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Canadian Remotely Piloted Aircraft Systems (RPAS) Research and Development Survey

Date: December 15, 2022
Author: Caidence Paleske

Aerospace

National Research Council Canada   Conseil national de recherches Canada

Canada

nrc.canada.ca

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Introduction

Since 2015, Transport Canada (TC) has been working with the National Research Council of Canada (NRC), industry, and international partners on remotely piloted aircraft system (RPAS) research and development (R&D) activities to advance the understanding of drone technology, support regulatory development, and ensure that drones are used safely. To have the greatest impact, R&D requires the collaboration of different stakeholders, including members from industry, academia, and government organizations, both domestically and internationally. Through the Canadian Drone Advisory Committee (CanaDAC), Transport Canada (TC) and RPAS industry stakeholders are working to support RPAS R&D in Canada and improve the collective mobilization of the R&D ecosystem in Canada. Initial work conducted by a CanaDAC R&D Task Group identified challenges in producing a detailed list of R&D activities that are currently planned or underway in Canada. Due to limitations in publicly available data, a key challenge recently identified through this work is producing a holistic picture of all the RPAS R&D activities in Canada. Being able to identify all Canadian-led RPAS R&D innovators and their research areas would increase awareness of activities underway and contribute to the development of a Canadian network of contacts within the RPAS R&D industry.

To address the challenges identified by the CanaDAC Task Group, TC and NRC decided to conduct a survey, as a first step, to assess the current research being conducted by Canadian RPAS stakeholders. The aim of this work was to further identify and characterize RPAS R&D activities performed in Canada. This information could then be used to build a network, assess where there are gaps, and to inform future work in this area such as developing working groups and forums to facilitate collaboration.

Methods

Participants were recruited via email using an agreed upon stakeholder list compiled by both TC and NRC. In addition, a link to the survey was shared in TC's Drone Zone newsletter in October which is distributed to a list of 934 stakeholders every other month. Participants were also encouraged to share the survey link with their peers who also conduct RPAS R&D. Data was collected over six continuous weeks during October and November 2022 using an online survey platform known as Qualtrics. In April 2018, Qualtrics achieved International Organization for Standardization (ISO) 27001 certification and uses Transport Layer Security (TLS) encryption (also known as HTTPS) for all transmitted data. Qualtrics has also achieved ISO 27017 and 27018 certifications. Surveys hosted on their platform are password protected and protected with HTTP refer checking. Their services are hosted by trusted data centres that are

independently audited using the SSEA-16 method. Qualtrics is based in Toronto, Ontario, Canada.

Participants were first presented with a description of the purpose of the survey as well as a question to confirm whether or not they wished to participate. If they answered "No", they were brought to the end of the survey. The questions and the structure of the survey were developed collaboratively between TC and NRC (Appendix A – Survey Contents (English)). Participants had the option to complete the survey in either French or English.

Although names and email addresses were collected for the purpose of creating a stakeholder network, they will not be mentioned in this report. Of the 131 stakeholders initially contacted, 48 individuals had clicked the survey link. Only those who agreed to participate and answered at least one question – besides providing their first and last name – were included in the analysis. A total of 40 participants were included, with 35 of those participants being male, four female participants, and one participant declining to identify their gender. Of the 40 participants, 38 of the stakeholders were those who were initially contacted via email, and two used the anonymous link. Those that used the anonymous link were recruited either via the newsletter or by another stakeholder sharing the survey link with them.

