4.1 Assignment of Pilot in Command (PIC)

A PIC shall be designated for every RPA flight and crew members must comply with PIC instructions or any person whom the PIC has authorized to act on their behalf. High endurance RPAS may require the need for more than one PIC during the duration of the flight, however, there can only be one PIC assigned at any one time.

4.2 Fuel/Energy Reserve Requirements

It is recommended that a 15% of flight time (up to 30 minutes) fuel/energy reserve be planned for VFR BVLOS operations. For IFR BVLOS operations, a fuel/energy reserve consistent with those required for manned IFR operations is recommended (see [CAR 602.88](#) (4)).

4.3 Operations at, or in the Vicinity of an Aerodrome

Most small RPAS operations do not require conventional aerodromes, and often employ non-dedicated locations (e.g. open field) for launch and recovery. These locations are not considered aerodromes.

Any small RPAS requiring operation from, or in the vicinity of a conventional aerodrome must comply with Part 6, Subpart 2, Division V of the Canadian Aviation Regulations to the extent they are applicable. Operations in the vicinity of aerodromes (e.g. wildlife control) are to avoid the pattern of traffic formed by manned aircraft in operation. Further guidance regarding operations at aerodromes can be found in SI 623-001 Section 6.18.

4.4 Approach and Recovery Limitations

By definition, GPS instrument approaches (e.g. as per CAR 722.08) are only applicable to IFR approaches into aerodromes with published GPS approach; not small RPAS using GPS to conduct landings to ad-hoc locations such as fields.

Small RPAS operations are, however, encouraged to stay away from aerodromes, even under IFR. The following approach/recovery guidelines could enable this without the infrastructure and requirements associated with aerodromes. These operations are comparable to a float plane pilot taking off from a lake in VMC after filing an IFR flight plan, flying IFR, then landing in VMC at another lake and closing the flight plan.

(1) This section addresses approach and recovery of an RPA in non-assessed locations (e.g. open fields) following the enroute IFR phase, as specified in the RPAS operator certificate per the definition of “Instrument Approach Procedure” in CAR 101.01 (1).

(2) Where the RPAS is authorized in the RPAS operator certificate for landing in IMC (including zero visibility), the operation must ensure that landing area is suitable for a safe landing (i.e. clear of persons not involved in the operation, livestock, obstacles etc.) and remains safe and clear for the operation

(3) Where the RPAS requires visual contact from a crew member at the landing site the meteorological conditions must be sufficient for such visual contact.

(4) Where the RPAS requires the use of an onboard sensor to safely conduct the landing, the meteorological conditions must be sufficient for the use of that sensor.

(5) Where the RPAS requires the use of a ground-based sensor to safely conduct the landing, the meteorological conditions must be sufficient for the use of that sensor.

4.5 Operation in Reduced Visibility VFR

This section is intended for proposed VFR operations conducted below the standard VFR visibility limits of CAR 602.115. The RPAS must be operated at a speed such that obstacles can be sensed and avoided in these meteorological conditions. RPAS configuration for operations in reduced visibility must conform to the RPAS Flight Manual recommendations. The sense and avoid system must also be configured to provide appropriate separation in these conditions. Takeoff and Landing visibility requirements must be identified and documented, and disseminated to the appropriate personnel.

4.6 System Capabilities and Equipment Recommendations

4.6.1 System Capabilities

[Section 6.4 of SI 623-001](#) presents the minimum system capabilities required for VLOS RPAS operations. The various recommendations below are based on the official Canadian Aviation Regulation definition of VFR, Night operations and IFR with the exception that the aircraft need not have “visual reference with the ground” to operate VFR. Since all of the system capabilities build from those required for VLOS operations, they are repeated here, although re-ordered, for convenience.

4.6.1.1 VFR – VLOS

For the purpose of VLOS operations there must be a means of:

- (a) Controlling the flight of the RPA (e.g. reporting altitude, airspeed, etc.);

- (b) Monitoring the RPAS (e.g. performance limitations, fuel/energy status, landing gear indications, control link status etc);
- (c) Communication as required by class of airspace or regulations;
- (d) Electronic surveillance (transponder) as required for the class of airspace or regulations;
- (e) Navigation;
- (f) Detecting hazardous environmental flight conditions (e.g. icing, thunderstorms, etc.);
- (g) Where the aircraft is to be handed over from one control station to another, the equipment required to execute the handover;
- (h) Mitigating the risk of loss of control of the RPA trajectory (e.g. route, course, or path);
- (i) Sensing and avoiding other aircraft;
- (j) Avoiding flight into obstacles and terrain;
- (k) Remaining clear of cloud to the distance required for the airspace and operation;
- (l) Aircraft lighting or illumination for night operations sufficient to maintain visual contact;

Note that many of these 'System Capabilities' may be achieved by direct visual observation.

4.6.1.2 Day VFR - BVLOS

In addition to the VLOS capabilities, the following capabilities are recommended for Day VFR BVLOS operations:

- (a) the capabilities required for VLOS operations listed in 4.6.1.1 a-k;
- (b) a means of reporting altitude adjusted for barometric pressure;
- (c) a means of reporting airspeed;
- (d) a means of reporting magnetic direction;
- (e) a means of reporting performance and limitations of the propulsion system;
- (f) a means of reporting the RPAS fuel or other indications of remaining flight time;
- (g) if the aircraft employs retractable landing gear, a means of providing the position of the landing gear; (note: rationalization is with gear up landing at an aerodrome)
- (h) sufficient radiocommunication equipment to permit the pilot to conduct two-way communications on the appropriate frequency with other airspace users and ATC appropriate for the class of airspace or regulation;
- (i) sufficient navigation equipment redundancy to permit the pilot, in the event of the failure at any stage of the flight of any item of that equipment, including any associated flight instrument display, to proceed to the destination or proceed to another suitable landing site or to a flight termination location, and
- (j) a means of performing a standard rate 1 turn ;
- (k) an adequate source of electrical energy for all of the electrical and radio equipment;
- (l) in respect of every set of fuses of a particular rating that is installed on the RPAS and if accessible to the pilot-in-command, a number of spare fuses that is equal to at least 50 per cent of the total number of installed fuses of that rating;
- (m) where the aircraft is to be operated within the Northern Domestic Airspace, a means of establishing direction that is not dependent on a magnetic source;
- (n) a means of illumination for all of the instruments used to operate the aircraft (control station);
- (o) a means of sensing and avoiding other aircraft;
- (p) a means of maintaining correct separation from other air traffic where required for the operation;
- (q) a means of avoiding flight into obstacles and terrain;
- (r) a means of sensing and remaining clear of cloud to the distance required for the airspace and operation; and
- (s) an ADS-B Out system.

4.6.1.3 Night VFR - BVLOS

For operations conducted under Night VFR the following system equipment/capabilities are recommended:

- (a) the capabilities required for (BVLOS DAY VFR) operations (a) to (s) (see above);
- (b) position and anti-collision lights that conform to 5XX.11.9.
- (c) a means of providing the outside air temperature;
- (d) a means of preventing malfunction caused by icing for each airspeed indicating system;
- (e) a means of preventing malfunction caused by icing to the sense & avoid system if it is sensitive to effects of ice.
- (f) a means of sensing and remaining clear of cloud to the distance required for the airspace and operation.

4.6.1.4 IFR - BVLOS

For operations conducted under BVLOS IFR the following system capabilities/equipment is recommended:

- (a) the capabilities required for BVLOS Night VFR operations (a) to (f) (see above);
- (b) a means of providing the aircraft attitude;
- (c) a means of providing the aircraft vertical speed;
- (d) a power failure warning or vacuum indicator that shows the power available to gyroscopic instruments from each power source;
- (e) an alternative source of static pressure for the altimeter, airspeed indicator and vertical speed indicator, where static pressure is required for said instruments.
- (f) a means of sensing cloud and remaining clear of cloud as required for the airspace and operation.

One of the key principles of operating under IFR is to behave predictably, and according to flight plan (or flight itinerary). [SI 623-001 Appendix H](#) Lists sample conditions for IFR Flight as part of the 'SFOC Template for Complex UAV Operator'.

4.6.2 Operational and Emergency Equipment

(1) The following operational and emergency equipment must be available to the appropriate crew member(s) when operating BVLOS:

- (a) checklists or placards that enable the aircraft to be operated in accordance with the limitations specified in the aircraft flight manual, aircraft operating manual, pilot operating handbook or any equivalent document provided by the manufacturer;
- (b) all of the necessary current aeronautical charts and publications covering the route of the proposed flight and any probable diversionary route, if the aircraft is operated in VFR OTT, VFR flight or IFR flight;
- (c) a current database covering the route of the proposed flight and any probable diversionary route, if the aircraft is operated in IFR flight, in VFR OTT flight or in VFR flight and database-dependent navigation equipment is used;

- (d) a hand-held fire extinguisher of a type suitable for extinguishing fires that are likely to occur;
- (e) a timepiece that is readily available to each flight crew member;

(2) A checklist or placards referred to in paragraph (1)(a) shall enable the RPAS to be operated in normal, abnormal and emergency conditions and must include

- (a) a pre-start check;
- (b) a pre-take-off check;
- (c) a post-take-off check;
- (d) a pre-landing check; and
- (e) emergency procedures.

(3) Emergency procedures referred to in paragraph (2)(e) must include

- (a) emergency operation of fuel, hydraulic, electrical and mechanical systems, where applicable;
- (b) emergency operation of instruments and controls, where applicable;
- (c) engine inoperative procedures;
- (d) Command and Control link emergencies; and
- (e) any other procedure that is necessary for aviation safety.

(4) Checks and emergency procedures referred to in subsections (2) and (3) must be performed and followed where they are applicable.

4.6.4 Unserviceable and Removed Equipment

RPAS are in a unique position to allow for long endurance flights while supporting crew changes. This result of this is that it is possible for the Pilot-in-Command role to change over the course of a flight. This change in PIC may occur at a common location (e.g. at a GCS), or may be transferred remotely. When transferring control it is imperative that complete information regarding equipment/system serviceability be communicated to the receiving pilot. The following practice is recommended:

A handover of an RPAS that has equipment that is not serviceable or from which equipment has been removed must not take place if, in the opinion of the originating pilot-in-command or the (intended) receiving pilot-in-command, aviation safety is more affected than by not doing the handover.

During a handover, the originating PIC must fully inform the receiving PIC of any known issues of serviceability.

4.7 Emergency and Contingency Procedures (Including ‘Lost Link’ Procedures):

In addition to the material provided in section [6.10 of SI-623-001](#), the following considerations are proposed as best practices for procedures concerning emergencies and contingencies during BVLOS operations.

4.7.1 Loss of Radiocommunication

A loss of two-way radiocommunications is distinct from a lost-link situation in that control of the aircraft trajectory is retained, however there is an interruption in the ability to communicate with

ATC and/or other airspace users. For small RPAS operations conducted under VFR and in Class B, C, or D airspace it is recommended that in the event of a two way radiocommunications failure that the PIC leave the airspace as soon as practicable by landing the aircraft at the nearest safe landing location. Establishing communication via an alternate means (e.g. telephone) should be considered as desirable in this situation.

For operations conducted under IFR, upon loss of radiocommunications, it is best practice to follow the existing regulations specified in [602.137](#) of the Canadian Aviation Regulations.

4.7.2 Loss of Control Link (referred to herein as Lost Link)

There are many acceptable approaches to satisfy safety management requirements during emergency conditions including that of a lost link. Some emergency conditions may require a diversion point where a recovery is attempted, whereas others may require a termination of flight (possibly as a controlled flight into terrain) to prevent undue risk to other airspace users.

4.7.2.1 Definitions

Definitions of generalized points that can assist in defining such emergency procedures are presented below and are suggested for use in the description of any proposed BVLOS operation.

Lost Link Point (LLP) – defined as a point, or sequence of points, where the aircraft will proceed and hold at a specified altitude, for a specified period of time, in the event the command and control link to the aircraft is lost. The aircraft will automatically hold, or loiter, at the LLP until the communication link with the aircraft is restored or the specified time elapses. If the time period elapses, the aircraft may autoland at a Divert / Contingency Point (DCP), proceed to another LLP in an attempt to regain the communication link, or proceed to a Flight Termination Point (FTP) for flight termination. LLPs may be used as FTPs. In this case, the aircraft may loiter at the LLP/FTP until link is re-established or fuel exhaustion occurs.

The LLP must be chosen with consideration for the airspace, other traffic, and communication requirements in that location.

Divert / Contingency Point (DCP) – defined as an alternate landing/recovery site to be used in the event of an abnormal condition that requires a precautionary landing. Each DCP must incorporate the means of communication with air traffic control (ATC) throughout the descent and landing (unless otherwise specified in the RPAS OC) as well as a plan for ground operations and securing/parking the aircraft on the ground.

For local operations, the DCP specified will normally be the airport or facility used for launch and recovery.

The DCP must be chosen with consideration for the airspace, other traffic, and communication requirements in that location.

Flight Termination Point (FTP): - defined as the location where the flight of the small RPAS may be terminated either directly by the pilot or automatically by the flight termination system. The following guidelines must be considered in the selection of suitable FTP's:

(1) Flight termination system requirements are identified in 3.4.11. Note that flight termination may occur at any point along the small RPA's flight path (and in locations other than FTPs) in the event of other types of critical system failures (i.e. failures other than lost link).

(2) A Flight Termination Point (FTP) is a location chosen to be safe for flight termination using the RPAS flight termination system, potentially including the intentional and deliberate process of performing controlled flight into terrain.

(3) Flight termination must be executed in the event that all contingencies have been exhausted and further flight of the aircraft cannot be safely achieved or other potential hazards exist that require immediate discontinuation of flight. Unless otherwise authorized, alternative contingency planning measures must allow for safe termination of the flight under any circumstances during all phases of flight. The Operator must ensure sufficient FTPs or other contingency plan measures are defined to accommodate flight termination at any given point along the route of flight. The location of these points is based on the assumption of an unrecoverable system failure and must take into consideration altitude, winds, and other factors.

