Remotely piloted aircraft systems (RPAS) technology for future passenger and freight transportation

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This project was conducted under the mentorship of TransLink staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of TransLink or the University of British Columbia.

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Executive Summary

Around the world, more people are moving to live and work in cities like Metro Vancouver. Cities densify by building upwards instead of sprawling outwards to accommodate the population growth. However, as cities grow vertically, the transportation network remains two-dimensional and may become increasingly congested. A new mobility choice that TransLink is interested in is how urban air mobility with autonomous aerial vehicles can be a form of transportation for passenger and freight transportation. The aerial vehicle industry is new, with currently only small personal or commercial package delivery aerial vehicles in use. However, the private sector is rapidly developing within a regulatory framework that is growing at the same time. A review of the current remotely piloted aircraft systems (RPAS) technology, industry and national regulatory framework are presented in this report. Within this RPAS industry and regulation context, TransLink can review its options in preparing for its transportation infrastructure for a possible future with autonomous aerial vehicles.

Table of Contents

Introduction

TransLink requested high-level research of automated aerial vehicle technology and its future applicability to move passenger and freight throughout Metro Vancouver. This type of technology is being developed by companies, such as UberAir, Alphabet Wing, Amazon Prime Air, and Boeing NeXT, as an option for personal and parcel transport. In 2019, Uber announced plans to launch its 2023 UberAir passenger service in Dallas-Fort Worth, Los Angeles and Melbourne, Australia[1]. Therefore, aerial vehicles could soon take part in future mobility services that are currently being served by ride-hailing, carsharing, bike-sharing, and public transportation.

While passenger aerial transportation is still under development, the ability to deliver products through the air is already impacting the future of freight transportation. Companies have successfully transported small packages, such as medical supplies, blood samples, organ donations, and other commercial goods in Africa, North America, and Oceania. With the speed of and resources available from the private technology industry in developing this as an alternative form of transport, governments and transportation authorities are looking to understand how automated aerial vehicles may fit into current forms of transportation.

Zipline UAS delivering medical supplies in Kenya

Methodology

Research for this report consisted of literature reviews of government regulations, global news scans and company profiles. The information gathered from this desk research was supplemented with e-mail or phone conversations with representatives from:

- Transport Canada
- B.C. Ministry of Transportation
- TransLink and,
- Unmanned Systems Canada

Industry knowledge from the *2019 Uber Elevate Summit* was obtained by attending as an academic researcher. From this Summit, the information from sessions on safety, regulations and business models were incorporated into this report.

RPAS: An overview

The term ‘remotely piloted aircraft system’ (RPAS) is used to classify the concept of an ‘automated aerial vehicle.’ This report uses RPAS when referring to automated aerial vehicles in the Canadian context. RPAS is the preferred terminology now used by the international aviation-related agencies, such as International Civil Aviation Organization (ICAO), Eurocontrol, the European Aviation Safety Agency (EASA), the Civil Aviation Safety Authority (CASA – Australia), the Civil Aviation Authority (CAA – New Zealand)[2].

According to the ICAO, RPAS is a: *“remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design*[3].

Due to the public perception of drones, international trends, and the movement towards a gender-inclusive industry, Transport Canada formally adopted ‘RPAS’ for legal and regulatory purposes. Transport Canada still uses ‘drone’ for public communications, but RPAS serves as an umbrella term for any craft that does not have a human pilot onboard. Transport Canada further defined RPAS as:

- Weigh 250 grams (g) up to and including 25 kilograms (kg), and
- Are operated within the RPAS pilot’s visual-line-of-sight.

RPAS: Types and Technology

As a young technology, RPAS is known to the public by many names. Depending on the sector or the country, RPAS may be called ‘drones,’ Unmanned Aerial Vehicles (UAV) and Unmanned Aircraft Systems (UAS). The following are acronyms frequently used in the RPAS industry:

UAVs (Unmanned Air Vehicle) is a ‘power-driven aircraft, other than a model aircraft, that is designed to fly without a human operator on board.’ While a term commonly used online, aviation agencies are moving away from using UAVs.

UAS (Unmanned Air Systems) is an unmanned airplane and all the associated support equipment, control station, data links, telemetry, communications, and navigation equipment necessary to operate the unmanned aircraft. This term is used by the Federal Aviation Administration (FAA).

Model Aircraft or Helicopter is a small plane or helicopter that does not weigh above 35kg. They are mechanically driven or launched into flight for recreational purposes and is not designed to carry persons or other living creatures. In Canada, a model aircraft may be exempt from the regulations that govern RPAS.

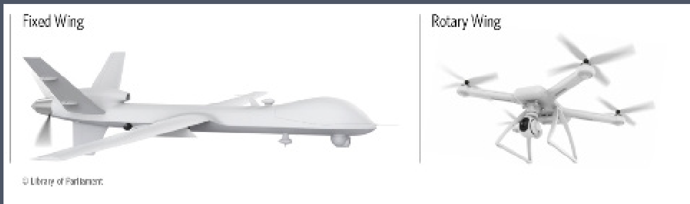
(e)VTOL is an RPAS that can take off, hover, and land vertically. An electric source may power this form of RPAS, and if so, a lowercase ‘e’ is a prefix.

(B)VLOS is the short form for visual line of sight. RPAS regulation and technology now allow for beyond the visual line of sight. If so, the ‘b’ is a prefix.

For other terms used in the RPAS industry, please refer to *Appendix 1: Frequently used RPAS Terms.*

RPAS varies in size and form and are classified as fixed-wing or rotor-wing. These forms allow forward flight or VTOL. However, as RPAS technology develops, development companies are combining fixed-wing and rotor-wing.

VTOL ability is an attractive RPAS feature because the craft can take off, fly, hover, and land vertically without the need to build a runway for taxi on and off. Regardless of the size and form, an RPAS must be made of lightweight composite materials to reduce weight, increase maneuverability, and absorb vibrations.



Fixed wing or rotary wing design, an early RPAS design,

RPAS may also include different technologies, including the following:

- High powered zoom lenses
- Cameras including night vision, infrared, ultraviolet, thermal imaging, and LIDAR (light detection and ranging)
- A wireless connection that allows for a human pilot to remotely control from the ground
- Radar technologies
- Global navigational satellite systems (GNSS)
- Communication, telemetry and more.

Newer models, such as the RPAS from Dà-Jiāng Innovations (DJI.Com), will include a helicopter and airplane detection system in all consumer RPAS by 2020[4]. RPAS flights in Hamburg, Germany, is testing the effectiveness of this technology[5].

For a diagram of quadcopter parts and components, please refer to *Appendix 2: Drone Parts and Components.*

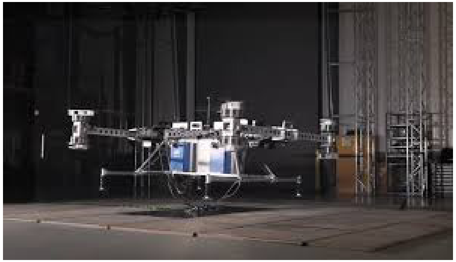
Jaunt Air Mobility UberAir model with combined fixed-wing and rotor-wing design.

RPAS Industry: Parcel

In 2018, a PricewaterhouseCoopers study valued the emerging global RPAS market for business services at over $127 bn[6]. The growth is due to the transition from military use, to personal recreational use to large scale commercial usage. China, Israel, and the United States are the countries that concentrate most of the investments towards RPAS[7]. Within this fast-growing and highly valued market, parcel delivery is occurring within a developed regulatory framework, with passenger transportation to follow on the lessons learned from RPAS parcel delivery.

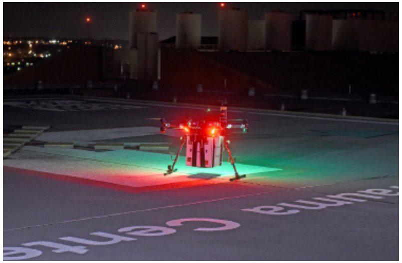
Parcel Delivery Company	**Description**	**Operation Status**	**Carrying Capacity**
Alphabet - Wing	The first company in the US to have FAA certification to operate as an airline. Certification only allows flights in southwest Virginia on clear days. The UAS cannot fly above 122m. Wing tested flights in Australia to obtain American certification. Currently, Wing is testing flights in Finland.	Yes, in Southwest Virginia	Packages under 1.5kg
Amazon Prime Air	In 2013, Jeff Bezos, CEO of Amazon, predicted his firm would deliver parcels with RPAS by 2018. Since FAA delayed in issuing the necessary permits, Amazon purchased land in Canada to carry out RPAS testing. In December 2016, Amazon Prime Air successfully delivered a package in Cambridge, England. On May 14, 2019, Amazon Prime Air held its formal groundbreaking at the site at the Cincinnati/Northern Kentucky International Airport in Hebron. However, Amazon Prime Air has yet to deliver packages regularly.	No. Amazon Prime Air licence only applies for trial flights.	Planned carrying load of 2.26kg or less
Boeing NeXt	NeXt is testing their Cargo Air Vehicle (CAV), an eVTOL, that took off, hovered, transitioned to forward flight and then landed safely in a controlled environment. It measures 5.33 meters, 6.1 meters, and 1.52 meters, and weighs 500 kilograms. 1. The CAV will operate in remote or dangerous situations.	No. Only the test model built.	Planned carrying load up to 226kg

Parcel Delivery Company	Description	Operation Status	Carrying Capacity
Drone Delivery Canada and Air Canada Cargo	Drone Delivery Canada (DDC) is a technology firm based out of Ontario, Canada, with a focus on designing, developing, and implementing a commercially viable RPAS delivery system within the Canadian geography. It is not a RPAS technology manufacture but purchases drones and drone parts for their drone delivery software platform. On June 4, 2019, DDC and Air Canada Cargo announced that they were in partnership to deliver goods by RPAS in Canada. This partnership is pending DDC's ability to obtain the required regulatory approvals to build 150,000 delivery routes in Canada.	Yes. limited deliveries in northern Ontario, Canada.	Packages up to 180kg
Kidney Delivery	Successful kidney delivery in April – First of its kind that happened from the University of Maryland to the Baltimore based hospital. The distance travelled was 4.8km in ten minutes	Yes	Packages up to 3kg
Hamburg Port Authority	The port is testing RPAS to unload empty cargo containers from ships.	Yes	Packages up 2000kg
Zipline	An American medical product delivery company that designs, builds and runs small UAS for delivery of medical supplies in Africa.	Yes	Packages up to 1.8kg



Boeing NeXt Cargo Air Vehicle prototype

Drone Delivery Canada Drone in Ontario, Canada



Kidney delivery by RPAS

RPAS Industry: Passenger

The listed companies are not the exhaustive list of eVTOL passenger companies. However, six out of the seven companies are partners with UberAir. The significance of these partnerships is that UberAir has published an ambitious timeline to have eVTOL flight demonstrations by 2020.

For UberAir's eVTOL timeline, please rever to *Appendix 3: UberAir Timeline*. For a more comprehensive list of RPAS companies and their eVTOL models, please refer to *Appendix 4: RPAS companies and description of their respective eVTOLs.*

eVTOL Company Name	Description	In operation?	Seating capacity
Bell Nexus, UberAir Partner	Conceptual design with a top speed of 288 km/h with a range of 241 km. It has a gross weight of 2,720 kg and will fit in a 12.2 m square footprint.	No	One pilot with four or six passengers
Boeing (Aurora Flight Services), UberAir Partner	The prototype designed for a fully autonomous flight from takeoff to landing, with a range of up to 80 kilometres. It measures 9.14 meters long and 8.53 wide. June 2019 test flight resulted in a crash[ii]	No	Two
EmbraerX, UberAir Partner	Conceptual design that includes a universal design in cabin.	No	One pilot with four passengers
Karem Aircraft Ltd., UberAir Partner	Conceptual design using proprietary technology belonging to Karem Aircraft Ltd.	No	Five passengers
Lilium	On May 4, 2019, Lilium tested its eVTOL full-scale, all-electric five-seater aircraft. Lilium is seeking a flight certificate for a five-seat air taxi from European Aviation Safety Agency and the FAA. It hopes to compete with Blade, a helicopter company serving Manhattan, JFK, Newark and LaGuardia. Lilium plans to keep human pilot as this helps to ease the certification process. Passengers would locate nearest "landing pad" across a network of cities and regions.	Possibly. One test flight with no passengers	Five passengers
Jaunt Air Mobility	The conceptual model combines fixed-wing design and helicopter propeller.	No	Four passengers
Pipistrel Vertical Solutions	Conceptual model unveiled at Uber Elevate Summit 2019.		One pilot and four passengers

Bell Nexus prototype model

Boeing - Aurora Flight Services prototype model

EmbraerX prototype model

Karem Aircraft Ltd. prototype model

Lilium Jet working model

Pipistrel Vertical Solutions prototype model

Annual Uber Elevate Summit for the on-demand aeriel ride-sharingv

UberAir prototype of passenger cabin

UberAir and other firms are ambitiously working towards a future of urban air mobility. However, there is no consensus from the aviation regulators that urban air mobility, with all its challenges, will at scale, will be achieved safely and realistically.

RPAS Industry: Challenges – Technological, Financial and Societal

Although RPAS technology is rapidly developing, the future of the RPAS industry faces limitations in three broad categories. The following list of examples is not comprehensive but provides the background context to the significant hurdles that need to be addressed before RPAS transportation at scale for passenger and freight is viable.

Technological

- Few working eVTOL passenger prototypes developed.
- The goal of fully autonomous eVTOL depends on artificial intelligence science that still requires significant testing and development.
- Energy infrastructure
    - Current lithium batteries do not have the energy rating required for long flights that carry heavy cargo[9].
    - The large electrified grid that will recharge eVTOLs needs to be built.
- According to Transport Canada, the realistic development of RPAS for personal transportation is still hypothetical at best[10].
- Technology to operate in extreme flight conditions (temperature, wind, weather, sea-level pressure, turbulence, pressure, skycover and high humidity) is still in development.
- Fast and stable wireless cellular networks are required for RPAS, and not all cities have 5G.

Technological challenge of RPAS eVTOL flight crashes

Financial

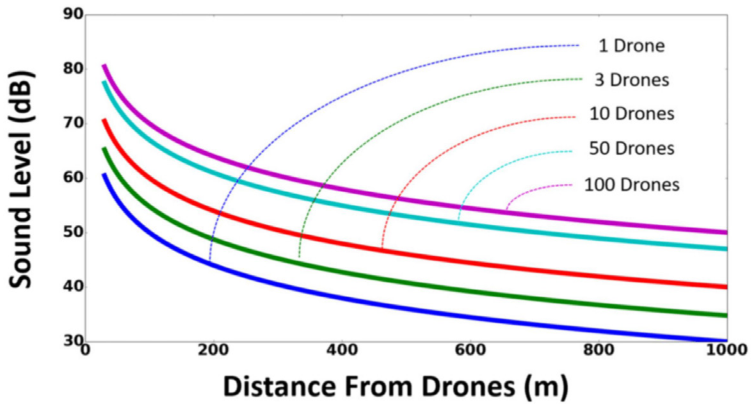
- Research and development of a safe and reliable RPAS industry to transport people have and will require billions of dollars in investment. Amortization of these costs may not occur fast enough to offer consumers a low price per flight option[11]
- For parcel/freight delivery, the current model of per delivery approach by companies makes infrequent routes more expensive.
- UberAir claims that eVTOLs are only financially viable areas where ride-hailing services, like Uber, exist and are a popular form of transportation[12].

Societal

- Widespread public acceptance for RPAS technology has not been reached and is a substantial requirement for the RPAS industry[13,14].
- While an autonomous RPAS transportation system is anticipated to possibly reduce costs in terms of employee salaries, push back from labour unions representing transit, maritime and aviation employees is also possible.
- Automation still requires significant research[15]. However, public acceptance of automated RPAS for personal travel is low to neutral[16].
- RPAS for passenger transport must obtain the same safety record of the present-day passenger airline industry and strive for a zero accident[17].
- The proliferation of RPAS raises the concern of personal privacy. The current regulations may not be able to cope with higher incidents of public conflict with RPAS in areas that not classified as restricted airspace[18].
- Governmental regulations are still being developed and then revised to keep pace with the development of RPAS technology.
- No regulation framework exists to allow for the potential of legal and safe transportation of human beings.
- Noise - RPAS propellers generate noise when spinning thousands of revolutions per minute to create lift and movement[19].

RPAS Industry: Challenges – Technological, Financial and Societal

Community group rally against RPAS.



Societal challenge of noise. Heavier loads and more drones flying increases dB

Overall, it is foreseeable that the most significant challenge or limiting factor that the RPAS industry will face is how it will obtain broad society acceptance[20]. Without community support for RPAS, the investments to solve the technological challenges may not be a sound financial investment.

RPAS in Canada: Regulation Context

In Canada, the regulatory framework for RPAS falls under the jurisdiction of Transport Canada – Civil Aviation (TCCA). Transport Canada (TC) is the federal regulator and is the department responsible for developing aeronautical regulations, policies and services of transportation in Canada by way of the *Canadian Aviation Regulations (CARs) and Standards*. It receives its authority to make regulations for RPAS under the *Aeronautics Act*.

