STANDARDS RESEARCH

Remotely Piloted Aircraft Systems (RPAS) – Identifying Gaps for National Operator Standards in Canada

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Executive Summary

National and international standards for remotely piloted aircraft systems (RPAS) are becoming more commonplace, driven by a mandate to reduce risks inherently associated with increasingly complex RPAS operations. The purpose of this report is to review existing RPAS standards, conduct a study of any related gaps and make recommendations on the development of new standards. RPAS standards are intended to serve as a foundation for regulations which aim to identify risks, increase safety, drive commercial and enterprise innovation, and ensure a minimum level of quality relating materials, processes, operating procedures, and human factors. With the RPAS sector still in its relatively early stages of development, this is a critical time for the analysis and development of national operational standards.

An extensive literature review and environmental scan reveals that although RPAS-related standards date back to 1944, very few countries have standards-based regulations (NFPA, 2019; Shivley et al, 2015; Amida, 2015; ANSI, 2018). Most existing standards are specific to the manufacturer, the RPAS operator, or the application (e.g., NFPA, 2019 pertaining to the use of RPAS to public safety operations). There is a general lack of standards at the national or international levels which provides a significant opportunity for Canada to contribute meaningfully. Safety and a need for quantifiable risk assessment are cited as the most common reasons to develop standards (Wackwitz and Boedecker, 2015; Ritzinger, 2014; Weibel, Edwards and Fernandes, 2011). According to Shivley et al. (2015) and ANSI (2018), most RPAS-specific operational elements currently lack standardization in areas such as licensing and training, operations, airworthiness, command control link and data security, detect and avoid systems, and airspace traffic management.

Data used to generate the final recommendations on the standardization requirements pertaining to commercial RPAS operations were gathered using the following three methods:

1. A survey with focused questions based on gaps identified through the literature review;

2. Key informant interviews based on the results of the survey; and

3. A full-day interactive workshop based on data gathered from the interviews.

Feedback received demonstrated a strong desire for expedited development of national RPAS standards for commercial operations. Specifically, respondents identified the following priority standard areas: personnel training, maintenance procedures, command and control link quality, operations near sensitive areas, and training of Aircraft Maintenance Engineer (AME)-like personnel.

The main recommendations based on the research results are the following:

1. Update the existing Transport Canada Standard 922 to covering the gaps of operational-specific factors related to enterprise operations including beyond visual line of sight, search and rescue, and package delivery.

2. Develop a standardized approach to:

   (a) certification to distinguish operators on the basis of an international safety rating system. This will increase safety and provide a common understanding of safety records and competency between operators; and

   (b) training and certification of RPAS maintenance personnel through existing and recognized training institutes.

Develop a standard requiring operators to adopt industry-wide best-practices including the use of manuals and proven procedures, coupled with regular inspections carried out by Transport Canada personnel. The application of this standard would provide quality assurance and quality control for the industry.

3. Engage the enterprise operators working directly with Transport Canada and other organizations to expand the capabilities and operational envelope of RPAS to help develop standards.

4. Develop standards to cover the gaps relating to data storage, sharing, protection, privacy, archiving and a means of carrying out a privacy impact study. This would provide a clearly laid out data management process that the industry can follow.

5. Leverage existing standards from other organizations (e.g., JARUS/SORA, ICAO, ISO, ANSI) and focus on developing standards specifically suited to Canadian commercial operations such as beyond visual line of sight, package delivery, and search and rescue.

6. Develop standards according to a schedule of identified priority areas which include training, maintenance, command and communications link quality, and proximity to sensitive areas.

7. Identifying the pertinent factors by which to clearly establish criteria for simple versus complex operations will be needed. It is important to recognize the vast differences between hobby RPAS and commercial operators when it comes to operational risk and mission complexity.

"Parallel to the global growth in use of commercial RPAS, concerns related to public safety, cyber-security, privacy, and Canadian-specific operations are also on the rise."

1. Introduction

A drone is an aircraft without a pilot on-board. It is controlled by a pilot through a ground control station, who can command the aircraft via radio and/or wireless frequencies. The aircraft configuration can be fixed wing, rotary wing, multi-rotor, or a hybrid combination. Typical payloads for commercial operations include cameras, laser transceivers, radar and many other sensors. Taken together, the drone, ground control station, payload, and mission crew are referred to as a remotely piloted aircraft systems (RPAS).

In reviewing existing standards and collecting input from stakeholders on the current state of the RPAS industry, one of the primary challenges is the incredible variety in both air vehicle systems and applications of such systems. RPAS and payload costs range from a few hundred dollars (small "selfie"-style RPAS) to hundreds of thousands of dollars (more complex RPAS utilized in geophysical exploration equipped with sensors such as light detection and ranging (LiDAR), magnetometers, and hyperspectral cameras). Nationally, the variability in terms of usage is also quite drastic. RPAS can be used to film a high-speed car chase on a movie set in downtown Vancouver, take scientific measurements north of the arctic circle in Alert Bay, Nunavut, or simply take a wedding photo or a family portrait at a backyard barbeque. They can be preprogrammed to map crops in the Prairies or be flown with first person view (FPV) goggles without GPS signals to increase the situational awareness of a firefighter in Halifax.

Parallel to the global growth in use of commercial RPAS, concerns related to public safety, cyber-security, privacy, and Canadian-specific operations are also on the rise. In this new ecosystem of consumer and commercial RPAS, the level of proficiency required to technically operate an RPAS has decreased dramatically over the last few years. Thus, the barrier to entry for this industry has been lowered resulting in both an increase in the number of RPAS and operators in established industries, as well as in new industries being disrupted by these technologies. RPAS exist within the aviation world, however they are separated from manned aviation by their lower capital equipment costs and consequence of failure. RPAS also belong in part to the world of industrial automation and the payloads that they often carry fall within the purview of remote sensing technologies. Any attempts at creating standards must recognize the presence of these multiple existing frameworks and work within them.