(4) Unless otherwise authorized, FTPs must not be located in built-up areas. Except for on- or near-airport operations, FTPs will not be located at heliports or aerodromes. For offshore locations, the operator must refer to appropriate charts and other publications to avoid maritime obstructions, shipping lanes, and other hazards.

(a) The operator is required to assess all designated areas prior to their identification as an FTP. The operator assumes full risk and all liability associated with the selection and use of any designated FTP.

(b) The FTP must be chosen to minimize the risk to persons or property on the ground, considering of aircraft size, performance, and the nature of the flight termination system.

(c) The FTP must be chosen with consideration for the airspace, other traffic, and communication requirements in that location.

A lost link procedure is essential to ensure airborne operations remain predictable. Operators will comply with the RPAS lost link procedures as defined in their final operational approval, known as an Operating Certificate or “OC”.

Note: *Lost link is not considered fly-away; the RPA is still operating predictably. (Fly-away is a loss of trajectory control)*

4.7.2.2 Lost Link Flight Planning – Before flight

Prior to commencing flight, the pilot in command of a small RPA must

- A. Determine and configure the time, location, and other parameters required for safe operation of the flight termination system in the event of lost link. They include, as applicable, lost link route of flight, transponder use, lost link orbit points, communications procedures, and pre-planned flight termination points (FTP), Divert/Contingency Points (DCP), Lost Link Point (LLP) or other contingency planning measures in the event recovery of the RPAS is not feasible. The plan of flight must comply with the guidelines set out in 4.7.2.4 (Lost Link Procedures). Accepting pre-programmed values is a means of compliance.
- B. If the plan of flight includes operation within Class C and D airspace, the lost link procedure must have the RPA immediately proceed to a LLP, DCP or FTP outside that airspace by the most expeditious route, unless doing so increases the risk of collision with other aircraft (e.g. an on- or near-airport operation may have DCP/FTP that is in the

vicinity of the operating point instead of flying through several miles of controlled airspace to leave).

- C. If the lost link procedure includes entering Class C and D airspace, then the lost link procedure must have the RPA hold immediately prior to entering Class C and D airspace outside at a location and for a period of time appropriate for the site before entering, to allow ATC to prepare and adjust the airspace / separation plan. Such a procedure must be co-ordinated with ATC prior to commencing the flight.
- D. Identify safe operation boundaries (path, location, altitude) for the flight
- E. Unless otherwise authorized in the RPAS OC, lost link procedures will conform to the guidelines set out in 4.7.2.4 (Lost Link Procedures) and must incorporate the following:
 - o Manoeuvres and procedures undertaken during lost link will conform to the flight plan as coordinated with ATC, and will avoid unexpected manoeuvres and/or altitude changes. The lost-link plan will provide sufficient time to communicate and coordinate with ATC.
 - o Lost link orbit points will not be within any published holding area, airway, Jet route, T route, Q route, or other area navigation (RNAV) published route.

4.7.2.3 Lost Link Flight Planning - During Flight

1. Only allow changes to parameters related to the lost link procedures if those changes are confirmed by receipt of a query to the RPA
2. If under air traffic control, the lost link flight profile must comply with the last ATC clearance (if ATC clearance is required), for a period of time sufficient for ATC to ensure conflict resolution without loss of required separation.
3. If under air traffic control, the lost link procedures and parameters must be identified and be immediately available to ATC, per guidelines set out in 4.7.2.4 (Lost Link Procedures).
4. if link is lost when flying IFR
 - a. execute lost link procedure
 - b. contact ATC as soon as possible
 - c. squawk appropriate lost link code
 - d. Where practicable, broadcast the location and intention of the RPA in plain language with respect to known location and destination on the appropriate frequency and at regular intervals and at appropriate times in advance of landing, such that traffic local to the RPA can receive the information.
 - e. land as soon as practicable at the nearest designated safe alternate recovery site (i.e. DCP or FTP)
 - f. Maintain ATS communications throughout, including (as applicable) diversion and landing at a DCP or flight termination.
5. if link is lost when flying VFR in uncontrolled airspace
 - a. execute lost link procedure
 - b. remain in VMC
 - c. remain in uncontrolled airspace
 - d. in the interest of flight safety and awareness, advise ATS of the situation as soon as possible
 - e. squawk appropriate lost link code , if equipped with a transponder

- f. Where practicable, broadcast the location and intention of the RPA in plain language with respect to known location and destination on the appropriate frequency and at regular intervals and at appropriate times in advance of landing, such that traffic local to the RPA can receive the information.
 - g. land as soon as practicable at the nearest suitable safe alternate recovery site (i.e. DCP or FTP)
 - h. Maintain ATS communications throughout, including (as applicable) diversion and landing at a DCP or flight termination.
6. when flying VFR in controlled airspace (lost link)
- a. execute lost link procedure
 - b. remain in VMC
 - c. contact ATC as soon as possible
 - d. squawk appropriate lost link code, if equipped with a transponder
 - e. Where practicable, broadcast the location and intention of the RPA in plain language with respect to known location and destination on the appropriate frequency and at regular intervals and at appropriate times in advance of landing, such that traffic local to the RPA can receive the information.
 - f. land as soon as practicable at the nearest suitable safe alternate recovery site (i.e. DCP or FTP)
 - g. Maintain ATS communications throughout, including (as applicable) diversion and landing at a DCP or flight termination.

4.7.2.4 Lost Link Procedures

Procedures for lost link will be defined by the following descriptions. The pre-planning of these actions must be appropriate for the context (e.g. class of airspace, whether under ATC, IFR vs. VFR, flying in an urban environment etc.). The emphasis here is on the pilot making safe, appropriate, and predictable pre-planning decisions, and effectively communicating this to ATC, ATS or others as concerned and required. In cases where a flight plan is filed, the selected procedure protocols will be communicated to ATC as part of the flight plan (or in an automated fashion cued by the discrete code generating a message to the air traffic controller at his workstation), along with any relevant parameters such as DCP, FTP, LLP locations for the specific flight and key timeout parameters (e.g. link recovery maneuver duration). In cases where ATC is involved, the options will be limited and well-defined (e.g. not (1) E.)

1. Link recovery actions by the RPA may include any of
 - A. no maneuver (e.g. continue with planned flight path, as may be safest in IFR)
 - B. circle or hold for TBD minutes
 - C. climb or descend for TBD minutes or by TBD feet of altitude
 - D. Proceed to LLP (Lost Link Point(s))
 - E. Other actions that may be appropriate for non-conflicted airspace (e.g. when flying behind a building), provided the actions are predictable and automatic (e.g. have the pilot walk around the building to regain the link).
2. Destination if link regained
 - A. continue to original destination
 - B. return to base (originating location)
 - C. divert to DCP (Divert/Contingency Point)
3. Procedure if link not regained
 - A. terminate flight immediately
 - B. return to base

- C. continue to original destination (See Comment 1)
- D. divert to FTP (Flight Termination Point) and terminate
- E. divert to DCP and autoland

- 4. Transponder procedure (if applicable)
 - A. squawk 74xx on link loss
 - B. squawk 74yy for return to base
 - C. squawk 74zz for continue to destination (See Comment 1)
 - D. squawk 74nn for flight termination

4.7.3 Flight Termination

Flight termination must not be initiated unless the risk to other airspace users and persons and property on the ground in terminating the flight is judged to be less than the risk of not doing so.

Where technically possible, immediately prior to or after initiation of a flight termination, the pilot should make a blind radio broadcast to advise other airspace users of the situation and location.

As soon as practicable after a flight termination event, the pilot must contact the appropriate ATS unit and any appropriate emergency services.

4.7.4 Sense and Avoid Maneuvers

In response to a warning generated by the sense and avoid system there may be a requirement to perform a manoeuvre which conflicts with air traffic control instructions. It should be recognized and identified in the application for the proposed operation that the sense and avoid manoeuvre will take priority.

5 RPAS Operator – BVLOS Company Practices

Note: The term ‘Operator’ in this document refers to the organization (company or other entity) that applies for an operating certificate for BVLOS operations. The operator has overall authority and control over the entire operation (including maintenance, training, etc.). The term operator is distinct from, and should not be confused with the RPAS Pilot, who has control and responsibility for the aircraft during flight.

This section presupposes that the RPAS operator undergoing the process to gain the authority to operate under BVLOS conditions already complies with all criteria applicable to a “Compliant Operator for VLOS”, as specified in [TC Staff Instruction 623-001, Appendix D](#).

This section addresses the “company practices” that should be in place within the organization that seeks to operate an RPAS BVLOS. These practices, added to those for required for a Compliant Small RPAS Operator for VLOS, are believed to be sufficient to result in the status of “Compliant RPAS Operator” for a small RPAS BVLOS in VFR, day, night and/or IFR flight. Similar to other parts of this document, the requirements are included here as part of a collection of Best Practices to guide the submission and review of SFOC applications for “Compliant Operators”. Please note that in this section, the term “certificate holder” means the company or other organization that has overarching control and responsibility for the proposed RPAS operation.

Notable additions over and above the recommendations for small RPAS operating VLOS contained in SI-623-001 include:

- Best practices regarding management agreements and duties of a Certificate holder,
- Limitations associated with the launch and recovery of RPA in non-assessed locations (e.g. open field) following an IFR enroute phase, and
- The establishment of recommendations associated with maximum flight duty times and minimum rest periods, including a system that monitors the flight duty time and time free from duty of each of its flight crew members.

While various roles are defined below, it is envisioned that a small operator may be able to incorporate many or all of these roles in a single individual. As indicated elsewhere in this document, the level of complexity of the organization, and the associated documentation/description is commensurate with the complexity of the proposed operation.

5.1 Guidance – General – RPAS Operator

In the description of the organization's operations it is expected that the certificate holder adequately describe the ability to:

- (a) maintain an adequate organizational structure;
- (b) maintain operational control;
- (c) meet training program requirements;
- (d) comply with maintenance requirements;
- (e) meet the RPAS Standards for the operation; and
- (f) conduct the operation safely.

The list above is not significantly different from that required of a Compliant Operator of small UAV Systems restricted to VLOS as described in SI-623-001 Appendix D(1). For BVLOS operations, the is recommended in addition to the criteria of SI-623-001 Appendix D(1)(b).

The applicant must have managerial personnel who perform the following functions:

- (a) operations manager,
- (b) chief pilot, and
- (c) where the applicant does not hold an approved maintenance organization (AMO) certificate, maintenance manager;

Additionally, the operator must have legal custody and control of at least one small RPAS, and must have in place an operational control system that ensures that aircraft are under the control of its operations manager.

5.1.1 Duties of a Certificate Holder

The certificate holder has the following duties:

- 1) Appoint an operations manager and chief pilot that meet the standards below
- 2) Appoint a maintenance manager that meets the standards below
- 3) Provide the operations and maintenance manager with sufficient financial and human resources to meet regulations
- 4) Authorize the maintenance manager to remove systems from service, where the removal is justified because of non-compliance or because of a risk to aviation or public safety

5.2 Personnel

5.2.1 Operations Manager

This section presents the recommended qualifications and responsibilities for an RPAS Operations Manager for an organization involved in commercial air services.

5.2.1.1 Qualifications

(A) hold or have held the appropriate training and experience (or license and ratings as appropriate) for which a pilot-in-command is required to hold for one of the RPAS operated by the RPAS operator or have acquired related flight operations experience with an RPAS operator or equivalent military experience; and

(B) have demonstrated to the RPAS operator knowledge with respect to the content of the operations manual, RPAS Operator Certificate and Operations Specifications and the provisions of the regulations and standards necessary to carry out the duties and responsibilities to ensure safety.

5.2.1.2 Responsibilities

The operations manager is responsible for safe flight operations. In particular, the responsibilities of the position include:

- (a) control of operations and operational standards of all RPAS operated;
- (b) operations co-ordination functions which impact on operational control (eg. maintenance, crew scheduling, load control, equipment scheduling);
- (c) contents of the air operator's Company Operations Manual;
- (d) the supervision of, and the production and amendment of, the Company Operations Manual;
- (e) training and qualifications of flight operations personnel;
- (f) liaison with the regulatory authority on matters concerning flight operations including any variation to the RPAS Operator Certificate;
- (g) liaison with any external agencies which may affect RPAS operator operations;
- (h) ensuring that the RPAS operator's operations are conducted in accordance with current regulations, standards and the Company Operations Manual;
- (i) ensuring that crew scheduling complies with flight and duty time regulations;
- (j) ensuring that all crew members are kept informed of any changes to applicable regulations and standards;
- (k) the receipt and actioning of any aeronautical information affecting the safety of flight;
- (l) dissemination of flight operations safety information;
- (m) qualifications of flight crews;
- (n) maintenance of a current operations library; and
- (o) ensuring that responsibilities for operational control functions are delegated to qualified personnel.

5.2.2 Chief Pilot

5.2.2.1 Qualifications

If the RPAS Operator Certificate authorizes VFR Day Only, VFR at Night, or IFR, then the Chief Pilot must hold the permit, license, or rating appropriate to the authorized operation and the category of aircraft operated (or better).

The chief pilot must be qualified in accordance with the RPAS operators training program to act as pilot-in-command on one of the RPAS operated by the RPAS operator;

The chief pilot must have demonstrated knowledge to the RPAS operator with respect to the content of the operations manual, provisions of the regulations and standards, and if applicable, the company check pilot manual and standard operating procedures.

5.2.2.2 Responsibilities

The chief pilot is responsible for the professional standards of flight crew and in particular:

- (a) developing standard operating procedures;
- (b) developing or implementing all required crew member approved training programs;
- (c) issuing directives and notices to the flight crews as required;
- (d) the actioning and distribution of accident, incident, and other occurrence reports;
- (e) the processing and actioning of any crew reports;
- (f) the supervision of flight crews;
- (g) assuming responsibilities delegated by the Operations Manager; and
- (h) ensuring that duties are delegated to qualified individuals

5.2.3 Maintenance Manager

The maintenance manager must be knowledgeable in the following areas (as applicable):

- (a) duties and responsibilities of the appointed position;
- (b) duties of persons who have been assigned functional responsibilities;
- (c) how the maintenance responsibilities interact with those of the operation
- (d) identification of acceptable reference data for maintenance schedules;
- (e) use of fleet sampling techniques;
- (f) control of repetitive inspections;
- (g) reliability programs;
- (h) types and methods of control of mandatory maintenance tasks;
- (i) defect control;
- (j) technical dispatch requirements;
- (k) maintenance release requirements;
- (l) control of elementary work and servicing;
- (m) responsibility for record keeping; and
- (n) the function of quality assurance.