NAV CANADA:

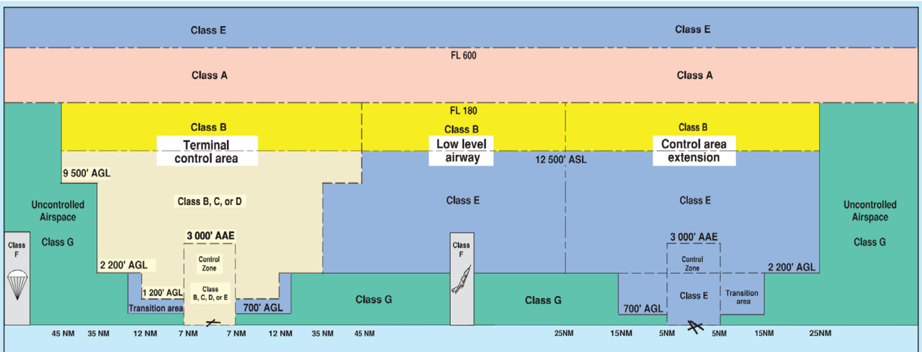
A feature of Canadian airspace is the inclusion of NAV CANADA and the Department of National Defense as Canada's air navigation service providers (ANSP). NAV CANADA was established as a Corporation in 1996 and is a privately run, not-for-profit corporation that owns and operates Canada's civil air navigation system (ANS). NAV CANADA is, therefore, responsible for air traffic control, airport advisory and flight information, and aeronautical information. Consequently, while RPAS regulations are issued by TC, in some controlled airspace, written authorization is required from NAV CANADA.

Seven classes separate Canadian Airspace, and each class supplies individual rules of access, flight regulations, and Air Traffic Control (ATC) responsibility. In general, RPAS operations are almost only allowed in Class G, the uncontrolled airspace.

Acronyms used in airspace classification:

ASL – Above sea level
IFR – Instrument flight rules
VFR – Visual flight rules

RPAS in Canada: Canadian Airspace

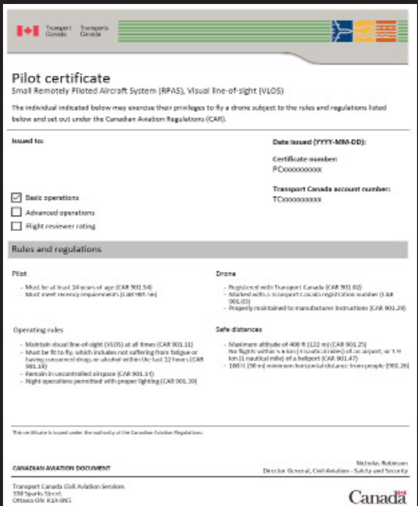


Canadian Airspace

Type of class	Description	RPAS operation allowed?
Class A	Controlled high-level airspace. IFR only.	
Class B	Controlled low-level airspace (above 12,500 feet ASL, up to 18,000 feet ASL). IFR and VFR only.	
Class C	Controlled airspace. IFR and VFR permitted. ATC provides separation for IFR and VFR flights, when necessary.	Yes, but only with Advanced Operations and with NAV Canada authorization
Class D	Controlled airspace. IFR and VFR permitted. ATC provides separation for IFR aircraft only.	Yes, but only with Advanced Operations and with NAV Canada authorization
Class E	Controlled airspace. IFR and VFR permitted. ATC provides separation for IFR aircraft only.	Yes, but only with Advanced Operations and with NAV Canada authorization
Class F	Special-use airspace. The airspace is controlled or uncontrolled and may also be a restricted or advisory area.	
Class G	Uncontrolled airspace.	Yes, with Basic Operation license

Please refer to *Appendix 5: Find your Drone Category* for Transport Canada's infographic on how airspace class determines RPAS Certification.

RPAS in Canada: Canadian Licence



Pilot certificate

Small Remotely Piloted Aircraft System (RPAS), Visual line-of-sight (VLOS)

The individual indicated below may exercise their privileges to fly a drone subject to the rules and regulations listed below and set out under the Canadian Aviation Regulations (CAR).

Issued to:

Date issued (YYYY-MM-DD):

Certificate number:
PCxxxxxxxxx

Transport Canada account number:
TCxxxxxxxxx

- [x] Basic operations
- [ ] Advanced operations
- [ ] Flight reviewer rating

Rules and regulations

Pilot

- Must be at least 14 years of age (CAR 901.54)
- Must meet recency requirements (CAR 901.56)

Drone

- Registered with Transport Canada (CAR 901.02)
- Marked with a Transport Canada registration number (CAR 901.03)
- Properly maintained to manufacturer instructions (CAR 901.29)

Operating rules

- Maintain visual line-of-sight (VLOS) at all times (CAR 901.11)
- Must be fit to fly, which includes not suffering from fatigue or having consumed drugs or alcohol within the last 12 hours (CAR 901.19)
- Remain in uncontrolled airspace (CAR 901.14)
- Night operations permitted with proper lighting (CAR 901.39)

Safe distances

- Maximum altitude of 400 ft (122 m) (CAR 901.25)
- No flights within 5.6 km (3 nautical miles) of an airport, or 1.9 km (1 nautical mile) of a heliport (CAR 901.47)
- 100 ft (30 m) minimum horizontal distance from people (901.26)

This certificate is issued under the authority of the Canadian Aviation Regulations.

CANADIAN AVIATION DOCUMENT

Nicholas Robinson
Director General, Civil Aviation – Safety and Security

Transport Canada Civil Aviation Services
330 Sparks Street
Ottawa ON K1A 0N5

Canada

Transport Canada Basic Operator RPAS-VLOS licence

In Canada, people wishing to fly their RPAS legally must obtain and carry an RPAS-VLOS Pilot Certificate as well as register and mark their RPAS. In Canada, there are two pilot certificates readily available upon completing a Transport Canada knowledge exam:

- Basic Operation, and
- Advanced Operation

In general, the regulations under these two licences apply to:

- RPAS weighing between 250 grams up to and including RPAS 25kg.
- RPAS pilots must only fly in uncontrolled airspace
- Operate under 122m ASL
- Respect no-fly aerodrome areas and,
- Follow the other rules in the *Canadian Aviation Regulations (CARs) Part IX – Remotely Piloted Aircraft Systems.*

For pilots wishing to fly outside the CARs regulation for basic or advanced operations, the *Special Flight Operations Certificate (SFOC)* is available. In general, this certificate applies for foreign operators, for RPAS weighing over 25kg and for unique environmental situations like flying an RPAS over people. The SFOC is not a requirement for pilots conducting commercial operations.

RPAS in Canada: Other Canadian statutes

Transport Canada is the sole authority with respects to airspace regulations. However, the following rules also apply when flying an RPAS.

- Relevant sections of the Criminal Code, including *Offences against Air or Maritime Safety*, *Breaking and Entering*, and *Mischief*
- Provincial Trespass Act
- Laws related to voyeurism and privacy

Provincially, the Ministry of Transportation and Infrastructure adhere to the Transport Canada RPAS regulations. However, an additional provincial step that British Columbia is taking is an effort to centralize the registration of all BC Government RPAS in a SharePoint RPAS Inventory[21].

At a local level, some municipalities have brought in regulation to monitor RPAS use, but it is unclear if cities have the authority do this[22]. Nonetheless, Calgary, Canmore, Richmond and Saskatoon have adopted bylaws that are within their authority to pass. These bylaws reference the TCCA regulations and then are typically applied to RPAS used in their municipal assets, such as parks, public/open spaces, school grounds and special events. Other municipalities, such as Squamish and Whistler, acknowledge RPAS use in their cities but direct RPAS pilots to the TCCA regulations.

1. Richmond, British Columbia
   Public Parks and School Grounds Regulation Bylaw No.8771.
2. Squamish, British Columbia
   RPAS pilots must apply for permission to use RPAS for filming or special events.
3. Whistler, British Columbia
   RPAS is not permitted in a 9km radius of the helipad. RPAS pilots must apply for permit to use RPAS in film or marketing.
4. Calgary, Alberta
   Parks and Pathways Bylaw 20M2003, and *Street Bylaw 20M88 Sec. 12*
5. Canmore, Alberta
   Section 7.5 (g) of Parks Bylaw
6. Saskatoon, Saskatchewan
   The Recreation Facilities and Parks Usage Bylaw, 1998

For weblinks to the municipal bylaws regarding RPAS, please refer to *Appendix 6: Weblinks to the bylaws for Calgary, Canmore, Richmond and Saskatoon.*

RPAS in Canada: Proposed regulation

Canada's most recent set of regulations came into effect on June 1, 2019. However, in May 2019, Transport Canada hosted *Drone Talks: Planning for Success*, a two-day industry meeting to discuss the following topics:

- Airspace and RPAS Traffic Management (RTM) Systems
- BVLOS Operations
- RPAS certification and airworthiness
- System of licensing and training for RPAS pilots

The Canadian RPAS industry is still evolving to keep pace with industry development. The impact of the June 1, 2019 regulations need monitoring for success; the Canadian RPAS industry will likely continue to evolve in the foreseeable future.

For the white papers and presentation slides for D*rone Talks: Planning for Success*, please refer to *Appendix 7: Transport Canada: Drone Talk White Papers* and *Appendix 8: Transport Canada: Drone Talk Workshop Presentations*.

Interjurisdictional Regulations

Given that RPAS operations require both air and land, it will be likely that certain aspects of operations will become the responsibilities of local municipalities. In NASA's *Urban Air Mobility Great Challenge Industry*

Day presentation, the following duties will fall to the local governments and communities:

- Land use and zoning
- Location of 'RPAS ports'
- Building code amendments to allow for future transportation uses
- Environmental regulations
- Community referendums
- Governmental representation
- Urban routing for RPAS
- Good Neighbour by-laws
- Noise Restriction by-laws, and more[22,23].

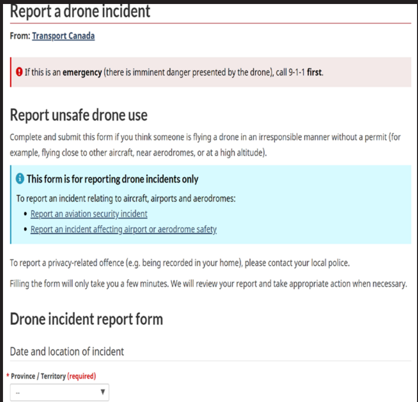
Applicable Precedent – Maritime Operations for public transportation

Currently, TransLink, through the Coast Mountain Bus Company, operates the SeaBus. Since the SeaBus travels through the Burrard Inlet, it is under the responsibility of Transport Canada Marine Safety (TCMS) and must follow federal regulations. Therefore, a precedent of a regional transportation authority and Transport Canada working in partnership for transportation options exist and may apply to future passenger transportation by RPAS.

Internationally, the Hamburg Port Authority (HPA) is working in partnership with NXP, KopterKraft OÜCity Air Traffic Management, FlyNex, DFS Deutsche Flugsicherung GmbH, and the Center of Applied Aeronautical Research. HPA is testing the economic feasibility of using large RPAS to carry loads up to two tonnes.

Conceptual drawing of large RPAS drones unloading shipping containers in the Hamburg Port

RPAS in Canada: Enforcement



Report a drone incident

From: Transport Canada

If this is an **emergency** (there is imminent danger presented by the drone), call 9-1-1 **first**.

Report unsafe drone use

Complete and submit this form if you think someone is flying a drone in an irresponsible manner without a permit (for example, flying close to other aircraft, near aerodromes, or at a high altitude).

This form is for reporting drone incidents only

To report an incident relating to aircraft, airports and aerodromes:

- Report an aviation security incident
- Report an incident affecting airport or aerodrome safety

To report a privacy-related offence (e.g. being recorded in your home), please contact your local police.

Filling the form will only take you a few minutes. We will review your report and take appropriate action when necessary.

Drone incident report form

Date and location of incident

* Province / Territory (required)

Online form to report drone incidents

Transport Canada has a '*Report a drone incident*' website where people can submit a form regarding irresponsible RPAS operations[24]. The information requested is required by TC for regulatory follow-up and will be used to investigate. If the RPAS pilot breaks other laws, local police will also be involved, and fines, depending on the offence, may also be issued.

If a pilot breaks more than one rule, multiple penalties may apply. For municipalities that have applicable bylaws, the associated fine or jail time may also apply on top of the penalties from Transport Canada[24].

Please refer to *Appendix 9: R v. Shah,* Canada's first case brought to the Provincial Court of Alberta regarding RPAS operations in restricted airspace.

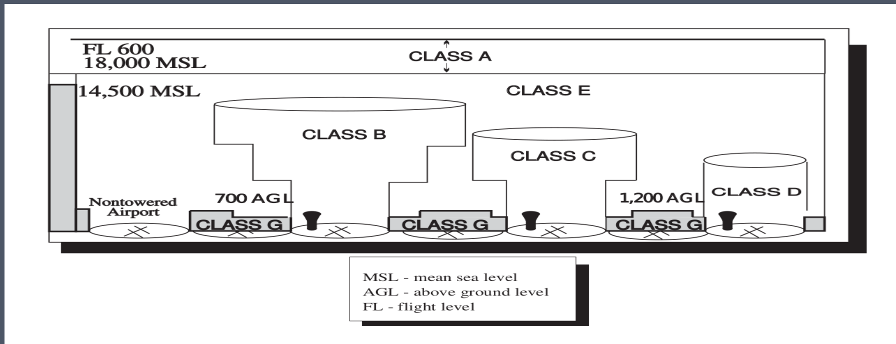
Fines for individuals:
Up to $1,000 for flying without RPAS certificate, for flying unregistered or unmarked RPAS, for flying in prohibited areas, and up to $3,000 for putting aircraft and people at risk.

Fines for corporations:
Up to $5,000 for flying without RPAS, for flying unregistered or unmarked RPAS, for flying in prohibited areas up to $15,000 for putting airplane and people at risk.

RPAS in USA: Regulation Context

In the United States, RPAS is called UAS. The regulatory framework for UAS falls under the jurisdiction of the FAA. The FAA oversees all aspects of civil aviation in the United States, including operating the air traffic control system, regulating safety, improving and maintaining infrastructure, administering airport grants, and conducting research and development activities. Unlike Canada, the United States has not commercialized their air traffic operations and infrastructure through an independent air navigation service providers (i.e. NAV CANADA). Canadian and American airspace almost share the same dimensions. However, in the United States, with only six different classifications, airspace is slightly different from Canadian airspace.

Most UAS operations occurs in the uncontrolled Class G airspace. UAS pilots may fly in controlled airspace as long as they have permission from Low Altitude Authorization and Notification Capability (LAANC), a collaboration between FAA and Industry.



American Airspace

RPAS in USA: American Licence

USDOT and FAA UAS Licence

Currently, it is not required for recreational or hobbyist UAS operators to obtain a licence. The recreational UAS operator must register and mark their UAS. Operators may only fly VLOS in uncontrolled airspace and must adhere to local laws, yield to all human-crewed aircraft and respect the no-fly zones of aerodromes. The UAS flown must not weigh more than 25 kg. However, for UAS commercial operators, a knowledge test must be passed to obtain the FAA *Remote Pilot Certificate*. Pilots flying for commercial purposes follow the FAA *Code of Federal Regulations, 14 CFR part 107 (Part 107)*. Part 107 allows operators to begin conducting routine commercial, civil small UAS operations with small UAS weighing less than 55 pounds. Similar to recreational operators, commercial operators must register and mark their UAS. Commercial operators, unless granted permission by the LAANC, may only fly VLOS in uncontrolled airspace. Commercial operators must adhere to local laws, yield to all human-crewed aircraft and respect the no-fly zones of aerodromes.

For greater detail regarding Part 107, please refer to *Appendix 10: Link to the Summary of Part 107*.

RPAS in USA: Other American statutes

State-level Regulation
The FAA has the authority to control traffic in navigable airspace. They are the authority that creates operational and safety regulations for airplanes in navigable airspace. However, each American state may have its law(s) that apply to UAS usage. These laws apply to the protection of personal privacy or the prohibition of UAS in hunting.

Commercial Regulations
In addition to the Part 107 Commercial Operator regulations, UAS companies may seek FAA approval to work as an airline. On April 23, 2019, Wing, an initiative of Google's parent company Alphabet, received Air Carrier Certification from the FAA. To obtain FAA Certification, Wing had to supply evidence that its operations were safe. Wing proved to the FAA that they could deliver packages at "a lower risk to pedestrians than the same trip made by car"[25].

Wing's evidence came from its more than the 70,000 test flights and 3,000 deliveries made in Canberra under the Australian RPAS rules.

Wing delivering coffee orders in Canberra

RPAS in USA: Proposed Regulation and Enforcement

By the summer of 2019, the FAA is proposing *Section 349* of the FAA *Reauthorization Act* of 2018 that will affect recreational operators. These changes will include:

- Recreational flyers must pass a knowledge test before flying.
- Operators will need to fly within the guidance of community-based organizations (CBOs), who have their own, FAA-approved sets of guidelines.
- FAA registration and external markings will need to be visible on each UAS.
- For any flight in controlled airspace, operators will need to obtain authorization through LAANC. Air traffic controllers will no longer approve UAS pilots to access controlled airspace.

A new set of relaxed UAS regulations is available after a two-year U.S Department of Transportation (USDOT) study which included the input from state, local or tribal governments. The USDOT reviewed information regarding night operations, BVLOS flights, package delivery, and detect-and-avoid technologies. The following is allowed in the proposed relaxation:

- Licensed UAS will be allowed to fly at night without any added regulatory clearance. UAS operating at night need to have an anti-collision light that is visible from 4.8 km away
- FAA will let licensed operators fly small UAS (no more than .25 kg) over areas that are populated

- For UAS larger than the limit, RPAS manufacturers must conduct testing that proves that a crashed RPAS would not cause serious bodily injury.

These relaxations are an attempt to balance the need to mitigate safety risks without inhibiting technological and operational advances.

