# Lifting Off: Commercial Drone Services and Regulations in Canada

**by**

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# Abstract

The rudimentary and inefficient regulatory structure for remotely piloted aircraft systems (RPAS) in Canada, more commonly known as drones, is a barrier to economic development of RPAS industry and commercial services in Canadian markets such as package delivery and air taxis. This project provides an overview of existing RPAS provisions in the Canadian Aviation Regulations and other relevant background information to contextualize the discussion, including scholarly research and an industry scan for commercial RPAS services which indicates industry and market readiness. Then, a jurisdictional scan is conducted to explore RPAS regulations that have already been developed in other countries and regions - the International Civil Aviation Organization (ICAO), the European Union Aviation Safety Agency (EASA), and the United States Federal Aviation Authority (FAA) - to better understand industry needs and existing regulatory strategies and considerations. The project concludes with a multi-criteria analysis of three policy options for Transport Canada, Civil Aviation (TCCA) to consider: (1) maintain status quo, with minor enhancements, (2) reduce regulatory barriers & provide industry incentives, and (3) develop regulations to certify large RPAS & complex operations using large RPAS in urban areas. Based on the multi-criteria analysis, option (3) scored the highest and is the recommended policy for TCCA to implement in order to support RPAS industry and the adoption of RPAS commercial services in Canadian markets.



**Keywords**: RPAS; drones; regulations; urban air mobility; package delivery; air taxi

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Thank you to my mom for her unyielding support,

To my friends who could always make me smile,

To my dog, Mishka, for being the best doggo.

# Table of Contents

# List of Tables

# List of Figures

# List of Acronyms

| | |
|---|---|
| ACLR | Airworthiness Criteria for Large RPAS |
| BVLOS | Beyond Visual Line-of-Sight |
| CARs | Canadian Aviation Regulation |
| ConOps | Concept of Operations |
| D&R | Durability & Reliability process |
| DDC | Drone Delivery Canada |
| EASA | European Union Aviation Safety Agency |
| FAA | (United States) Federal Aviation Administration |
| ICAO | (United Nations) International Civil Aviation Organization |
| JARUS | Joint Authorities for Rulemaking of Unmanned Systems |
| NPA | Notice of Proposed Amendment |
| PDRA | Pre-defined Risk Assessment |
| ROC | RPAS Operator Certificate |
| RPAS | Remotely Piloted Aircraft System |
| SFOC | Special Flight Operations – Remotely Piloted Aircraft Systems Certification |
| SORA | Specific Operational Risk Assessment |
| TCCA | Transport Canada, Civil Aviation |
| UAM | Urban Air Mobility |
| UAS | Unmanned Aircraft System |
| VLOS | Visual-Line-of-Sight |

# Executive Summary

The current regulatory framework in Canada for remotely piloted aircraft systems (RPAS), more commonly known as drones, and complex commercial RPAS operations, such as package delivery or air taxis that require larger aircraft, is rudimentary and inefficient. Given the booming drone industry worldwide, the importance of regulations as an economic enabler, and currently operating commercial RPAS service providers that indicate industry and market readiness, Transport Canada, Civil Aviation (TCCA) must act with urgency to allow for these economic opportunities and technological innovations to develop unimpeded. In particular, TCCA must explore the concept of Urban Air Mobility, which is the integration of new technologies such as drones into urban communities, and establish a regulatory development approach that can support these new commercial services while remaining congruent with the Canadian context.

In order to better understand the problems and challenges associated with RPAS regulations, and where Canada and the RPAS industry currently stands, this paper began with a literature review of the Canadian regulatory framework and context, followed by an industry scan of relevant leading industry stakeholders. This informed the problem identification portion of the analysis, which revealed that Canada's regulatory framework is ill-equipped to enable complex RPAS operations, or the safe operation of large RPAS. It also indicated that the drone market is attracting billions of dollars of investment globally, and key industry leaders are already providing or in the process of establishing RPAS services such as package delivery and air taxis – marking strong industry readiness. Lastly, scholarly sources, in addition to consultation data gathered by TCCA, confirm that a lack of regulations are a significant barrier to economic growth, providing urgency for TCCA to act in order to enable these budding commercial RPAS services in Canadian markets and society.

Next, this paper conducted jurisdictional scans of other regions' regulatory documents and considerations for large RPAS and complex RPAS operations. The jurisdictional scan confirms existing understandings on the problem of RPAS regulations, such as the importance of the size of the aircraft and complexity of the operation, and highlights the importance of close collaboration with key industry stakeholders. The jurisdictional scan also revealed the many technical considerations and regulatory

approaches taken, which informed the development of policy options and criteria for options analysis.

Given these findings, three policy options are evaluated using multi-criteria analysis: (1) *Maintaining status quo, with minor enhancements*, (2) *Reducing regulatory barriers while providing industry incentives*, and (3) *Developing regulations to certify large RPAS & complex operations using large RPAS in Urban Areas*. The analysis establishes four criteria to evaluate which policy option should be recommended: (i) economic opportunity, (ii) stakeholder acceptance, (iii) implementation timeline, and (iv) cost to government, with the first two criteria receiving doubled points-weighting due to their relevance and significance. option (3) *Developing regulations to certify large RPAS & complex operations using large RPAS in urban areas* scored the highest, and thus is the recommended policy option for TCCA to implement.