5.3 Operational Control System

Operational control is the exercise of authority over the formulation, execution, and amendment of an operational flight plan in respect of a flight. Compliant operators are expected to have an operational control system in place that meets the following criteria:

Responsibility and Authority:

Operational control is delegated to the pilot-in-command of a flight by the Operations Manager, who retains responsibility for the day to day conduct of flight operations.

Centres:

Current information on the location of the RPAS operator's aircraft must be maintained at the main base of operations, sub-base or where appropriate, from the location from which the flight following is being conducted. Definitions for these terms are provided below.

“main base” means a location at which an RPAS operator has personnel, aircraft and facilities for the conducting of aerial work and that is established as the principal place of business of the operator

"sub-base" - means a location at which an RPAS operator positions aircraft and personnel and from which operational control is exercised in accordance with the air operator's operational control system;

Flight Following and Flight Watch:

“Flight Watch” means maintaining current information on the progress of the flight and monitoring all factors and conditions that might affect the Operational Flight Plan. RPAS Flight Watch is conducted by the pilot in command at all times that the RPA is airborne.

“Flight Following” means the monitoring of a flight's progress, and the provision of such operational information as may be requested by the pilot-in-command. Meteorological information provided to the pilot-in-command by the flight follower must not include analysis or interpretation. Flight Following procedures and the standards of qualifications for the individual performing this function must be described in the RPAS operator's Company Operations Manual.

5.4 Manuals and Records

As was required for a VLOS to be considered compliant, the BVLOS operator must keep a series of manuals and records that reflect the details of their specific operation. For guidance purposes suggested documentation content can be found in appropriate sections identified below.

Company Operations Manual – Appendix 8

Standard Operating Procedures – Appendix 8

Operational Flight Plan(s) – Appendix 8

Training Records – Appendix 7

RPAS Operating/Maintenance Manual – Appendix 3

5.5 Flight Time and Flight Duty Limitations and Rest Periods

Every RPAS Operator must establish:

- (a) maximum flight duty times and minimum rest periods; and
- (b) a system that monitors the flight duty time and time free from duty of each of its flight crew members and must include in its operations manual the details of that system.

Flight Time Limitations and Rest Periods:

The following material is provided as a best practice for RPAS flight time limitations; it is based upon part VII (700.15) of the Canadian Aviation Regulations:

RPAS Operators should not schedule flight crew members for duty if the flight crew member's total flight time in all flights will, as a result, exceed

- (a) 1200 hours in 365 consecutive days;
- (b) 300 hours in 90 consecutive days;
- (c) 120 hours in 30 consecutive days or, in the case of a flight crew member on call, 100 hours in any 30 consecutive days;
- (d) 56 hours in 7 consecutive days; 8 hours in 24 consecutive hours; or
- (e) 4 hours of consecutive flight time.

An RPAS operator may assign a flight crew member for flight time, and a flight crew member may accept such an assignment, where the flight crew member's flight time will, as a result, exceed the flight time referred to above if:

- (a) the increase in flight time is authorized in the RPAS air operator's air operator certificate; and
- (b) the RPAS operator and the flight crew member comply with the Commercial Air Service Standards.

A flight crew member who reaches a flight time limitation established by this section is deemed to be fatigued and must not continue on flight duty or be reassigned to flight duty until such time as the flight crew member has had the rest period required specified below.

Flight Duty Time Limitations and Rest Periods

This section identifies the recommended flight duty time limitations and rest periods for RPAS operations.

(1) Subject to subsection (2) no RPAS operator should assign a flight crew member for flight duty time, and no flight crewmember should accept such an assignment, for flight time without a scheduled rest period of at least the following:

- (a) a minimum of 60 consecutive minutes of rest between rotational shifts of scheduled flight time; and
- (b) 10 consecutive hours of rest prior to reporting to any scheduled flight event.

(2) Subject to subsections (5) and (7) no RPAS operator should assign a flight crew for flight duty time if the flight crew member's flight duty time will, as a result, exceed 14 consecutive hours in any 24 consecutive hours.

(3) Where the flight is conducted under Subpart 5 or 6 pursuant to the Commercial Air Service Standards, a flight crew member must receive at least 24 consecutive hours free from flight duty following 3 consecutive flight duty time assignments that exceed 12 consecutive hours unless the flight crew member has received at least 24 consecutive hours free from flight duty between each flight duty time assignment.

(4) If a duty time of more than 14 hours occurs, a minimum rest period of 24 hours must be granted immediately afterwards.

(5) Following a flight duty time assignment, an RPAS operator must provide a flight crew member with the minimum rest period and any additional rest period required.

(6) A flight crew member must use a rest period to obtain the necessary rest and must be adequately rested prior to reporting for flight duty.

(7) Where flight duty time includes a rest period, flight duty time may be extended beyond the maximum flight duty time referred to in subsection (1) by one-half the length of the rest period referred to in paragraph (b), to a maximum of 3 hours, if

- (a) the RPAS operator provides the flight crew member with advance notice of the extension of flight duty time;
- (b) the RPAS operator provides the flight crew member with a rest period of at least 60 consecutive minutes in suitable accommodation in between rotational shifts; and
- (c) the flight crew member's rest is not interrupted by the RPAS operator during the rest period.

(8) The minimum rest period following flight duty time referred to in subsection (5) and prior to the next flight duty time must be increased by an amount at least equal to the extension to the flight duty time.

(9) An RPAS operator may assign a flight crew member for flight duty time, and a flight crew member may accept such an assignment, where the flight crew member's flight duty time will, as a result, exceed the flight duty time referred to in subsection (1) if

- (a) the increase in flight duty time is authorized in the RPAS operator certificate; and
- (b) the RPAS operator and the flight crew member comply with the Commercial Air Service Standards.

Unforeseen Operational Circumstances

The maximum flight time and the maximum flight duty time referred to above may be exceeded if

- (a) the flight is extended as a result of unforeseen operational circumstances;
- (b) the pilot-in-command, after consultation with the other flight crew members, considers it safe to exceed the maximum flight time and flight duty time; and

(c) the RPAS operator and the pilot-in-command comply with the *Commercial Air Service Standards*.

Delayed Reporting Time

Where a flight crew member is notified of a delay in reporting time before leaving a rest facility and the delay is in excess of 3 hours, the flight crew member's flight duty time is considered to have started 3 hours after the original reporting time.

Requirements for Time Free From Duty

(1) Subject to subsection (2), a small RPAS operator must provide each flight crew member with the following time free from duty:

- (a) one period of at least 36 consecutive hours within each 7 consecutive days or one period of at least 3 consecutive calendar days within each 17 consecutive days;
- (b) one period of at least 24 consecutive hours 13 times within each 90 consecutive days and 3 times within each 30 consecutive days; and
- (c) where the flight crew member is a flight crew member on call, one period of at least 36 consecutive hours within each 7 consecutive days or one period of at least 3 consecutive calendar days within each 17 consecutive days.

(2) An RPAS operator may provide a flight crew member with time free from duty other than as required by paragraphs (1)(a) and (b) if

- (a) the time free from duty is authorized in the RPAS operator certificate; and
- (b) the RPAS operator and the flight crew member comply with the *RPAS Standards*.

(3) An RPAS operator must notify a flight crew member on call of the commencement and duration of the flight crew member's time free from duty.

Appendix 1 Terms and Definitions

The following are the terms and definitions necessary to understand this document and its guidance.

Note: *The international community is no longer using the term UAV (unmanned air vehicle). The new terms that have been adopted are: RPA (remotely-piloted aircraft) and RPAS (remotely-piloted aircraft system), UA (unmanned aircraft) and UAS (unmanned aircraft system). These terms are more appropriate because they designate these “vehicles” as aircraft and recognize that the RPAS/UAS includes not only the airframe but also the associated elements required for flight. Although the new terminology will not be incorporated into the CARs for some time, the terms RPA and RPAS are becoming more familiar and will be used throughout this document.*

command and control link (C2)

- means the data link between the RPA and the control station for the purposes of managing the flight.

control station

- means the facilities and/or equipment remote from the RPA from which the RPA is controlled and/or monitored.

crew member

- means, in the case of an RPAS, a person assigned to duties essential to the operation of the RPAS during flight time.

Declaration of Compliance

- manufacturer's declaration that the Type Design for the RPAS described is in compliance with the Design Standards of AWM 5xx for Small RPAS

flight visibility

- means
 - a. The visibility forward from the cockpit of an aircraft in flight; (*visibilité en vol*),
or
 - b. The visibility from forward sensing equipment

Note: *A sensor isn't necessarily visual, so “looking” wasn't an equivalent statement*

handover

- means the act of passing pilot-in-command responsibilities from one control station or pilot to another.

lost link

- means the loss of command and control link contact with the RPA such that the pilot-in-command can no longer manage the aircraft's flight.

operator

- in respect of an aircraft, means the person that has possession of the aircraft or the RPAS, as owner, lessee or otherwise.

payload



- in the case of an RPAS, means a system, an object or collection of objects on-board or otherwise connected to the RPA that performs, or is related to, a mission function but is not required for flight.

radio line-of-sight

- means the limit of direct reliable radio communication given the equipment being used and the prevailing conditions.

flight termination system

- means a system that, upon initiation, terminates the flight of an RPA in a manner so as not to cause significant damage to property or severe injury to persons on the ground.

Note 1:

This system has the following characteristics:

- *An independent or automatic means to initiate;*
- *Results in a predictable ground footprint of the RPA or RPA debris;*
- *Interrupts the current trajectory of the RPA;*
- *Does not result in severe, or worse, injury to persons on ground;*
- *Does not result in significant damage to property;*
- *Includes a means to ensure the system is functional; and*
- *Has established and defined delay times, functional characteristics.*

Note 2:

Activation of the system may result in destruction or damage of the RPA itself.

sense and avoid

- means the capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action.

smallRPA

- means an RPA with a maximum permissible take-off weight of 25 kg (55 pounds) or less.

small RPAS

- means a set of configurable elements consisting of a small RPA, its associated control station(s), the required command and control links and any other system elements as may be required, at any point during flight operation.

Statement of Conformity

- manufacturer's statement that the assembled small RPAS conforms with the Type Design as declared in the Declaration of Compliance and the owner's statement that the RPAS will be maintained in accordance with the Manufacturer Specified Maintenance Program

visual line-of-sight (VLOS)

- means unaided (corrective lenses and/or sunglasses exempted) visual contact with aircraft sufficient to be able to maintain operational control of the aircraft, know its location, and be able to scan the airspace in which it is operating to decisively see and avoid other air traffic or objects.

visual observer

- means a crew member who is trained to assist the pilot-in-command in the safe conduct of the flight under visual line-of-sight.

The following existing definitions from the CARs are included here to provide context.

type

- means a classification of aircraft having similar design characteristics; (type)

type certificate

- means:
 - (a) a document issued by the Minister to certify that the type design of an aircraft, aircraft engine or propeller identified in the document meets the applicable standards for that aeronautical product recorded in the type certificate data sheets, or
 - (b) a document issued by the foreign airworthiness authority having jurisdiction over the type design of an aeronautical product that is equivalent to a document referred to in paragraph (a) and that has been accepted by the Minister for the purpose of issuing a certificate of airworthiness;

type design

- means
 - (a) the drawings and specifications, and a listing of those drawings and specifications that are necessary to define the design features of an aeronautical product in compliance with the standards applicable to the aeronautical product,
 - (b) the information on dimensions, materials and manufacturing processes that is necessary to define the structural strength of an aeronautical product,
 - (c) the approved Sections of the aircraft flight manual, where required by the applicable standards of airworthiness,
 - (d) the airworthiness limitations Section of the instructions for continued airworthiness specified in the applicable chapters of the Airworthiness Manual; and
 - (e) any other data necessary to allow, by comparison, the determination of the airworthiness and, where applicable, the environmental characteristics of later aeronautical products of the same type or model;

Note: *Small RPAS built to a type design which complies with the Best Practice standards described in this document may be considered “Compliant” through the SFOC applicant’s submission of (a) a signed Statement of Conformity from the designer/assembler, for the use of a design which has previously been accepted as compliant by Transport Canada, or (b) the required documentation for demonstrating that the design meets the Best Practices outlined in this document, for the use of a design which has not previously been reviewed by Transport Canada. It is not intended that small RPAS should require a type certificate.*

Unmanned Aircraft (UA)

- means a power-driven aircraft, other than a model aircraft, that is designed to fly without a human operator on board

Appendix 2 Proposed SMALL RPAS DESIGN STANDARD

SUBCHAPTER A - SMALL RPAS (Up to 25 Kg)

(Additional Subchapters, as yet undeveloped, will cover larger RPAS)

5XX.1 Definitions:

Remote Probability – a probability no greater than one occurrence every 1000 flight hours.

Extremely Remote Probability – a probability no greater than one occurrence every 1,000,000 flight hours.

Small RPAS – those RPAS with a RPA of MGTOW of 25kg or less (not including LERPAS class)

LERPAS – low energy RPAS – as specified in the CARAC phase 1 submission “an RPA that has been analyzed and/or demonstrated, for the case of an uncontrolled impact, to not impart a peak energy of more than 12J/cm² on a stationary person or object in the most unfavourable of circumstances.

Note: while the above definition has not been adopted formally, some class of “very small” RPAS which are not subject to the design requirements described herein is expected – this class may also have unique operational restrictions placed upon them

Payloads – A system, an object or collection of objects onboard or otherwise connected to the RPA that performs, or is related to, a mission function but is not required for flight.

Control Link - the system for transmitting and receiving all required command and control information between the RPA and control station.