American RPAS Enforcement and Criminal Offenses

Enforcement of Part 107 is under the authority of the FAA to apply. However, due to the relative inexperience of UAS operators, the FAA will initially supply non-enforcement methods, such as operator education and informational letters about UAS regulations[26].

The FAA will work with local law enforcement to discourage dangerous use. If penalties are applied, they may include stiff fines, criminal charges and possible jail time[27]. As of July 2019, there is no the American equivalent to Transport Canada's Report a drone incident webpage.

RPAS International Case Studies

Across the world, there are different regulatory frameworks for RPAS to operate. The difference may be due to the political climate, environmental geography, lower population density, or different cultural norms and values. This flexibility has allowed rapid development with RPAS that moves the industry closer to a future of urban air mobility by allowing transnational companies, like Alphabet and Amazon, to operate in one country to obtain certification in another country. The cases below add to the examples already provided in this report.

New Zealand

Air New Zealand and Zephyr Airworks are working to bring the world's first electric air taxi service. Kitty Hawk Corporation, a California based company, developed Cora, an eVTOL that flies with the aid of twelve fans. Flight tests began in 2017 over Canterbury, but the eVTOL is unlikely to be available for consumer sales. Instead, the vehicles would be part of an airline or rideshare flying in air corridors. The Civil Aviation Authority of New Zealand (CAANZ), the national aviation authority, oversees RPAS regulations. At this point, it does not seem like a RPAS pilot licence is needed. However, there are general RPAS rules that the pilot must follow.

Singapore

Airbus is testing its RPAS and 'Skyways' to speed up shore-to-ship deliveries to and from anchored vessels. This approach differs from HPA due to the ships not being docked at the port, but still in anchorage further from shore. Airbus Singapore's trails may apply to the freighters that anchor in English Bay as they wait to dock into the Port of Vancouver.

TransLink: RPAS for Passenger and Freight

The RPAS industry offers TransLink the opportunity to consider an alternative transportation option. While the RPAS industry is optimistic that personal transportation will be happening soon, the horizon for a secure RPAS transportation network will require more time. Transport Canada will be the authority and regulating body for RPAS, but there may be actions that TransLink could consider in its future in RPAS.

Policy and public perception considerations:

- Review and decide if RPAS is a model of transportation that will be sustainable and embraced by Metro Vancouver residents.
- If RPAS transportation is an acceptable option for residents, consider what problems may be solved with RPAS technology. TransLink should understand the cost, timelines, stakeholder engagement and partnerships as these will be an essential consideration for RPAS uptake.
- Conduct research on how the public perception of RPAS changes as this technology becomes more publicized through industry initiatives and public campaigns, such as UberAir and NASA's UAM Grand Challenge.
- Follow Transport Canada's work on the future of Canada's RPAS Traffic Management System, RPAS certification and airworthiness and RPAS licensing and BVLOS. The first three topics will impact the use of RPAS for personal and freight transportation.

Technological considerations:

- Follow RPAS projects happening in Hamburg and Singapore. These two cities are excellent examples of port cities using RPAS technologies to integrate with maritime freight delivery. TransLink could research the outcomes of these projects to see if the techniques apply to the Metro Vancouver context.

TransLink: RPAS for Passenger and Freight

- Plan to negotiate or request permission to operate RPAS transportation on land currently leased from a municipality or private owner.
- Plan to significantly renovate and invest in existing properties to convert them to Transport Canada's *TP312 Aerodrome Standards and Recommended Practices.*
- Conduct research on which TransLink property is best suited to for *TP312* upgrades to serve as a convenient RPAS hub for freight and passenger transport.
- Identify where TransLink could pilot RPAS technologies and monitor what benefits RPAS brings to the region. Due to liability concerns, RPAS tests between Waterfront Station to Lonsdale Quay, and from the base of to the peak of Grouse Mountain could be ideal. These two routes could operate over areas with fewer permanent built infrastructure.
- Review how eVTOL at scale will affect the load on the electric grid that is currently set to serve TransLink's expanding fleet of transit and service vehicles, including train and Seabus. TransLink may need to increase electrical demands and request cities to build larger electric grids.
- Follow the UberAir trails in the United States and Australia to understand how eVTOL increases the demand on the electric energy grid.
- Research the potential for GHG reduction of eVTOL over fuel-based modes of transportation.
- Review and seek parallels in the operating partnership of aerial mobility and the SeaBus.

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Chin, Shareen. 2019. Cover Page - Vancouver with RPAS. Google Earth Pro with stock RPAS image, Vancouver.

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Appendix 1: Frequently Used Terms

Term	Definition
Aerodrome	A location from which aircraft flight operations take place, regardless of whether they involve air cargo, passengers, or neither. Aerodromes include small general aviation airfields, large commercial airports, and military airbases.
Controlled Airspace	Controlled airspace is airspace of defined dimensions within which Air Traffic Control services are provided. The level of control varies with different classes of airspace. Canadian airspace is the region of airspace above the surface of the Earth that falls within a region roughly defined as either Canadian land mass, the Canadian Arctic or the Canadian archipelago, as well as areas of the high seas.
Drone	Although no longer used as a term, the Office of the Privacy Commissioner of Canada defines 'drones' as: [A] catch-all term that refers to any vehicle that can operate on surfaces or in the air without a person on board to control it, and that can vary in size, shape, form, speed, and a whole host of other attributes.
Fixed wing aircraft	A fixed-wing aircraft is a flying machine, such as an airplane or aeroplane, which is capable of flight using wings that generate lift caused by the aircraft's forward airspeed and the shape of the wings.
Global navigational satellite systems (GNSS)	GPS or GLONASS (Globalnaya Navigazionnaya Sputnikovaya Sistema), the Russian version of GPS.
Gyroplane	An autogyro, also known as a gyroplane or gyrocopter, is a type of rotorcraft that uses an unpowered rotor in free autorotation to develop lift. Forward thrust is provided independently, typically by an engine-driven propeller.

Remote pilot	A person charged by the operator with duties essential to the operation of a remotely piloted aircraft and who manipulates the flight controls, as appropriate, during flight time.
Remotely piloted aircraft (RPA)	An unmanned aircraft which is piloted from a remote pilot station.
Unmanned aircraft (UA)	Any aircraft intended to be flown without a pilot on board is an unmanned aircraft. They can be remotely and fully controlled from another place (ground, another aircraft, space) or pre-programmed to conduct its flight without intervention.
Quadrotor	A quadcopter, also called a quadrotor helicopter or quadrotor, is a multirotor helicopter that is lifted and propelled by four rotors. Quadcopters are classified as rotorcraft, as opposed to fixed- wing aircraft, because their lift is generated by a set of rotors (vertically oriented propellers)
Multi-rotor	A multirotor or multicopter is a rotorcraft with more than two rotors. An advantage of multirotor aircraft is the simpler rotor mechanics required for flight control.

Source

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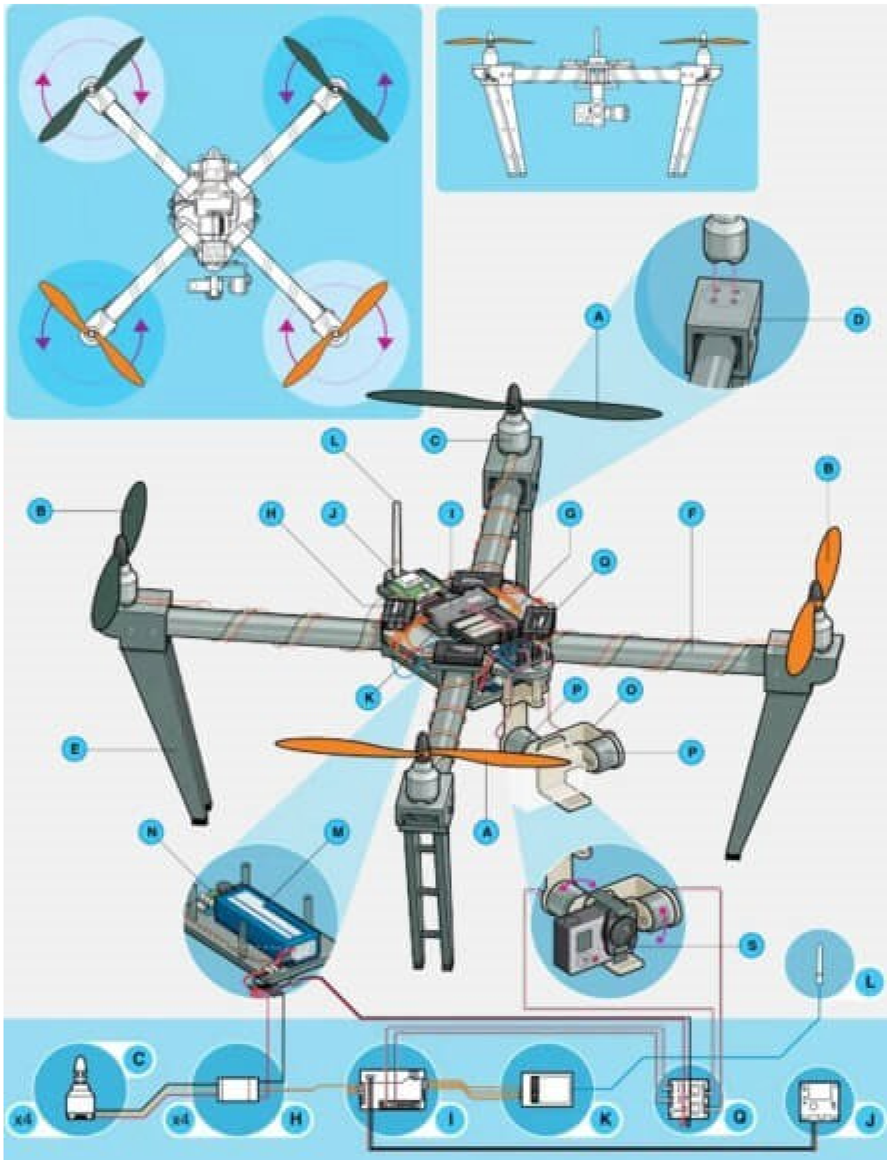
Appendix 2: Drone Parts and Components

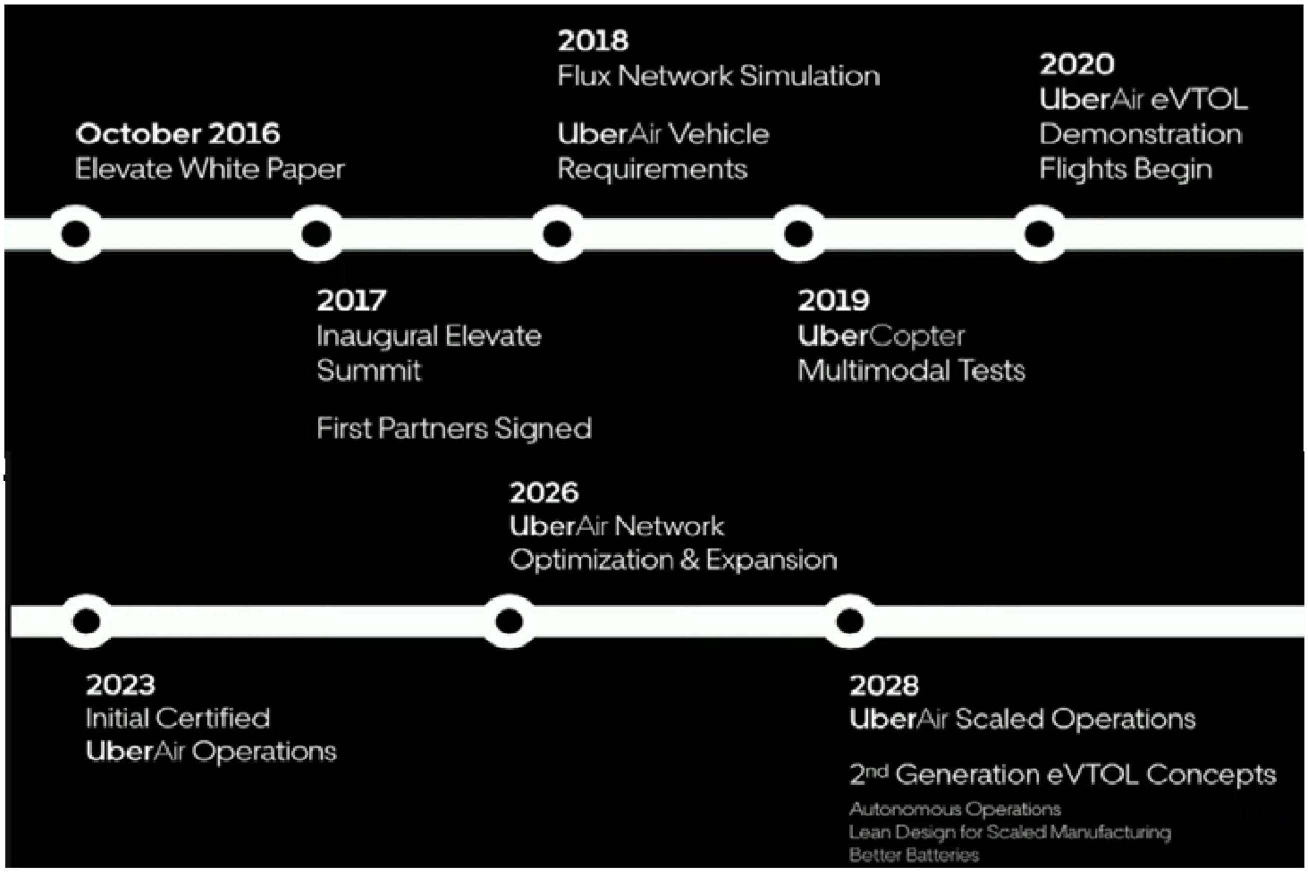


a) Standard Prop
b) Pusher prop
c) Brushless mor
d) Motor mount
e) Landing gear
f) Boom
g) Main drone body part
h) Electronic speed controllers
i) Flight controller
j) GPS Module
k) Receiver
l) Antenna
m) Battery
n) Battery monitor
o) Gimbal
p) Gimbal motor
q) Gimbal controller unit
r) Camera
s) Sensors
t) Collision avoidance system

Source:
DroneZone. 2019. *Drone Parts And Components – Quick Overview.* February 4. Accessed April 30, 2019. https://www.dronezon.com/learn- about-drones-quadcopters/drone-components-parts-overview-with-tips/.

Appendix 2: Drone Parts and Components

Appendix 3: UberAir Timeline



Appendix 4: RPAS companies and description of their respective

Aircraft	Passengers	Range	Country	Power	Website
Aergility ATLIS	0	200miles	USA	Hybrid	www.aergility.com
Aircraft	Passengers	Range	Country	Power	Website
A³ Vahana	TBD	TBD	USA	Electric	www.vahana.aero
Aergility ATLIS	0	200miles	USA	Hybrid	www.aergility.com
aEro2	2	120/800km	Swiss	Electric/hybrid	dufour.aero
aeroG Aviation aG-4	12	?	USA	Hybrid Electric	
AgustaWestland Project Zero	1		ITALY	Hybrid Electric	www.leonardocompany.com
Airbus Helicopters CityAirbus	2		France	Electric	www.airbushelicopters.com
AirisOne	5	200 miles	Bermuda		airisaero.com
AirspaceX MOBi	5	104 km	USA	Electric	www.airspacex.com
Aston Martin Volante	3		UK	Hybrid Electric	https://global.astonmartin.com/en-us/the-aston-martin-volante-vision-concept
Astro AA360 ("Passenger Drone")	2	25min	USA	Electric	FlyAstro.com
Aurora Flight Sciences eVTOL	2		USA	Electric	www.aurora.aero
Avianovations Hepard	2	75/400km		Electric/FC	hepard.avianovations.com
Axix SkyRider SuvA	5		USA	Electric	www.axixgp.com/
Bartini Flying Car	04-Feb	150/550km	Russia	Electric/ Hydrogen	www.bartini.aero
Bat 600	2		GER	Electric / hybrid	www.autoflightx.com
Bell Air Taxi	Not annouced	Not annouced	USA	Not annouced	http://www.bellflight.com
Boeing Cargo Aerial Vehicle	0		USA		
Carter Air Taxi	6		USA	Electric	www.cartercopters.com
Cartivator SkyDrive	1		Japan	Electric	cartivator.com
DeLorean Aerospace DR-7	2		USA	Electric	www.deloreanaerospace.com
EAC Whisper	2	30min	France	Electric	www.eac-whisper.com