# Chapter 1.

# Introduction

## 1.1. Problem Statement

The current regulatory framework in Canada for the safe and legal use of large remotely piloted aircraft systems (RPAS), more commonly known as drones, and complex commercial RPAS operations, such as package delivery or air taxis that require larger aircraft, is rudimentary and inefficient. This poor regulatory structure – particularly the Special Flight Operations certification (SFOC), which is the only path to certification of large RPAS and complex RPAS operations – is a significant barrier to economic opportunity and technological development of the RPAS industry in Canada, due to regulatory unpredictability for industry stakeholders (Transport Canada, 2020; Olsen, 2017; Dalamagkidis et. al., 2010). As a result, large RPAS and complex RPAS operations are on the rise in other countries that have regulations in place, such as the United States, while Canada's development is stifled. **Transport Canada Civil Aviation (TCCA), the regulatory authority for aviation in Canada, must consider developing new regulations or a new approach for large RPAS and complex RPAS operations to allow for this economic and technological innovation to develop unimpeded, while ensuring a high level of safety.**

## 1.2. Framing & Scope

This paper focuses on identifying and understanding regulatory challenges regarding a new area of aviation, Urban Air Mobility (UAM), which sees the use of large RPAS conducting complex operations in urban environments. Commercial drone services such as package delivery or air taxis rely on operating large RPAS in urban environments due to the need for these aircraft to carry heavy payloads, indicating the need to develop regulations to allow for the safe adoption of these services into society. This specific gap in drone aviation conceptions and regulations is explored in this paper to identify how TCCA can move forward to address these public policy concerns in Canada. As such, this paper will not spend time on the numerous other areas of RPAS aviation issues and considerations, such as small RPAS or military drones, unless they

contribute to or are relevant to the topic of commercial RPAS services in urban areas using large RPAS.

### 1.2.1. Size & Complexity as Primary Considerations

There is a myriad of RPAS that are used for different purposes, from agriculture and surveillance to photography and other arts, to goods delivery and military uses. The characteristics of the aircraft, particularly its size and weight, will vary based on its intended usage. For example, RPAS used for photography are typically small and lightweight because they only need a mounted camera and should be agile, while military drones are large and heavy because they carry weapons and need to be powerful enough to fly high in the sky. The type of operation that an RPAS is intended to carry out also contains different levels of safety risk, which reflects the level of complexity of the operation. For example, RPAS used for photography in the middle of a forest is a non-complex operation because the risks of injury to persons or property are low, while the same RPAS used for photography in the middle of a city is more complex because the same risks are higher. These factors - size and complexity - are the two primary considerations when conceptualizing the spectrum of RPAS regulations. Simply put, as the size of the RPAS and complexity of the intended operation increases, the safety risks also increase, thus warranting more restrictive and comprehensive regulatory frameworks to ensure safety. As we will see in the background section and jurisdictional scans, this fundamental understanding of the importance of size and complexity is consistent throughout regulatory conceptions in Canada and other regions.

### 1.2.2. Large Drones & Complex Operations

The focus of this research will be on large drones intended to conduct complex operations, namely package delivery and air taxis, in urban environments. In the global regulatory context, this is the next frontier of RPAS regulations because non-complex operations using small drones already enjoy regulatory provisions in many countries, including Canada. Developing regulations for such operations is simpler because of the lower safety risks and less advanced technology that is required. In contrast, regulations governing the use of large RPAS for complex operations require more careful thought and planning to ensure a reasonable level of safety. For example, regulations governing large drones may need safety technology such as automated detect-and-avoid systems

to reduce the chance for crashes, while requiring the same technology for a small drone would be overburdening because the small drone does not pose the same level of safety risk in the event of a crash. However, if the same small drone was intended to operate above people, regulations could then require more comprehensive safety technology such as a detect-and-avoid system, if the risk assessment warrants it. Already, we see the difficulty regarding the development of reasonable restrictions and expectations, especially for an area of aviation that is so new and unmatured. As such, this project sets out to better understand the considerations and challenges regarding the regulation of large drones conducting complex operations to determine how Canada should move forward with its regulatory approach to be able to safety adopt these aircraft, and the commercial services they are intended to provide, into Canadian markets and society.

### 1.2.3. Urban Air Mobility

An effective framing for these challenges is expressed in the Concept of Operations (ConOps) for Urban Air Mobility (UAM) in the United States, described in detail in Section 4.3.1 of this paper. In this ConOps, the Federal Aviation Authority (FAA) describes “the envisioned operational environment that supports the expected growth of flight operations in and around urban areas” in order to “develop an air transportation system that moves people and cargo [in] places previously not served or underserved by aviation using revolutionary new aircraft,” drones (FAA, 2020). This concept of UAM provides the baseline of considerations for the ‘next level’ of aviation, which sees the integration of RPAS and relevant services into urban communities. As such, this is an extremely significant regulatory undertaking that may require a complete reconceptualization of aviation rules and processes as they are currently understood (FAA, 2020). For example, new air traffic management systems and infrastructure will need to be developed to support a safe UAM environment.