Lost Link - means the loss of control link contact with the RPA such that the pilot-in-command can no longer alter or otherwise modify the RPA flight path.

5XX.2 General

5XX.2.1 - This subchapter (A) sets out:

- a) The airworthiness standards for a remotely piloted aircraft system that includes an aircraft of MGTOW of 25 kg or less (not including LERPAS); and
- b) The requirements for inspections, equipment and instruments, and operating information necessary for this remotely piloted aircraft system, which shall be met to obtain a “Special Certificate of Airworthiness - Small RPAS”

5XX.3 Flight (Performance etc.)

5XX.3.1 - The aircraft shall be safely controllable and manoeuvrable during all flight phases including, where applicable:

- a) Taxi;
- b) Takeoff or Launch;
- c) Climb;
- d) Level flight;
- e) Descent;
- f) Go-around;
- g) Landing or Recovery; and
- h) At all permissible aircraft speeds and in all permissible aircraft configurations.

5XX.3.2 - It shall be possible to make a smooth transition from one flight condition to another (including turns and slips) without danger of exceeding the limit load factor, under any probable operating condition.

5XX.3.3 - If the RPA can aerodynamically depart from controlled flight:

- a) the probability of such a departure from which recovery is not possible using a prescribed technique shall be extremely remote, or,
- b) there shall be a means of initiating flight-termination in the event of such a departure.

5XX.3.4 - The RPA pilot shall be provided sufficient and timely flight and systems information to adequately operate the RPA.¹

5XX.3.5 - A centre of gravity envelope, where the RPA remains safely controllable, shall be established. The RPA centre of gravity, including all modifications, consumables, configurations and payloads, shall remain within this envelope during flight.

5XX.3.6 - A performance envelope in terms of speed, climb rate, load factor(s) and any other operating parameters, for all permissible RPA weights and configurations, shall be established to determine the operating limitations of the RPA.²

5XX.4 RPAS Design and Construction

5XX.4.1 - The suitability of each part, component, and assembly, having an important bearing on safety and operations, shall be established.

5XX.4.2 - Materials and Workmanship – The workmanship shall be of a high standard and the suitability and durability of materials used for parts, the failure of which could adversely affect safety, shall:

- a) Be established by experience or tests;
- b) Meet accepted specifications that ensure their having the strength and other properties assumed in the design data; and
- c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

5XX.4.3 - Fabrication Methods - The structure of the RPA shall be fabricated to possess consistent strength and structural characteristics. If a fabrication process (such as gluing, spot welding, or heat-treating) requires close control to reach this objective, the process shall be either performed under a documented process specification or shall be subject to a quality assurance process that reliably ensures the required structural characteristics.

5XX.4.4 – Fasteners:

- a) Fasteners with suitable locking mechanisms shall be employed in locations where the failure of the fastener would prevent continued controlled flight.
- b) Fasteners that are repeatedly assembled and disassembled during the operation and maintenance cycles of the RPAS (including those within control stations and other non-aircraft components) shall be sufficiently durable to withstand these cycles or replaced at appropriate intervals.

¹ (In many cases this may include: fuel or other energy source, angle of attack, angle of sideslip, speeds, g-loads –ONLY IF THEY ARE REQUIRED BY THE PILOT TO MAINTAIN CONTROL! May also include communication between an observer and a pilot, communication between ATC and pilot and/or ATC and UA)

² Amount of detail here to be defined in self declaration– best glide speed, Vmca, Vmcg, Vd, Vcruise, Vs, Vr,

5XX.4.5 Protection of Structure - Each part of the RPAS structure (including control stations and other non-aircraft components) shall be suitably protected against deterioration or loss of strength in service due to any cause, including:

- a) Weathering;
- b) Corrosion; and
- c) Abrasion.

5XX.4.6 – If the RPA operation requires application of propulsive power while the aircraft remains stationary on the ground, then a suitable means shall be provided to restrain the RPA.

5XX.4.7 – RPAS sub-systems (including control stations and other non-aircraft components) that present the potential for fire shall be designed to minimize this risk.

5XX.4.8 - RPAS designs (including control stations and other non-aircraft components) should avoid sharp edges and incorporate energy absorbing materials.

5XX.5 RPA Structure

5XX.5.1 - The RPA shall be designed to have sufficient strength for all expected operating conditions, including those with propulsion system failures and involving environmental factors such as gusts.

5XX.5.2 - Representative limit load cases shall be demonstrated to prove compliance with a 1.5 safety factor.

5XX.5.3 - The RPA structure and control systems shall not exhibit unintended binding, chafing or permanent deformation due to any expected flight and ground loads (including launch and recovery loads).

5XX.6 Propulsion System

5XX.6.1 - If a single failure within the propulsion system could result in the loss of control of the RPA trajectory:

- a) the probability of such a failure under all expected operating conditions shall be extremely remote, or
- b) there shall be a means of initiating flight-termination in the event of such a failure.

Note: Loss of propulsion on a fixed wing RPA or a helicopter RPA is not necessarily loss of trajectory control – loss of one engine in a quad-rotor with no means of alternate control may result in a loss of trajectory control.

5XX.6.2 - The installation of the propulsion system shall ensure safe operation throughout the RPA flight envelope.

5XX.6.3 - Any propellers or rotors shall have sufficient strength to ensure safe operation throughout the flight envelope.

5XX.6.4 - Each fuel system shall be constructed and arranged to ensure fuel flow at a rate and pressure established for proper engine and auxiliary power unit functioning under all permitted operating conditions.

5XX.6.5 - Each fuel tank and its associated plumbing and related components shall be able to withstand, without failure, the vibration, inertia, fluid, and structural loads that it may be subjected to in operation.

5XX.6.6 - Each electrical source for propulsion shall be constructed and arranged to ensure energy delivery at the required voltage and current levels under all permitted operating conditions.

5XX.6.8 - Each electrical source for propulsion and its associated wiring and related components shall be able to withstand, without failure, the vibration, inertia, temperature and structural loads that it may be subjected to in operation.

5XX.6.9 - The RPA design shall incorporate provision for adequate cooling of propulsion system components.

5XX.7 Command and Control

5XX.7.1 General

5XX.7.1.1 The RPAS shall be designed to allow the pilot in command to adequately command and control the trajectory of the RPA under normal operating conditions.

5XX.7.1.2 Manipulators, inceptors or other mechanisms employed to make command and control inputs shall be intuitive and easy to operate without need for exceptional skill or strength.

5XX.7.1.3 The mechanical and electrical components of a control station shall be designed to be physically robust for intended operations, assembly, disassembly and transport, and shall not present a physical obstruction to flight crews.

Note: Consideration of other risks, such as incursion by rodents, may be appropriate for some control stations and ancillary equipment

5XX.7.1.4 Information required for RPA operations shall be presented in a timely and unambiguous fashion and a minimum set of information required for RPA control shall be defined in the type design and displayed to the pilot at all times.

Note: this information may be acquired by visual observation of the RPA for flight within visual line of sight.

5XX.7.1.5 Any system for controlling RPAS payload shall not interfere with the operation of the RPA by the pilot in command.

5XX.7.1.6 Control station and data link status information shall be displayed to the pilot in command.

5XX.7.1.7 - Warning information shall be provided to alert crew member(s) to unsafe system operating conditions and to enable them to take appropriate corrective action.

5XX.7.1.8 - Systems, controls, and associated monitoring and warning means shall be designed to minimise crew member errors that could create additional hazards.

5XX.7.1.9 - Any required placards shall be prominently available to the pilot at appropriate times and locations within the control station area.

5XX.7.1.10 - The permissible operating and environmental conditions and capabilities for the control station shall be specified and verified.

5XX.7.1.11 - The control station and surroundings must allow the flight crew to perform their duties without undue fatigue or concentration.

5XX.7.1.12 – The functioning of the control station and associated RPA shall be tested and demonstrated in an integrated manner.

5XX.7.1.13 - The Control Station and associated link(s) to the RPA shall be designed such that the probability of the RPA receiving an incorrect command, is extremely remote.

Note: the above includes security provisions against malicious hacking

5XX.7.1.14 – There shall be a means to synchronize and positively transfer control between control stations and pilots in command if multiple control stations are in use.

Note: These means, and associated procedures, shall provide the receiving pilot in command all information required for timely RPA control, response to emergencies and general operating state of the RPA.

5XX.7.1.15 The probability of loss of control of RPA trajectory caused by control station handovers:

- a) shall be extremely remote in all expected operating conditions, or,
- b) such a loss of control shall result in the activation of a flight-termination system.

5XX.7.1.16 In the case of an RPAS where the RPA may be operated by a variety of permissible control station designs, the above criteria (5XX.7.1.1 – 5XX.7.1.14) shall be met by each combination which are to be specified in the design data associated with the special C of A.

5XX.7.1.17 - Data and control links: In the case of an RPAS where the RPA may be operated by a variety of permissible data and control link designs, the above criteria (5XX.7.1.1 – 5XX.7.1.15) shall be met by each combination which are to be specified in the design data associated with the special C of A.

5XX.7.1.18 - In cases where the control station relies on a source of power outside the direct control of the RPAS crew, a means to retain control of the RPA in the event of power failure shall be present.

Note: the above applies to control stations that normally plug into a local power grid

5XX.7.1.19 For systems capable of simultaneously controlling multiple RPA from a single control station:

- a) the criteria 5XX.7.1.1 through 5XX.7.1.17 shall apply for all possible combinations, and,
- b) the system shall present information to the pilot in command in an unambiguous fashion so that the status and situation of each RPA can be readily discerned and acted on, under both normal and emergency operations, as required, and,
- c) the system shall permit the pilot in command to direct commands to any or all of the multiple RPA without undue attention or effort.

5XX.7.2 Flight and Navigation Information

5XX.7.2.1 - The RPAS shall provide the pilot a means to determine the following parameters in a timely manner:

- a) RPA Present position
- b) RPA Altitude
- c) RPA Heading
- d) RPA Speed
- e) Fuel or other indication of remaining flight time
- f) RPAS Operating status.
- g) any parameters at a resolution and accuracy level sufficient to allow compliance with Air Navigation System requirements as mandated operational requirements.

5XX.7.2.2 The information defined in 5XX.7.2.1 shall be provided in an unambiguous fashion, under all normal operational conditions.

Note: The list above was deemed the minimum necessary to maintain sufficient awareness of the aircraft.

Note: Some or all of this information may be provided through visual observation of the RPA, if the RPA operation is limited to operation within visual range

5XX.7.3 Navigation Systems

5XX.7.3.1 - An RPAS shall have a means to determine the position, altitude, speed and heading of the RPA in flight sufficiently accurate and in the appropriate format for the operation and associated airspace.

Note: A pilot and/or observer may meet this requirement for flight within visual range operations

5XX.7.3.2 - Any database used by an RPAS navigation system shall have a geographical coverage area compatible with the type of operation being conducted and be of an acceptable aviation standard – if available. The RPAS operator shall have procedures in place to ensure that the database will be updated in accordance with the appropriate data revision cycle. This includes a contract with a database supplier and the inclusion, in the appropriate company manuals, of the person responsible for installing the updates in the RPA. The RPAS operator shall have a procedure in place for pilots to report database errors and for information on database errors to be passed on to other pilots, the avionics manufacturer and other appropriate individuals.

Note: The above is to ensure that the pilot has the most up to date and relevant information to base his/her decisions on. It was based on CARS 624.25 and may belong in Part 6 UAS regulations – it is included here just to make sure it is not missed!

5XX.7.3.3 - If the primary UAS navigation system depends on components that are not fully under the control of the UAS pilot (such as GPS) a secondary source of navigation information shall also be available to the pilot.

Note: This is to ensure that the pilot can still navigate the UAS, even if others, outside of the pilot's span of control, "turn off" the primary navigation system
Note: Examples of secondary sources include: a camera with visual feed to the pilot, and reporting airspeed, heading and time to the pilot or an alternate GNSS.

5XX.7.4 Autopilot System

5XX.7.4.1 - If an automatic pilot system is installed, it must meet the following:

- a) Each system must be designed so that the automatic pilot can be quickly and positively overridden or otherwise disengaged by the pilot to allow more direct control of the RPA trajectory.

Note: This is to ensure that the UAS pilot can take immediate action if and when necessary
Note: As an example: The above does not require the pilot to have the ability to control the RPA control surfaces, but rather must be able to turn the RPA on demand without typing in an alternate waypoint.

- b) No autopilot system shall create hazardous loads on the RPA or hazardous deviations in the flight path, under any flight condition appropriate to its use.
- c) If the automatic pilot system has several modes of operation, the mode in use shall be indicated clearly to the pilot in command.
- d) The pilot shall have clear indications of any commanded flight parameter (e.g. airspeed, altitude) and or flight path (waypoints) and the RPA performance with respect to them.

5XX.7.5 Radiocommunication and Control Links

Note: In commonality with all other CARS, Radiocommunication links are limited to those systems used to communicate with other aircraft and ATC. They do not include command, control and data links specific to RPAS.

5XX.7.5.1 Any radiocommunication system installed in an RPAS shall mimic the functionality and performance of a manned aircraft radio system, i.e. be transparent to other airspace users and air traffic control regardless of the location of the RPA in relation to the control station.

Note: the definition of mimic: copy or imitate closely

5XX.7.5.2 The normal operating envelope for the control link shall be established.

5XX.7.5.3 - The probability of a failure of the control link that results in loss of timely control of the RPA trajectory shall be:

- a) extremely remote, or
- b) the failure shall be the automatic initiation of “Lost Link Procedures” as identified in 5XX.9.2

Note: the intention of lost link is to perform procedures and manoeuvres to regain link or safely recover the RPA. Extended flight in lost link, performing routine operations, is not acceptable.

Note: as a guideline, the inability to update commands for more than 7 seconds has been proposed by ASTM as the onset of a “lost link”

5XX.7.5.4 - The RPA control system shall be tolerant of random, short term loss of signals (or digital packets) that are shorter than what constitutes a lost link situation.