In order to arrive at metrics needed to create standards related to the RPAS itself, rigorous assessment of a variety of engineering processes must be made in areas such as material fabrication, radio frequency link testing, positioning accuracy, and a plethora of additional technical fields. This report aims to identify gaps in the existing standards and posit recommendations for future standards development. As the paradigm shifts to a world where RPAS are increasingly pervasive and relevant in a wide variety of applications, including the beyond visual line of sight (BVLOS) regulatory framework, the standards created must account and allow for industry innovation.

Assessing the current state of Canadian standards in RPAS requires consideration of the broader categories of what needs to be addressed:

- RPAS (i.e., material properties, mean rate of failure for individual components, hardware and electronics, communication links);
- Operations (i.e., proper standards of practice and safety considerations);
- Training (i.e., establishing expectations for knowledge requirement and minimum proficiency);
- Maintenance (i.e., recommended care and assessment criteria and tools); and
- Data (i.e., interoperability, accuracy, storage and privacy).

A cross-sectoral review of the need and desire for standards-based solutions is presented in section 2 with a keen awareness of the wide gamut of sectors that RPAS are increasingly applied in. This is followed by a summary of the research findings along with the key recommendations and conclusion.

2. Methodology

2.1 General

The research steps followed were:

1. An environmental scan and literature review of existing national and international standards and other relevant best-practices and their applicability in Canada.
2. Identification of key stakeholders from varied sectors across Canada.
3. Key informant interviews.
4. A cross-sectoral stakeholder workshop to assess need, and possible scope.

The current state of national RPAS standards was established through an environmental scan and literature review. A gap analysis was employed to identify which areas of RPAS-related operations would benefit most from the development of standards. Based on the gap analysis, a survey comprised of 23 questions was used to gather feedback from the subject matter experts about how best to proceed with the standardization of the commercial RPAS industry in Canada and to identify key informants for interviews. Results from follow-up interviews with the key informants were leveraged to help to shape the agenda of a full-day, cross-sectoral workshop intended to create an engaging dialogue about the future of Canadian RPAS standards. Results of the workshop were synthesized into clear recommendations about RPAS standardization based on industry and stakeholder input.

2.2 Environmental Scan & Literature Review

The history of RPAS standards dates to at least 1944 when the Chicago Convention resulted in the foundation of the International Civil Aviation Organization (ICAO). Several articles of that convention specifically mention pilot-less aircraft and they remain relevant to this day (Dalamagkidis, 2009). The modern version of that document is the ICAO *Manual for Remotely Piloted Aircraft Systems (RPAS)* (ICAO, 2015).

The over-arching goal of standards related to RPAS is to minimize hazards to people, property or other manned aircraft. Regulations (e.g., Transport Canada, Regulations Amending the Canadian Aviation Regulations (Remotely Piloted Aircraft Systems): SOR/2019-11) are meant to ensure that the standards are met in order to help protect people and property from aircraft and RPAS crashes and mid-air collisions between them. However, although nearly all countries have some level of regulations and laws governing the legal use of RPAS within their borders, very few have any standards in place which should form the basis for the regulations (NFPA, 2019; Shivley et al., 2015; Amida, 2015; ANSI, 2018).

Safety and a need for quantifiable risk assessment are cited as the most common reasons to develop standards (Wackwitz and Boedecker, 2015; Ritzinger, 2014; Weibel, Edwards and Fernandes, 2011 and others). There is agreement in the literature that the collaborative consensus model of developing harmonized certifications, regulations, and standards is the best current approach (Honorato, 2012; EASA,

2018; Dalamagkidis, 2009 and others). Ritzinger (2014), ISO/TC20-16 (2019), and ICAO RPAS CONOPS (2017) advocate for the implementation of a stepped or tiered approach to standardization. Based primarily on complexity and risk of an operation, as well as RPAS weight, a tiered approach separates simple from complex missions.

According to Shivley et al. (2015) and ANSI (2018), most RPAS-specific operational elements currently lack standardization in areas such as licensing and training, operations, airworthiness, command control link and data security, detect and avoid systems, and airspace traffic management. Since RPAS are more frequently sharing airspace with piloted aircraft, standards related to maintaining a safe separation between the two are becoming increasingly important. The European Union through the European Aviation Safety Agency (EASA) followed by the US through the American National Standards Institute Unmanned Aircraft Systems Standardization Collaborative (ANSI-UASSC), are leading the way in the development of operational systems to help RPAS and conventional aircraft safely navigate both controlled and uncontrolled airspace. ANSI has recently (December 2018) published a comprehensive roadmap detailing all areas where gaps currently exist relating to all aspects of RPAS operations. Included in the report are recommendations on which standards areas to focus future efforts on, along with the key stakeholders and organizations that should be involved in their development. The US Federal Aviation Administration (FAA), through its partnership with the Association for Unmanned Vehicle Systems International (AUVSI), is focusing efforts on developing standards in the areas of credentialing, airworthiness, operations/procedures, and airspace/infrastructure through four respective working groups. The Joint Authorities for Rulemaking on Unmanned Systems (JARUS) represents the national aviation authorities and regional safety organizations from 59 countries and is regarded as a leader in the development of "…a single set of technical, safety and operational requirements for the certification and safe integration of unmanned aircraft systems (UAS) into airspace and at aerodromes." (JARUS, 2012).