EHang 184	1		CHN	Electric	www.ehang.com/ehang184
EHang 216	2		CHN	Electric	
Embraer DreamMaker	4		Brazil	Electric	
Flexcraft	09-Jul	926km	Portugal	Hybrid	www.flexcraft.pt
Hi-Lite Lynx-us	15-May	550km	USA	Hybrid	www.vtolcruze.com
HopFlyt Venturi	4	185km	USA	Electric	www.hopflyt.com
HoverSurf Formula	5	450km	USA	Hybrid	hoversurf.com/formula
Jetoptera J2000	2	322km	USA	Turbine	www.jetoptera.com
Jetpack Aviation(unnamed)	1	20min	USA	Electric	www.jetpackaviation.com
Joby Aviation S2 (defunct)	2		USA		www.JobyAviation.com
Joby Aviation S4	4	246km	USA	Electric	www.JobyAviation.com
Karem Butterfly			USA		www.karemaircraft.com
KARI PAV	05-Apr	50km	S Korea	Electric	www.kari.re.kr/eng.do
Kármán XK-1	08-Feb		USA	Electric	http://karman.aero
Kitty Hawk Cora	2	100km	USA	Electric	www.cora.aero
Kitty Hawk Flyer	1	20-Oct	USA/New Zealand	Electric	www.Flyer.aero
Lilium Jet	5	300km	GER	Electric	www.Lilium.com
M470	0/2	500km	UAE	Electric	http://www.digirobotics.com/Drone-UAD-M470.html
ManDrone	1		Netherlands	Electric	www.onemandrone.com/
Napoleon Aero VTOL	4	100km	Russia	Electric	
Neoptera eOpter	05-Feb		UK/France	Hybrid/ FC	www.neoptera.aero
Opener BlackFly	1	70km	USA	Electric	www.opener.aero
PAV-UL Ultralight	1		UK	Electric	pav-x.com
PAVX	1	15/75min	UK	Electric/Hybrid	pav-x.com
Piasecki eVTOL			USA		www.piasecki.com
Pipistrel (unnamed)	06-Feb		Slovenia	Electric	www.pipistrel.si
Pop.Up Next	2	50km	France	Electric	
PteroDynamics Transwing	4		USA	Electric	www.pterodynamics.com

Ray Research VTOL Aircraft	5	1800km	Swiss	Hybrid	www.RayAircraft.com
Rolls-Royce EVTOL	4	800km	UK	Hybrid	https://www.rolls-royce.com/innovation.aspx#electrification
SKYLYS Aircraft AO			USA		
Starling Jet	5	1500miles	UK	Turbine	www.samadaerospace.com
Supervolant Pegasus			GER		www.supervolant.com
Terrafugia TF-2 Lift + Push	4	400km	USA	Hybrid	www.terrafugia-tf2.com
Terrafugia TF-2 Tiltrotor	4	500km	USA	Hybrid	www.terrafugia-tf2.com
Transcend Air Vy 400	06-May	450miles	USA	Hybrid	www.transcend.aero
Urban Aeronautics CityHawk	9	300km	Israel	Hydrogen Engine	www.urbanaero.com
VerdeGo Aero PAT200	2		USA	Hybrid	verdegoaero.com
Vertical Aerospace (unmanned)	2		UK	Electric	www.vertical-aerospace.com
Vertiia	2	250km	AUS	Electric	www.vertiia.com
Vickers WAVE eVTOL	4		NZ	Electric	vickersaircraft.com
Vimana (unnamed)	4	900km	USA	Hybrid	https://vimana.global
Vision VTOL	02-Jan		USA	Electric	www.visionvtol.weebly.com
Volocopter 2X	2		GER	Electric	www.volocopter.com
VRCO NeoXCraft	2	60min	UK	Electric	vrco.co.uk/the-project
Workhorse SureFly	2	70miles	USA	Hybrid	https://workhorse.com/index.php/surefly
X01	2		France	Electric	eva.xyz
XTI Aircraft Trifan 600	6	1060km	USA	Hybrid	http://www.xtiaircraft.com/
Y6S	2	130km	UK	Electric	autonomousflight.com
Zenith Altitude EOPA	4	463km	Canada	Hybrid	www.zenith-altitude.com

Source

Aerospace Expert. 2018. *COMPARATIVE ANALYSIS OF THE MAIN EVTOL AIRCRAFT IN CURRENT DEVELOPMENT.* 11 1. Accessed April 27, 2019. https://aerospaceexport.com/comparative-analysis-of-the-main-evtol-aircrafts-in-current-development/.

KNOW BEFORE YOU GO!

FIND YOUR DRONE CATEGORY

YOU NEED A PILOT CERTIFICATE – BASIC OPERATIONS TO:

Fly +30 m from bystanders

Fly in uncontrolled airspace (where no air traffic control is provided)

YOU NEED A PILOT CERTIFICATE – ADVANCED OPERATIONS TO:

Fly less than 30 m from or over bystanders

Fly in controlled airspace with air traffic control approval

YOU NEED A SPECIAL FLIGHT OPERATIONS CERTIFICATE TO FLY:

At an advertised event

A drone over 25 kg

25kg+

Above 122 metres (400 feet)

122 m+ (approximately a 30- storey building)

Canada.ca/**drone-safety**

Appendix 6: Bylaws for Calgary, Canmore, Richmond and Saskatoon

Municipality	Bylaw Name	Link
Calgary	Parks and Pathways Bylaw 20M2003 Sec. 24(c)	https://www.calgary.ca/CA/city-clerks/Documents/Legislative-services/Bylaws/20m2003-ParksPathways.pdf?noredirect= 1
	Street Bylaw 20M88 Sec. 12	http://publicaccess.calgary.ca/lldm01/livelink.exe?func=ccpa.general&msgID=CyAcqyqyKI&msgAction=Download
Canmore	Section 7.5 (g) of the Town of Canmore Parks Bylaw	https://canmore.ca/documents/bylaws/5-parks-bylaw-2019-09
Richmond	PUBLIC PARKS AND SCHOOL GROUNDS REGULATION BYLAW NO. 8771	https://www.richmond.ca/__shared/assets/BL8771_051115_Effective 08011541498.pdf
Saskatoon	The Recreation Facilities and Parks Usage Bylaw, 1998	https://www.saskatoon.ca/sites/default/files/documents/city- clerk/bylaws/7767.pdf

Appendix 7: Transport Canada: Drone Talk White Papers

Transport
Canada White Paper

Drone Talks: Planning for Success

May 29-30, 2019
Workshop #1: Airspace and RTM System

EXECUTIVE SUMMARY

Safety in the airspace over Canada is a responsibility shared by NAV CANADA, the department of National Defence (DND) and Transport Canada. With the proliferation of Remotely Piloted Aircraft Systems (RPAS), it is in the interest of all Canadians that this new form of aircraft be managed and integrated safely into the existing air traffic management system. The establishment of an RPAS Traffic Management (RTM) framework will ensure that Canada's airspace remains a safe space for all that use it.

Transport Canada will use the vision, principles and high-level requirements in this paper for building the roadmap that will lead to the implementation of a RTM framework for Canada.

BACKGROUND:

The Remotely Piloted Aircraft Systems (RPAS) industry is a new sub-sector of aviation that has experienced rapid and unprecedented growth. The emergence of RPAS is fundamentally changing the composition of the aviation transportation sector and is introducing new challenges, risks and opportunities in the process.

One of the challenges introduced by the democratization and evolution of RPAS is the introduction of non-traditional technology into a highly regulated airspace. Establishing a Remotely Piloted Aircraft Systems Traffic Management (RTM) framework will preserve the efficiency of the existing aviation system, support economic opportunities, and is crucial to ensure the safety of Canadians is maintained.

NAV CANADA and DND are Canada's air navigation service providers (ANSP) responsible for air traffic control, airport advisory and flight information, and aeronautical information. NAV CANADA is a privately run, not-for-profit corporation that owns and operates Canada's civil air navigation system (ANS). It was established as a Corporation in 1996 by way of the *Civil Air Navigation Services Commercialization Act* (CANSCA).

Transport Canada is the federal regulator and is the department responsible for developing aeronautical regulations, policies and services of transportation in Canada by way of the Canadian Aviation Regulations (CARs) and Standards. It is also responsible for uncontrolled airspace in Canada. It receives its authority to make regulations for RPAS under the *Aeronautics Act.*

RTM will be an air traffic management ecosystem capable of managing remotely – and ultimately autonomously –RPAs operating in Canadian airspace, and which will include such features as drone tracking and remote identification. It is envisioned RTM development will ultimately identify services, roles/responsibilities, information architecture, data exchange protocols, software functions, infrastructure, and performance requirements for enabling the management of RPAS operations beyond controlled airspace. The development and deployment of RTM services will be progressively introduced with the emergence of new technologies and operational uses for RPAS.

In July 2018, a workshop was hosted by Transport Canada in partnership with Unmanned Systems Canada to advance the conversation on RTM in Canada by building on previous discussions, engaging key players, identifying critical questions, and thinking collectively about ways to move forward. The workshop discussions included the assessment of various visions, missions, guiding principles and high- level requirements that have been put forward by other jurisdictions and international associations.
Conversations on RPAS traffic management continued at Unmanned Systems Canada 2018 in the fall of 2018.

In early 2019, a sub working group of the RPAS Traffic Management Action Team (RTMAT), a committee co-chaired by Transport Canada and NAV CANADA that consists of technical, policy and operational specialists and representatives of the RPAS industry, spent several months developing a vision, guiding principles and high-level requirements for Canada's RTM. A report of the findings was prepared in March 2019 with a view that the recommendations will inform the roadmap for Canada's RTM. The findings of the report have been incorporated into this White Paper and will serve as a starting point for RTM discussion at this RPAS Workshop Event.

SOLUTIONS/RECOMMENDATIONS:

Based on the work of the RTMAT, it is proposed that Canada adopt a **vision** for the development of an RTM in Canada whereby RPAs would be progressively integrated into all classes of airspace in Canada, operating safely and efficiently alongside other aircraft.

In support of achieving the vision for RPAS integration, the following **guiding principles** will serve to shape the necessary work:

1. Fair access to airspace on the understanding that the safety of the aviation system, the preservation of life and the prevention of injury is paramount.

2. Innovation and economic development are to be encouraged.

3. Integration must recognize and accommodate a diversity of traffic and be prepared for increasing traffic density and increasing automation leading to autonomy (scalability).

4. Cyber-security and overall system resilience are a priority.

5. Public policy and social acceptance needs to continue to be built, including ensuring privacy and data protection concerns are mitigated.

6. A multi-disciplinary and collaborative approach will be taken.

In addition to adhering to the guiding principles, the means of integrating RPAs into Canadian airspace will adhere to the following **high level requirements**:

1. Establish validated applicable aeronautical and other data sources and update information on a routine basis;

2. Allow for the provision of:
    a. Situational awareness;
    b. Access to airspace;
    c. Separation between aircraft and/or operating environments; and
    d. System integrity, redundancy, and resiliency.

3. Have a means of interfacing with air traffic management systems for other aircraft, both civilian and military, and be interoperable between RTM systems;

4. Have an open, scalable architecture amenable to updates and integration with other systems;

5. Establish communication and navigation requirements to ensure that RPAS are suitably equipped to operate safely in their respective environments; and

6. Be risk- and performance-based as much as practicable.

CONSIDERATIONS:

The airspace in Canada is and will be managed for individual and collective benefit. All types of users will have access to it, to the extent they can be integrated safely.

The high-level approach presented in this paper purposely does not include target dates and timelines given the early stages of RTM development in Canada and the constant evolution of this industry. The RTMAT believed it appropriate to wait on setting timelines until the roadmap – the plan for how RTM will be set up in Canada – has been established. The roadmap is notionally expected by late 2019.
However, the absence of a roadmap would not preclude addressing immediate safety concerns related to RPAS or traditional aviation.

At this point in time it is envisioned that the roadmap to RTM implementation would be a phased-in approach. RTM in Canada would need to take into account the varied background of RPA pilots and the different kinds of operations that will be undertaken. Some pilots will be well versed in aviation and aeronautics while others will have limited or no background. It will also need to take into account the range of activities and reasons for flying, from hobbyist to commercial operator and everything in between.

The RTMAT looked at how RTM is being implemented in other jurisdictions, such as the United States, the UK, Australia, New Zealand, Singapore and countries in the EU to inform the vision, principles and high-level requirements.

The recently released ICAO document, *UTM – A Common Framework with Core Boundaries for Global Harmonization,* offers guidance on establishing an RTM traffic management framework and is attached to this white paper for information and consideration.

ACTION BY THE GROUP:

It is requested that the group discuss and provide feedback on the above vision, guiding principles and high-level requirements for the establishment of RTM in Canada. Transport Canada also invites alternate or complementing propositions to those elaborated above.

Appendix 7: Transport Canada: Drone Talk White Papers Continued

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Transport
Canada White
Paper

Drone Talks: Planning for
Success May 29-30, 2019
Workshop #2: Beyond Visual Line-of-Sight
Operations

EXECUTIVE SUMMARY

Transport Canada intends to approve routine Beyond Visual Line-of-Sight (BVLOS) operations for Remotely Piloted Aircraft Systems (RPAS) in 2019, beginning with lower risk operations. The department is considering leveraging the Specific Operational Risk Assessment (SORA) process by the Joint Authorities for Rulemaking of Unmanned Systems (JARUS) to serve as the basis for the methodology to approve routine operations. For operations that fall outside of the Part IX regulatory requirements, the department intends to adapt the SORA concepts to create a methodology that recognizes Canada's unique airspace environment and low population densities in Canada's remote and rural regions in order to enable lower risk BVLOS operations, and allow VLOS operations over 25 kilograms outside of populated areas.

BACKGROUND:

RPAS have proven themselves as a versatile economic tool and an enabler of innovation in Canada. The ability of an RPAS to safely go BVLOS of the pilot in command and visual observers increases the scope and complexity of the operation, introduces greater safety considerations, but also increases the economic value of the operation; BVLOS operations will be transformative for Canada's RPAS industry by enabling longer-range surveys with greater efficiencies and cost-savings than traditional aviation or visual line-of-sight operations (VLOS), while also offering the potential to unlock new applications across Canada's economy, such as in the agriculture, natural resources, and public safety sectors, and in for delivery solutions in Canada's Arctic, Northern, and remote and rural areas.

To date, TC's approach to approving beyond visual line-of-sight operations has been incremental and limited to trials for public safety operations, at test ranges, or experimental operations that offer research benefits to Canada. TC recognizes the importance of BVLOS operations to Canada's RPAS industry, and the need for a coordinated approach that will enable operations in a safe manner. The department has mapped out its strategy to enable BVLOS operations in Canada, outlined in three phases, which was previously presented at Unmanned Systems Canada in November 2018 (Annex A).

In moving forward in implementing this strategy, TC is considering utilizing the Specific Operations Risk Assessment (SORA) model by the Joint Authorities for Rulemaking of Unmanned Systems (JARUS), which provides a methodology for both industry and civil aviation authorities to inform authorizations of RPAS operated in the specific category. The department's policy framework is based on SORA concepts, and will include definitions, safety objectives, and guidance for industry to allow for the authorization of routine operations in specific operating environments, and also establish a path forward to regulatory development.

SOLUTIONS/RECOMMENDATIONS:

TC's strategy to integrate BVLOS operations into Canadian airspace consists of phases that will accommodate the maturation of technology and ensuring the safety of Canada's aviation system. To this end, the first phase of the strategy will continue to support technology development and validation at the test ranges and through pilot projects, the second phase focuses on authorizing routine operations using the existing Special Flight Operations Certificate process, and the third will include activities to advance regulatory development.

In enabling routine BVLOS operations, TC has established guiding principles for the creation of a policy framework, and the development of future regulations. The department will seek to:

- Ensure a risk-based approach to approving operations;
- Facilitate the integration of RPAS into Canadian airspace, and enable RPAS traffic management;
- Leverage feedback from stakeholders in the implementation of the strategy;
- Harmonize the Canadian BVLOS approach with international partners, where possible.

The JARUS SORA provides guidance to civil authorities by providing a holistic and system-level risk assessment model to evaluate both ground and air risks to a given operation by establishing a classification of Ground Risk Classes (GRC) and Air Risk Classes (ARC). The ARCs and GRC dictate the required Specific Assurance and Integrity Levels (SAIL), which determines the required level of robustness and assurance for each Operational Safety Objectives (OSOs). The following definitions provide the basis for a Canadian operational risk assessment for lower risk BVLOS operations:

- Population Centre: An area with a population of at least 1,000 and a density of 400 or more people per square kilometer, based on the latest available census data.
- Rural Area: An area outside of a population centre, where the population is not concentrated and is dispersed at a density greater than 0.1 persons per square kilometer, based on the latest available census data for Aggregate Dissemination Areas.
- Isolated Area: An area outside of a population centre, where the population is not concentrated and is dispersed at a density of 0.1 persons per square kilometer or less, based on the latest available census data for Aggregate Dissemination Areas.
- Atypical Airspace: Atypical Airspace is defined as any of the following:
    - Restricted Airspace, with permission from the coordinating authority;
    - Northern Domestic Airspace as defined in the Designated Airspace Handbook, outside an Airport Environment, at or below 400 ft AGL;
    - Within 100 feet (30 m) or less above and 200 feet (61 m) or less horizontally from any building or structure located in uncontrolled airspace outside of an Airport Environment.

Under this proposed methodology, TC intends to begin authorizing lower risk BVLOS operations in 2019, specifically in two categories: isolated areas and atypical airspace, and rural areas and atypical airspace, also known as Airspace Encounter Categories 10 and 12 in the JARUS SORA (Annex B). When seeking an authorization for a BVLOS operation in 2019, applicants will be required to demonstrate that:

- Their operating environment meets the criteria and definitions for the relevant ARC and GRC;
- An assessment of the ground and air risk of the operation has been completed, the appropriate SAIL determination has been made, and the associated OSO levels have been met; and,
- The appropriate performance requirements have been met for detect and avoid solutions

TC is also developing an operational evaluation that will assist operators meet the required SAIL criteria under the OSOs. The intent of this process is to provide a means for operators to meet the requisite assurance and robustness levels for higher level SAIL criteria through testing, test range operations, or experience gained through traditional aviation or visual line-of-sight operations.

CONSIDERATIONS:

This approach to approve routine operations in lower-risk environments leverages the operational experience gathered during the 2018 trials, and will also position industry to begin conducting BVLOS operations in the defined isolated and rural areas in applications in public safety, wildlife and natural resource surveys, precision agriculture, and for linear inspections. The department welcomes additional comments on the impact of the approach being considered on these use-cases, or how the approach will affect other use-cases.