### 1.2.4. Commercial Services

Another relevant facet of consideration is the focus on commercial services. Allowing the adoption of commercial drone services such as package delivery or air taxis is one of the primary motivators for regulatory authorities to develop more comprehensive RPAS regulations, since the lack of regulations obstructs economic opportunity and the realization of public benefits through increased or improved services.

Many commercial RPAS services cannot be provided if there are no regulatory structures in place to safely allow them, as they will often require the use of large drones operating in urban environments. As we will see in the review of the Canadian Aviation Regulations (CARs), the regulatory structure supporting such aircraft and operations in Canada is present but inefficient and rudimentary due to a lack of structure and predictability for industry stakeholders. This provides the economic and public motivation to allow for these economic opportunities to flourish and for the public to access and benefit from the new services. Although the focus for this paper is package delivery and air taxis, other commercial services or aircraft that are relevant under the conception of UAM would benefit, such as the use of RPAS at urban construction sites.

### 1.2.5. Public Acceptance & Ethical Considerations

The above considerations and framing are primarily focused on the economic perspective of these issues: loss of potential commercial services, loss of revenue or economic opportunity, the benefit of regulations for commercial operations, and so forth. It should be noted that other important considerations such as public acceptance and ethics are present in these discussions, but are not prioritized in this analysis. For example, a common public consideration is the level of noise that is produced by a drone; commercial services such as package delivery in an urban area, regardless of economic benefits, must take noise levels into account in respect of the general public. This particular point on noise levels is supported by consultation and industry expectations (Transport Canada, 2021; Amazon, 2022). Another relevant ethical consideration is privacy concerns related to drone services in urban areas: some individuals may not be comfortable with drones flying near or over their property, especially if the drones are equipped with camera technology. These considerations are important from a regulatory perspective, but have been deprioritized in this analysis as the focus of this research is on economic impacts and the role of regulations as an enabler of commercial operations. These considerations are still included in the multi-criteria analysis, however, they play a small role in the overall scoring, which is reflective of the deprioritization of these considerations throughout the literature.

### 1.2.6. Boundaries of the Analysis & Recommendations

This analysis *will not* undertake a comprehensive overview of the substantial regulatory language employed by other jurisdictions with the intent to inform how Canadian RPAS regulations should be written, i.e., this paper does not write new regulations. However, recommendations are made that include high-level technical regulatory strategies observed throughout the research that may be applicable in Canada. Additionally, this analysis provides an overview of regulations with the intent of exploring global progress (and potential Canadian backwardness), and current problem identification and basic conceptualization of RPAS regulatory concerns, in order to inform how TCCA should approach RPAS regulatory development within the Canadian context. Furthermore, this analysis aims to reveal industry readiness and subsequent urgency for regulatory responses.

Another facet of RPAS issues that go beyond the boundaries of this analysis are questions on pilot certifications. It is assumed that all the provisions and recommendations of this paper would or do include requirements for adequate training and certification for pilots. While pilot certification is an important factor in general, it is not necessarily relevant to the discussions of this paper, which focus on large RPAS and complex operations from a commercial perspective.

## 1.3. Roadmap

This paper is structured as follows: first, background is provided on the current state of RPAS regulations in Canada and the readiness of industry through an industry scan of commercial services using large RPAS; second, jurisdictional scans are conducted on regions that are leading the development of drone regulations and adoption of commercial drone services, namely the International Civil Aviation Organization, the European Union Aviation Safety Agency, and the United States, to assess the comparative policy landscape and inform the method of policy analysis; third and lastly, a multi-criteria analysis is conducted to identify and evaluate policy recommendations.

# Chapter 2.

# Methodology

After structuring the problem, the research proceeded to do a review of the literature on the subject, including context on the existing Canadian regulatory framework and an industry scan, then a jurisdictional scan on other countries and their experiences with RPAS regulation. The literature review and jurisdictional scan informs the multi-criteria analysis that follows. These three steps became fundamental to identifying and assessing the policy options on how Canada may move forwards with regulations for large RPAS and complex RPAS operations in urban areas. Note that conceptual findings from the jurisdictional scans have already been employed in previous sections to inform framing and relevant considerations, such as the importance of size and complexity.

## 2.1. Jurisdictional Scans

The primary purpose of the jurisdictional scan is to shed light on how other countries or regions are approaching regulatory challenges associated with large RPAS and complex RPAS operations. Countries and regions were selected based on their progress with RPAS regulations and technology, and the level of partnership or regulatory congruence that exists between them and Canada. This information was gathered through government and regional websites. The jurisdictional scans also provide a high-level overview of technical regulatory information that will inform recommendations and contribute to future developments in this sector.

## 2.2. Multi-Criteria Analysis

A multi-criteria analysis is employed to undertake a robust analysis of policy options. A multi-criteria analysis utilizes criteria that are selected based on objectives identified by regulatory authorities, including TCCA, and information gathered throughout the literature review, jurisdictional scans, and industry case studies. These criteria and their measures are described and rationalized during the multi-criteria analysis section of the paper.