Results

A total of 34 participants completed the survey in English, and six completed it in French. When asked what type of organization they currently work for, most participants selected "industry" (n=18), eight selected "college or university", five selected "government", and nine selected "other". For the nine individuals that selected "other", additional work was done to attempt to categorize them into one of the three provided categories based on how they answered the open text box, or provide an additional category to capture their workplace. Final counts are presented in Figure 1.
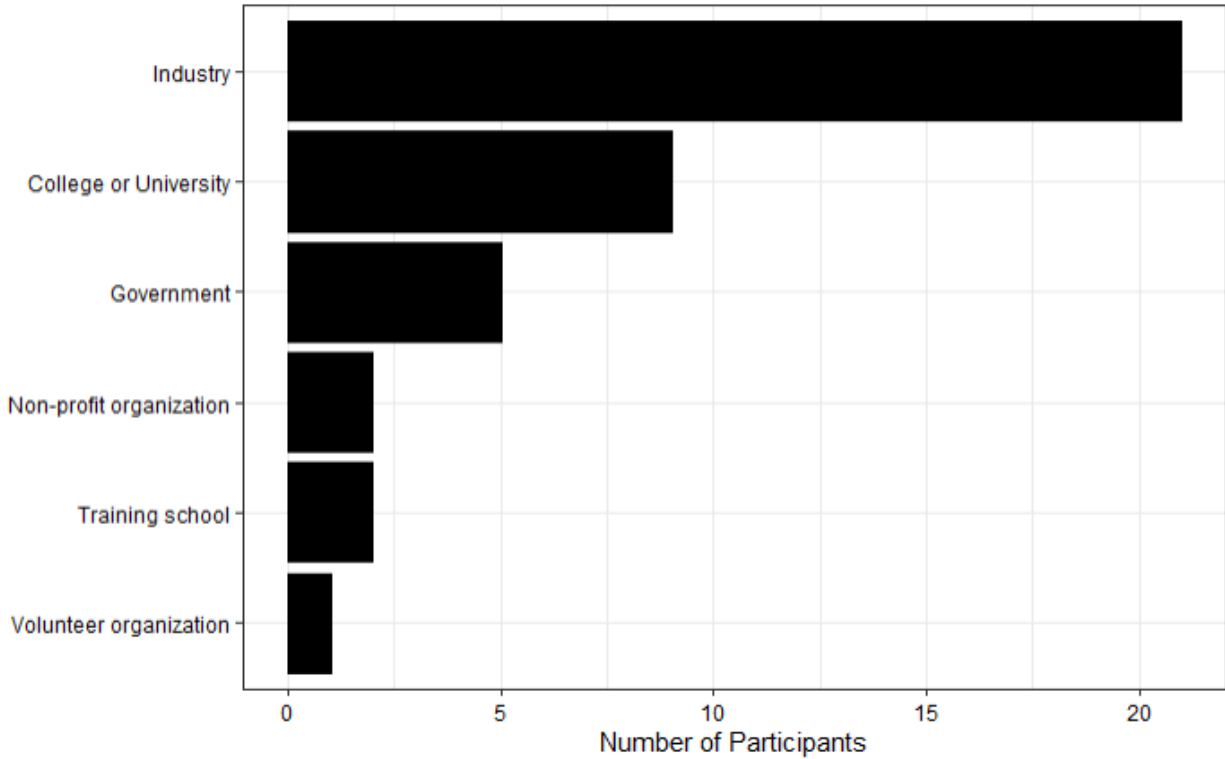
Figure 1. Updated organization type counts.

Research Information

Participants were provided a list of R&D areas predefined by TC and NRC and were prompted to select any areas that were applicable to their current activities within the RPAS industry. The areas of research and the number of participants that indicated each area can be found in Table 1.

Table 1. RPAS R&D Areas of Research and Counts

Area of Research	Count
RPAS integration into the airspace (RPAS Traffic Management)	23
Detect and Avoid systems (development or testing)	21
Autonomy	21
Air to Air collision severity and probability	15
Radio signal integrity (C2 link)	15
Urban Air Mobility (UAM) and/or Advanced Air Mobility (AAM)	15
RPAS flying in severe weather	14
Cybersecurity	11
Human factors	11
Air to Ground collision severity and probability	10
RPAS tolerance or detection of icing	10
Social acceptance of RPAS	8
RPAS noise emissions	7
Economic and environmental impacts	6

A total of nine participants selected "Other" and provided their own words to describe their research, which are listed below:

- Image processing and computer vision
- Electric propulsion
- RPAS vehicle design
- RPAS flight performance testing
- C-RPAS
- Mitigation methods, general R&D
- C-UAS – sensor effectiveness in congested RF environments
- RPAS manufacturer
- Test site for industry activities

The median number of research areas selected by the stakeholders was four (SD = 3.3). Participants also had the opportunity to provide additional details about their work. Fourteen participants wrote additional details, which can be found in Appendix C – Research Area Comments. One comment was not included in the appendix because it included strategic information that could not be anonymized.

Funding Information and Sources

When asked to select any applicable sources of funding that they have received for RPAS R&D within the last five years, 31 participants selected "Government funding (e.g., grants and contributions)", 18 selected "Private Canadian investors", seven selected "Private international investors", and 10 selected "Other". Five participants declined to answer this question. Because participants could select multiple funding sources, it was of interest to know the number of sources that each participant received funding from. The total number of funding sources indicated by each participant can be found in Table 2, with most participants selecting two sources of funding.

Table 2. Number of funding sources selected by participants.