TC is considering the SORA risk model to scope operational categories and establish its safety objectives for BVLOS operations, while also ensuring that its approach remains consistent with its international partners. However, the SORA process is not the exclusive means by which operators can apply for BVLOS operations; applicants are free to use other risk models, provided they meet the safety objectives, performance requirements, and operate within the defined operational risk categories. The department will retain the SFOC process to authorize operations and will publish guidance material in Summer 2019.

The proposed taxonomy of airspace categories accommodates the current state of technology in lower- risk operational environments, and, as technology matures, will allow for the progressive expansion of BVLOS authorizations into additional operational environments. The definitions used for the operational categories are based on 2016 census data and Statistics Canada's statistical hierarchy, which provides a viable dataset to assess both ground and air risk. Statistics Canada's datasets are also accessible to the public, and can be visualized to assist applicants plan their operations. TC intends to continue to mature and adapt this framework, and will continue to seek out more accurate datasets and tools to refine its risk analysis as appropriate.

The intent to leverage the SORA risk model and establish safety objectives will enable industry to explore the viability of BVLOS RPAS operations in key economic sectors, while also allowing the industry to generate operational data to help mature the policy framework, and assist in the creation of evidence-based regulations.

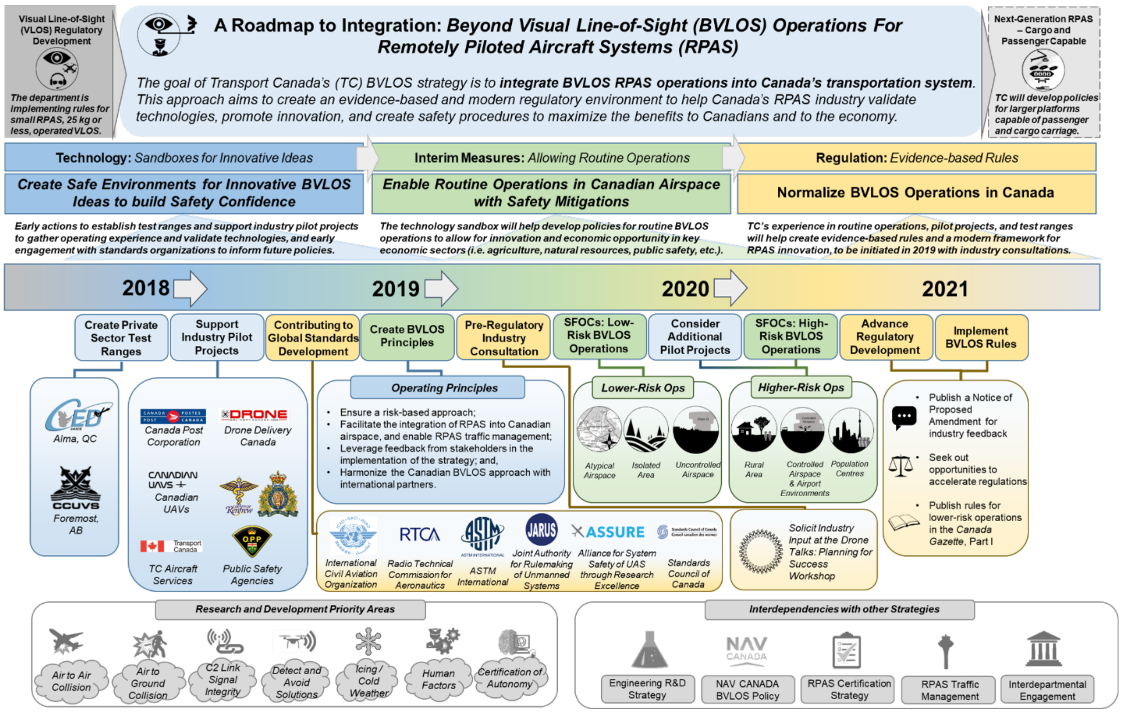
ACTION BY THE GROUP:

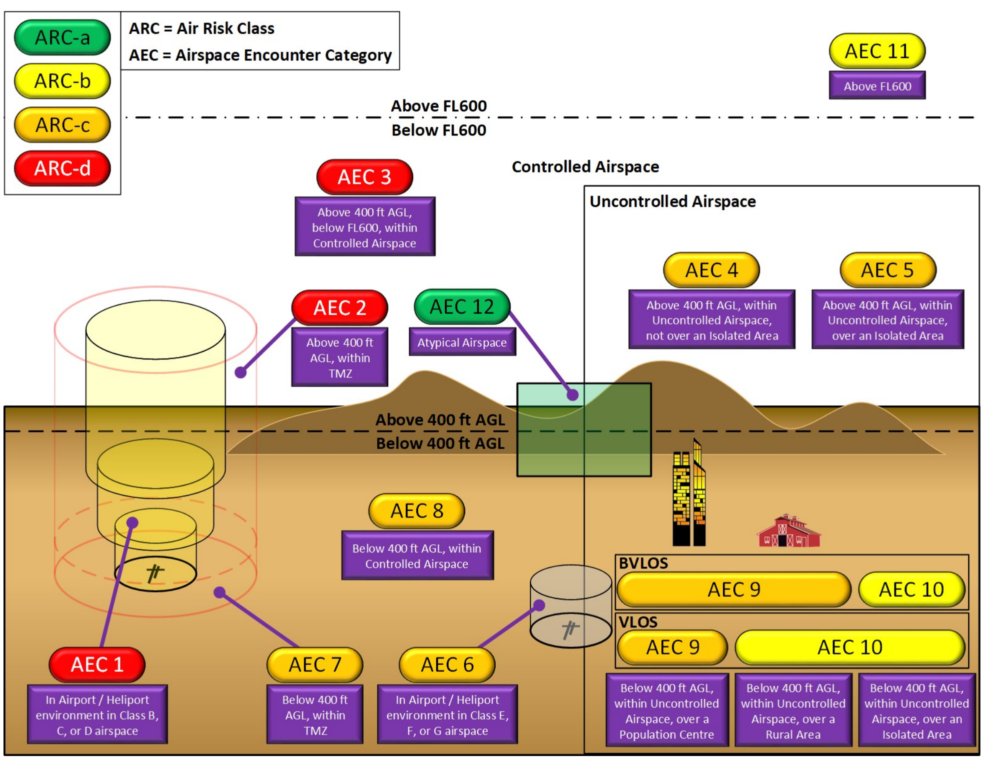
- In advance of implementing its strategy and approach to approve routine operations, TC is seeking:

- Feedback on its strategy and the approach being proposed to authorize routine BVLOS operations in Canadian airspace;
- Identification of additional considerations related to the implementation of the SORA in the Canadian context;
- Comments on the policy and technical questions presented.

APPENDICES:

- Annex A: Roadmap to Integration: Beyond Visual Line-of-Sight Operations
- Annex B: SORA Categories





Transport Canada White Paper

Drone Talks: Planning for Success May 29-30, 2019
Workshop #3: RPAS Airworthiness and Certification
BACKGROUND:

EXECUTIVE SUMMARY:

It is recognized worldwide that there is a need to modernize aircraft certification processes in order to accommodate emerging products and technologies, such as Remotely Piloted Aircraft Systems (RPAS) into a more adaptable framework that stimulates innovation while enhancing aviation safety.

This paper outlines a proposed vision for establishing airworthiness criteria, setting forth a risk-based approach applicable to RPAS larger that 25Kg that is scalable to their kinetic energy and intended operational usage. This proposal draws from proceedings by the Joint Authorities for Rulemaking of Unmanned Systems (JARUS).

Around the world there is a trend to reform certification processes to accommodate emerging products, respond to new technological innovation, and modernize legacy aircraft fleets to improve efficiency.

The rigidity of the existing regulatory framework and standards prescribing specific design features rather than taking a holistic view is driving the need for modernization. This rigidity stifles innovation and creates long approval times for implementation of new technologies.

This is especially pertinent for RPAS as the number flown in Canada continues to grow (as of April 28, 2019, there were 9,563 RPAS registered in Canada through Transport Canada's new Drone Management Portal), and the technology continues to rapidly evolve with increasing levels of automation and autonomy. The industry looks for opportunities to generate greater efficiencies and economies of scales recognizing the high costs associated with training and employing traditional pilots.

FAA and EASA have recently initiated a modernization of their respective aircraft products standards in order to support industry innovation and rapid deployment. For instance, the FAA's emphasis has been on restructuring regulatory requirements towards a risk based approach. This includes moving away from the notion of categorization by weight, and instead towards the alignment of approvals based on the operational risk and kinetic energy. For example, certification standards for various aspects of an airplane's design would vary depending upon its performance levels. More stringent standards would apply to high speed airplanes, which are higher risk and higher performance airplanes than low speed airplanes.

To this end, the FAA has also taken the following steps:

- Introduced policies outlining streamlined processes to aid in the adoption of safety enhancing equipment on aircraft based on non-interference with certified systems (NORSEE).
- Adopted a revamp of the Part 23 amendment 64 certification standards. The new certification

standards emphasize the use of consensus standards – which are a proposed "means of compliance" to satisfy the new Part 23 system performance-based standard.[1] Note: Various standards bodies, such as the ASTM, RTCA, EUROCAE, and ISO, are currently working on developing consensus standards, with attention also being given to the harmonization of efforts.

These new performance based standards are being adapted and adopted to reflect the reality of RPAS and Urban Air Mobility (UAM). As such, there are efforts across United States and the European Union to create performance based standards that allow the RPAS industry to innovate and keep pace with the technological advancement proposed.

In the Canadian context, many of the same challenges are being experienced, with concerns raised regarding the long approval times for implementation of new technologies. Thus far, Canada has been actively monitoring and influencing the development of new standards and approval processes, and the modernization of Transport Canada's regulatory framework – through active participation in consensus standard committees such as ASTM, RTCA, and JARUS[2], as well as membership in the International Civil Aviation Organization (ICAO).

Transport Canada has also launched a R&D program to support the safe integration of RPAS into the national airspace with the results being used to inform and influence the regulatory framework.

However, moving forward, as the technology continues to develop, it is apparent that Canada must also further explore and develop an approach to accommodating emerging RPAS products. In particular, what does the future in Canada look like in terms of RPAS airworthiness requirements and the system of certification? What is Canada's vision and a path forward for achieving that vision?

SOLUTIONS/RECOMMENDATIONS:

In response to the aforementioned challenge, Canada would introduce a risk-based approach to airworthiness for Category B and certification for Category C RPAS, consistent with the approach being taken by JARUS members, United States and European Union. Under a risk-based approach, Transport Canada may evaluate and categorize RPAS based on weight and kinetic energy. The delineation between RPAS categories follows:

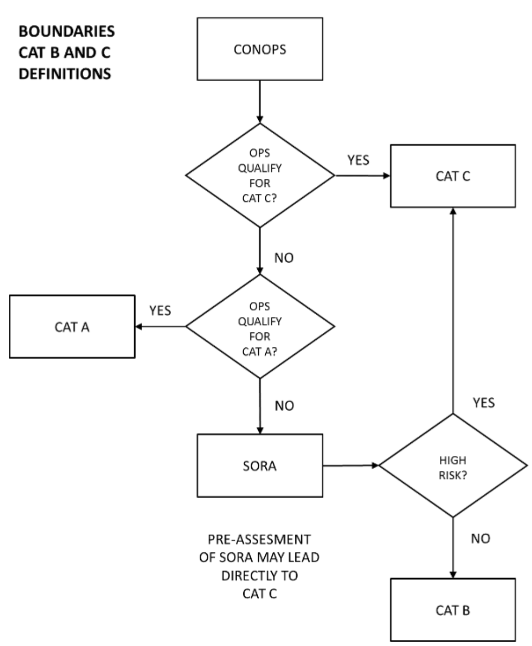
- Category A: RPAS of less than 25kg operated in VLOS. This RPAS category is currently addressed by Part IX, Subpart 1. Transport Canada relies on the declaration by RPAS manufacturers meeting the SAFE requirements.
- Category B: RPAS of 25Kg or more having a kinetic energy of less than 1084KJ operated in either VLOS or BVLOS. Transport Canada does not envision a type certification process for this RPAS category, but rather a RPAS flight authority regime. It is further envisioned that Category B may include RPA having a capacity to carry a maximum of one passenger for private/non-commercial use only. A new regulatory framework is contemplated to achieve an acceptable level of safety by largely relying on rigorous design and manufacturing practices employed by the RPAS manufacturer and a declaration of conformance to acceptable design standards (compliance basis). As a minimum, RPAS manufacturers would be required to adhere to best industry practices and endorse industry consensus standards for designing, testing and manufacturing RPAS. RPAS manufacturers would be required to obtain an "RPAS Manufacturer Authorization" and document their procedures for the design and manufacture in a "RPAS Manufacturer's Procedures Manual" (RMPM) which would be the subject to approval. Through

the civil aviation surveillance program, the Minister would conduct program validation inspections predicated on the RPAS manufacturer's RMPM.

- Category C: RPAS with a kinetic energy of 1084KJ or higher operated in either VLOS or BVLOS, and including passenger carrying capability (e.g. a 2600 Kg aircraft with maximum cruise speed of 100 km/h equates to 1003KJ). This RPAS category will be subject to a type certification process and issued a type certificate. Existing regulations governing type certification would be leveraged to the
maximum extent practical to include this category of aeronautical products. In addition, existing standards, policies and advisory material would be amended as required to facilitate the type certification process. This would include standards for RPAS specific considerations such as Detect and Avoid (DAA) systems, Command and Control (C2) links, Remote Pilot Stations (RPS), and autonomy.

To facilitate the categorization of RPAS[3], Transport Canada would request manufacturers to prepare a concept of operations (CONOPS) and an operational risk assessment (ORA) (e.g. ASTM ORA, JARUS SORA). The RPAS categorization may be adjusted based on residual risk factors from the ORA. The conceptual CONOPS prepared by the manufacturer would be provided to prospective operators to form the basis of their CONOPS. The CONOPS would serve as a base to define the category in conjunction with the fixed conditions, and the risk assessment would be used to identify any risk not foreseen on CAT B, which could result in the need for a CAT C process.

Figure 1. Delineation process – JARUS WG – 7 Decision Process



Canada would leverage existing aviation standards and practices wherever appropriate for RPAS by applying safety continuum concepts to tailor appropriate certification requirements for the aircraft type, its intended mission, area of operation, its control method, and intended airspace. Canada would also

[2] With respect to JARUS, Canada is currently working collaboratively with at least 61 other countries, as well as the European Aviation Safety Agency (EASA), FAA, TCCA and EUROCONTROL, in order to contribute to the development of JARUS work products. In 2015, the Stakeholder Consultation Body (SCB), representing all industry communities of interest, was also established to allow stakeholders the opportunity to support JARUS activities.

[3] Note: TC also participates in JARUS Working Group-7 which works on the delineation across categories and is the establishment of fixed conditions to better facilitate delineation.

look to enhancing and expanding the existing system of delegation for aircraft to cope with anticipated high demand in the future.

This vision is guided by the following key principles:

- Employing a risk-based approach to approving and regulating operations.
- Performance-based airworthiness regulations supported by industry consensus standards.
- Supporting innovation, while also recognizing that the safety of the aviation system, the preservation of life, and the prevention of injury is paramount.
- Recognizing and preparing for increasing levels of automation and autonomy (i.e. scalability); includes consideration of the public and social acceptance.
- Harmonizing with international partners, where possible.

CONSIDERATIONS:

As RPAS technology continues to develop, with a focus on more autonomous, higher risk operations, the need for a robust, but also modernized and flexible system of certification and airworthiness for RPAS becomes paramount.

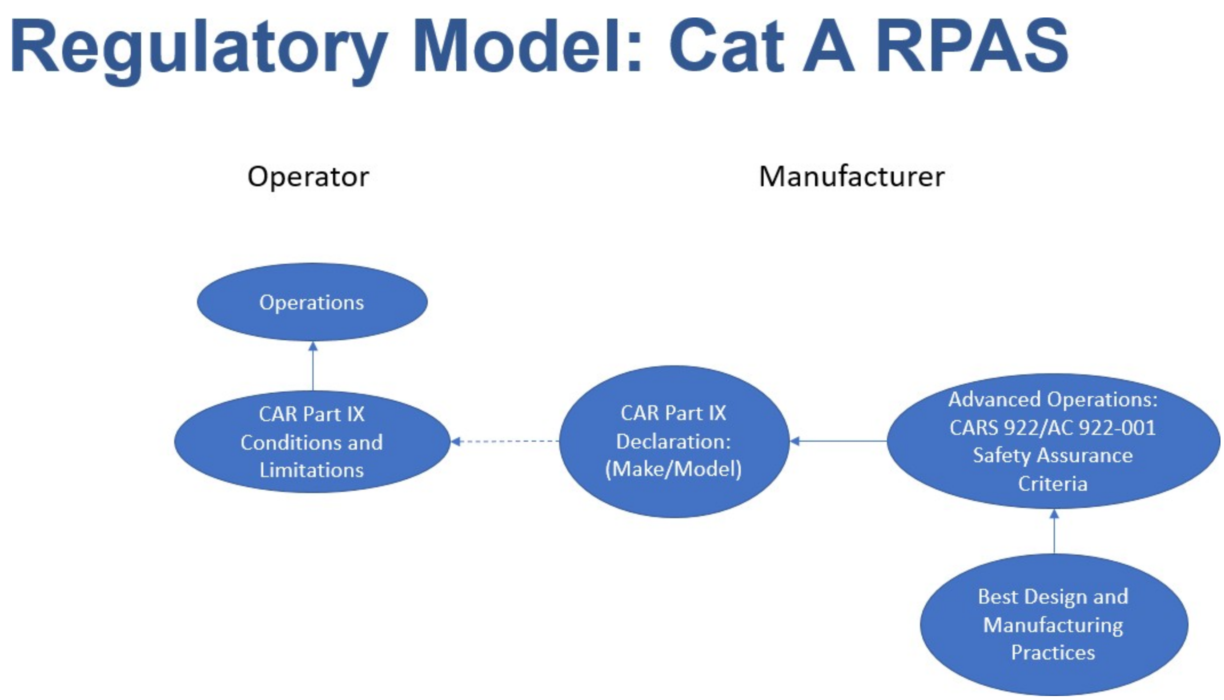
The proposed solution would have the benefit of supporting a timely introduction of new products to the market and allowing the Canadian industry to compete internationally (includes certification of modifications to type certified products). It reflects a reasonable expectation for safety based on Transport Canada safety assurance continuum concepts. The safety continuum recognizes that the public expects progressively higher levels of safety assurance for passenger-carrying aircraft compared to those used for recreational aviation. In a similar fashion, the public will expect progressively higher levels of safety for UAS, based on size, weight, performance, intended use, and area of operation.