Note: Effectively, 5XX.7.5.3 and 5XX.7.5.4 mean that the manufacturer is responsible for identifying just how much lag between data updates can be acceptable and still constitute timely data. This may be a function of flight state, as the requirements for cruise may be different than those for say landing.

Note: Command and Control Link performance specifications are not otherwise specified herein as the systems involved in Sense and Avoid, Lost Link and Flight Termination for a Small RPAS are expected to mitigate any other risks incumbent with a failed Command and Control Link.

5XX.8 Sense and Avoid Systems

Note: The subgroup developing these recommendations unanimously agreed that “All RPAS shall have a means to sense conflicting air traffic and avoid collisions with other aircraft” and “For RPAS where the pilot in command and / or associated observers cannot adequately perform the sense and avoid function by direct, unaided visual means, the RPAS shall incorporate a sense and avoid system” These two requirements are now found in Section 6 of the recommended changes to the CARs.

The above determines the total scope of a sense and avoid system (consistent with ICAO UASSG decision 2012)

5XX.8.1 For the purposes of this section (5XX.8), the following definitions apply:

- a) The **collision volume** is a cylindrical volume of airspace centered on the RPA with a horizontal radius of 500 feet and vertical height of 200 feet (± 100 feet) within which avoidance of a collision can only be considered a matter of chance.
- b) The **conflict point** is the time of a predicted collision or point of closest approach that is within the collision volume.
- c) The **manoeuvre time, T**, shall be the time required for the specific RPA to execute a manoeuvre that ensures the point of closest approach of a conflicting aircraft remains outside the collision volume. The manufacturer of the RPAS shall determine and document this value or the means of how it is determined in real time.

5XX.8.2 – A system providing a means of sense and avoid shall:

Note: in all of the functions below, it is assumed that any associated links are functional – in the case of a lost link the system shall perform without need of pilot action.

- a) **Provides a Detection Function –**
 - o Detect aircraft within 1nm horizontally and 500 feet vertically, and,

- Detect aircraft predicted to come within 500 feet horizontal and 100 feet vertical at 15 + 2T seconds prior to this situation.

Note: the 15 + 2T seconds above provides recognition of closing velocities, RPA manoeuvring performance and human factor considerations.

b) **Provide a Separation Function –**

- Inform the pilot in command if the detected aircraft is predicted to come within 1 nm horizontally and 500 feet vertically, and,
- Provide the pilot in command sufficient information to enable appropriate and timely action.

Note: The system may determine a de-conflicting manoeuvre for the RPA and indicate to the pilot in command this solution – the pilot may manually execute this manoeuvre or command the system to perform the manoeuvre.

c) **Provide a Collision Avoidance Function:**

- Warn the pilot in command if the detected aircraft is predicted to come within 500 feet horizontally and 100 feet vertically (the collision volume CV³),
- The minimum warning time shall be 15 + 2T seconds prior to the conflict point.
- The indication shall provide the pilot in command sufficient information to enable appropriate and timely action.
- The system shall determine an avoidance manoeuvre for the RPA and indicate this solution to the pilot in command

Note: the pilot may manually execute this manoeuvre or accept the system performing the manoeuvre.

- The avoidance manoeuvre shall be consistent with rules of the air (ref 602.19).and,
- The system shall implement without authorization from the pilot the appropriate avoidance manoeuvre at 2T seconds prior to the conflict point and inform the pilot of this action.,

Note: the idea of the pilot being able to override the automatic collision avoidance manoeuvre was debated by SG2 – and the result was that SG2 believes that at 2T seconds prior to the conflict point the SAA system should always execute the manoeuvre – resulting in lower probability of collision.

d) **Provides a “Well Clear” Indication:**

- After the resolution of any conflict situation, the system shall provide a “clear of conflict” indication to the pilot in command and any systems that may have been overridden by the SAA system.

Note: It is expected that other systems will automatically return the RPA back to its original path (or mission profile) once clear of the conflict.

e) **Operates in multiple aircraft/conflict/collision scenarios** (based on TCAS refs - under 10k')

- a. The system shall be able to track and deal with multiple aircraft conflict scenarios at the same time and prioritize based on estimated risk of collision.
- b. The system shall be able to detect at least 25 aircraft, display/handle at least 8 threats, develop avoidance manoeuvres for at least the 3 highest risk aircraft scenarios

³ The chance of a collision occurring between two aircraft within the collision volume is considered to be 1 in 10. (ref FAA SAA Workshop document)

Note: The numbers 25, 8 and 3 are taken from consideration of TCAS regulation and general knowledge of UAS operations.

Note: The SAA System may provide operational guidance:

- a) For RPAS operations requiring avoidance of specific meteorological conditions, and/or terrain and/or obstacles, the sense and avoid system **may** be the means to adhere to these limitations, so long as such use does not degrade its capability to sense and avoid other aircraft.
- b) SAA sensor data may be used for mission and/or payload purposes so long as such use does not degrade its capability to sense and avoid other aircraft.

f) **Provides system oversight functions:**

- a) For sense and avoid systems that have any operational restriction (e.g. cannot operate within cloud), the system or the operation shall have a means to ensure that the RPA reliably avoids these conditions or shall have an alternate means to assure collision avoidance.
- b) Indication of the system serviceability shall be provided to the pilot for any operation where the system is required.

g) **Is Compatible with existing Collision Avoidance Systems**

- a) The system shall not reduce the effectiveness or reliability of existing collision avoidance systems on board the RPA or other aircraft (TCAS, ADS-B)

h) **Use of ADS-B**

- i. The system may use the ADS-B broadcasts from other aircraft for detection and resolution functions, however this cannot be the sole means of detecting other aircraft. (ADS-B In)

Note: - The subgroup submitting these recommendations unanimously agreed that “The RPA shall broadcast its own ADS-B information. (ADS-B Out)” – this requirement is found in the Section 6 recommendations

Note: Whether or not positive control by ATC provides an adequate means of sense and avoid is dealt with in Section 6 of the CARS

5XX.8.4 - A Sense and Avoid system shall meet the following performance standard:

- a) Field of Regard: +/- 180 degrees relative to the direction of flight horizontally, + / - 15 degrees vertical with minimal blockage by other parts of the aircraft. The blocked area in the field of regard must be different for each sweep of the detection sensor or the sensor shall be positioned such that an area of at least +/- 60 degrees horizontal and +/- 15 degrees vertical from the direction of travel are clear at all times.

Note: the decision of the full 360 field of regard (+/- 180) was driven by concerns of a manned aircraft overtaking the small RPAS and not seeing it.

- b) Detection Sensor Resolution: 50 sq. ft.⁴ @ range of [(RPA max velocity + 124 knots) * (15 +2T seconds) or 1 nm] whichever is greater.

Note: the intention is to detect manned aircraft of the approximate size and speed of a Cessna 172, considered representative of likely conflicting GA aircraft.

Note: The 15 + 2T seconds parameter in the equation was based on FAA See and Avoid guidance and considerations of pilot reaction time

- c) Detection Sensor Accuracy – sufficient to meet the system functions defined in 5XX.8.3

⁴ approximate cross sectional area of a Cessna 172

- d) System Reliability – The probability of failure of the system to avoid a conflicting aircraft shall be less than 10^{-3} per flight hour⁵ when the system indicates it is serviceable.

Note: Elsewhere in 5XX: if the SAA fails in a lost link scenario, flight termination is required. (an outcome of the above is as follows: if a ground based sensor is incorporated in the SAA, the data link is part of the SAA, therefore a data link failure = failure of SAA)

Note: SAA Test Scenarios- In order to demonstrate/validate the functionality of the SAA, it should be subjected to conflict scenarios with a variety of other aircraft types, flight path geometries and closure speeds.

5XX.9 Lost Link

5XX.9.1 – For the purposes of this section, a “regain of link” is when the control station has updated its “timely data” and the Pilot in Command has effective trajectory control of the RPA (including all effects of latency, etc.)

Note: the requirement below stems from 5XX.7.5.3 Details of the exact operational procedures are defined in CARS Section 6.

Note: the intention of lost link is to perform procedures and manoeuvres to regain link or safely recover the RPA. Extended flight in lost link, performing routine operations, is not acceptable.

5XX.9.2 – If the probability of a lost link situation is greater than extremely remote, when a Lost Link situation occurs the RPAS must be capable of supporting Lost Link Procedures defined in CARS Section 6⁶. The system must therefore have the following capabilities:

- a) Provide the Pilot an indication of the situation (and details of loss) (or, in the case of visual range operations, this may be by the response of the RPA to control input)
- b) Accept or incorporate a series of pre-programmed instructions to perform automated manoeuvres and/or procedures with the sole objective of regaining link without jeopardizing safety. These manoeuvres and procedures shall be compliant with the applicable requirements for unmanned aircraft flight in a given airspace defined in CARS Section 6⁷.

Note: These manoeuvres may be different, depending on mission phase, situation, etc. – these procedures are defined by operational requirements

Note: The manoeuvres may include various changes in flight path to return the RPA to a designated area or an area where the link(s) was functional and/or may include a period of remaining on the course of when the link was lost.

Note: The lost link procedures may include variation of RPA and control station command and control link system configurations in attempts to regain link (change frequencies, broadcast modes, etc.)

Note: The lost link procedures may include broadcasts (VHF radio and/or automatic switching to emergency transponder codes) to identify lost link situation to other air traffic and/or ATC.

⁵ This is believed to be one order of magnitude more reliable than manned aviation. For proposed operations with less reliable systems, see Appendix 5 as a means to include local knowledge of airspace density to achieve the desired level of risk.

⁶ Exact numbering not yet determined.

Note: for visual operations, a pre-determined set of control positions resulting in flight termination upon loss of command is one means to meet this requirement.

- c) Alter transponder codes, “Squawk” and change communication system settings, if required to be compliant with operational requirements in the given airspace.
- d) The RPA shall be capable of executing lost link procedures without interrupting the functionality of the SAA system.
- e) The pilot shall be able to determine and input into the system, prior to takeoff, the length of time and/or other criteria, between loss of link and automatic flight termination (as per 5XX.10).

Note: The pilot may just accept criteria already programmed into the system by the OEM.

- f) During the execution of lost link procedures, the control station must be able to provide the pilot an estimated position of the RPA. The nature of this estimation shall be clear and unambiguous.
- g) The RPA shall immediately and automatically activate the flight termination system during a lost link situation in any of the following circumstances:
 - i) There is a failure of SAA functionality (the RPAS and pilot have no means to avoid collision with other aircraft)
 - ii) There is a loss of trajectory control by the on-board autopilot or equivalent system.
 - iii) There is a loss of navigation capability
 - iv) The flight violates a predetermined geographical boundary.

5XX.9.3 - There shall be a means for the Pilot in Command to:

- a) Review, define and/or modify the lost link procedures
- b) Review, define and/or modify the activation criteria for the flight-termination system.

Note: The above means shall include a verification (e.g. read back) of any changes. “Pilot (and control station) must know what the aircraft is going to do.”

Note: In the case of multiple control stations, the Pilot in Command shall be able to review the lost link procedures that are currently in force.

5XX.10 Flight Termination System

5xx.10.1-Unless it can be demonstrated that the probability of each and every specific situation described in this document requiring the activation of the flight termination system is extremely remote or lower, the RPAS shall be equipped with a flight termination system as a “last resort” and irreversible safety mechanism in the event that control of the RPA is lost and the safety of others cannot be assured. The flight termination system shall be designed such that, upon initiation, it causes the flight of the RPA to be terminated in such a manner to minimize the probability of severe injury to persons on the ground or significant damage to property.

Note: Flight Termination is not a “return to base” or similar procedure, but rather an immediate manoeuvre to remove the RPA from the airspace. The final result may be destruction or damage of the RPA itself.

5xx.10.2 - The flight termination system shall have all of the following characteristics:

- a) Designed to minimize the ground footprint of RPA or RPA debris;
- b) Interrupts current trajectory of the RPA;
- c) Includes a means to determine that the system is functional;

- d) Predictable outcome(s), and;
- e) Probability of failure of extremely remote.

5xx.10.3 - The flight termination system shall be capable of both automatic and pilot initiation. The automatic aspects of the system may be set up to operate in lost link situations only; the command and control link may provide activation capability to the pilot, when this link is operational.

Note: The above does not preclude the use of a dedicated flight termination communication/control link between the RPA and the control station.

5xx.10.4 - If the pilot has a means to alter the automatic flight termination criteria before or during flight, there must be a positive means to verify the alterations.

5xx.10.5 - The flight termination system shall always be active in flight. At all points within a flight (including during lost link), there shall be valid criteria for automatic activation of the flight termination system.

Note: 5XX.10.5 prevents the pilot from de-activating the flight termination system, either intentionally, or unintentionally through making an error in changing the activation criteria.

5XX.10.6 The RPA shall immediately and automatically initiate the flight termination system if the aircraft is in a lost link situation and any of the following circumstances occurs (as defined in 5XX.9.2 f):

- a) A failure of SAA functionality (the RPAS and pilot have no means to avoid collision with other aircraft)
- b) Loss of trajectory control;
- c) Loss of navigation capability.
- d) Violation of a pre-determined geographical boundary

Note: Flight Termination System – Demonstration/Verification. The means of demonstrating and validating the flight termination system shall be determined by the RPAS designer/manufacturer. There must be sufficient documented testing and analysis to demonstrate and verify the reliability and functionality of the system. In cases where flight termination results in destruction of the RPA, the designer/manufacturer must conduct and document sufficient testing to prove the reliability of the system. For systems designed to preserve the RPA following flight termination, verification may occur through periodic demonstrations of the system.

5XX.11 Systems and Equipment

5XX.11.1 General Function and Installation

5XX.11.1.1 - Each item of installed equipment in a RPAS shall:

- a) Be of a kind and design appropriate to its intended function;
- b) Be labelled as to its identification, function, or operating limitations, or any applicable combination of these factors, if appropriate;
- c) Be installed according to limitations specified for that equipment; and
- d) Function properly when installed.

5XX.11.1.2 - There shall be a means to assure that, prior to taxi and takeoff or launch, the RPAS and its subsystems are operating correctly.