## 2.3. Limitations

This analysis would have benefitted from accessing internal TCCA data such as pending SFOC applications, consultations with key industry stakeholders, and internal policy considerations. However, this data is either very difficult to access for a graduate student, or simply unavailable to the public. These limitations restrict the analysis and recommendations that are possible and relevant, but could not be reasonably obtained by the researcher. The same can be said about conducting open-ended interviews to key policy makers, whom in most cases are not authorized to speak publicly about this issue. If RPAS regulatory development is further pursued by TCCA, the findings and analysis produced in this project can be combined with internal data to inform a regulatory approach that is congruent with the Canadian context.

# Chapter 3.

# Regulatory Background & Industry Context

## 3.1. Canadian RPAS Regulatory Context

Currently within the Canadian Aviation Regulations (CARs), there are numerous restrictions on the types of RPAS that can be piloted and operations that can be conducted with RPAS. Most regulations refer to the use of small RPAS, which have a maximum take-off weight between 250g (0.55 pounds) and 25 kg (55 pounds). To legally operate RPAS that exceeds 25 kg, which will be referred to as 'large RPAS' in this analysis, the operator must gain a Special Flight Operations – Remotely Piloted Aircraft Systems Certification (SFOC). In regard to operations conducted using large RPAS, restrictions are generally based on: the proximity of the operation to people and buildings (altitude and horizontal distance), the types of payloads that the RPAS is transporting (e.g., hazardous materials), and whether the RPAS is being operated within visual line-of-sight (VLOS) of the pilot or a designated visual observer. Transporting living creatures and operating an automated RPAS that does not allow for a pilot to take immediate control of the aircraft are currently prohibited.

The remainder of this section provides more detail on the regulatory framework for RPAS that currently exist in the CARs, which is important for understanding barriers and areas for regulatory expansion as the analysis progresses. A table at the end of this section provides a summary of the information.

### 3.1.1. Basic and Advanced Operations – Small RPAS

Provisions for the operation of small RPAS (drones weighing less than 25kg) are divided into Advanced and Basic Operations (Canadian Aviation Regulations, §901.53-§901.73). Advanced Operations refer to operations that occur:

1. At a distance of less than 100 feet (30 m) but not less than 16.4 feet (5 m), measured horizontally and at any altitude, from another person unless they are involved in the operation.

2. At a distance of less than 16.4 feet (5 m) from another person, measured horizontally and at any altitude.
3. Within a controlled airspace or within three nautical miles from the centre of an airport or heliport.

Basic Operations refer to operations that are not intended to conduct any of the advanced operations mentioned above. In short, Advanced Operations are 'advanced' because they are occurring in close proximity to people or in a location where other aviation operations may be occurring (an airport/heliport) – they are higher risk operations. Basic Operations, then, are lower-risk operations that occur far away from people or other operations.

### 3.1.2. Special Flight Operations Certificate – Remotely Piloted Aircraft Systems Certification (SFOC)

The SFOC is a 'catch-all' certification which provides the provisions for the operation of RPAS that go beyond the Basic and Advanced Operations using small RPAS described above. When applying for an SFOC, the applicant must provide information to TCCA such as the intent of the operation, the aircraft being used, information about the operator, safety plans and emergency procedures, and so on (Canadian Aviation Regulations, §903.02). An SFOC must be issued if the intended operation includes:

1. The operation of an RPAS having a maximum take-off weight of more than 25 kg (55 pounds).
2. The operation of a system beyond visual line-of-sight (VLOS) of the pilot.
3. The operation of a system by a foreign operator or pilot who has been authorized to operate RPAS by the foreign state.
4. The operation of a system at an altitude greater than 400 feet above ground level or 100 feet above any building or structure.
5. The operation of a system where the aircraft is transporting hazardous payloads (e.g., explosive or corrosive materials) or weaponry.

Although the SFOC is a useful provision to have during the very early stages of RPAS regulatory development, where a comprehensive regulatory framework or approach has yet to be determined, the progress and innovation of the RPAS industry and other

regulatory authorities indicates that movement beyond this wide-encompassing, unstructured approach of the SFOC to a more comprehensive and predictable regulatory structure would be beneficial. The lack of structure in the current SFOC process – i.e., the lack of provisions for large RPAS aircraft or operations – results in unpredictability for applicants who are unsure of what compliance may entail, or whether compliance is even possible. This rudimentary provision for large RPAS and complex RPAS operations is the primary motivation for action, and the fundamental regulatory barrier to economic opportunity and innovation in this brand-new area of aviation.

The table below summarizes the current regulatory framework for RPAS in Canada. Note that not all regulations are mentioned in the interests of brevity and simplicity – for example, provisions about pilot certifications were omitted. Only the regulations which are pertinent to the topic of large RPAS and complex operations are included.