The approach further recognizes that a one-sized approach to certifying RPAS is not practically effective in integrating RPAS into the national airspace system. Technical and operational risks can be mitigated through a combination of compliance to Airworthiness Standards, Operational Limitations and Operational/Emergency Procedures.

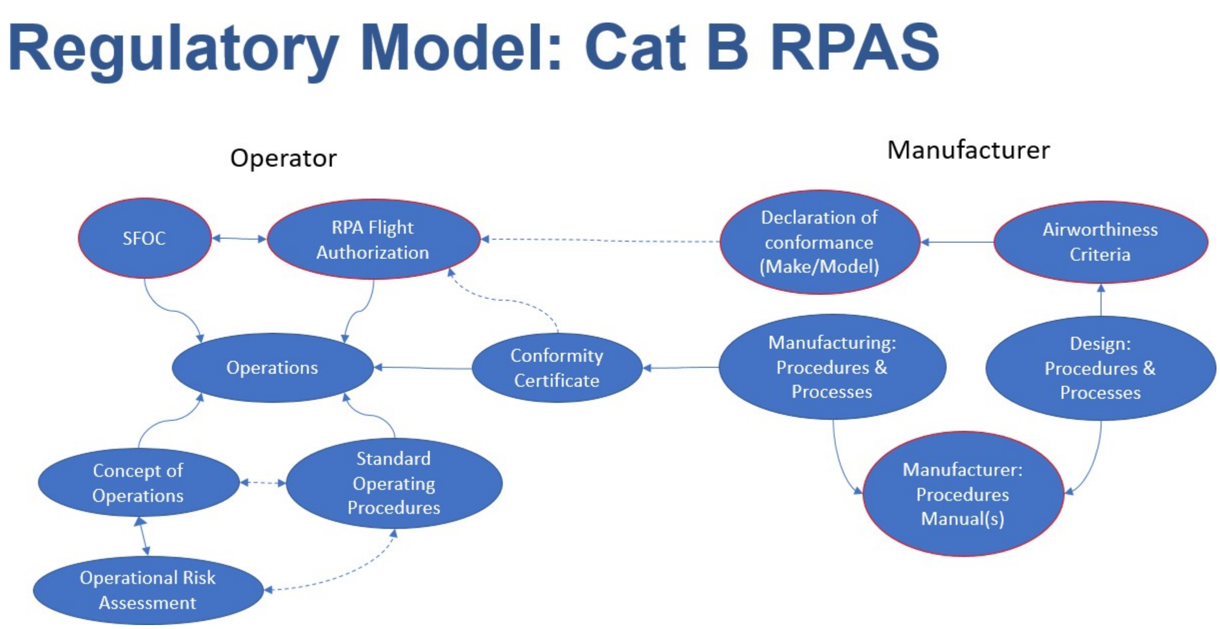
Finally, this approach recognizes the need for a R&D program in which industry, academia and government agencies work together to promote an environment for innovation. This R&D program would support the introduction of new technologies, identify and characterize relevant operational hazards through empirical data which could then be reflected in the regulatory framework in the form of performance and safety objectives.

ACTION BY THE GROUP:

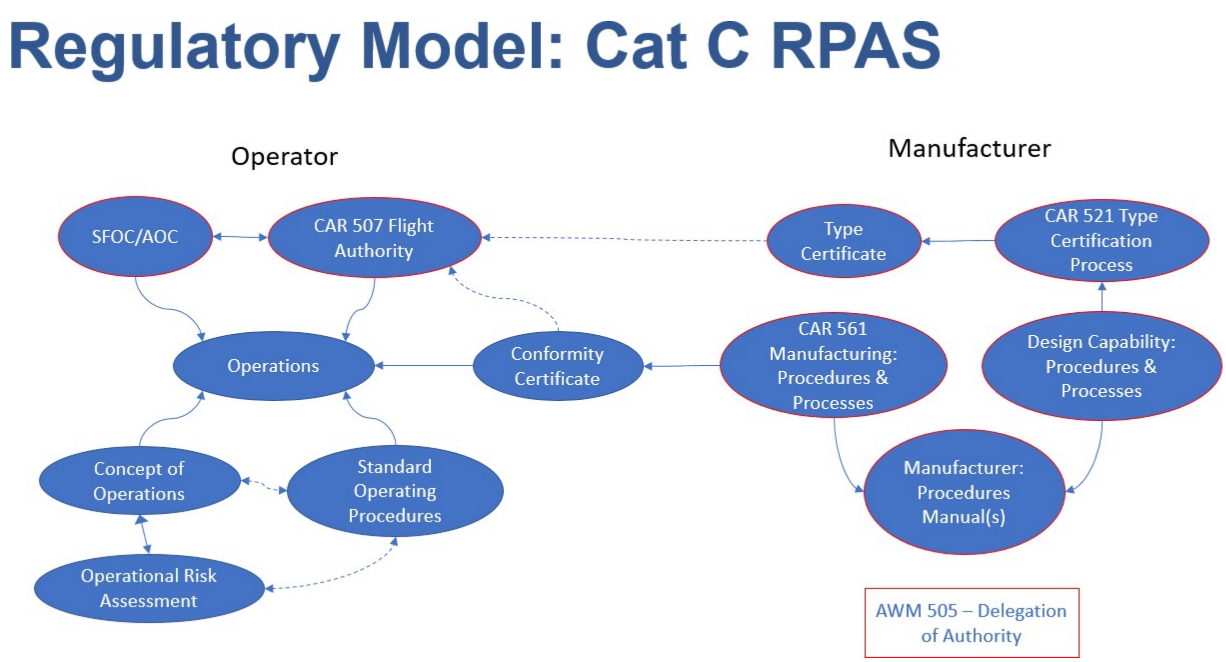
- Request the group to provide feedback on the proposed vision and outlined considerations, and if consensus exists, endorse its principles.
- Transport Canada invites alternate or complementing propositions to those elaborated above.



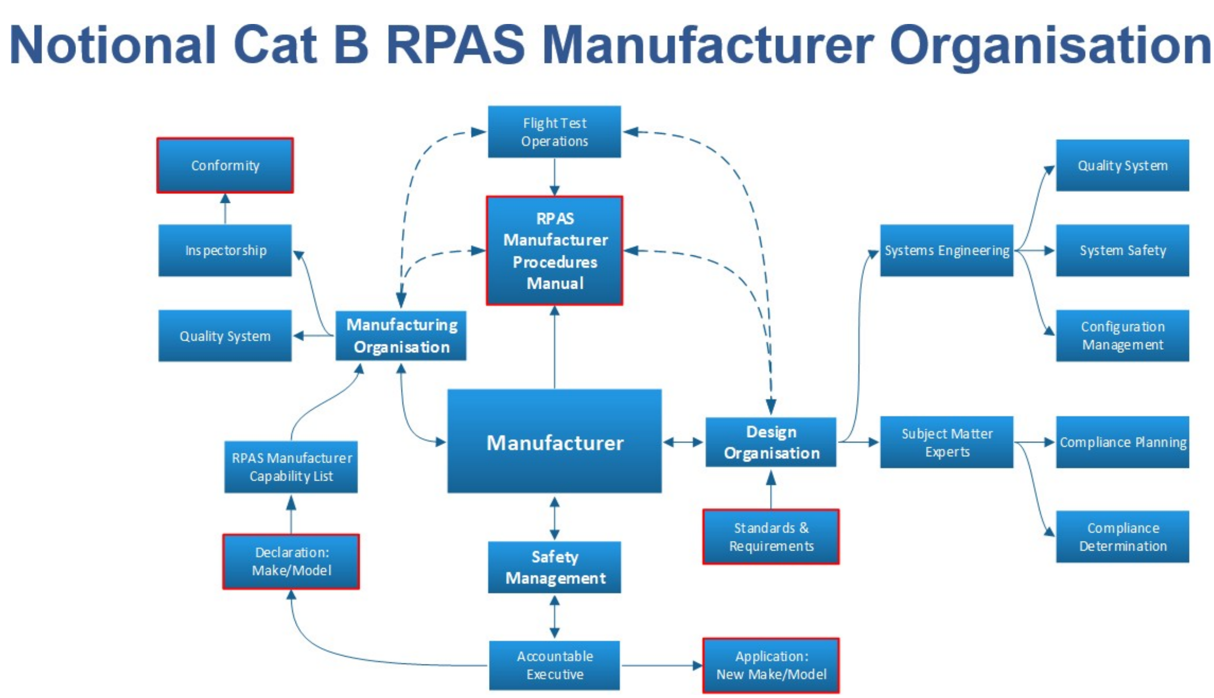
Appendix B - Regulatory Model – Cat B RPAS



Appendix C - Regulatory Model – Cat CA RPAS



Appendix D – Notional Cat B RPAS Manufacturer Organization



Transport Canada White Paper

Drone Talks: Planning for Success May 29-30, 2019
Workshop #4: Pilot Certification and Training

EXECUTIVE SUMMARY

RPAS operations are becoming increasingly complex, and RPAS machinery is becoming ever more automated. Increased operational complexity and machine automation will change the requisite knowledge, skills, and abilities of future requirements for pilots.

A graduated, stepped approach that is based on risk should be taken towards BVLOS training and certification. Human factors, operating environment, and equipment will all factor into this discussion.

Although related in theme, direction on licensing for International Instrument Flight Rules (IFR) RPAS operations will be issued separately by the International Civil Aviation Organization (ICAO) and thus are out of scope for this paper.

BACKGROUND:

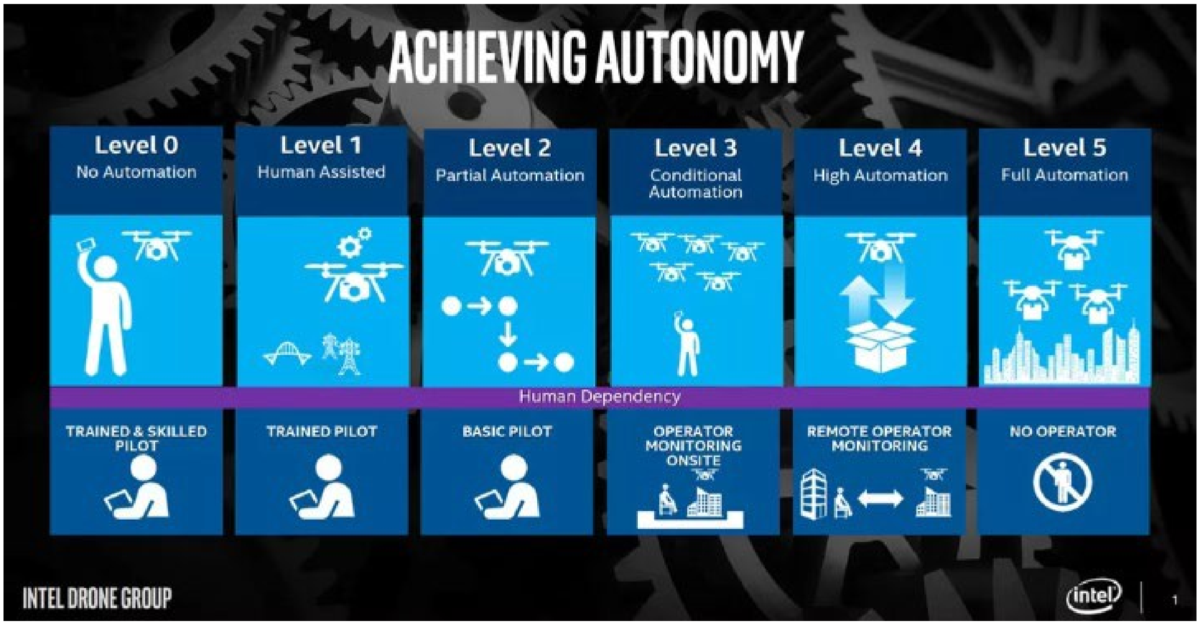
In January 2019, Canada published VLOS regulations that addressed training and certification standards for drone pilots. For basic operations (flying in uncontrolled airspace, not near or over people), the requirements were limited. For advanced operations (flying controlled airspace, or near or over people), the standards were more stringent (including a more difficult exam and an in-person flight review), due to a higher degree of risk. As Canada looks toward BVLOS operations and beyond, it is time to consider what pilot certification and training will look like as technologies advances, new use-cases emerge, and potential risk shifts. For purposes of this paper, 'training' refers to the process in which an individual obtains the knowledge and skills required for an activity, whereas 'certification' refers to the verification or 'check' that the knowledge and skills have been obtained to the desired level.

Through the development and implementation of the VLOS regulations, Transport Canada noted that there is a growing divergence between what new aviation entrants and existing aviation stakeholders see as the level and type of training required for RPAS pilots. The purpose of this paper is to propose a set of principles that can be used to guide pilot training and certification in the future.

This paper highlights two documented models of RPAS pilot certification and training. Although both models ultimately view the crew as being removed from the operation as it becomes fully automated, the path to reaching this point and the approach in doing so differs.

1. Intel Model:

The Intel Model is loosely based on the SAE J3016 “Levels of Driving Automation” standard created to describe automation / autonomy in self-driving cars.[4] Since the SAE model was developed for an industry in which the “pilot” (driver) can be relatively unskilled, it appears that some assumptions with respect to the relative safety of automated and autonomous systems (compared to a potentially unskilled operator) have been incorporated into the model. The result, translated into the RPAS context, is the premise that as machine automation increases, the knowledge and skill-level of the pilot is reduced.



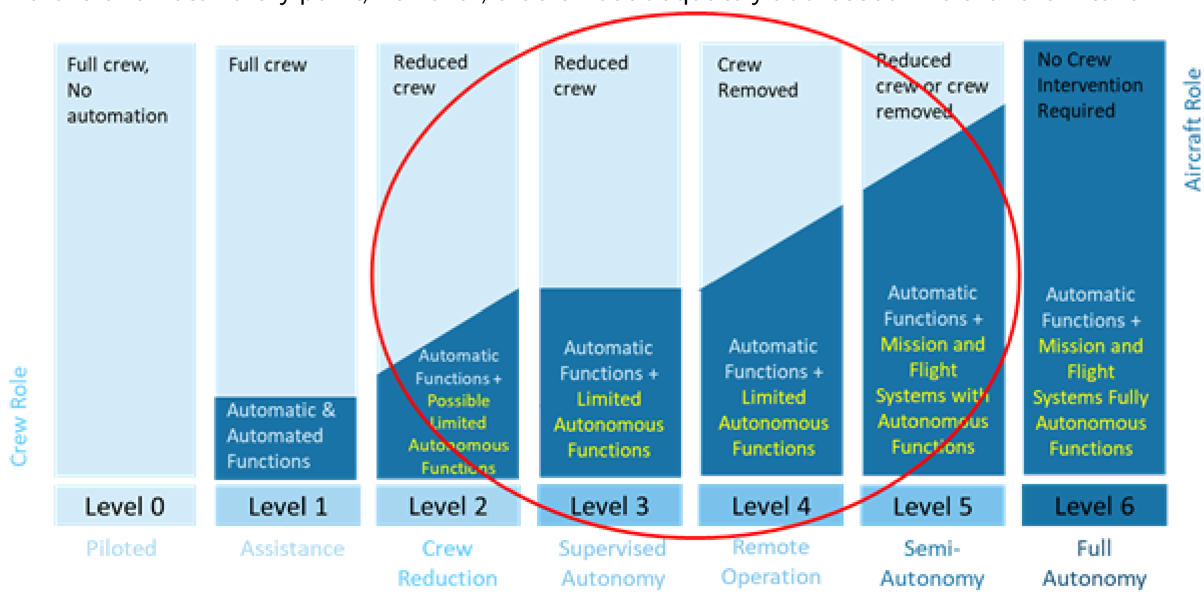
This model may be more cost-effective from a pilot and organizational perspective, and thus may be more appealing to large organizations. However, it poses some potential risk, particularly in more complex environments. If the basic understanding of aviation principles is removed from the pilot, then he or she may lack the knowledge and skills to respond if something unexpected occurs during the drone flight. Of note is the transition through Levels 2, 3, and 4 of the SAE & Intel models; Level 3 in particular represents significant risk in both the automotive and aviation contexts as the pilot/driver is not required or expected to continuously monitor the automated system, but it still expected to take over control when the system encounters an issue that it is incapable of managing. Experience in automated systems and human-machine teaming has shown that this type of arrangement presents significant challenges for human and overall system performance.