5XX.11.2 Equipment, Systems, and Installations

5XX.11.2.1 - Each item of equipment, each system, and each installation:

- a) When performing its intended function, shall not adversely affect the response, operation, or accuracy of any equipment essential to safe operation;
- b) Shall be designed to minimize hazards to the safe operation of the RPA in the event of a probable malfunction or failure.

Note: “probable” above refers to malfunctions that have a reasonable likelihood of occurring, or can be envisioned to occur.

5XX.11.2.2 - If a single failure of an RPA system could result in the loss of control of the RPA trajectory:

- a) the probability of such a failure under all expected operating conditions shall be extremely remote, or
- b) there shall be a means of initiating flight-termination in the event of such a failure, or
- c) there shall be an alternate means of regaining control.

5XX.11.3 Airspeed System

5XX.11.3.1 - Any airspeed indication must provide true airspeed (the indication consistent with the occurring dynamic pressure if the aircraft is at sea level with a standard atmosphere) with a minimum practicable instrument calibration error.

5XX.11.3.2 - Throughout the RPA flight envelope, the airspeed system must indicate true airspeed at sea level with a standard atmosphere, to within an allowable installation error of not more than the greater of

- a) +3% of the calibrated airspeed
- b) 5 knots.

5XX.11.3.3 - The design and installation of the airspeed measuring system shall provide a positive drainage of moisture from any associated plumbing.

5XX.11.3.4 - The airspeed measuring system shall have a means to operate reliably and accurately in icing conditions or cloud, if such operations are permitted.

Note: If the airspeed system is not reliant on pitot and static pressures, it must be shown to meet the performance requirement of 5XX.11.3.2.

5XX.11.4 Pressure Altitude System

5XX.11.4.1 - Any static pressure system shall be calibrated to indicate pressure altitude (with a standard atmosphere) with a minimum practicable instrument calibration error.

5XX.11.4.2 - Throughout the RPA flight envelope, the pressure altitude presented to the pilot must have an overall altitude error of less than 30 feet.

5XX.11.4.3 - If the pressure altitude system is not reliant on static pressure, it must be shown to be equivalent to or better than pressure-based systems in all operating conditions.

5XX.11.4.4 - The altitude measuring system shall have a means to operate reliably and accurately in icing conditions or cloud, if such operations are permitted.

5XX.11.5 Direction Sensing System

5XX.11.5.1 - Except as provided in 5XX.11.5.2:

- a) Any direction sensing system must be installed so that its accuracy is not excessively affected by the RPA vibration or magnetic fields; and
- b) The compensated installation may not have a deviation, in level flight, greater than ten degrees on any heading.

5XX.11.5.2 - A magnetic non-stabilised direction sensing system may deviate more than ten degrees due to the operation of electrically powered systems if either a magnetic stabilised direction sensing system, which does not have a deviation in level flight greater than ten degrees on any heading, or a gyroscopic direction sensing system, is installed. Deviations of a magnetic non-stabilised direction sensing system of more than 10 degrees must be placarded.

5XX.11.5.3 - A system that provides aircraft heading that is not reliant upon the earth's magnetic field shall provide such indication with the inclusion of the position appropriate magnetic deviation. Such a system shall also meet the requirement of 5XX.11.5.2.

5xx.11.6 Ground/Surface Feature and Cloud Detection Systems

5XX.11.6.1 Any system installed to assist the pilot in detecting surface features (such as terrain, obstacles, built-up areas, assemblies of persons or other ground based features) or atmospheric features such as clouds, rain or icing, shall:

- a) Identify the specific feature(s) detected and have documented performance
- b) Provide the pilot with an indication of system serviceability
- c) Provide the pilot with sufficient information to enable the pilot to avoid the detected obstacle or condition without undue skill or training.
- d) Be compatible with, and subordinate to, SAA, lost link and flight termination systems.

<p>Note: The above section, 5XX.11.6, applies to systems that are installed to assist the pilot in compliance with operational requirements for low altitude and/or VFR flight specified in Part 6.</p>
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5XX.11.7 Launch and Recovery Systems

5XX.11.7.1 - Operation of the launch and recovery system shall not pose a safety hazard.

5XX.11.7.2 - The performance envelope for both a safe launch and a safe recovery of the RPA shall be specified, including, but not limited to:

- a) Clear areas required for launch and recovery
- b) meteorological conditions
- c) wind components
- d) density altitude
- e) launch/recovery equipment settings
- f) Permissible RPA configurations/loadings
- g) Required system checks

5XX.11.7.5 - If a failure of launch or recovery systems can result in loss of control of the RPA trajectory:

- a) the probability of such a failure under all expected operating conditions shall be extremely remote, or
- b) a flight-termination system shall be initiated, or
- c) there shall be safe alternatives available to conclude the RPA operation.

5XX.11.8 High-intensity Radiated Fields (HIRF) Protection –

5XX.11.8.1 If the operation of the RPAS includes flight in areas where HIRF are probable, the RPAS electrical and electronic systems that perform functions whose failure would prevent the continued safe flight and recovery of the RPA shall be designed to mitigate this risk.

5XX.11.8.2 Any RF emissions by the RPAS shall be evaluated according to applicable regulations, and any findings and/or approvals gained shall be included in the type design.

Note: 5XX.11.8.2 concerns both spectrum compliance and protection of persons.

5XX.11.9 Lighting

5XX.11.9.1 Any RPA anti-collision light system shall:

- a) Consist of one or more anti-collision lights
- b) Meet the requirements of [paragraphs \(i\) through \(iv\)](#) below:
 - i. Field of coverage. The system must consist of enough lights to illuminate the vital areas around the RPA, considering the physical configuration and flight characteristics of the RPA. The field of coverage must extend in each direction within at least 75° above and 75° below the horizontal plane of the RPA, except that there may be solid angles of obstructed visibility totaling not more than 0.5 steradians.
 - ii. Flashing characteristics. The arrangement of the system, that is, the number of light sources, beam width, speed of rotation, and other characteristics, must give an effective flash frequency of not less than 40, nor more than 100, cycles per minute. The effective flash frequency is the frequency at which the RPA's complete anti-collision light system is observed from a distance, and applies to each sector of light including any overlaps that exist when the system consists of more than one light source. In overlaps, flash frequencies may exceed 100, but not 180 cycles per minute.
 - iii. Colour: Each anti-collision light must be either aviation red or aviation white.
 - iv. The intensity of the anti-collision lighting shall be sufficient to make the RPA visually conspicuous to pilots of manned aircraft within 500 feet of altitude at a range of 1 nm at night, clear of cloud.

5XX.11.9.2 Each part of a position light system must meet the applicable requirements below:

- a) Left and right position lights. Left and right position lights must consist of a red and a green light spaced laterally as far apart as practicable and installed on the RPA such that, with the RPA in the normal flying position, the red light is on the left side and the green light is on the right side.

Note: a single unit displaying red and green to respective sides may meet this requirement

- b) Rear position light. The rear position light must be a white light mounted as far aft as practicable on the tail or on each wing tip.

Note: a single unit may meet this requirement

- c) The intensity of the position lighting shall be sufficient to make the RPA visually conspicuous to pilots of manned aircraft within 200 feet of altitude at a range of 1000ft at night, clear of cloud.

Note: Any strobe light system required by CARS Section 6 is covered by the material in this section, particularly 5XX.11.9.1 ii

5XX.11.10 Systems for IFR flight

5XX.11.10.1 If the RPAS is to be approved for IFR flight, the systems required by Part 605 Division 2 – Aircraft Equipment Requirements - IFR shall be TSO'd systems where such standards exist.

Note: No TSO exists for Sense and Avoid and Flight Termination Systems

5XX.12 Payloads

5xx.12.1 - All Payloads

- a) Payloads shall not create a hazard to the safe operation of the RPA.
- b) The limitations for payloads on the RPAS shall be defined and, either:
 - a. a list of permissible payloads shall be provided, or,
 - b. the criteria for permissible payloads are clearly defined and all foreseeable payloads that meet these criteria can be shown to meet the requirements of this section, or,
 - c. the criteria for permissible payloads are clearly defined and test and analysis procedures to ensure specific payloads meet the requirements of this section are provided. In this case, the owner/operator of the UAS must perform these tests and analyses and keep appropriate records of the satisfactory outcome of the tests and analyses
- c) In addition to a) and b) of this section, a permissible payload shall also meet the following criteria:
 - i. The maximum electrical power load of all payload configurations plus maximum electrical power loads of all other systems on board shall be within the power allowance of the RPA power system.
 - ii. Payloads shall be designed and tested to avoid the inadvertent transmission of any EMI that affects the control of the RPA
 - iii. Payloads, associated fairings and their attachment to the RPA shall be designed and tested to withstand maximum expected loads during flight, including launch and recovery loads, or be placarded to impose flight restrictions to limit the RPA to acceptable flight operations.
 - iv. Any possible payload installation and operation shall not present a hazard to persons on the ground or other air space users.

Note: this includes ensuring there is a means to prevent inadvertent release of any slung, towed or otherwise carried payloads.

5xx.12.2 – Payloads used for “Flight Decisions”

- (a) Payloads which are used to perform a role in the control of the RPA shall conform to the airworthiness standards for the flight control system and all other sections of this standard.

Note: These systems are “not required for flight” but may be used in some cases – an example is using the orientation and image of a camera to assist the pilot in navigation close to a fixed object.

5XX.12.3 – Interchangeable Payloads - In the case of a RPAS where the RPA may be operated with a variety of permissible payloads, the above criteria (5XX.12.1, 5XX.12.2) shall be met by each combination which is specified in the Type Design of the RPAS.

5XX.13 Manuals and Documentation

5XX.13.1 The RPAS shall have an Operating Manual that includes operating limitations, standard operating procedures, emergency procedures, assembly instructions and RPAS performance data.

5XX.13.2 The RPAS shall have a Maintenance Manual (which may be part of the Operating Manual) that defines actions that shall be taken to keep the RPAS in conformity with its Type Design.

Note: The recommended structure of an Operating Manual is found in Advisory Circular 5xx (included below for now)

Suggested Basic Structure of a Small RPAS Operating Manual (incorporating the Maintenance manual) *This outline is not exhaustive*

Note: Mandatory (safety critical) items will be identified by underlining.

1. **General.**
 - a. *Description of the RPAS*
 - b. *Engine, propeller, rotor*
 - c. *Three-view drawing*
 - d. *Flight Controls, control deflections*
 - e. *Ancillary controls*
 - f. *Displays*
 - i. *Flight-related (Altitude, airspeed, magnetic heading, position, attitude)*
 - ii. *Control settings*
 - iii. *Switches and caution/warning lights*
2. **Limitations**
 - a. *Weight*
 - i. *Maximum weight*
 - ii. *Centre of Gravity Limits*
 - b. *Speed (or other that are appropriate for the UA)*
 - i. *Maximum speed (V_{Dive})*
 - ii. *Manoeuvring Speed*
 - iii. *Best Gliding speed (max L/D)*
 - c. *Manoeuvring and limit load factors (or equivalent)*
 - d. *Prohibited manoeuvres*
 - e. *Weather conditions (e.g. icing conditions?)*
 - f. *Safety footprint for operational phases such as launch and recovery*
3. **Powerplant – propeller**
 - a. *Maximum power*
 - b. *Maximum engine/motor speed – propellers*
 - c. *Fuel system, indicators; battery state indicators*
4. **Emergency procedures**
 - a. *Engine failure*
 - b. *Fire*
 - c. *Gliding*
 - d. *Landing*
 - i. *Conventional horizontal run*
 - ii. *Parachute*
 - iii. *Net*
 - iv. *Other*
 - e. *Other emergencies:*
 - i. *loss of navigation aids*
 - ii. *loss of command link*
 - iii. *Control Jam*
 - iv. *Structural failure*
 - v. *Etc.*
 - f. *flight-termination*
5. **Standard operating procedures**
 - a. *Pre-flight inspection*
 - b. *Synchronization or other initialization procedures*

- c. *Start up, taxi*
 - d. *Take off/launch*
 - i. *Conventional horizontal run;*
 - ii. *Hand Launch;*
 - iii. *Catapult;*
 - iv. *Winch;*
 - v. *Other*
 - e. *Cruise*
 - f. *Landing/recovery*
 - i. *Conventional horizontal run*
 - ii. *Parachute*
 - iii. *Net*
 - iv. *Other*
 - g. *Post flight/shutdown landing and shutting down powerplant*
- 6. Performance**
- a. *Take-off*
 - b. *Wind limitations*
 - c. *Landing/recovery*
- 7. *Mission equipment***
- a. *List of equipment*
 - i. *Identify flight critical equipment*
 - ii. *Identify equipment that may direct the trajectory*
- 8. Assembly and adjustment**
- a. *Assembly and disassembly instructions*
 - b. *Rigging*
- 9. Maintenance Manual**
- a. *wings or envelope;*
 - b. *structure;*
 - i. *Doors and Hatches*
 - ii. *Fasteners*
 - iii. *Non-metallic components, including fabric or other covering*
 - c. *engine(s) and propeller(s);*
 - d. *command and control systems.*
 - e. *Environmental/type of use considerations*
 - f. *simple periodic maintenance activities based either on the number of flying hours or on calendar periods of use (whichever is reached first);*
 - g. *major maintenance activities necessitating thorough checks which could require partial disassembly;*
 - h. *acceptance inspection following the first XX hours of use of a new system;*
 - i. *necessary inspections following removal from storage;*
 - j. *a table containing the checks and deadlines that allows the owner to add his/her signature and the date the check is carried out. Any problems encountered, solutions applied and replaced parts should be noted;*
 - k. *specify any instruments, special tools, jigs, fixtures or tooling used to help assess acceptable tolerance levels The manual specifies life-limited parts*
 - l. *information, drawings or cut-away diagrams necessary to show how to assemble the various parts which can normally be disassembled. These criteria may also be taken into account by the propeller manufacturer;*
 - m. *repair procedures*
 - n. *etc., etc., etc.*

Appendix 3 Recommended Documentation Content

A3.1 Company Operations Manual

Note, this list of suggested content for the Company Operations Manual is not exhaustive, however this section has been written to capture the most onerous case (BVLOS IFR). It is expected that the company would scale this back as appropriate to the actual operation.