**Table 3.1. Summary of Canadian RPAS Regulations**

| State of Regulation | Restrictions for the Aircraft | Restrictions for Operations |
|---|---|---|
| **Allowed, with certification under Basic or Advanced Operations** | Maximum take-off weight between 250 g (0.55 pounds) and 25 kg (55 pounds). | Is not conducted at an altitude greater than 400 feet above ground level or 100 feet (30 m) above any building or structure if the aircraft is being operated at a distance of less than 200 feet (61 m) from the building or structure;<br><br>Is not conducted at a distance of less than 100 feet (30 m) or 16.4 feet (5 m) from another person, measured horizontally from any altitude, unless that person is involved in the operation or unless the manufacturer of the RPAS has issued the necessary declaration for that aircraft model;<br><br>Conducted within VLOS of the pilot;<br><br>Does not include the transportation of hazardous materials. |
| **Allowed, with certification under Special Flight Operations Certification (SFOC)** | Maximum take-off weight beyond 25 kg (55 pounds). | Conducted at altitudes greater than 400 feet above ground level or 100 feet above any building or structure;<br><br>Conducted beyond visual line-of-sight (BVLOS) of the pilot;<br><br>Includes the transportation of hazardous materials. |
| **Prohibited** | Operation of a fully automated RPAS that does not allow for the pilot to take immediate control of the aircraft. | Transportation of living creatures. |

### 3.1.3. Current Initiative: Certification of Lower-Risk Operations Beyond Visual Line-of-Sight (BVLOS)

In an effort to reduce industry barriers, stimulate innovation, and pave a path forward for more complex RPAS operations, TCCA's current initiative is to provide

amendments to the CARs to enable routine lower-risk operations - such as delivering supplies to remote communities, first responder operations, natural resources and wildlife surveys, and infrastructure inspections – to occur BVLOS of the pilot without the requirement for a SFOC. The VLOS restriction was identified as an irritant by industry stakeholders in consultations conducted by TCCA, and TCCA recognizes that there is a unique potential for BVLOS operations in Canada, particularly in economic sectors such as oil and gas and deliveries to remote communities or rural areas (Transport Canada, 2020).

To do this, TCCA is proposing to introduce an RPAS Operator Certification (ROC) based on certain operational requirements that are scalable to the size, nature, and complexity of the operations, activities, hazards, and risks associated with the RPAS operation. TCCA plans on observing various thresholds that would trigger the requirement for an ROC, including the weight of the RPAS, the size of the organization, the geographical distribution of the organization, the number of pilots, and the size of the RPAS fleet. The purpose of this is to create a framework for an organization or an individual pilot to have certain elements and processes in place to ensure that risks are being managed, such as standard risk mitigation practices, standard operating procedures, and adequate safety staffing responsibilities (Transport Canada, 2020).

Removing the need to acquire an SFOC to conduct operations BVLOS through an ROC indicates the perceived benefit by TCCA and industry stakeholders of bypassing the SFOC. Although the SFOC is an effective way to provide a broad avenue to the certification of complex operations or the use of large RPAS in the early regulatory stages, it is inefficient and unpredictable, and lacks the proper structures and framework to ensure safe operations and processes for complex operations. This current proposal by TCCA is a necessary first step to opening the door to more complex operations such as door-to-door deliveries or the transportation of passengers, as these operations would likely need to occur with the RPAS operating BVLOS of the pilot. Although the current proposal only covers lower-risk operations, TCCA plans to address the more complex operations noted above in a future amendment (Transport Canada, 2020). TCCA can benefit from this analysis when attempting to address these more complex considerations as the next step in its regulatory strategy.

### 3.1.4. Canadian Ownership Requirement: Canada Transportation Act

There are certain provisions of the Canada Transportation Act, namely §55, §57 and §61, that would apply to RPAS when they are carrying cargo or passengers (i.e, providing an air service as defined in the Act). Most importantly, an RPAS operator providing an air service is subject to the Canadian ownership and economic licensing provisions of the Act, meaning that the operator must be 51% controlled by Canadians and also requires the operator to hold an economic license issued by the Canadian Transportation Agency (Transport Canada, 2020). Irrespective of the purpose or benefits of these ownership provisions, they act as a barrier to foreign operators providing air services in Canada. From the perspective of commercial RPAS services, foreign businesses looking to provide air services such as cargo delivery or air taxis will face challenges if they cannot meet the ownership standard in the Act, which has a negative impact on the ability for Canadian markets to adopt these new services and technologies.

### 3.1.5. International Civil Aviation Organization (ICAO) Membership

Canada is one of the original 52 member states of the ICAO, which is the United Nations agency responsible for the safe and cooperative development of international civil aviation. TCCA works closely with ICAO to ensure that Canada's interests and positions are represented on the international stage. TCCA provides technical expert assistance to ICAO in the development of standards and recommended practices, which are recommended to member states across the globe. TCCA is committed to promoting ICAO as a leading organization in advancing aviation safety and cooperation worldwide (Government of Canada, 2010; Transport Canada, 2022).

Based on these commitments, Canada has a responsibility to support ICAO objectives, which includes the development of RPAS regulations that are internationally harmonized. Canada also has a reputational interest in demonstrating competence and coordination with aviation regulations on the international stage, especially given Canada's involvement with ICAO, including being the host of ICAO's Unmanned Aviation Symposia 2022, and housing the headquarters of ICAO in Montreal, Quebec (ICAO, 2023).