Number of Funding Sources	Count
Four	1
Three	6
Two	16
One	12

For those that selected "Other", the following were mentioned as sources of funding:

- Internal R&D funding
- Retained earnings
- United States of America government
- Memberships
- Charitable donations
- Industry grants
- Business revenue (2)
- IRAD
- None

Because there were several mentions of internal revenue as being a source of funding for our stakeholders, a new category was created to encapsulate this data. Of the 10 stakeholders that selected "Other", the four who listed internal R&D funding, retained earnings, and business revenue as being sources of funding were placed into this category and removed from the "Other" category.

Participants were then asked to select a range that most accurately reflects the amount of funding they had received for RPAS R&D within the last five years. Fourteen participants selected "Under $100,000 per year", five selected "Between $100,000 and $250,000 per year", and 13 selected "Over $250,000 per year". Eight participants declined to answer this question.

Table 3. Distribution of organizations by funding ranges.

Organization Type	Under $100K	$100K - $250K	Over $250K
College or university	6	1	0
Government	0	0	2
Industry	4	4	10
Non-profit organization	1	0	1
Training school	2	0	0
Volunteer organization	1	0	0
Total	14	5	13

It was also of interest to know the distribution of funding being allocated to different organization types (Table 3). In addition, the number of funding sources per range was calculated. For those that selected "Under $100,000 per year", 57% of them had more than one source of funding. For those that selected "Over $250,000", 23% had only on source of funding, while the majority of those with over $250,000 of funding per year selected two sources of funding (54%) (Figure 2).
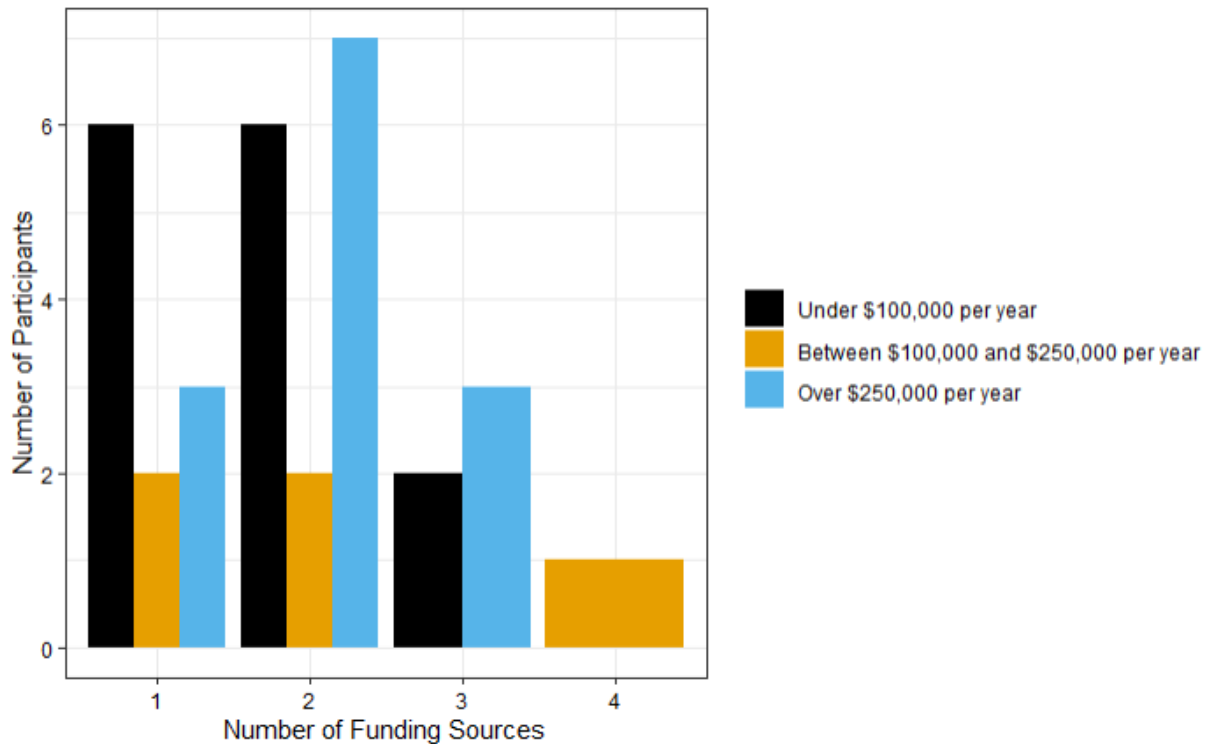

Figure 2. Funding ranges grouped by number of funding sources selected.