In summary, this is a period of rapid development of standards, rules, and systems meant to allow for the safe, efficient, and profitable deployment of RPAS into regional, national, and international airspace. While the US and the European Union appear to be at the forefront of standards development, there exist significant opportunities for Canada to contribute to this effort both on a national and international level.

2.3 Gaps in Current Standards

Listed below are the broad categories in which gaps in RPAS-related standards have been identified, based on the macro-level environmental scan. Generally, these gaps represent areas that are currently not covered or not sufficiently covered by standards with specific reference to RPAS. In a few specific cases, the standard may exist but must be adapted to RPAS and/or Canadian operations.

- Design and construction (e.g., avionics, C2 & C3, electrical, power and propulsion, noise);
- Safety (e.g., parachutes, operational risk assessment, weather, geo-fencing);
- Quality assurance and quality control (QA/QC) (e.g., terminology, compliance audit programs);
- Maintenance (e.g., flight crew and maintenance technician manuals, schedules);
- Enterprise operations (e.g., beyond visual line of sight (BLVOS), automation, inspections, delivery, biohazards);
- Data (e.g., Unmanned Traffic Management (UTM), handling, forensics, privacy, counter RPAS); and
- Human factors (e.g., displays, warnings, controls, crew competency, selection and training).

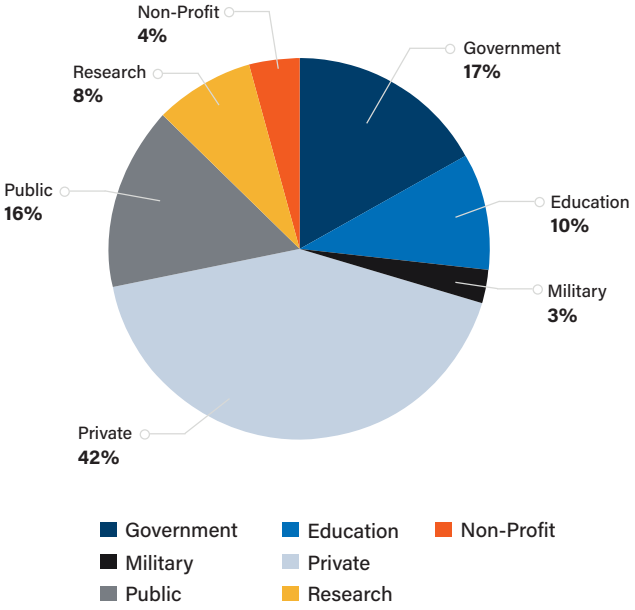
The literature review revealed that adequate standards exist for only a fraction of all the myriad of categories pertaining to RPAS operations. This is in one way problematic, but it also serves as an excellent catalyst for the industry to move concertedly forward to address the significant gaps in standards and contribute to the overall safety of recreational, commercial, and enterprise RPAS flights.

3. Cross-sectoral Interviews

A survey instrument was developed based on the standards gap analysis. The survey questions were organized into the following categories:

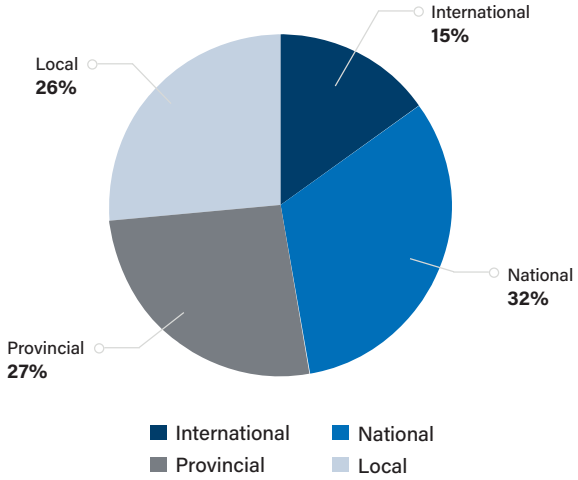
- **Respondent Profile –** The sector the respondent or respondents organization worked in, their involvement with RPASs through their work, their geographic scope of operation, and their involvement with standards development.
- **Assessing Need for Canadian RPAS Standards –** Whether Canada needs RPAS standards, how standards will impact safety, the RPAS industry, Canadian perception of the industry by others, and industry growth (as well as ranking gaps in existing standards).
- **Implementation of Standards –** How and if standards should be adopted, and which sectors, people, companies, or organizations should be involved in their development.

Figure 1 – *RPAS Sector Association.*



- 50.8% of respondents were associated with RPAS operations including training, piloting, operations management, and research and development.