### 3.1.6. Transport Canada Regulatory Priorities

Transport Canada is committed to developing new ways to manage risk and modernize legislative, regulatory, and policy frameworks. Since 2018, Transport Canada has been working with the Innovation Centre to help develop regulations and manage risks by:

1. Evaluating new, emerging and disruptive technologies.
2. Generating knowledge, skills and data about these new technologies, and
3. Sharing results inside and outside of government (Transport Canada, 2021).

These regulatory commitments and partnerships are congruent with the objective of supporting RPAS regulations and markets, which are a new, emerging, and disruptive technology that requires research and collaboration across sectors.

## 3.2. Industry Scan

One of the primary motivating factors for the development of large RPAS and complex operations regulations is the enabling of economic opportunity and technological innovation, now and in the future. This section conducts an industry scan for large drones and complex operations to demonstrate market anticipation and industry readiness, whose economic benefits can be enabled in Canadian markets through better regulations.

### 3.2.1. Global Investment and Market Share Forecasts

Drone technology is making its way into almost every industry, with massive investments from companies and venture capitalists. Much of the market research and forecasting that has been completed on drones can only be accessed through purchase, making their use unavailable for this analysis. However, it is clear from numerous estimates and journalistic articles that drones are beginning to grow across a multitude of industries and is attracting billions of dollars of investment. Although some these estimates are not exclusive to large drones, it still indicates the growing use and economic benefit of drones, especially for commercial services:

- Dronegenuity released an article in 2020 indicating over 120 potential commercial drone use applications, from hospitality and restaurants to healthcare and disaster relief, to retail and delivery services (Dronegenuity, 2020).
- Forbes notes the US$5 billion investment in drone aircraft development between 2020 and 2022, which has led to the development of 170 different air taxi, cargo, and vertical take-off-or-landing craft by almost 130 different companies (Forbes, 2022).
- The drone package delivery system market size in Canada is estimated to be US$43 million in 2019, forecasted to reach US$1.68 billion by 2030 (Statista, 2022).
- Various market reports estimate global drone market sizes, ranging from:
    - US$2.7 billion in 2020, forecasted to reach US$21.7 billion by 2030 (Business Wire, 2020).
    - US$7.7 billion in 2022, forecasted to a readjusted size of US$17.5 billion by 2028 (Global Newswire, 2022).
    - US$13.44 billion in 2020, forecasted to reach US$501 billion by 2028 (Grand View Research, 2021).

Additionally, up-and-coming technologies such as 5G networks are expected to provide significant growth opportunities in the drone market through high-speed internet that expands the range of drones to remote or difficult terrains and reduces barriers to automated flight (Grand View Research, 2021). This research indicates that the drone industry is attracting billions of dollars of investment globally and is expected to grow further as technology evolves and operations gain regulatory approval.

### 3.2.2. The Importance of Regulations as an Economic Enabler

One of the most significant enablers of drone technology and economic innovation are regulations. When the United States' civil aviation regulatory authority, the Federal Aviation Administration (FAA), granted exemptions for companies to operate drones in 2016, drone industry growth advanced considerably due to the consumer drone registry and coherent guidelines regarding safe and legal operation (Insider Intelligence, 2022; Grand View Research, 2023). TCCA already recognizes the importance of developing regulations for enabling economic innovation, especially for complex operations such as air taxis or package delivery that typically require the use of larger, heavier drones operating in urban environments (Transport Canada, 2020;

Transport Canada, 2021). In its consultation with RPAS users from various industries such as agriculture, mining, and law enforcement, TCCA observed that 80% of industry stakeholder respondents identified the lack of regulations in Canada as a barrier to economic growth (Transport Canada, 2020).

Scholarly discussions on aviation regulations also emphasize the importance of regulations as an economic enabler. Olsen (2017) makes the argument that “safety regulation promotes aviation commerce” by pointing to the historical example of the US, whereby safety regulation of civil aviation in 1926 brought about the growth of commercial aviation companies such as airlines and manufacturers, which allowed the aviation industry to thrive. Olsen maintains that drones can see similar results through regulatory development (646-647). Olsen specifically notes the feasibility of drone package deliveries by Amazon, with regulatory support being the single inhibiting factor for their introduction into US airspace (650); as we will see in this analysis, regulatory cooperation between the FAA and Amazon did indeed enable commercial package delivery services to occur. Dalamagkidis et. al. (2010) echo these arguments by pointing to the failure of regulatory authorities across the globe to support the expansion of drones into civil and commercial domains by pointing to their “limited and/or restrictive” regulatory frameworks (3; 6).

### 3.2.3. Industry Stakeholders: Complex Operations Using Large Drones

The following section provides examples of industry stakeholders who engage in complex operations using large drones to demonstrate that these operations and technology are already being developed and implemented today commercially. These business innovations provide the motivation for TCCA to develop regulatory frameworks to facilitate the safe and legal implementation of complex drone operations using large drones in urban areas. The examples used, two of which are from the US, also illustrate the importance of collaboration between regulatory authorities and key industry stakeholders. Lastly, these examples indicate industry readiness to provide commercial RPAS services using large drones.