Within each range, it was also of interest to know what types of funding were selected by the stakeholders. Within each of the three funding ranges, most stakeholders within a given range had selected receiving government funding (i.e., grants and contributions) (Figure 3).
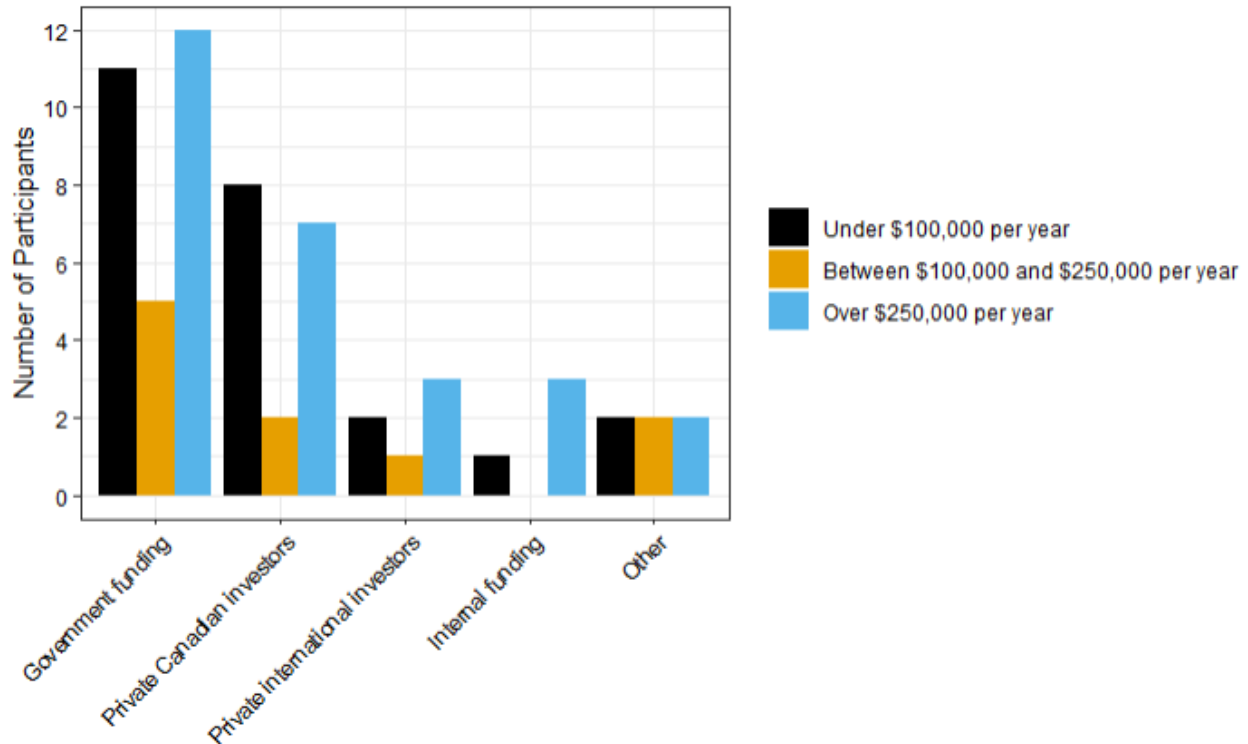
Figure 3. Types of funding selected by stakeholders within each funding range.