The Operations manual shall include the following, as applicable to the operation:

- (a) preamble related to use and authority of manual;
- (b) table of contents;
- (c) amending procedures, amendment record sheet, distribution list and list of effective pages;
- (d) copy of RPAS SFOC's and Operations Specifications;
- (e) chart of company management organization;
- (f) duties, responsibilities and succession of command of management and operations personnel;
- (g) description of operational control system, including:
- (h) flight authorization and flight preparation procedures;
 - i. preparation of operational flight plan and other flight documents;
 - ii. procedures to ensure the flight crew are advised, prior to flight, of any RPAS defects that have been deferred (MEL or other means);
 - iii. flight watch, flight following and communications requirements;
 - iv. dissemination procedures for operational information and acknowledgement;
 - v. fuel/energy and oil requirements;
 - vi. weight and balance system;
 - vii. accident/incident reporting procedures and procedures for reporting overdue RPA;
 - viii. use of check lists;
 - ix. maintenance discrepancy reporting and requirements on completion of flights; and
 - x. retention period of operational flight plans and flight documents;
- (i) sample of operational flight plan and weight and balance form;
- (j) flight data retention and flight data recording procedures as applicable;
- (k) operating weather minima and applicable requirements for IFR, VFR, VFR at night, VFR over-the-top and, if applicable, use of reduced VFR visibility limits in uncontrolled airspace;
- (l) instrument and equipment requirements;
- (m) instrument approach procedures and alternate aerodrome requirements;
- (n) procedures pertaining to enroute operation of navigation and communication equipment, including sense and avoid systems;
- (o) operations in hazardous conditions such as icing, thunderstorms, white-out, windshear;
- (p) performance limitations, as applicable;
- (q) securing of cargo;
- (r) briefing procedures for persons other than crew members;
- (s) use of RPAS Flight Manual, RPAS Operating Manual, Standard Operating Procedures and Minimum Equipment Lists as applicable;
- (t) aircraft ice, frost and snow critical-surface contamination procedures;
- (u) procedures for carriage of dangerous goods, as applicable;
- (v) fuelling procedures including:
 - i. fuel contamination precautions;

- ii. bonding requirements;
 - iii. fuelling with engine running;
 - iv. list of emergency equipment, how to use equipment and periodic inspection details;
- (w) emergency procedures for:
- i. preparation for emergency landing/ditching; and
 - ii. emergency control station evacuation;
- (x) minimum flight crew required and crew member qualifications;
- (y) flight time, flight duty time limitations and rest requirements;
- (z) training programs including copy of company training and qualification record form(s);
- (a-a) operational support services and equipment;
- (a-b) use of oxygen; and (*e.g. as may be required for a high altitude control station*)
- (a-c) procedures related to the aerial work operation including, as applicable;
- i. carriage of external loads;
 - ii. low level flight precautions;
 - iii. towing precautions, pick-up and release procedures;
 - iv. external load procedures, including flight and ground crew signals and briefing procedures, steps to be taken before starting an external load operation, hazards of oscillating loads, low density loads and unfamiliar load configurations; and
 - v. operational restrictions related to the operations.
- (a-d) operations conducted from control stations that are situated above 10,000 ft. ASL and associated oxygen requirements for crew members;
- (a-e) emergency procedures for: (*see Comment 4*)
- (i) loss or degradation of command and control link;
 - (ii) use of flight-termination system;
 - (iii) loss of visual contact (if required in the operation); Loss or degradation of sense and avoid capability
 - (iv) control station failures; and
 - (v) fly-aways;
- (a-f) procedures to prevent and manage incidents of interference with RPAS command and control links;
- (a-g) procedures to prevent and manage incidents of interference with a crew member; and
- (a-h) procedures for shipment of hazardous RPAS components. (*e.g. Lithium Batteries*)

A3.2 Standard Operating Procedures

(1) General

- (a) table of contents;
- (b) list of effective pages;
- (c) amending procedure; and
- (d) preamble;
- (e) communications;
- (f) crew co-ordination;
- (g) use of check lists;
- (h) standard briefings; and
- (i) standard calls.

(2) Normal Procedures (as applicable to the operation)

- (a) assembly;
- (b) pre-flight tests;
- (c) weight and balance control requirements;
- (d) launch and recovery;
- (e) taxi;
- (f) take-off and climb;
- (g) cruise;
- (h) descent;
- (i) approaches IFR, visual, VFR and circling as applicable;
- (j) landing;
- (k) missed approach and balked landing procedure;
- (l) stall recovery, as applicable;
- (m) crew coordination such as standard briefings and calls and handovers
- (n) use of on-board navigation and alerting aids;
- (o) refuelling/battery charging or replacement; and
- (p) use of check lists

(3) Abnormal and Emergency Procedures

- (a) emergency landing and/or use of flight termination system
- (b) equipment failure (all RPAS elements including launch and recovery systems);
- (c) loss or degradation of command and control link; loss of visual contact (if required in the operation);
- (d) Loss or degradation of sense and avoid capability;
- (e) control station failures;
- (f) fire, RPA / control station;
- (g) emergency control station evacuation;
- (h) inadvertent encounter with in-flight icing.
- (i) fly-aways;
- (j) pilot incapacitation; and
- (k) potential conflict with other aircraft.

A3.3 RPAS Operations Manual – Additions for Low Visibility Operations

The RPAS Operations Manual shall contain the following information if authorization for operation in low visibility (one nautical mile in controlled airspace) is requested:

(i) a company established minimum safe operational IAS and configuration for reduced visibility operations for each RPAS type for which this authority is sought; and

(ii) company low visibility operational procedures and considerations including, but not limited to:

- (A) wind;
- (B) gross weight and weather considerations;
- (C) route / terrain knowledge and/or restrictions (availability of forced landing areas, potential for white-out, etc.);
- (D) time of day restrictions (e.g. no low visibility operations at dawn or twilight);

- (E) communications;
- (F) sense and avoid system; and
- (G) terrain and obstacle avoidance system

A3.4 Operational Flight Plan

This section contains the requirements and minimum content of the operational flight plan standard. It is modeled after 722.14. It is assumed that the lack of situational awareness will mandate the need for operational flight planning, except in the familiar circumstances of the work zone.

VFR flights operated within an aerial work zone for the purpose of conducting an aerial work operation would not normally require an operational flight plan.

Recommended Minimum Content of an Operational Flight Plan

- (a) RPAS operator name;
- (b) date;
- (c) aircraft registration(s);
- (d) aircraft model(s);
- (e) type of flight - IFR, VFR, VFR at night;
 - (f) pilot-in-command name(s);
- (g) departure aerodrome/location;
- (h) destination aerodrome/location;
- (i) alternate aerodrome/location, if applicable;
- (j) routing to destination by successive navigational way points with associated tracks for each;
- (k) routing to alternate aerodrome/location;
- (l) planned cruise altitudes to destination and alternate, if applicable;
- (m) estimated time enroute and, if applicable, to alternate;
- (n) fuel/energy burn enroute and from destination to alternate;
- (o) fuel/energy as applicable for the type of flight plan:
 - (i) taxi;
 - (ii) destination;
 - (iii) alternate;
 - (iv) contingency; or
 - (v) holding reserve;
- (p) weights, as applicable
 - (i) total fuel/energy on board;
 - (ii) zero fuel weight;
 - (iii) planned maximum take-off weight;
- (q) signature of pilot-in-command or means of certifying acceptance.
- (r) communication
 - data link transition times/locations
 - spectrum management
- (s) handovers, as applicable
 - Time(s)
 - Location (s)
 - Receiving pilot(s)
- (t) other information pertinent to the safe completion of the flight.

The operational flight plan shall permit the flight crew to record the fuel/other energy state and the progress of the flight relative to the plan.

The RPAS operator shall specify, in its Operations Manual, how formal acceptance of the operational flight plan by the pilot-in-command shall be recorded.

Appendix 4 Criteria for a Compliant Operator of Small UAV Systems adapted to BVLOS

(Adapted From Transport Canada SI-623-001)

The material in section 5 of this Best Practices has been written with reference to [Appendix D of Transport Canada Staff Instruction 623-001](#). This section is most comparable to Part VII of the Canadian Aviation Regulations, which concerns the requirements for commercial air services. Since the Staff Instruction is potentially subject to change or evolution, the authors of this Best Practice have elected to replicate the selected content from SI-623-001 at the time of writing in this Appendix.

The material contained in this Appendix was intended to support the material in Section 5 of this Best Practices, and may be out of date, and as such should not be used directly for SFOC Applications/Review. For that purpose, the reader is directed to the most recent [Staff Instructions contained on Transport Canada's website](#).

Note: While much of the VLOS Compliant Operator criteria is applicable to BVLOS, some sections of this criteria are superseded by other best practices indicated elsewhere in this document, the superseded text has been deleted and replaced with ***Superseded by BVLOS Best Practices Elsewhere in this Document***

A Compliant operator of a small UAV system, restricted to visual line-of-sight (VLOS), will meet the following requirements:

1. General
 1. The Certificate applicant must demonstrate the ability to:
 1. maintain an adequate organizational structure;
 2. maintain operational control;
 3. meet training program requirements;
 4. comply with maintenance requirements;
 5. meet the standards contained herein; and
 6. conduct the operation safely.
 2. For the purposes of section (a) above, a Certificate applicant shall have the following:

Superseded by BVLOS Best Practices in Section 5 of this document.

2. Flight Operations
 1. Operating Instructions
 1. The UAV operator shall ensure that all operations personnel are properly instructed about their duties and about the relationship of their duties to the operation as a whole; and
 2. The operations personnel of a UAV operator shall follow the procedures specified in the operations manual in the performance of their duties.
 2. Operational Control
 1. The UAV operator shall not operate a UAV system unless it is under the control of its operations manager.
 3. Operational Flight Plan

1. The UAV operator shall not permit a person to commence a flight of a UAV unless an operational flight plan has been prepared in accordance with the procedures specified in its operations manual.
2. Minimum Content of an Operational Flight Plan:

Superseded by BVLOS Best Practices in Appendix 3 of this document

3. The operational flight plan shall permit the flight crew to record the fuel/other energy state and the progress of the flight relative to the plan.
4. The UAV operator shall specify, in its operations manual, how formal acceptance of the operational flight plan by the PIC shall be recorded.
4. Maintenance of Aircraft
 1. The UAV operator shall not permit a person to conduct a take-off/launch of a UAV that has not been maintained in accordance with the UAV operator's approved maintenance manual.
5. Built-up Area and Site Survey
 1. The UAV operator shall not operate over a built-up area at altitudes and distances less than those specified in Section 602.14 of the CARs, or conduct a take-off/launch, approach or landing/recovery within a built-up area of a city or town, unless the operator conducts a site survey in accordance with Section 6.19 of this SI.
3. Personnel Requirements
 1. Designation of Pilot-in-command
 1. The UAV operator shall ensure that a PIC is designated at all times during a UAV flight.
 2. Pilot Qualifications
 1. The UAV operator shall not permit a person to act and no person shall act as a pilot of a UAV system unless the person:
 1. is deemed compliant as per Appendix B – Criteria for a Compliant Pilot of Small UAV systems; and
 2. has fulfilled the requirements of the UAV operator's ground and flight training program.
 3. Crew Member Qualifications
 1. The UAV operator shall not permit a person to act and no person shall act as a crew member of a UAV unless the person
 1. has fulfilled the requirements of the UAV operator's training program.
 4. Training
 1. Training Program
 1. The UAV operator shall establish and maintain a ground and flight training program that is designed to ensure that each person who receives training acquires the competence to perform their assigned duties.
 2. The UAV operator's ground and flight training program shall be conducted in accordance with the Training Standard provided in paragraph (e) below and will include:
 1. company indoctrination training;
 2. upgrading training;
 3. training in the specific work to be conducted; and
 4. initial and recurrent training, including

5. UAV type training,
 6. procedures for passing piloting control from one control station or pilot to another,
 7. aircraft servicing and ground handling training,
 8. emergency procedures training,
 9. training for personnel who are assigned to perform duties associated with the flight, and
 10. any other training required to ensure a safe operation.
3. The UAV operator shall:
 1. include a detailed syllabus of its ground and flight training program in its operations manual; and
 2. ensure that adequate facilities and qualified personnel are provided for its ground and flight training program.
5. Training - Standard
1. Company Indoctrination Training - This training is required for all persons assigned to the operation. Company indoctrination training shall include, as applicable ;
 1. Canadian Aviation Regulations and applicable standards;
 2. UAV SFOC and the conditions specified therein;
 3. company reporting relationships and communication procedures, including duties and responsibilities of crew members and the relationship of their duties to other crew members;
 4. flight planning and operating procedures including
 1. operational preparation procedures related to reconnaissance of aerial work areas before low level flight operations; and
 2. operational restrictions;
 5. fuelling procedures, including fuel contamination precautions;
 6. critical surface contamination and safety awareness program;
 7. use and status of the operations manual including maintenance release procedures and accident/incident reporting procedures;
 8. meteorological training appropriate to the area of operation;
 9. navigation procedures appropriate to the area of operation;
 10. carriage of external loads;
 11. operational control system; and
 12. weight and balance system.
 2. Upgrading Training
 1. Upgrading training to PIC on a UAV type shall include:
 2. completion of applicable qualification training related to assigned duties; and
 3. completion of type training as PIC on the UAV type and a PIC competency check.
 3. Ground Technical Type Training (Initial and Recurrent)
 1. This training shall ensure that each crew member is knowledgeable with respect to the systems of the UAV system and all normal, malfunction and emergency procedures, as applicable to their assigned duties. Ground technical type training programs shall include:
 1. aircraft systems operation and limitations as contained in the UAV system operating manual, manual supplements, standard operating procedures;