[4] SAE International is a global association of engineers that develops standards for engineering professionals in various industries.

2. <u>NRC model</u>:

3. The NRC model is based on the premise that as automation increases, the need for a pilot in the system is slowly reduced; however, the pilot's knowledge and skill level remain high. This approach appears to be less cost-effective from a pilot and organizational perspective, but it offsets some of the potential risks of the Intel model. Like the Intel model, the NRC model ultimately results in a fully autonomous operation. However, in the interim steps to automation, the NRC model recognizes that while automation may reduce the presence of the pilot, the pilot's need for sufficient aviation knowledge and skills training are still needed. In the NRC model, should unanticipated challenges arise during the flight, the pilot would be better positioned to effectively respond due to his or her aeronautic knowledge and skill.

There is one noteworthy point, however, that is not adequately addressed in either the Intel or NRC

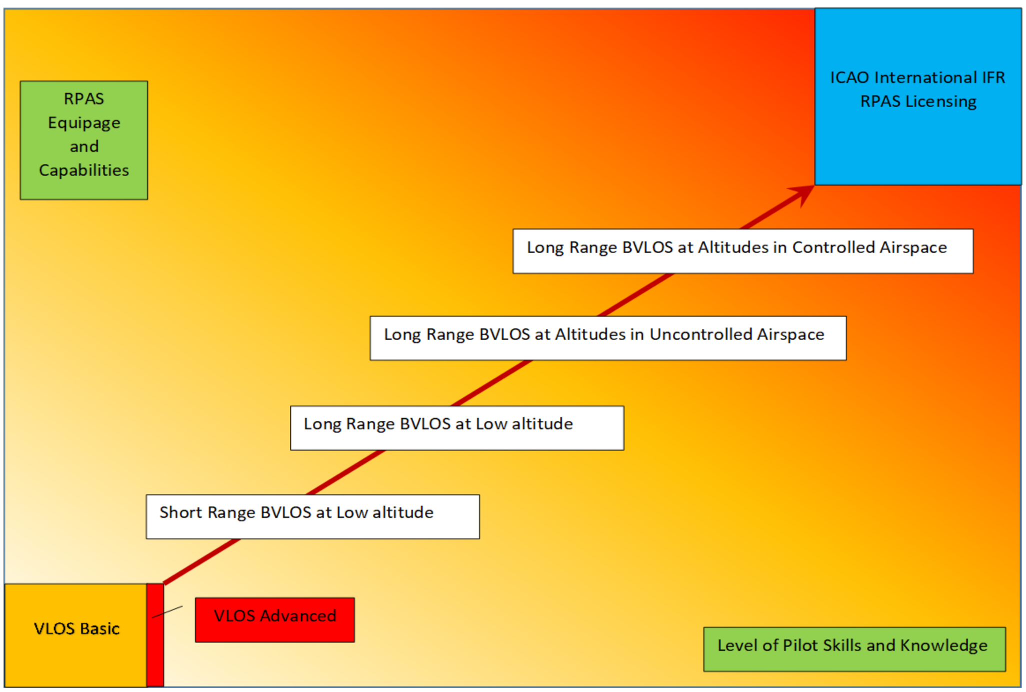


model. Neither system is intrinsically designed to take into account that the programing and managing of automated systems introduces its own workload and complexity. The existing aviation system has started to address this over the last few decades as aircraft have become more complex and automated. Training specific to human factors and a focus on system management skills are becoming more and more critical as the level automation increases; this in turn will require pilots to receive additional training and knowledge in these areas.

SOLUTIONS/RECOMMENDATIONS:

This paper supports the step-by-step approach taken by both models in the consideration of BVLOS drone pilot training and certification. When developing a certification and training regime for BVLOS pilots, this paper recommends that a similar 'stepped' approach be taken, which takes risk, operating environment and machine into consideration.

The graph below represents a visual interpretation of one potential approach, illustrating how pilot skills and knowledge may change according to the type of operation (risk) and machine. In this illustration, as the type of operation becomes more advanced, so too does the RPAS capability, pilot knowledge and training. Training and certification standards should consider being in alignment with the Specific Operations Risk Assessment (SORA) findings for a particular drone operator and operating environment. However, even where the emphasis is decreased on the pilot, skill and knowledge should not be removed. The shift in emphasis is from hand-eye coordination to situational awareness, decision- making, and operational management (including emergency response e.g., system failure conditions).



Technological advancements in aviation have demonstrated that human factors must be also considered throughout pilot training and certification. Aviation knowledge remains critically important to RPAS pilots. However, as RPAS system complexity increases, the requirement for RPAS pilots to become 'system managers' also increases. One of the challenges in approaching pilot training and certification will be to find the right balance between traditional aviator knowledge and system management; so that in the event that a problem arises during a flight, the pilot is able to resolve the issue – whether it be system-based or mechanical.

This paper recommends that as Transport Canada moves forward to develop RPAS pilot training and certification requirements, the following **principles** be adhered to:

1. New RPAS pilots will need to integrate with the existing aviation environment.
2. Increased RPAS automation will change pilot participation, and may modify (though not remove) pilot knowledge requirements.
3. Increased RPAS automation will change pilot participation, and will alter pilot skill requirements.
4. Aviation and human safety remain paramount.
5. Human factors must remain a consideration when addressing pilot training and certification.

CONSIDERATIONS:

The traditional understanding of 'pilot' will change as RPAS operations continue to increase in complexity. What a 'pilot' signifies may vary – in terms of physicality, expertise, and skill. Moreover, it is quite likely that as types of RPAS operations become regularized, there will no longer be a one-type-fits- all type of training.

Different standards for different types of pilots could open up the field to those who would not previously have been considered good aviator prospects; for example, those who may not be able to pass the Assistive Technology Professional (ATP) medical exam. This could have the potential of increasing the number of RPAS pilots, while also adding diversity to the existing pool as well.

Finally, as we move towards more increased automation, we must also consider automation and decreased pilot participation from the perspective of the public who may have concerns about drones. As we move forward in developing training and certification for RPAS pilots, public perception and acceptance must also be kept in mind. As such, it is important to underline that the premise of 'safety first' underpins all training and certification considerations, a message that must also be emphasized by professional educators going forward.

ACTION BY THE GROUP:

It is requested that the group discuss the principals drafted by Transport Canada on how to approach BVLOS RPAS pilot training and certification requirements in the domestic Canadian context. Additional approaches or considerations that this paper may have overlooked would also be welcomed.

RTM in Canada – Overview

- This workshop aims to provide participants with a better understanding of RTM and what we want to accomplish
- New entrants want to use Canada's airspace and its safety is a responsibility shared by NAV CANADA, Transport Canada and the Department of National Defense
- The establishment of a RPAS Traffic Management (RTM) framework will ensure that Canada's airspace remains a safe space for all that use it
  - RTM is intended to address how to safely manage RPAs in the national airspace

#CANDronePlan 2

The Path Forward

- RTM Action Team (RTMAT) struck in January 2019 to address RTM
  - Co-chaired by Transport Canada and NAV CANADA technical, policy and operational specialists and representatives of the RPAS industry and DND
  - Provides multi-disciplinary forum for the regulator, makes policy recommendations, supports implementation of RTM, serves as focus group regarding regulations, standards and development of RTM, and will develop roadmap for RTM
- Five Sub-Working Groups of the RTMAT have been struck to date
  - Operating Environments Assessment
  - Vision, Principles and High Level Requirements
  - RTM Roadmap
  - Legislative and Regulatory
  - Review Other State RTM Rollout Review

#CANDronePlan 3

The Path Forward (continued)

- The RTMAT agreed to the vision and principles as presented in the white paper, namely

VISION

- That remotely piloted aircraft systems (RPAS) will be completely integrated into all classes of airspace in Canada, operating safely and efficiently alongside other aircraft.

GUIDING PRINCIPLES

1. Fair access to airspace on the understanding that the safety of the aviation system, the preservation of life and the prevention of injury is paramount
2. Innovation and economic development are to be encouraged
3. Integration must recognize and accommodate a diversity of traffic and be prepared for increasing traffic density and increasing automation leading to autonomy (scalability)
4. Cyber-security and overall system resilience are a priority
5. Public policy and social acceptance needs to continue to be built, including ensuring privacy and data protection concerns are mitigated
6. A multi-disciplinary and collaborative approach will be taken

#CANDronePlan 4

The Path Forward (continued)

RTM Roadmap Sub-Working Group is in the early stages of its work

- Roadmap will be Canada's high level strategy for how itwill accomplish RTM implementation
  - Describes what will be accomplished, how it will be done and over what period of time
  - Roadmap integrates work of two other RTMAT sub-working groups
    - Operating Environments Assessment
    - Vision, Scope, Principles, and Common Requirements

Current plan is to present a draft of the roadmap at the Unmanned Systems Canada conference in the fall of this year

Input from Drone Talks will be considered by the RTMAT

Considerations

Much to consider for RTM roadmap in Canada, such as

- RTM is heavily dependent on technological solutions
  - Technological solutions must be adaptable across all operations and RPASs
- RTM phasing is risk- and performance-based
  - Safety remains a paramount and more complex operations will be allowed as technology permits
- Other jurisdictions that are engaged in proving concept of operations
  - EU U-Space 1-4 and US UTM TCL 1-4, Switzerland, Dubai Civil Aviation Authority, etc.

Considerations (continued)

- Canada's demographic and geographic context (see Annex 1)
  - Canada population density is 3.7 people per square kilometer US is 33, China 145, Switzerland is 207
  - 80% of Canada's population lives in urban areas and 20% in rural areas
  - Nearly 90% of Canadians live within 200km of the US border
- RPAS is a game changer on how airspace is used and managed
  - Evolving RPAS technology will affect all modes and all aspects of air transportation
  - Already big changes underway to ATM by way of Eurosky, NextGen, and ADS-B

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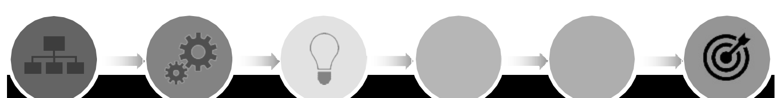

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Workshop Discussion Questions

- What factors should be taken into consideration in developing Canada's RTM framework and what complementing services would be suited for the Canadian context and the intended kinds of operations?
- What advantages and disadvantages does Canada have over other states in establishing its RTM ?
- If a phased-in approach is adopted for implementing RTM in Canada, what aspect of RTM should receive the highest priority for implementation?

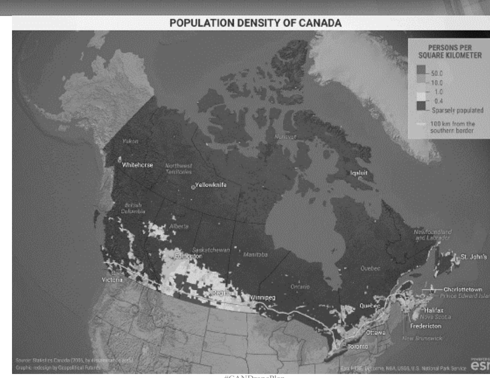
Workshop Discussion Questions (2)

- Is it preferable that RTM be managed by a single entity or many entities and what role could industry play in the operation of the RTM?

Workshop Discussion Questions (3)

- Medium and longer term, and how should an urban air mobility system interface/interact with the RTM?

ANNEX 1



Beyond Visual Line-of Sight

Drone Talks: Planning for Success

May 29th – 30th, 2019
Victoria Hall, Ottawa

Transport Canada Transports Canada

#CANdroneplan #DronesForCanada #BVLOStrials

Canada

Introduction

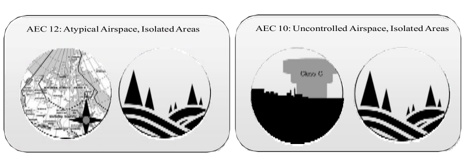
- Transport Canada plans to authorize routine Beyond Visual Line-of-Sight (BVLOS) operations later in 2019:
  - Continue a risk-based approach, leveraging industry feedback, planning for RTM solutions, and harmonizing with international partners.
- TC is following a strategy to stimulate innovation, allow operations, and advance regulatory development:

Technology: Conducive	Interim Measures: Allowing	Regulation: Evidence-based
Environment for Innovative Ideas	Routine Operations	Rulemaking
The creation of mechanisms to validate technology and build safety confidence	Approval of routine BVLOS operations with safety mitigations	The integration of BVLOS operations into the aviation system with modern rules

#CANdroneplan #DronesForCanada #BVLOStrials

Introduction

- TC intends to allow operations, beginning with two lower risk Airspace Encounter Categories (AECs):



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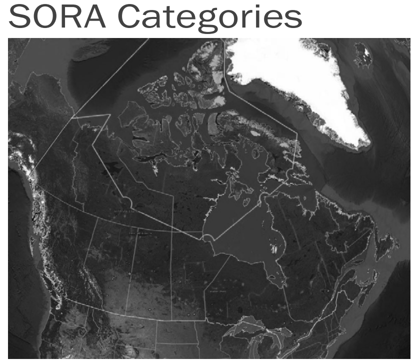
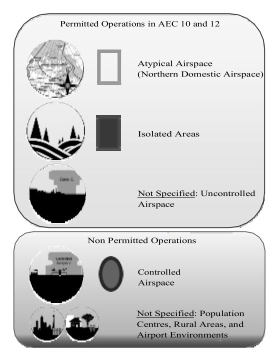
SORA Categories





SORA Process

Concept of Operations to Transport Canada

- Step 1: Determination of RPAS Intrinsic Ground Risk Class
- Step 2: Final GRC Determination
- Step 3: Determination of initial Air Risk Class
- Step 4: DAA and Robustness Levels
- Step 5: Specific Assurance and Integrity Levels (SAIL) Determination
- Step 6: Identification of Operational Safety Objectives (OSOs)
- Step 7: Adjacent Area and Airspace Considerations
- Step 8: Finalize Comprehensive Safety Portfolio and determination of safety confidence

RPAS Authorization from TC

Max RPAS Characteristic Dimension	1 m / approx. 3 ft	3 m / approx. 10 ft	8 m / approx. 25 ft	>8 m / approx. 25 ft
Typical Kinetic Energy Expected	< 700 J	< 34 kJ	< 1084 kJ	> 1084 kJ
Operational Scenarios	Intrinsic GRC			
VLOS/BVLOS over controlled ground area	1	2	3	4
VLOS outside of a population centre	2	3	4	5
BVLOS outside of a population centre	3	4	5	6
VLOS within a population centre	4	5	6	8
BVLOS within a population centre	5	6	8	10
VLOS over gathering of people	7			
BVLOS over gathering of people	8			

ARC-a ARC-b ARC-c ARC-d

SORA Process

Concept of Operations to Transport Canada

- Step 1: Determination of RPAS Intrinsic Ground Risk Class
- Step 2: Final GRC Determination
- Step 3: Determination of initial Air Risk Class
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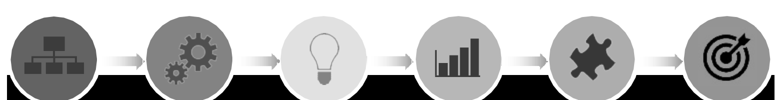
- Step 8: Finalize Comprehensive Safety Portfolio and determination of safety confidence

RPAS Authorization from TC

SAIL Determination				
	Final ARC			
Final GRC	a	b	c	d
1	I	II	IV	VI
2	I	II	IV	VI
3	II	II	IV	VI
4	III	III	IV	VI
5	IV	IV	IV	VI
6	V	V	V	VI
7	VI	VI	VI	VI
>7	Category C (Certified)			

BVLOS Discussion Questions

- Based on the GRC and ARC concepts, what risk environments (AECs) are the primary enablers of BVLOS commercialization within the next 3 years?
- Aside from the regulatory framework, what is limiting your organization from operating BVLOS today?
- What are the most significant strengths of the Canadian RPAS industry today?



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BVLOS Supplementary Questions

- Are there additional considerations in adapting the SORA model to authorize BVLOS operations in Canada?

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BVLOS Supplementary Questions

- Are there BVLOS approaches in other states that could be considered in the Canadian context?

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BVLOS Supplementary Questions

- How will this approach to adapt the SORA model impact your existing BVLOS concept of operations?

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RPAS Airworthiness and Certification

Drone Talks: Planning for Success

May 29th – 30th, 2019
Victoria Hall, Ottawa

Transport Canada Transports Canada

Canada

Executive Summary of White Paper

- Need to modernize aircraft certification processes
  - Accommodate emerging products and technologies, such as Remotely Piloted Aircraft Systems (RPAS) into a more adaptable framework that stimulates innovation while enhancing aviation safety.
- Outlines a proposed vision for establishing airworthiness
  - criteria Risk-based approach applicable to RPAS larger that
  - 25Kg Scalable to their kinetic energy and intended operational usage
  - Draws from proceedings by the Joint Authorities for Rulemaking of Unmanned Systems (JARUS).

Key Principles

- Employing a risk-based approach to approving and regulating operations.
- Performance-based airworthiness regulations supported by industry consensus standards.
- Supporting innovation, while also recognizing that the safety of the aviation system, the preservation of life, and the prevention of injury is paramount.
- Recognizing and preparing for increasing levels of automation and autonomy (i.e. scalability); includes consideration of the public and social acceptance.
- Harmonizing with international partners, where possible.
- Research & Development program provides input to regulatory development.