Figure 2 – *Geographic Scope of Operations.*

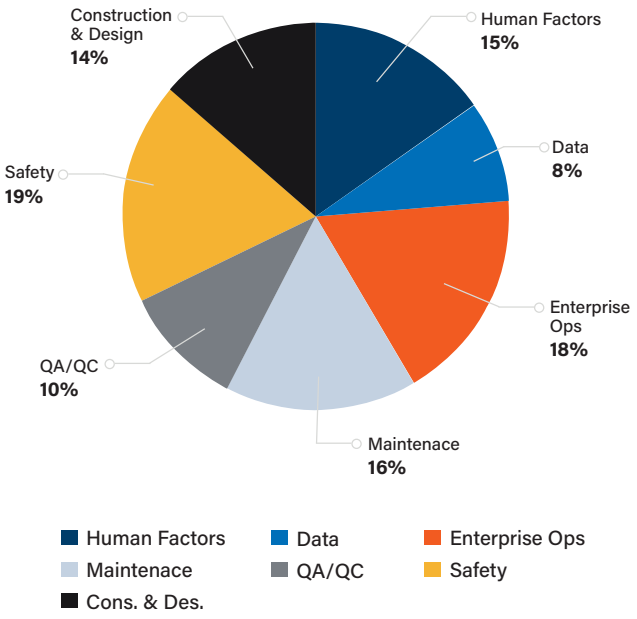


- Private operators represent the single largest sector of the respondents which helps to frame the remaining responses.
- The geographic scope of operations of the respondents indicates that the focus of standards should be on a national level.
- It is important that Canadian RPAS standards align closely with other national or international standardization efforts in order to maintain a high degree of interoperability.
- Canadian RPAS operators need to remain competitive on a global scale and any proposed national standards should reflect this inherently by understanding the standardization efforts of other countries or regions.
- 94% of respondents strongly agree or agree that commercial RPAS operations in Canada should be standardized and that they will improve operational safety.
- 97% of respondents strongly agree or agree that standards will be beneficial to the RPAS industry, will help it grow (80%), and improve the international perception of Canadian RPAS operations (93%).
- Collectively, these responses clearly indicate that RPAS standards are wanted and indeed needed by most respondents. There is also a sense of urgency around the timing of their development with most wanting them developed soon (i.e., prior to 2023).

- Respondent comments suggest that Canada is already lagging behind other countries with respect to standards development, especially in the areas shown in Figure 3. The presence of standards will also help inform and improve RPAS regulations according to survey comments.

The survey results unambiguously call for the standardization of Canadian RPAS operations as soon as possible, mainly in the areas of safety, enterprise operations, maintenance, human factors, and construction and design.

Figure 3 – *Areas Where Commercial RPAS Standards need to be Developed*



- **Human factors** relates to such items as maximum length of time that a RPAS pilot can command an aircraft before taking a break, minimum training requirements for air and ground crew for specific mission types, and any medical fitness requirements and currency criteria.

- **Maintenance** pertains to aircraft maintenance schedules, tools, and parts as well as training requirements of RPAS maintenance engineers, and will likely be specified by manufacturers.

- **Construction and Design** will, again, be most likely the domain of manufacturers and touches on the minimum quality of materials used in aircraft construction as well as related systems quantified through industry-accepted metrics, such as mean-time-between-failure (MTBF).

- **Data** covers elements including minimum positional quality of photogrammetric data, file and compression types for images and video, as well as security and encryption of data transmission, storage, and archiving.

- **QA/QC** deal with the specific means of ensuring that the proper steps are taken to achieve minimum quality levels prior to the mission and check data quality prior to delivery to the client.

- **Enterprise Operations** refers to standards for specific types of RPAS operations such as video capture, aerial surveying, LiDAR capture, infrastructure inspection, BLVOS, and first responder missions.

- **Safety** is a broad category addressing all aspects of operational safety including equipment requirements, minimum distance separations to bystanders and aircraft, redundancy and fail-safe mechanisms, emergency procedures, and incident/accident reporting.

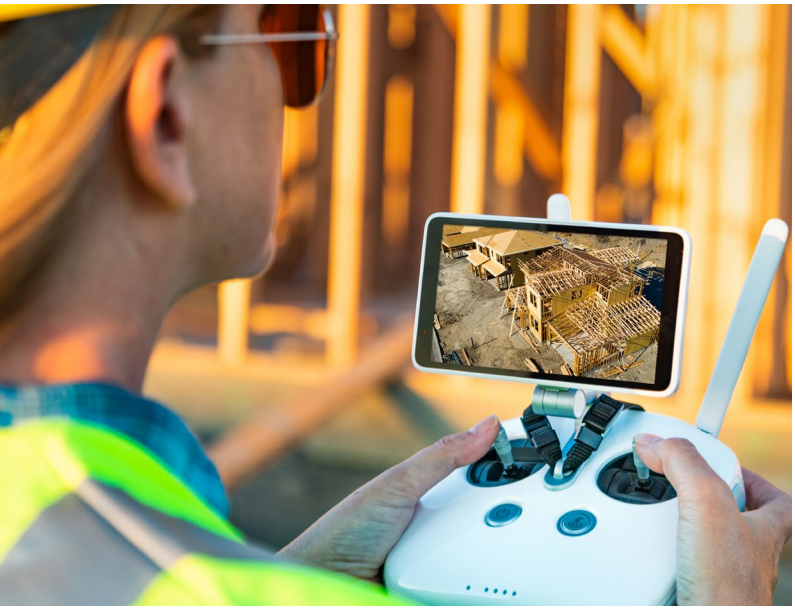
In summary, standards for the following areas of RPAS operations were identified as important to pursue based on the survey results:

- Safety and maintenance are top priorities with nearly equal focus on enterprise operations, human factors (including testing and flight reviews), and QA/QC.

- National RPAS standards need to be developed. They will improve operational safety and benefit the commercial RPAS industry in Canada.

- Standards could positively impact how other countries perceive the Canadian RPAS industry and help it grow.

- Academia and pilots should be involved in standards development with the inclusion of specific organizations such as Transport Canada, ground/flight schools, and Unmanned Systems Canada.



"Respondents noted that standards should be flexible and sensitive to the specific operational risks, largely governed by the proximity to people and sensitive locations, as well as the weight/size of the vehicle."

4. Key Informant Interview Results

A series of questions, developed based on the survey results, were used to carry out personal interviews with 20 key informants who agreed to be contacted directly.