The median number of research areas selected by the stakeholders being equal to four, but most stakeholders selected a funding range of "Under $100,000 per year". As such, the number of research areas selected compared to the amount of funding received was examined (Figure 4). Only stakeholders that provided a funding range could be included in this metric. The two stakeholders that selected more than 10 research areas indicated that they received under $100,000 per year in funding. Because the survey question related to selecting the different research areas specified "current activities", it is possible that stakeholders selected many different areas even if that area of their work is smaller compared to others or that a project can address multiple areas at a given time. For example, a single project could investigate aspects of social acceptance, human factors, autonomy, economic and environmental impacts, and cybersecurity within a single study.
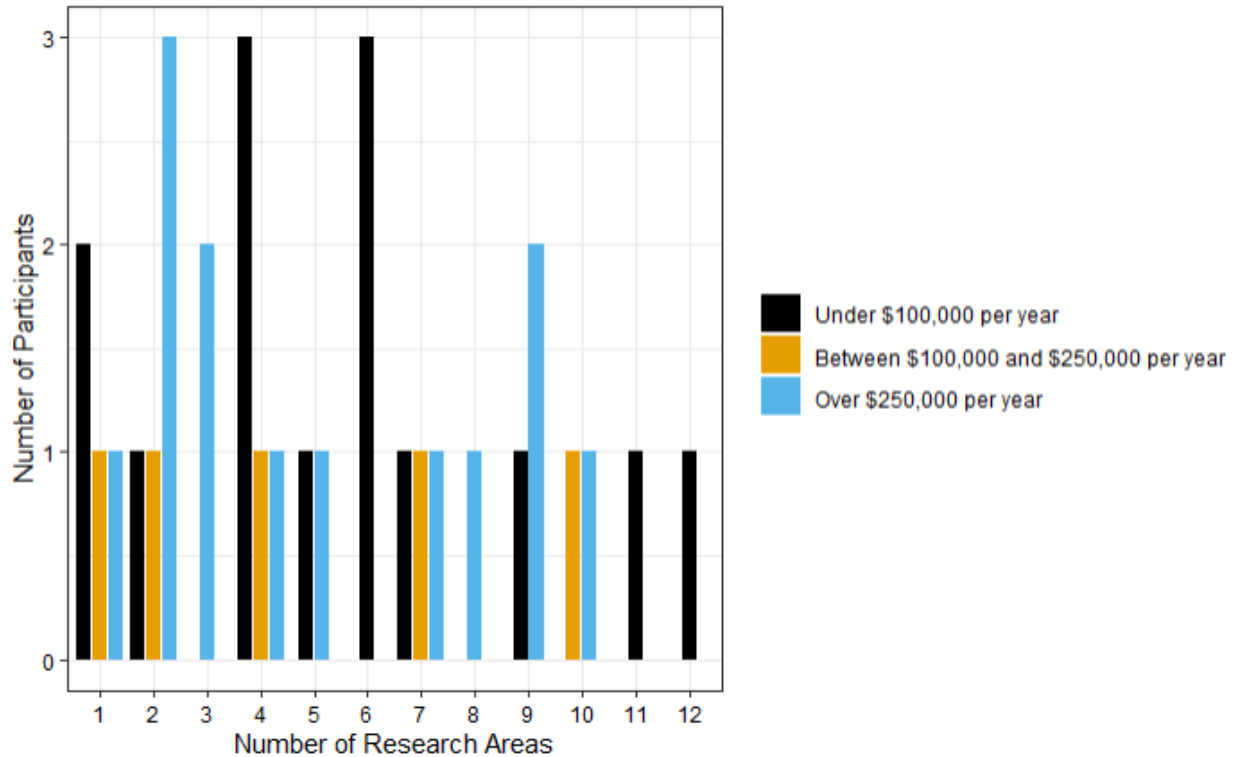
Figure 4. Number of research areas within each funding range.

Working Group Interest and Feedback

When respondents were asked if they would be interested in participating in an RPAS R&D stakeholder group, should one be established, 28 respondents said "yes", one said "no", and seven selected "Unsure – I would like more details if the group were established". For the purpose of creating a network of Canadian RPAS stakeholders, this data is anonymized in the report, but tied to each individual in the final dataset to be used by TC and NRC to create potential working groups in this area.

Lastly, participants were provided with an open-ended textbox where they could provide any final thoughts about the survey. A total of 12 respondents provided additional details, with one respondent highlighting that they believe "partnerships and collaboration are key for this industry to move forward". Similarly, another participant stated that "in order to capture the full potential of RPAS for Canada, we need to encourage collaboration and research across industry, academia, and government regulation." Others mentioned that they see the value in having greater access to "developmental grants or the encouragement of private investment", and that they wished there were more "financial supports for the RPAS field from Canadian government and private industries".

Some participants provided feedback that related to how to best create advancement in RPAS R&D going forward. One participant mentioned that "engaging with undergraduates to help them with student projects and support research in all aspects of RPAS sciences will be a great foundation for attracting talent to this exciting and increasingly important area of the Canadian economy". Other participants mentioned that it would be beneficial for industry to have a "clear regulatory framework for air mobility as well as dedicated space to test the technology" and that it would be beneficial for Canada to have a "National Aviation Strategy".

Ways Forward and Summary

Based on participant responses from the survey, the top three most frequently mentioned areas of R&D being conducted in Canada are RPAS integration into the airspace, detect and avoid system development or testing, and investigations into autonomy. The three least frequently mentioned areas were social acceptance of RPAS, RPAS noise emissions, and economic and environmental impacts. It is impossible to know whether the least mentioned areas are the least mentioned because these areas are not as likely to receive funding, or because there are fewer stakeholders with interest in these areas. The top three areas clearly reveal that the development of the technology is of the utmost importance to most Canadian stakeholders currently. However, if investigations into social acceptance and potential impacts of the technology were assessed in tandem or collaboratively, this could provide stakeholders with key information about how Canadians are perceiving RPAS activities longitudinally.