### *Amazon Prime Air: Package Delivery*

One of the most promising examples of commercial use of large drones is Amazon's drone delivery project. Amazon Prime Air promises to make drone deliveries of ordered packages a reality, with deliveries made directly to the consumer's backyard. The service is in the process of being launched in Lockeford, California, where Amazon has worked with local authorities and the FAA to earn an air carrier certificate - an established regulatory requirement to engage in this complex drone activity (Amazon, 2022), which will be explored in the US jurisdictional scan (Section 4.3.2).

It should be noted that Amazon Prime Air is not the only business in the United States developing RPAS delivery service business models and aircraft. As will be described in more detail in the US jurisdictional scan, there are a multitude of businesses, including big names like UPS, which have also received air carrier certification or are in the process of having their designs and applications reviewed (FAA, 2022). Additionally, the FAA has completed 15 environmental assessments of drone operation proposals, many of which are for package delivery operations and were found to have no significant impact. This increases industry confidence to develop and conduct RPAS delivery services in the US and indicates the feasibility of adopting complex operations in highly populated urban areas in the near future (FAA, 2022).

#### Amazon Prime Air Technology

Amazon uses the MK27-2 aircraft for its deliveries in Lockeford, developed internally by Amazon. The MK27-2 can reach speeds of 80km/h and can carry a maximum of 2.2kg. An advertised selling point of the aircraft is the low amount of noise it produces, as it is "generally quieter than a range of sounds you would commonly hear in a typical neighbourhood," making it more publicly acceptable for use in urban areas. Amazon also unveiled its newest development in November 2022, the MK30, which is 25% quieter than its predecessor and has an increased range (Amazon, 2022).


**Figure 3.1. Amazon Prime Air MK27-2**
Retrieved from *Freight Waves*, November 2022.

### *Drone Delivery Canada (DDC)*

DDC is a company focused on designing, developing, and implementing commercially viable drone systems. DDC has developed drone aircraft and software to support these efforts. Their aim is to support governments, remote communities, and commercial or industrial applications such as emergency services, last-mile delivery, agriculture, and more (DDC, 2023). In partnership with the University of British Columbia's Faculty of Medicine, DDC has been transporting a variety of cargo, including dangerous goods, to the Stellat'en First Nation and the Village of Fraser Lake in British Columbia (DDC, 2022).

DDC is the first publicly traded drone delivery company that has been granted a domestic cargo license under the Canada Transportation Act, which is mandatory for any air carrier intending to provide scheduled, commercial air services in Canada, including the carrying of cargo or passengers (DDC, 2021); this is the same provision discussed in Section 3.1.4 as a potential barrier to foreign operators. DDC is also the only RPAS operator to obtain certification for the transportation of dangerous goods (DDC, 2022).

The certifications, operations and technology that DDC has obtained and developed are a strong indication of industry preparedness for complex RPAS operations in Canada. Additionally, TCCA should recognize that DDC is a key industry stakeholder of RPAS in Canada, given the maturity of their operations and their leading position in the Canadian market.

**DDC Technology**

DDC utilizes the virtual flight management software “FLYTE” to conduct operations (DDC, 2023). All DDC flights are overseen from the Operations Control Centre in Toronto, Canada, where RPAS operators monitor flights using data from FLYTE, including commercial air traffic, weather, and other sensor data. Apart from this 24/7 monitoring, all DDC drones operate autonomously. Flights are supposed to land on allocated ‘DroneSpot’ infrastructure points (DDC, 2023), however, there is little explanation on what this infrastructure entails beyond media reports that developers must supply a footprint of 30-35 feet for the drone spot (Kucharsky, 2021).

DDC has three different RPAS models for its operations: the Sparrow, the Canary, and the Condor. The Sparrow and Canary are similarly designed: both have a maximum range of 20km, are electrically powered, and can carry a maximum payload of 4kg with a maximum take-off weight of 24.5 and 25 kg respectively – as such, these are still considered ‘small RPAS’ under the CARs. The Condor is a larger model in comparison, with a range of 200km, a maximum payload of 180kg with a maximum take-off weight of 476kg, and is gas-powered (DDC, 2023). While the Sparrow and Canary can carry out short-range delivery operations, the Condor is currently being tested and developed to enable farther and heavier deliveries.


**Figure 3.2. DDC Sparrow**
Retrieved from *Vertical Magazine*, March 2023


**Figure 3.3. DDC Canary**
*Cision*, September 2022.


**Figure 3.4. DDC Conodor**
Northern Ontario Business, October 2020

### *Joby Aviation: Passenger Transport (Air Taxi)*

Joby Aviation has proposals of air taxi routes in New York City and Los Angeles, which would occur between airports within each city respectively. Joby boasts that an air taxi flight between a downtown heliport and the JFK Airport in New York would take 7 minutes, while driving would take 49 minutes. The flights would be carried out by its four-passenger electric-powered vehicle, which is piloted on-board, and is expected to be certified by the FAA by 2024 (Joby Aviation, 2023). In 2022, Joby received its Part 135 Air Carrier Certificate, which allows Joby to operate a commercial air taxi service. Joby also received airworthiness approval from the US Air Force in December 2020 through its use of military testing facilities, but still requires full FAA approval of its aircraft to conduct commercial operations. Joby has also applied for certification of its aircraft in Japan as of October 18, 2022, as Japanese and US regulatory authorities reached an agreement to deliver a streamlined approval process for US applicants in Japan (Joby Aviation, 2022). This foreign approval process indicates a potential regulatory strategy for the approval of large and complex drone operators in Canada.