Results of the key informant interviews show that there is a high level of homogeneity and agreement in the responses to many of the questions. This indicates that, despite the wide range of backgrounds of the respondents (government, private industry, flight school), there is a degree of consensus regarding the standardization of commercial RPAS operations in Canada. Most favour the adoption of existing standards adapted to the specific needs of Canadian RPAS operations mainly because there is an underlying urgency to their implementation. In certain cases, adapted standards (such as those relating to safety, construction and design, and maintenance) can be adopted from those developed by manufacturers or other standards development organizations (SDOs), because they are more related to aircraft and/or equipment than specific operational elements. In addition to potentially speeding up the process of implementing standards, the adoption path also improves the key element of interoperability. Several respondents expressed their disappointment with the fact that Canada still does not have RPAS standards and there is an unwillingness to delay their development unnecessarily. There is less certainty that the adopted/adapted standards will meet or exceed the needs of Canadian RPAS operations. With respect to human factors and operational standards specifically, the respondents felt strongly that the particular challenges of operating RPAS across a landscape and climate range as diverse as Canada's, warrants the development of uniquely Canadian standards that could also set a global standard for enterprise operations.

Respondents noted that standards should be flexible and sensitive to the specific operational risks, largely governed by the proximity to people and sensitive locations (e.g., large crowds or aerodromes), as well as the weight/size of the vehicle. A higher level of standards should be considered for riskier missions where a heavier RPAS (e.g., more than 10 kg) is being flown in close proximity (< less than 5 m) to bystanders (those not directly involved in the operation), at or over public events, aerodromes, or large crowds. Less risky missions flown with a lighter RPAS far away from people and not in controlled airspace should be guided by less strict standards. Beyond this over-arching topic, standards should focus on training (pilot, flight crew, maintenance personnel), development of manuals and improving operational consistency, and quality of equipment and procedures. Despite the large number of operational RPAS training schools, there is currently no fully standardized training curriculum for RPAS pilots, ground crew, or maintenance personnel. This means that RPAS pilots who receive their training from different flight schools will not necessarily have the same knowledge base, which is very different from the training private pilots currently receive. Standardized

training manuals need to be developed to address this gap, as well standardized operating procedures for a wide variety of common enterprise-level missions such as photogrammetric surveying and mapping, volumetric analysis, infrastructure inspection, first-responder and search and rescue missions, and video capture. Standards based on proven best practices need to be developed in order to improve operational consistency relating to safety, data capture and security, and aircraft operational limits. Manufacturers' declarations of safety assurance are a step in the right direction towards design and manufacturing standardization, as well minimum requirements for ground control station function and failsafe mechanisms.

5. Workshop

The final engagement method used to solicit input from the Canadian RPAS industry was a one-day workshop carried out in Vancouver on June 25, 2019. Twenty-five participants from a wide variety of RPAS-related sectors were invited to the workshop which featured an overview of the research results to date held in the morning, followed by a World Café discussion in the afternoon focusing on the four topics below:

1. Tiered Standards – Simple vs Complex Operations
2. Prioritization of Standard Topics
3. Engagement
4. How Should Canada Develop Their Own Standards?

The above topics captured the main themes and questions identified through the key informant interviews (see section 4) and discussion summaries are presented in sections 5.1 to 5.4.

5.1 Tiered Standards – Simple versus Complex Operations

More complex missions involving a higher risk factor, as calculated using a specific operational risk assessment (SORA), require more training compared with simpler missions with a lower risk profile. Existing SORA tools, such as the one published by JARUS (2019), can be effectively leveraged to calculate the specific air and ground risk of a mission and match crew experience and training requirements to ensure that the mission can be carried out safely and effectively. The following factors all play a role in determining who can fly a complex mission and what experience/training is required:

- equipment (fixed wing versus multirotor, reliability, type of payload and endurance, and weather requirements);
- environment (temperature, icing conditions, wind velocity/direction, humidity, altitude above sea level, density of atmospheric particulates, and visibility); and
- maintenance (manufacturers assurance rating, frequency and assessment of airworthiness).

It was also found that, although standards pertaining to specific areas of RPAS operations do exist, they are "invisible" in the sense that there is very little public awareness of them. Most existing standards and standard operating procedures (SOP) have limited national scope or application. Some of the RPAS areas where standards are found to be missing include human factors (e.g., behaviour, ethics, and performance), SOPs for specific mission types (e.g., videography, SAR, rural surveys), and crew training and evaluation. These standards gaps are closely aligned with the gaps identified through the literature review, survey, and key informant interviews. This underscores the need to focus any future standards development efforts on these specific areas.

5.2 Prioritization of Standard Topics

Based on a list of important standards areas identified through the survey and key informant interviews, each area was ranked by workshop participants from 1 (lowest priority) to 10 (highest priority). Figure 4 summarizes the results.

The individual topics above can be merged into the following broad categories:

- **Training** – Pilot and crew training manuals, maintenance procedures and records, AME training and development of manuals, and guidelines for proficiency testing.

- **Manufacturing –** Processes and materials testing, hardware QA/QC, and C2 link quality.
- **Operations –** SORA related to enterprise operations such as BVLOS, first-responder, package delivery, and inspections
- **Human Factors –** maximum length of time that a RPAS pilot can command an aircraft before taking a break, medical fitness requirements, and currency criteria