Since there was no limit on the number of research areas a respondent could select, it is possible some topics were selected because they are of interest to the individual, or perhaps the individual has read about the research topic but did not actually conduct any research themselves. The amount of funding and the number of research areas do not seem to correlate. For example, a couple participants selected 11 or more research topics, but reported they received less than $100,000 in funding per year. This seems unlikely, so it is possible that the question pertaining to current RPAS research areas was misinterpreted. Alternatively, it is possible participants have multiple smaller ongoing R&D projects or one larger project that touches upon several different research areas. Since there is uncertainty regarding the interpretation of this question, it is recommended that further guidance should be added to similar questions in the future to ensure that all participants are interpreting it the same way. Additionally, it is suggested that future surveys ask that participants only select their top three or five areas of RPAS R&D.

Further, it would be beneficial to have clear funding options that are currently available to Canadians conducting R&D in these areas. Although most participants indicated that they have at least two funding sources, with 78% of respondents indicating that they have received government funding in the last five years, open-ended feedback from some participants suggests that knowing where they can find funding to conduct their research would be beneficial. It was also clear that stakeholders who participated in this survey desire more ways to collaborate with other researchers on R&D. Future work should ask stakeholders how many collaborative projects they engaged in versus how many internal projects. This would allow TC and NRC to gauge the level of current collaboration, and better facilitate collaborative relationships going forward for the current RPAS R&D activities in Canada.

Appendix A – Survey Contents (English)

Introduction Page

Thank you for your interest in this survey!
Please read this first page carefully to ensure you understand the purpose of the survey and the types of information that you will be asked to provide.

Since 2015, Transport Canada (TC) has been working with the National Research Council of Canada (NRC), industry, and international partners on remotely piloted aircraft system (RPAS) research and development (R&D) activities to advance the understanding of drone technology, support regulatory development, and ensure drones are used safely. To have the greatest impact, R&D requires the collaboration of different players. Members from industry, academia, and government organizations (both domestically and internationally) all play a key role in progressing R&D activities.

Due to limitations in publicly available data, a key challenge recently identified through this work is producing a holistic picture of all the RPAS R&D activities in Canada. Being able to identify all Canadian-led RPAS R&D innovators and their research areas would increase awareness of activities underway and contribute to the development of a Canadian network of contacts within the RPAS R&D industry. This information could then be used to assess potential gaps or areas of duplication, inform future R&D work, and support greater organization and mobilization of the sector in Canada.

To address this challenge, TC (in collaboration with NRC) is conducting a survey of those persons involved in RPAS R&D activities in Canada. Responses will feed into the creation of a comprehensive scan and aggregated responses will be publicly shared. Please note:

- The survey is made up of 10 questions and should take no longer than 10 minutes to complete.
- Participation in this survey does not mean you are agreeing to join a stakeholder forum (or any type of working group), nor does it require any further action on your part once you have completed the survey. By providing your contact information in this survey, you consent to TC contacting you regarding your interest in future stakeholder groups or activities.
- Personal information (e.g., contact information) will be kept strictly confidential and not shared. Although survey findings (e.g., areas of research) will be shared on an aggregate basis, you have the option to not disclose certain information.

Survey Questions

After reading the statement, would you like to participate in this survey?

○ Yes, I want to participate.

○ No, I do not want to participate.

1 First name:

_____

2 Last name:

_____

3 Which gender do you identify with most?

○ Male

○ Female

○ Non-binary

○ Transgender male

○ Transgender female

○ Self-describe: _____

○ Prefer not to answer

---

4 Organization type:

○ Government

○ Industry

○ College or University

○ Other: _____

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5 Name of workplace:

_____

6 Position/job title:

_____

7 Email:

_____

8.1 From the following list, select any areas that are applicable to your current activities within the RPAS industry (select all that apply):

☐ Air to Air collision severity and probability

☐ Air to Ground collision severity and probability

☐ RPAS integration into the airspace (RPAS Traffic Management)

☐ Radio signal integrity (C2 link)

☐ Detect and Avoid systems (development or testing)

☐ RPAS tolerance or detection of icing

☐ RPAS flying in severe weather

☐ Autonomy

☐ Cybersecurity

☐ Social acceptance of RPAS

☐ Urban Air Mobility (UAM) and/or Advanced Air Mobility (AAM)

☐ Human factors

☐ Economic and environmental impacts

☐ RPAS noise emissions

☐ Other (please specify)