RPAS Categories

Category A: RPAS of less than 25Kg operated in VLOS.

- Addressed by Part IX, Subpart 1.
- Declaration by RPAS manufacturers meeting the SAFE requirements.
- Risk Based surveillance.

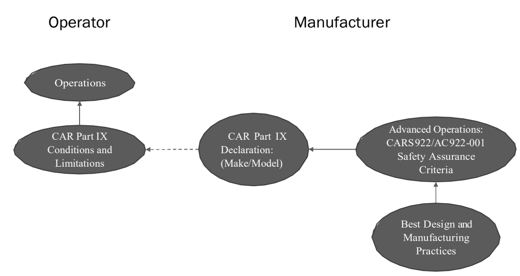
Category B: RPAS of 25Kg or more with kinetic energy less than 1084KJ operated in VLOS or BVLOS.

- RPAS flight authority regime (No Type Certification).
- Envisioned Category B may include RPA having a capacity to carry one passenger for private/non-commercial use only.
- New regulatory framework largely relying on robust design and manufacturing practices employed by RPAS manufacturers, a declaration of conformance to acceptable design standards and flight authority.

Category C: RPAS with kinetic energy of 1084KF or more operated in VLOS or BVLOS

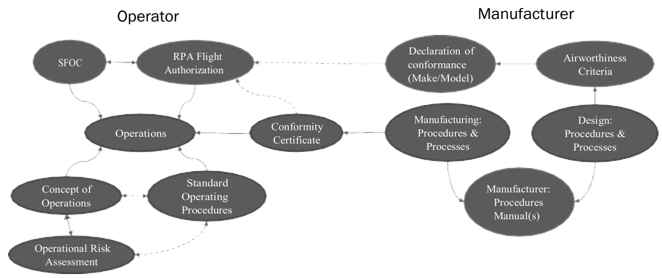
- Subject to a type certification process and issued a type certificate and flight authority.
- Leverage/amend existing regulations, policies and advisory material governing type certification to the maximum extent practical.
- Performance based requirements and industry consensus standards (e.g. 14 CFR Part 23-64, JARUS, ASTM, CS-UAS, etc.).
- Increasing levels of autonomy.
- Minimum Operational Performance Standards (MOPS) as applicable: Detect and Avoid (DAA), Command and Control (C2), etc.

Regulatory Model: Cat A RPAS



Regulatory Model: Cat B RPAS

Drone Talks: Planning for Success



Regulatory Model: Cat C RPAS

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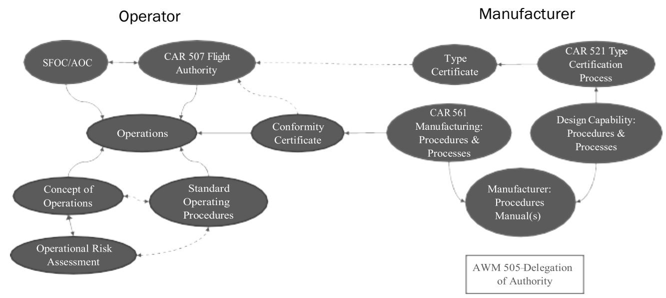

Notional Cat B RPAS Manufacturer Organisation

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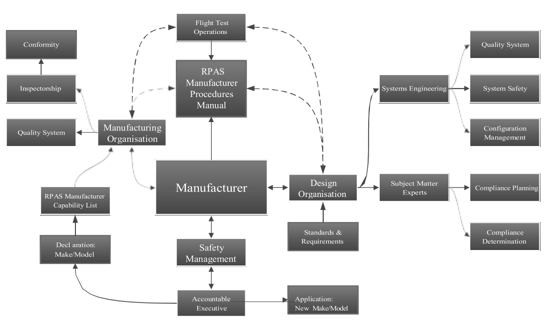

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Input from the Audience…

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- Would you support a risk based approach for RPAS airworthiness and/or operational approval? What is your rationale and what are the key impacts or considerations?
- Is the proposed RPAS Manufacturer Authorization process for category B RPAS, which places accountability largely on manufacturers, a reasonable approach? What are the key considerations and/or implications that TC should contemplate?
- Should a traditional Type Certification process be applied for category C RPAS? What key rationale, impacts or considerations would you highlight?

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Input from the Audience…

Drone Talks: Planning for Success

- What should the threshold(s) and/or parameter(s) be for delineating category B and C

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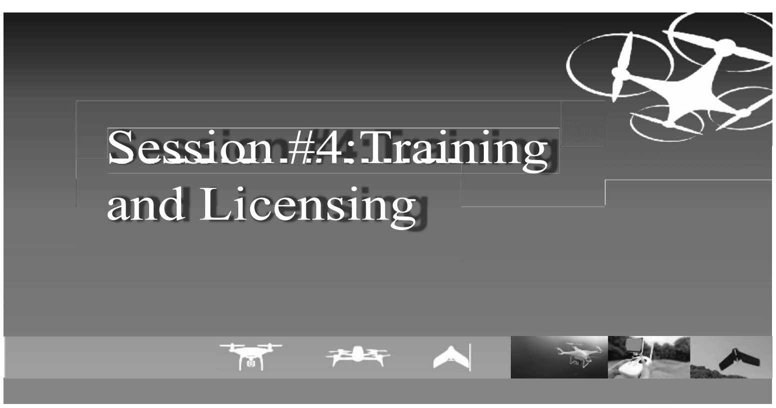

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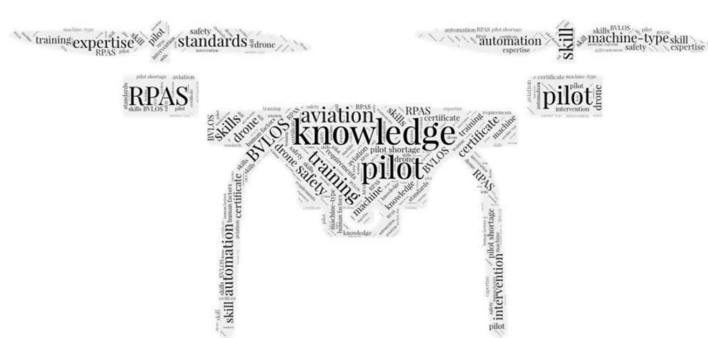

#CANDronePlan

2

Setting the scene

- Small RPAS VLOS regulations were published January 2019; TC's regulatory focus is now shifting to BVLOS and larger RPAS
- Risk-based approach necessitates different requirements for pilots flying larger machines and/or in complex environments
- Opportunity to leverage best practices from international partners (e.g., JARUS, FAA, Australian CAA) and assess work done through industry consensus standards (e.g., ASTM)

What will BVLOS pilot certification and training look like in the future?

Considerations

- Machine automation increasing
- Operations becoming more complex
- Economic opportunities and growth of industry
- Public acceptance
- Reconciling the traditional aviation approach with new industry entrants

Proposed Principles:

1. New RPAS pilots will need to integrate with the existing aviation environment.
2. Increased RPAS automation will change pilot participation, and may modify (though not remove) pilot knowledge requirements.
3. Increased RPAS automation will change pilot participation, and will alter pilot skill requirements.
4. Aviation and human safety remain paramount.
5. Human factors must remain a consideration when addressing pilot training and certification.

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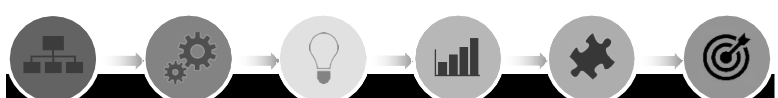

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Discussion Questions

1. What tasks do you foresee RPAS pilots performing in 5 years? 10 years? Do you expect a pilot's role(s) to change; if so, how? What is the knowledge and skill set that individuals will need to operate RPAS of the future?
2. How much additional knowledge and skill to you think is required to safely fly BVLOS compared to what is required under the existing VLOS certificate program? What additional knowledge or skills do you see as required?
3. At what threshold do you think a machine-specific training should be required for each RPA? What criteria (e.g., risk level, size or configuration of machine) should be used to determine this threshold?

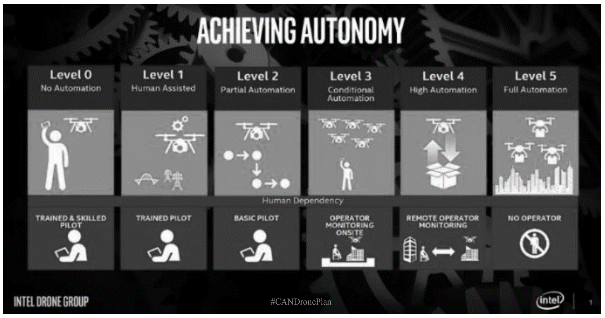
Additional Question

- Are there other approaches that you feel should be considered as we move forward on BVLOS licensing and certification?

Additional Question

- What do you see as the advantages and disadvantages of working within the training and licensing system of the existing Canadian Aviation Regulations vs. structuring a brand new program for RPAS pilot licensing and certification?

Intel Model



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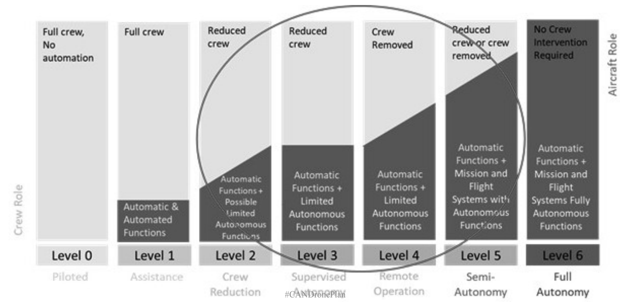
NRC Model



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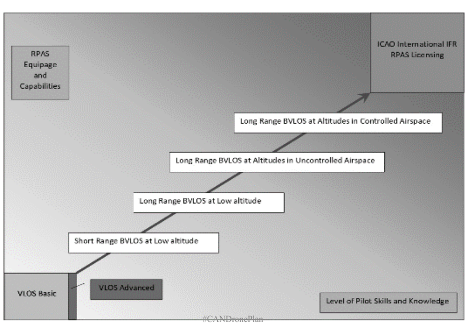
A Potential TC Model



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Appendix 9: R v. Shah

R v. Shah

Few judicial decisions exist in Canada relating to the operation of drones or RPAS. However, in *R v. Shah*, the Provincial Court of Alberta released its decision on the first reported case on drones in Canada.
While key charging section in this case has since been revised, this case is Canada's first in terms of the unique factors associated with drone operations.

On January 12, 2017, Mr. Shah recreationally operating a drone in a park in proximity to the Calgary International Airport (YYC). A Calgary police officer on patrol as a passenger in a police vehicle, noticed lights in the sky that he estimated to be at a height at or above the trees in the area. The Officer directed his partner to drive to the park where they saw Shah walking to his car with a drone. The police seized the drone and charged Shah under several provisions in the Criminal Code and the Canadian Aviation Regulations. Shah's drone weighed less than a pound.

Mark Wuenennberg, a Civil Aviation Inspector with Transport Canada, testified and supplied two primary risked posed by Shah flying his drone close to YYC: (i) loss of link; and (ii) "fly away":

1. Loss of link occurs where a drone loses connection with the device controller. Some models are equipped with special features that deal with loss of link by automatically returning the drone to its point of origin in the event of loss of link; and
2. "Fly away" refers to a situation where the device experiences a total loss of control and does not behave predictably. This type of problem occurs more often than may be expected. Mr. Wuenennberg testified that the occurrence rate for such instances could be as high as 40 percent with certain types of drones.

   These situations can be extremely dangerous. An operator losing control of their device without the proper safety features could potentially pose a significant risk to aviation safety. This is especially true in cases such as Shah occurring in close proximity to airports.

   In arriving at Judge Hawkes decision, it was stressed that Shah had been found guilty of creating a likely hazard to aviation safety. Shah's case seems to have served as deterrent to all recreational drone operators to stay away from airports, Canada's drone regulations are evolving[1].

   This case is an example of how the Crown only needs to prove beyond a reasonable doubt that an act violates the regulations. However, once the act is proven, the defendant can establish a due diligence defence or reasonable excuse on a balance of probabilities[2]. Drone operators must comply with the rules for operations as set out in the regulations and other applicable laws; they should also consider whether their conduct is reasonable in the circumstances.

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[1] Carrasco, E. *Canada: Case Summary: R v. Shah*, http://www.mondaq.com/canada/x/656936/Aviation/Case+Summary+R+v+Shah
[2] Dentons, *R v. Shah – Lessons learned from Canada's first drone case*, https://www.jdsupra.com/legalnews/r-v- shah-lessons-learned-from-canada-s-85388/

Appendix 10: Link to the Summary of Part 107

FAA News

Federal Aviation Administration, Washington, DC 20591

June 21, 2016

SUMMARY OF SMALL UNMANNED AIRCRAFT RULE (PART 107)

Operational Limitations	• Unmanned aircraft must weigh less than 55 lbs. (25 kg). • Visual line-of-sight (VLOS) only; the unmanned aircraft must remain within VLOS of the remote pilot in command and the person manipulating the flight controls of the small UAS. Alternatively, the unmanned aircraft must remain within VLOS of the visual observer. • At all times the small unmanned aircraft must remain close enough to the remote pilot in command and the person manipulating the flight controls of the small UAS for those people to be capable of seeing the aircraft with vision unaided by any device other than corrective lenses. • Small unmanned aircraft may not operate over any persons not directly participating in the operation, not under a covered structure, and not inside a covered stationary vehicle. • Daylight-only operations, or civil twilight (30 minutes before official sunrise to 30 minutes after official sunset, local time) with appropriate anti-collision lighting. • Must yield right of way to other aircraft. • May use visual observer (VO) but not required. • First-person view camera cannot satisfy “see-and-avoid” requirement but can be used as long as requirement is satisfied in other ways. • Maximum groundspeed of 100 mph (87 knots). • Maximum altitude of 400 feet above ground level (AGL) or, if higher than 400 feet AGL, remain within 400 feet of a structure. • Minimum weather visibility of 3 miles from control station. • Operations in Class B, C, D and E airspace are allowed with the required ATC permission. • Operations in Class G airspace are allowed without ATC permission. • No person may act as a remote pilot in command or VO for more than one unmanned aircraft operation at one time. • No operations from a moving aircraft. • No operations from a moving vehicle unless the operation is over a sparsely populated area. • No careless or reckless operations. • No carriage of hazardous materials.

	• Requires preflight inspection by the remote pilot in command.
	• A person may not operate a small unmanned aircraft if he or she knows or has reason to know of any physical or mental condition that would interfere with the safe operation of a small UAS.
	• Foreign-registered small unmanned aircraft are allowed to operate under part 107 if they satisfy the requirements of part 375.
	• External load operations are allowed if the object being carried by the unmanned aircraft is securely attached and does not adversely affect the flight characteristics or controllability of the aircraft.
	• Transportation of property for compensation or hire allowed provided that-
	  o The aircraft, including its attached systems, payload and cargo weigh less than 55 pounds total;
	  o The flight is conducted within visual line of sight and not from a moving vehicle or aircraft; and
	  o The flight occurs wholly within the bounds of a State and does not involve transport between (1) Hawaii and another place in Hawaii through airspace outside Hawaii; (2) the District of Columbia and another place in the District of Columbia; or (3) a territory or possession of the United States and another place in the same territory or possession.
	• Most of the restrictions discussed above are waivable if the applicant demonstrates that his or her operation can safely be conducted under the terms of a certificate of waiver.

Remote Pilot in Command Certification and Responsibilities	• Establishes a remote pilot in command position.
	• A person operating a small UAS must either hold a remote pilot airman certificate with a small UAS rating or be under the direct supervision of a person who does hold a remote pilot certificate (remote pilot in command).
	• To qualify for a remote pilot certificate, a person must:
	  o Demonstrate aeronautical knowledge by either:
	    ▪ Passing an initial aeronautical knowledge test at an FAA-approved knowledge testing center; or
	    ▪ Hold a part 61 pilot certificate other than student pilot, complete a flight review within the previous 24 months, and complete a small UAS online training course provided by the FAA.
	  o Be vetted by the Transportation Security Administration.
	  o Be at least 16 years old.
	• Part 61 pilot certificate holders may obtain a temporary remote pilot certificate immediately upon submission of their application for a permanent certificate. Other applicants will obtain a temporary remote pilot certificate upon successful completion of TSA security vetting. The FAA anticipates that it will be able to issue a temporary remote pilot certificate within 10 business days after receiving a completed remote pilot certificate application.
	• Until international standards are developed, foreign-

	certificated UAS pilots will be required to obtain an FAA-issued remote pilot certificate with a small UAS rating. A remote pilot in command must: • Make available to the FAA, upon request, the small UAS for inspection or testing, and any associated documents/records required to be kept under the rule. • Report to the FAA within 10 days of any operation that results in at least serious injury, loss of consciousness, or property damage of at least $500. • Conduct a preflight inspection, to include specific aircraft and control station systems checks, to ensure the small UAS is in a condition for safe operation. • Ensure that the small unmanned aircraft complies with the existing registration requirements specified in § 91.203(a)(2). A remote pilot in command may deviate from the requirements of this rule in response to an in-flight emergency.
Aircraft Requirements	• FAA airworthiness certification is not required. However, the remote pilot in command must conduct a preflight check of the small UAS to ensure that it is in a condition for safe operation.
Model Aircraft	• Part 107 does not apply to model aircraft that satisfy all of the criteria specified in section 336 of Public Law 112-95. • The rule codifies the FAA's enforcement authority in part 101 by prohibiting model aircraft operators from endangering the safety of the NAS.