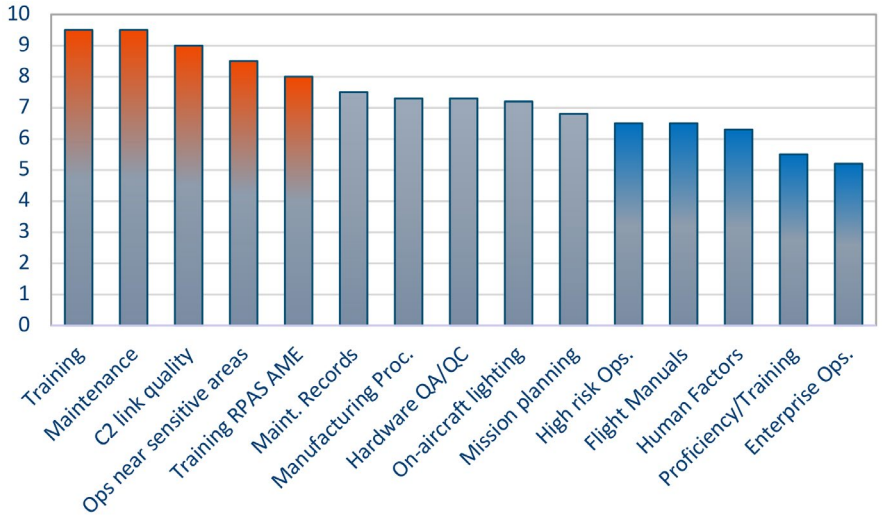
Training (for pilots, ground crew, and maintenance personnel) is consistently high on the list. The recommendation is to prioritize the development of a national standardized training curriculum for RPAS pilots, ground crew, and maintenance personnel. This will ensure that all pilots and related crew members receive consistent and complete training which will increase safety and reduce operational risks related to human factors. Standards development related to aircraft and equipment maintenance are also important because, as systems become more complex and operations near regular aircraft increases, there is a need to ensure a minimum standard level of airworthiness. These standards would be more the domain of manufacturers, with the possible involvement of academia, research institutes, or other SDOs. Command and control (i.e., C2) link quality is seen as another important area of standards development because, it is the main means of remotely controlling the aircraft and is critical to areas of safety and mission success. Creating standards related to ensuring that a minimum level of C2 link is maintained at all times should also be of high priority to prevent the potentially dangerous situation of a flyaway.

5.3 Engagement

The list of suggested participants who should be engaged in RPAS standard development reflects the broad spectrum of sectors that this technology crosses. Although certainly not exhaustive, the list below captures the key stakeholders that should be involved in the development of national RPAS standards:

- Manufacturers – including aircraft, payloads, safety systems, ground stations, and modifications.
- Professional Organizations – local, national, and international organizations, including Model Aeronautics Association of Canada (MAAC) and Unmanned Systems Canada (USC).
- Government – local, municipal, provincial, and national government bodies, including Transport Canada, Royal Canadian Mounted Police (RCMP), military, and Privacy Commissioner.

Figure 4 – *Suggested rollout order of RPAS standards*



"Attention should also be focused on ensuring that Canadian standards integrate well with other national and international bodies to maximize the potential for interoperability and multi-national collaboration."

- Professional Operator Groups – include a representative from each group such as The Canadian Drone Institute and regional RPAS groups.
- Private Companies and Corporations – private organizations such as industry innovators and developers, insurers, and media.
- Volunteer Organizations – organizations representing search and rescue personnel and firefighters.
- Academia – stakeholders from universities, colleges and technical schools.

5.4 How Should Canada Develop Their Own Standards?

The recommendation is to focus on developing a transparent, auditable process of standards development without necessarily tying them to existing regulations. The advantages of developing national (rather than international) standards is that existing individual standards from other organizations can be adapted and adopted where the opportunity exists in order to speed up the process and ensure that the unique requirements of Canadian RPAS operations are met and exceeded. The options to publish guidance documents should be explored with the aim of ensuring that the documents are "alive" with respect to updates, revisions and amendments carried out in a timely manner.

Although safety is one of the main justifications for the development of standards, the additional benefits of competitiveness and marketability also need to be taken into consideration. There is a high level of agreement amongst the survey respondents, key informants and workshop attendees that the standardization of RPAS operations will give Canadian operators a global competitive advantage over other, non-standardized operators. Attention should also be focused on ensuring that Canadian standards integrate well with other national and international bodies to maximize the potential for interoperability and multi-national collaboration. Through the adoption of certain existing standards from ISO, ANSI or ICAO as well as manufacturers, for example, a higher degree of compatibility can be achieved which will aide in the integration of Canadian standards with those of other counties and regions. It is recommended that a thorough examination of which existing standards should be adopted and which are best developed by Canadians. For instance, design and construction standards of RPAS specifically suited to long distance enterprise operations in cold and/or wet conditions over mostly sparsely populated areas would be unique to Canadian operations.

6. Recommendations and Conclusion

Based on the results of the cross-sectoral survey, key informant interviews, and the workshop, the main recommendations pertaining to the standardization of commercial RPAS operations in Canada are outlined in this section. Standards provide metrics for, and a quantifiable means of, determining whether a process or component meets an established minimum level of performance. They are often intended to serve as the foundation for regulations which aim to increase public safety and reduce operational risks. Lack of industry standards can result in poorly informed regulations and an ad-hoc approach to operational safety. With the RPAS sector still in its relatively early stages of development, this is a critical time for the analysis and development of national operational standards.

The gap analysis identified weaknesses in standards pertaining to design and construction, safety, QA/QC, maintenance, enterprise operations, data, and human factors. This is seen as a significant opportunity for Canada to contribute meaningfully to the development of national and international RPAS standards.

Concerning design and construction, currently, Transport Canada Standard 922 *(RPAS Safety Assurance)* requires designers, manufacturers, owners, pilots, or maintainers of small RPAS operated within visual line of sight to declare that a RPAS meets the applicable technical requirements to operate either in restricted airspace, near people, or over people. The recommendation is to update this standard to include operational-specific factors related to enterprise operations including BVLOS, search and rescue, and package delivery.