_____

☐ I do not wish to disclose my area(s) of research

8.2 Do you wish to provide any further details about your work?

_____

_____

_____

_____

_____

9.1 What sources of funding have you received for RPAS R&D within the last five years (select all that apply)?

☐ Government funding (e.g., grants and contributions)

☐ Private Canadian investors

☐ Private international investors

☐ Other: _____

☐ I do not wish to disclose this information

9.2 If you would like to provide more details on the source(s) of funding you have received, please insert them here:

_____

_____

_____

_____

_____

10 What range most accurately reflects the amount of funding you have received for RPAS R&D within the last five years?

○ Under $100,000 per year

○ Between $100,000 and $250,000 per year

○ Over $250,000 per year

○ I do not wish to disclose this information

11 If an RPAS R&D stakeholder group/forum was established, would you be interested in participating? If established, this group/forum would bring together key R&D players

to share updates from different areas to enhance information sharing and collaboration in the R&D field.

○ Yes

○ No

○ Unsure - I would like more details if the group is established

12 Do you have any final thoughts that you would like to share before completing this survey?

_____

_____

_____

_____

_____

Appendix B – Survey Contents (French)

Page de presentation

Merci pour l'intérêt que vous portez à ce sondage!

Veuillez lire attentivement la première page afin de bien saisir le but de l'exercice et la nature de l'information que vous serez prié de fournir.

Depuis 2015, Transports Canada (TC) collabore avec le Conseil national de recherches du Canada (CNRC), l'industrie et des partenaires internationaux à des activités de recherche et de développement (R-D) sur les systèmes aériens sans pilote (SATP) qui nous aideront à mieux comprendre la technologie des drones, faciliteront l'élaboration de règlements et feront en sorte que l'usage des drones ne pose aucun danger. Pour qu'elle ait un impact maximal, la R-D exige la collaboration de différents acteurs. Les membres de l'industrie, les universités et les organisations gouvernementales (canadiennes et étrangères) jouent tous un rôle capital dans l'avancement de la R-D.

 Les données publiquement disponibles étant limitées, une des principales difficultés récemment mise en relief dans le cadre de ce travail concerne l'absence de vue générale de la R-D sur les SATP poursuivie au Canada. Or, si on pouvait identifier tous les innovateurs canadiens qui s'intéressent à la R-D sur les SATP et préciser la nature de leurs travaux, on connaîtrait mieux les activités en cours et développerait plus facilement un réseau national de spécialistes en la matière. Pareilles informations permettraient d'évaluer les lacunes éventuelles et les domaines où il y a redondance, d'étayer les recherches futures et de parvenir à une meilleure organisation et mobilisation de l'industrie au pays.

 Pour surmonter cette difficulté, TC (en concertation avec le CNRC) a entrepris de sonder ceux qui poursuivent de la R-D sur les SATP au Canada. Leurs réponses contribueront à brosser un tableau complet de la situation et seront agrégées avant d'être rendues publiques. Veuillez noter ce qui suit.

- Répondre aux dix questions du sondage ne devrait guère demander plus de dix minutes.
- Participer au sondage ne signifie pas que vous acceptez d'adhérer à un forum d'intervenants (ou à un groupe de travail quelconque). Aucune autre intervention ne sera requise de votre part une fois que vous aurez répondu au questionnaire. En donnant vos coordonnées, vous consentez néanmoins à ce que TC

communique avec vous pour savoir si vous souhaitez prendre part à des activités ou à un groupe d'intervenants futurs.

- Les renseignements de nature personnelle (coordonnées, par exemple) resteront strictement confidentiels et ne seront pas partagés. Même si les résultats du sondage (à savoir, les domaines de recherche) seront diffusés sous forme agrégée, vous pouvez, si vous le désirez, choisir que certaines informations ne le soient pas.

Questions de l'enquete

Après avoir lu ce qui précède, acceptez-vous de participer au sondage?

○ Oui, j'aimerais y participer.

○ Non, je préfère ne pas y participer.

1 Prénom

_____

2 Nom

_____

3 À quel genre vous identifiez-vous le plus souvent?

○ Homme

○ Femme

○ Non binaire

○ Transgenre masculin

○ Transgenre féminin

○ Ma description : _____

○ Je préfère ne pas répondre.