2. use and operation of navigation and ancillary equipment;
 3. equipment differences of UAV of the same type, as applicable;
 4. UAV performance and limitations;
 5. weight and balance procedures; and
 6. UAV servicing and ground handling procedures.
4. UAV Servicing and Ground Handling Training
1. Training in UAV servicing and ground handling for each crew member, as applicable to their duties and applicable to the UAV type, shall include:
 2. fuelling/charging procedures:
 1. types of fuel, oil and fluids used in the UAV;
 2. correct fuelling procedures;
 3. procedures for checking fuel, oil and fluids and securing of caps; and
 4. procedures for charging batteries.
 3. use and installation of protective covers; and
 4. procedures for operating in cold weather such as:
 1. moving the UAV or other components of the UAV from a warm facility when precipitation or high humidity is present;
 2. engine pre-heat procedures including proper use of related equipment; and
 3. managing battery degradation.
5. UAV Flight Training Program (Initial and Recurrent)
1. The initial and recurrent flight training program shall ensure that each crew member is trained to competently perform the assigned duties including those relating to abnormal and emergency duties. Simulated malfunctions and failures shall only take place under operating conditions which do not jeopardize safety of flight. Flight training programs shall include, as applicable to the UAV system:
 1. standard operating procedures for normal, abnormal and emergency operation of UAV systems and components;
 2. use of check lists and pre-flight checks;
 3. crew member co-ordination procedures;
 4. normal take-offs/launches, circuits, approaches and landing/recovery including, as applicable, ground manoeuvring and hovering;
 5. control station fire procedures, including smoke control;
 6. fire control and handling of hazardous materials;
 7. simulated engine and system malfunctions and failures including hydraulic and electrical systems;
 8. simulated failure of navigation and communication equipment;
 9. stall (clean, take-off/launch and landing/recovery configuration) prevention and landing/recovery procedure;
 10. autorotations and anti-torque system malfunctions, as applicable;
 11. rejected take-off/launch and landing/recovery procedures;
 12. use of performance information and performance calculation procedures;
 13. simulated emergency descent;

14. collision avoidance techniques;
 15. operational procedures involving visual observers;
 16. steep turns and flight characteristics;
 17. briefings on recovery from turbulence and windshear; and
 18. flight manoeuvres used in specific operations.
6. Training and Qualification Records
 1. The UAV operator shall, for each person required to receive training, establish and maintain a record of:
 1. the person's name and, where applicable, personnel permit/licence number,
 2. if applicable, the person's medical category and the expiry date of that category;
 3. the dates on which the person, while in the UAV operator's employ, successfully completed any training or competency checks; and
 4. information relating to any failure of the person, while in the UAV operator's employ, to successfully complete any training or competency check or to obtain any qualification required herein.
 2. The UAV operator shall retain the records referred to in paragraphs (A) (III) and (IV) above, for at least three years.
4. Manual Requirements
 1. Operations Manual
 1. The UAV operator shall establish and maintain an operations manual that meets the requirements of Section (b) below.
 2. Contents of Operations Manual
 1. The operations manual, which may be issued in separate parts corresponding to specific aspects of an operation, shall include the instructions and information necessary to enable the personnel concerned to perform their duties safely and shall contain the information required by the standards in Section (5)(a) below.
 2. The operations manual shall be such that
 1. all parts of the manual are consistent and compatible in form and content;
 2. the manual can be readily amended;
 3. the manual contains an amendment control page and a list of the pages that are in effect; and
 4. the manual has the date of the last amendment to each page specified on that page.
 3. Distribution of Operations Manual
 1. The UAV operator shall provide a copy of the appropriate parts of its operations manual, including any amendments to those parts, to each of its crew members and to its ground operations and maintenance personnel.
 2. Every person who has been provided with a copy of the appropriate parts of an operations manual pursuant to subsection (i) above, shall keep it up to date with the amendments provided and shall ensure that the appropriate parts are accessible when the person is performing assigned duties.
 4. Standard Operating Procedures

1. The UAV operator shall, for each operation that is described in the operations manual, establish and maintain type-specific standard operating procedures that meet the standards described in Section (5)(b) below.
 2. The UAV operator that has established standard operating procedures shall ensure that a copy of the standard operating procedures is available at the control station.
5. Manuals - Standard
1. Operations Manual Content – ***Superseded by BVLOS Best Practices in Appendix 3***

 2. Standard Operating Procedures (SOPs) - ***Superseded by BVLOS Best Practices in Appendix 3***

Appendix 5 Mid Air Collision Risk Analysis

Deriving the reliability requirements for a Sense and Avoid (SAA) system necessitates a fault-tree analysis. A sample fault tree for a Mid-Air Collision is presented in this section, supporting a reliability requirement for a sense and avoid system on the order of $1E-3/hr$.

The analysis presented in here is particularly conservative, and encapsulates several assumptions. A more liberal analysis could be justified by using the $3E-7$ target level of safety from the historical GA mid-air collision rate, and removing the 10X factor on loss of separation, and not performing rounding down to 1. It should be noted that this approach homogenizes the statistics over the entire national airspace, whereas one can expect a higher probability of mid-air collision in dense airspace, particularly if it is uncontrolled, and a lower probability in 'unpopular airspace'.

When operating under an SFOC, some of the risks can be mitigated by specifying the location. The use of airspace models and statistics may allow for a locally accurate value to be populated for the probability of aircraft being in close proximity and on intersecting paths. By selecting areas of operation that are 'unpopular' it may be possible to develop operational experience with Sense and Avoid systems that are unproven or have low reliability numbers (e.g. systems in development). The use of known airspace statistics promulgated through a fault tree method similar to that presented here may assist in the development of the safety case associated with these proposed operations.

Analysis

Consider Figure 1, which depicts a fault-tree for a single mid-air collision between two aircraft. The top of the tree denotes the catastrophic event: A mid-air collision between a manned and an unmanned aircraft. Table 1 derived from Simon et al¹ indicates that the historical probability of mid-air collision, P_{Midair} , for GA aircraft in the US is established at $3E-7$ per flight hour. For convenience, the probability of such a collision can be assumed at $P_{Midair} = 1E-7$ per flight hour as a more conservative (factor of three) estimate.

The actual collision event is preceded by the probability that two aircraft are involved in a near-miss incident, whereby the near-miss volume is penetrated. The FAA SAA workshop paper indicates a 1 in 10 chance of a collision resulting from aircraft in this state, establishing this occurrence to be $P(NMAC) = 1E-6$ per flight hour.

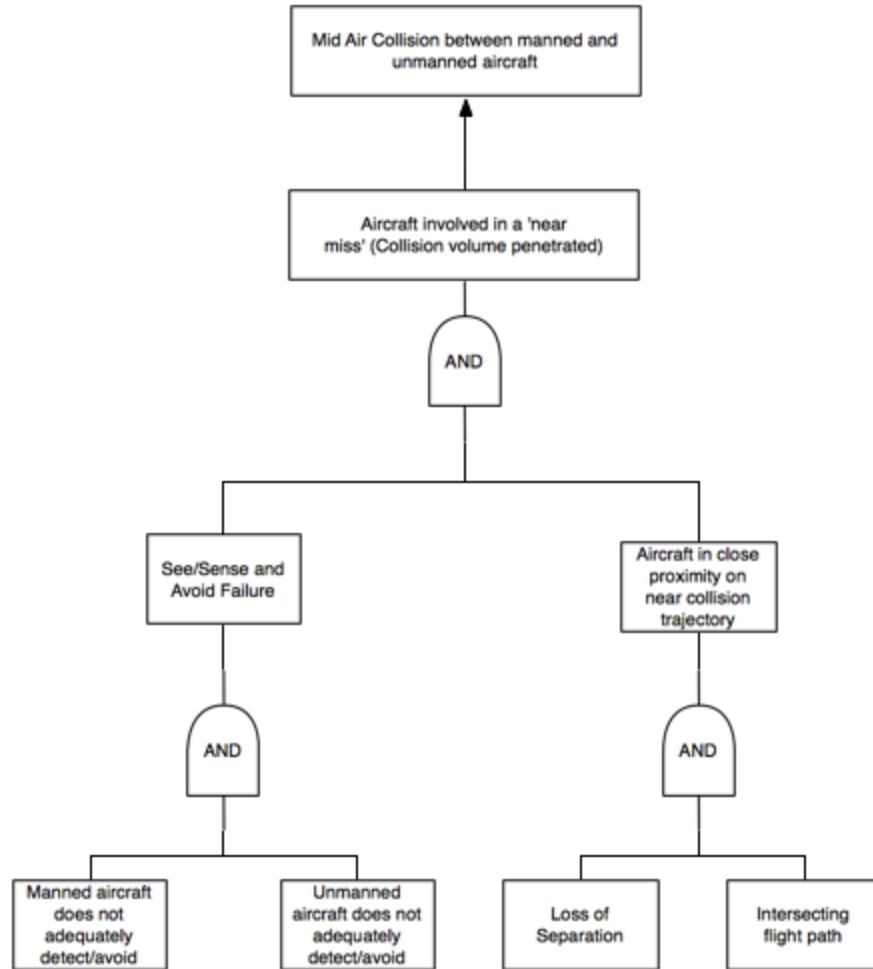


Figure 1 Mid-air Collision Fault Tree Analysis

The mid-air collision is preceded by the 'near miss' event. Two factors leading to a 'near miss' event are 1) failure of see/sense and avoid AND 2) Traffic in close proximity and on collision course. Determination of the required reliability of the sense and avoid system is driven by the probability of air traffic being in close proximity and on a collision course. A 2012 study conducted by the Canadian Transportation Safety Board (TSB)ⁱⁱ indicated 101 reported loss of separation or risk of collision incidents for 4,278,000 flying hours in 2012. Based on this data, the probability of loss of separation, $P_{SepLoss}$, can be established to first order at $P_{SepLoss} = 2.4E - 5$. The worst-case scenario can be estimated by taking the year with the highest number of reported losses of separation over the last 10 years (216 in 2004), which establishes the estimate of $P_{SepLoss} = 5E - 5$. It is likely that a higher number of losses of separation or risk of collision were undetected and unreported, therefore $P_{SepLoss}$ is raised by a factor of 10 and assumed to be $P_{SepLoss} = 5E - 4$.

Table 1 Mid-Air Collision Rates in the U.S. from 1999 to 2008

Year	Number of Incidents	GA Flight Hours	Active Aircraft	Incidents per flight hour ($\times 10^{-7}$)
1999	9	31,756,405	219,464	2.83
2000	19	30,974,861	217,533	6.13
2001	8	29,132,999	211,446	2.75
2002	5	27,040,100	211,244	1.85
2003	10	27,329,430	209,708	3.66
2004	10	28,125,896	219,426	3.56
2005	7	26,982,383	224,352	2.59
2006	7	27,705,164	221,943	2.53
2007	4	27,851,982	231,607	1.44
2008	5*	N/A	N/A	N/A
Mean	8.4	28,544,358	218,525	3.04

* Data acquired till May 2008.

This conclusion is supported by the authors of Simon et al, who derive a similar value by modeling the traffic density experienced by a King Air 350 equivalent aircraft observing a typical traffic pattern near an aerodrome. The caveat is that the resulting analysis will result in heavier than normal traffic estimates. Their paper, “Deriving Sensible Requirements for UAV Sense and Avoid Systems”, details the traffic patterns of a spanning sub-set of the top 100 aerodromes in the US, ranked from the most to least busy. It can be observed that both the number of movements and proximity risk decrease exponentially with rank, showing full one order of magnitude decrease between the top 25 and bottom 25, with negligible difference observed in traffic and proximity risk for the last 25 airports. The mean value for the proximity risk is observed to be $1.68E-3$, weighed heavily in favour of the busier aircrafts. Meanwhile the previous $P_{SepLoss} = 5E - 4$ is equivalent to the 50th ranked airport at Jacksonville, FA and can be treated as the nominal value for use in the analysis.

Table 2 Spanning sub-set of the top 100 busiest aerodromes in the US

Rank	Airport	2007 Movements	Movements per hour	# of Aircraft in Terminal Area at any one time	Aircraft Proximity Risk
1	Van Nuys, Van Nuys, CA	248,764	37.56	9	6.42E-3
25	David Wayne Hooks Memorial, Houston TX	94,573	14.39	4	1.07E-3

50	Craig Municipal, Jacksonville FA	78,135	11.89	3	5.36E-4
75	Napa County, Napa, CA	63,354	9.64	2	1.79E-4
100	Birmingham-Shuttleworth International, Birmingham, AL	57,037	8.68	2	1.79E-4

Based on the value of $P_{SepLoss}$, the probability of failure for the sense and avoid system, $P_{SAAFail}$ is derived to be $P_{SAAFail} = 2E - 3$ per flight hour, which is then rounded down to $1E-3$ for similarity with other aviation probability standards. Note that $P_{SAAFail}$ represents the failure of the overall solution space, i.e. the failure of SAA systems aboard both manned and unmanned aircraft. This value is similar to that derived in Simon et al, who calculate a historical manned see and avoid failure rate of $7E-3$ near aerodromes. Furthermore, they derive a manned vs. unmanned risk of sense-and-avoid failure at $1.4E-2$, which implies that the failure rate for each aircraft is $1.18E-1$ per flight hour.

For similar-sized manned and unmanned platforms, the risk may be shared between the manned and unmanned aircraft as a function of the cross-section area, with typical GA aircraft cross-section area on the order of 4 m^2 . The human visibility of a small UAS ($< 25 \text{ kg}$) platform is limited, therefore the responsibility for detection in a manned – small UAS collision falls completely on the unmanned platform, therefore, for this example the required reliability of the sensing hardware is $P_{Sense} = 1.4E - 2$ per flight hour.

ⁱ Simon, J. N., Braasch, M. S., "Deriving sensible requirements for UAV sense-and-avoid systems," in Digital Avionics Systems Conference, 2009. DASC '09. IEEE/AIAA 28th, vol., no., pp.6.C.4-1-6.C.4-12, 23-29 Oct. 2009

ⁱⁱ Aviation Statistics - Transportation Safety Board. Date accessed: Sept 2013.

Web:<http://www.tsb.gc.ca/eng/stats/aviation/2012/ss12.asp>