Regarding safety, one of the main areas of concern is that beyond the new levels of certification issued by Transport Canada, there is no other means of distinguishing the safety record and competency between one operator and another. A standard relating to certification from a national or international approval body is recommended to help clients distinguish operators on the basis of an international safety rating system.

QA/QC are established through the application of industry-wide best practices and use of manuals and proven procedures. A standard stating the requirement of an operator to adopt these practices, coupled with regular inspections carried out by Transport Canada personnel, is recommended. Using the manned aviation industry as an example, once a certain level of QA/QC is achieved, the need for inspections declines as the sector becomes self-regulated.

There is currently no recognized RPAS-specific maintenance qualification, similar to an Aircraft Maintenance Engineer (AME) in the manned aviation sector. With most commercial RPAS lacking any documentation relating to maintenance procedures and schedules, it is recommended that a standardized approach to RPAS maintenance personnel training and certification be established through existing and recognized training institutes. This would serve to ensure that RPAS, particularly those used for BVLOS and/or enterprise operations, are properly maintained and create new opportunities for education leading to a higher level of expertise and ultimately innovation.

While Transport Canada no longer differentiates hobby RPAS pilots from commercial operators with respect to the certification process, it is still important to recognize the vast differences between these two groups when it comes to operational risk and mission complexity. In many ways, the enterprise operators who are working directly with Transport Canada and other organizations to expand the capabilities and operational envelope of RPAS should be engaged to help develop standards, as they have the experience and expertise required to inform the process.

The current lack of standards relating to data storage, sharing, protection, privacy, and archiving is regarded as an opportunity to develop national RPAS data standards. With a clearly laid out data management process to follow, including a standardized way of carrying out a privacy impact study, this would greatly benefit the national RPAS industry.

The current state of the Canadian RPAS industry is dominated by small-scale operators who tend to underplay the importance of human factors in daily operations. Given the limited scope to which human factors are covered under the Transport Canada regulations, the RPAS industry can look to the manned aviation sector to determine the specific factors that should be considered for standardization.

The best avenue through which national RPAS standards are to be developed needs to be identified as soon as possible. Survey, interview, and workshop respondents expressed a sense of urgency regarding standards development. Effective engagement of key stakeholders at the outset of the process is important in order to determine the specific steps of the standards development process. The main recommendation is to identify and engage the stakeholders, identify the best way to proceed with standards development, and select an auditor to oversee the process for full transparency.

In the standards development process, a critical initial step is to determine which, if any, existing standards are suitable for adoption followed by adaptation to Canadian operations. Leveraging specific existing standards from organizations such as JARUS/SORA, ICAO, ISO, and ANSI will help identify which new standards need to be developed that are specifically designed to meet the unique requirements of Canadian commercial operations. The recommendation is to thoroughly review the available literature and documents specifically, ANSI (2018), Dukovitz (2018), Foltz et al. (2019), ICAO (2015), ISO/TC20-16 (2019), and Honorato (2012) to identify the candidate standards suitable for adoption via adaptation. Through this process and the workshop results, the specific standards that need to be newly developed will be determined.

With a list of which standards to adapt/adopt and which to build from scratch, the final recommendation is to proceed according to a schedule of identified priority areas which include training, maintenance, operations, and human factors. Furthermore, it is recommended to solicit input from key stakeholders identified via the survey and workshop in order to establish clear criteria for simple versus complex operations with respect to pertinent factors affecting operational risk. A list of suggested stakeholders is provided in Section 5.3.

In conclusion, standardization of commercial RPAS operations in Canada will increase safety and reduce risk to the public and manned aviation, while stimulating competition and economic growth of the industry. The process of developing national RPAS standards must be initiated quickly and proceed transparently. An organizational committee comprised of key participants needs to be struck to clearly identify which standards to roll out first, taking into consideration any existing standards that can be adapted to Canadian operations. A designated auditing body should oversee the development process.

Appendix A

Survey Respondent Affiliation

Private Sector	Public Service (Police, Fire, Paramedics)	Flight Schools	Academia
10 respondents: ▪ UAV Tower Innovations ▪ Ideas First ▪ InDro Robotics ▪ CKMM Photographic ▪ Maven Media Group ▪ Aerovision Canada ▪ Drone is Situ ▪ Skyworthy ▪ BlueForce	**4 respondents:** ▪ Abbotsford Police Department ▪ Winnipeg Fire Paramedic Service ▪ RCMP	**5 respondents:** ▪ Brampton Flight Centre ▪ InDro Robotics ▪ Waterloo Wellington Flight Centre	**1 respondent:** ▪ Southern Alberta Institute of Technology (SAIT)

Reference

Amida, T. (2015). *Design and Evaluation of UAV Ground Control Station by Considering Human Factors Standards and Guidelines,* Ryerson University, Toronto, Ontario.

Anand, Saurabh (2007). *Domestic Use of Umanned Aircraft Systems: an Evaluation of Policy Constraints and the Role of Industry Standards,* Washington Internships for Students of Engineering, August 2, 2007.

ANSI (2018). *Standardization Roadmap For Unmanned Aircraft Systems,* Unmanned Aircraft Systems Standardization Collaborative Version 1.0, December 2018.

Benharrosh, Benjamin (2014). *Operations in France: What needs Improving?,* UVSI RPAS 2014 Conference, June 2014.

Boyd, Peter (2014). *Future Direction for Aircraft Certification: Certifying Unmanned Aircraft Systems,* FAA/Asia Pacific Bilateral Partners Dialogue Meeting, March 2014.

Brewer, Nick (2012). *Working Group-6 (system safety) AMC UAS.1309 development Brief to industry,* JARUS Workshop, December 6, 2012.