---

4 Nature de l'organisation

○ Gouvernement

○ Industrie

○ Collège ou université

○ Autre (préciser) : _____

---

5 Nom du lieu de travail

_____

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6 Poste/titre

_____

7 Courriel

_____

8.1 Dans la liste que voici, sélectionnez les domaines auxquels se rapportent vos activités actuelles dans l'industrie des SATP (cochez toutes les réponses qui s'appliquent) :

☐ Probabilité et gravité d'une collision en vol avec le sol

☐ Probabilité et gravité d'une collision en vol avec une autre aéronef

☐ Intégration des SATP à l'espace aérien (gestion du trafic des SATP)

☐ Intégrité des signaux radio (liaison C2)

☐ Systèmes de détection et d'évitement (développement ou essais)

☐ Tolérance ou détection du givrage par les SATP

☐ Vol des SATP dans des conditions météo extrêmes

☐ Autonomie

☐ Cybersécurité

☐ Acceptation des SATP par la société

☐ Mobilité aérienne urbaine (MAU) ou mobilité aérienne avancée (MAA)

☐ Paramètres humains

☐ Retombées économiques et impact environnemental

☐ Bruit des SATP

☐ Autre (préciser) : _____

☐ Je préfère ne pas divulguer la nature de mes recherches.

8.2 Aimeriez-vous fournir plus de précisions sur vos travaux?

_____

_____

_____

_____

_____

9.1 D'où venaient les fonds qui ont financé vos activités de R-D sur les SATP ces cinq dernières années (cochez toutes les réponses qui s'appliquent)?

☐ Gouvernement (p. ex., subventions et contributions)

☐ Investisseurs privés du Canada

☐ Investisseurs privés de l'étranger

☐ Autre (préciser) : _____

☐ Je préfère ne pas divulguer cette information.

9.2 Si vous voulez fournir d'autres précisions sur vos sources de financement, faites-le ici.

_____

_____

_____

_____

_____

10 Veuillez indiquer la fourchette qui illustre le mieux la quantité des fonds que vous avez obtenus pour réaliser vos travaux de R-D sur les SATP au cours des cinq dernières années.

○ Moins de 100 000 $ par année

○ De 100 000 $ à 250 000 $ par année

○ Plus de 250 000 $ par année

○ Je préfère ne pas divulguer cette information.

11 Si on créait un groupe ou un forum de R-D sur les SATP, aimeriez-vous y participer? Advenant le cas où il verrait le jour, pareil groupe ou forum réunirait les principaux acteurs dans le domaine pour qu'ils fassent le point de la recherche sur différents sujets en vue d'un meilleur partage de l'information et d'une plus grande collaboration en R-D.

○ Oui

○ Non

○ Je ne sais pas. J'aimerais en savoir plus sur le groupe, une fois qu'il sera formé.

12 Y a-t-il d'autres réflexions dont vous aimeriez nous faire part avant de clore le sondage?

_____

_____

_____

_____

Appendix C – Research Area Comments

- We are the largest manufacturer in the world of electric propulsion test stands. Our tools are used by thousands of businesses, university, and research center. We have a good idea of what manufacturers of drones, electric aircrafts, motors, and propellers need to test their propulsion system for efficiency, reliability, characterization, preventative maintenance, etc...
- Also developing a C-UAS Mission Planning & Assesment tool which provides feedback on the effectiveness of the RF and IR sensors via Modelling and Simulation. The modelling includes the effects of a congested spectrum, terrain, buildings, environmental factors, etc.
- Use of 5G, Edge Computing and AI/ML for connected-drones
- Ground based Obstacle Avoidance, Human Machine Teaming
- Our focus is to develop a fully autonomous RPAS that operates with the latest regulations to address market needs in the various market verticals we have identified.
- We are developing an eVTOL (2027) which will have autonomous flight capability in a second phase (2030).
- While we are not a research organization our focus, in responding to disasters, our work deals with airspace integration and safety in countries outside of North America.
- mainly focussed on dynamics and control and guidance of RPAS
- BVLOS, BVLOS integration into civil aviation, UTM, traffic risk models, integrated phased array radar, sense and avoid, civil aviation regulation changes for BVLOS with minimal impact to civil aviation with minimal impact to aircraft with legacy avionics, multispectral imaging, transitioning aircraft (VTOL fixed wing), RF identification, autonomy, swarm operations, cellular network redundant C2, reliability: electronics, software, redundancy, tethered multi-rotor as radar platform or radio base station
- I am bringing experience from a long career in commercial aviation maintenance, engineering and operations to help capture best practices that may be applicable to the rapidly advance and intersection of RPAS with manned aviation
- We operate a 70 acre facility, 20 mins north of [removed to keep anonymity]. The space allows us to conduct applied research to help commercial sectors better utilize RPAS technologies.
- We manufacturer DAA sensors for crewed and uncrewed aircraft systems.
- We are not doing research work per say, but we are directly dealing with these factors in our day to day operations.