Claude Le Tallec and Patrick Le Blaye (2017). *Low Level RPAS Traffic Identification and Management.* EUCASS 2017, Jul 2017, MILAN, Italy. ffhal-02000558f

Dalamagkidis, K, Piegl, L. A. and Valavanis, K. P. (2009). *On integrating Unmanned Aircraft Systems into the National Airspace System: Issues, Challenges, Operational Restrictions, Certification, and Recommendations,* Springer Science+Business Media, B.V.

Dukovitz, Z. (2018). *ISO Releases First Draft of Drone Standards for Public Comment,* UAV Coach, November 30, 2018.

EASA (2018). *Safe Operations of Drones in Europe: Update on EASA's Activities,* Cologne, Germany.

FAA (2013a). *Sense and Avoid (SAA) for unmanned aircraft systems (UAS),* SAA Workshop Second Caucus Report, 2013.

FAA (2013b). *Sense and Avoid (SAA) for Unmanned Aircraft Systems (UAS).* Second FAA sponsored SAA workshop, final report, January 18, 2013.

FAA (2013c). *Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap,* P.6-8, 23-30

Ferguson, A. *Opening the Skies to Beyond Visual Line of Sight Drone Operations,* www.precisionhawk.com, accessed Apr. 12, 2019.

Foltz, J., Hinaman, A., McCabe, J. and Jenny, M. (2019). *UAS Standards – What Exists and What's Coming.* Lecture presented at FAA UAS Symposium in Baltimore Convention Center, Baltimore.

Honorato, R. (2012). *JARUS: A Harmonized Approach to UAS Rulemaking,* ICAO & LACAC UAS Seminar, 2012.

ICAO (2017), *Remotely Piloted Aircraft Systems (RPAS) – Concept of Operations (CONOPS) for International IFR Operations,* Feb. 2017.

ICAO (2015). *Manual on Remotely Piloted Aircraft Systems (RPAS),* Feb. 2015, First Edition.

ISO/TC20-16 (2019), *Unmanned Aircraft Systems,* ISO Technical Committee 20, Subcommittee 16.

JARUS (2012). *CS-LURS Public Consultation,* JARUS Workshop, December 6, 2012.

Jones, E., Harron, G., Hoffa, B., Lyall, B., and Wilson, J. (2012). *Review of regulations and information in support of human factors guidelines for unmanned aircraft system (UAS) ground control station (GCS) design,* Year 1 report. Available at www.researchintegrations.com/publications.

Jones, E., Harron, G., Wilson, J., Hoffa, B., and Lyall, B. (2013). *Review of regulations and information in support of human factors guidelines for unmanned aircraft system (UAS) ground control station (GCS) design,* Year 2 report. Available at www.researchintegrations.com/publications.

Muller, F. (2014). *RPAS situation in The Netherlands according to DARPAS,* UVSI RPAS 2014 Conference, June 2014.

NFPA 2400 (2019). *Small Unmanned Aircraft Systems (sUAS) Used for Public Safety Operations,* National Fire Protection Association.

OHS Online (2018). *New NFPA Standard Issued for Public Safety Drone Operations,* Dec 6, 2018, www.ohsonline.com, accessed Apr 11, 2019.

Paolo Marra, "The Italian Regulated RPAS Market", UVSI RPAS 2014 Conference, June 2014.

Pauner, C., Kamara, I. and Viguri, J. (2015). *Drones. Current challenges and standardization solutions in the field of privacy and data protection,* Trust in the Information Society Conference, ITU Kaleidoscope, Barcelona, Spain, Dec. 9-11, 2015.

Pitchford, M. *What's needed to ensure safety and security in UAV software,* Military Embedded Systems, www.mil-embedded.com, accessed Apr 14, 2019.

Post and Parcel (2018) *Developing Health and Safety Standards for Drone Delivery,* Jul. 16, 2018, www.postandparcel.info, accessed Apr. 10, 2019.

Public Law 112 Congress (2012). *A Modernization and Reform Act of 2012,* 112-95, Feb. 14, 2012, Sec. 332-336.

Quigley, P. (2015). *Launching Drones,* Sep. 25, 2015, www.astm.org, accessed Apr 13, 2019.

Fortner, R. (2014). *Austrian Experiences with the First National VLOS Regulation Implemented in 2014,* UVSI RPAS 2014 Conference, June 2014.

Isdahl-Engh, R. D. (2014). *The current status in Norway and what needs improving,* UVSI RPAS 2014 Conference, June 2014.

Ritzinger, M. (2014). *Practical Aspects & Upcoming Developments of European Regulations for UAS below 150kg in Context with Austrian Rulemaking,* Joanneum University of Applied Sciences.

Shivley, R. J., Hobbs, A., Lyall, B., and Rorie, C. (2015). *Human Performance Considerations for Remotely Piloted Aircraft Systems (RPAS),* Remotely Piloted Aircraft Systems Panel (RPASP), Second Meeting (RPASP/2), Montreal, Canada, 15 to 19 June, 2015.

van de Leijgraaf, R. (2012). *JARUS A Harmonised Approach to UAS Rulemaking,* JARUS Workshop, December 6, 2012.

Wackwitz, K. and Boedecker, H. (2015). *Safety Risk Assessment for UAV Operation: Safety Hazard Identification, Safety Risk Assessment, Safety Risk Mitigation, Safety Risk Documentation + Case Study,* Hamburg, Germany.

Weibel, R., Edwards, M., and Fernandes, C. (2013). *Establishing a risk-based separation standard for unmanned aircraft self separation,* 11th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference, AIAA 2011-6921, September 2011.

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