**Figure 3.5. Joby Aviation S4**
Retrieved from *Electric VTOL News*, March 2023. The S4 is electrically powered, can carry four passengers, has a max range of 240km, and can reach speeds of up to 320 km/h

In regards to business investments and partnerships, Delta Airlines Inc. invested $60 million in Joby as of October 11, 2022, and may increase investments up to $200 million if certain milestones are achieved during the partnership (Bloomberg News, 2022). Additionally, Joby has expanded its partnership with Uber, which will allow for the integration of aerial ridesharing services into the Uber app, and also partnered with engineers from Toyota to assist with factory layouts, manufacturing process development, and high-volume production (Joby Aviation, 2023). These partnerships and investment commitments indicate high economic confidence for air taxis in the US.

Air taxis are slightly further in the future compared to package delivery, due to the higher risks associated with transporting people, the need for larger and heavier aircraft, and more complicated operations and technologies. However, these operations proposals, technological developments, high business investments, and growing certifications indicate a promising future for the introduction of commercial air taxi services in urban areas. In regards to the spectrum of RPAS progress, TCCA recognizes that the so-called “last-mile delivery” that Amazon is undertaking is a highly anticipated

drone commercial service in Canada, which will then provide the regulatory preconditions expected to be necessary for the safe adoption of air taxis (Transport Canada, 2021).

### 3.2.4. Lower Emissions

All of the aircraft models mentioned above, excluding the DDC Canary, are electrically-powered aircraft. Many of the aircraft or vehicles that conduct delivery or taxi operations currently are gas-powered. If RPAS commercial services are enabled in Canada, their adoption can lead to lower greenhouse gas emissions. Given the prevalence of delivery and taxi services in our communities today, this can potentially become a significant reduction of emissions. The potential for reduced emissions puts the supporting of RPAS regulations and industry in even greater alignment with TCCA objectives and public responsibility. Additionally, reduced greenhouse gas emissions improve the economic viability and attractiveness of RPAS as a new form of transportation.

# Chapter 4.

# Jurisdictional Scans: Regulations Across the Globe

The following section conducts jurisdictional scans of states and regional organizations who have published regulatory documents or considerations for RPAS. Particular attention is paid to jurisdictions that discuss the regulation of large RPAS or complex operations. This analysis will review three jurisdictions: the United Nations International Civil Aviation Organization (ICAO), the European Union Aviation Safety Agency (EASA), and the United States Federal Aviation Agency (FAA).

## 4.1. International Civil Aviation Organization (ICAO)

ICAO is the UN agency for aviation, who helps states develop and implement regulations, while setting safety standards to be recognized and aspired to globally. ICAO also conducts audits of member states to gauge their safety and security oversight capabilities. The work done by ICAO helps to achieve regulatory consistency and harmony for aviation authorities across the globe (ICAO, 2023).

### 4.1.1. Risk-Based Approach

ICAO recommends a risk-based approach to regulating RPAS that considers various safety factors such as the size of the aircraft, location and geographical factors, as well as the complexity of the operations being conducted. These factors are thought to influence the risk of fatality to a person, damage to property, or collision between an RPAS and another airspace user, and as such become the guiding considerations when developing regulations to ensure safe operations (ICAO, 2023).

### 4.1.2. Use of Regulatory Categorizations

Following the risk-based approach, ICAO suggests a regulatory categorization scheme of three levels: low-risk category, regulated minimal risk category, and regulated acceptable risk category. The low-risk category refers to operations that contain lower risks to safety and thus would not require authorization by the state's regulatory

authority. Examples of low-risk categorizations include VLOS operations, or aircraft that operate within specific parameters such as mass or speed. The regulated minimal risk category is one step up, which refers to operations that are still unlikely to result in fatality but may still require some operational regulations such as altitude restrictions or pilot/aircraft authorization requirements. The final, highest risk category is the regulated acceptable risk category, which is reserved for complex operations or the use of heavier or larger RPAS. These operations would require more significant risk mitigation regulations, such as approval and maintenance of the aircraft, more stringent remote pilot licensing, or more extensive operational rules (ICAO, 2023). Air taxis, package delivery in urban areas, or BVLOS operations are some examples of operations categorized under regulated acceptable risk.

### 4.1.3. Model Regulations for Regulatory Authorities

Following a review of existing RPAS regulations across states, ICAO produced Model Regulations (Part 101, 102, and 149) for RPAS based on commonalities and identified best practices. Part 101 indicates that RPAS weighing 25kg or less, who are operating in “Standard” operating conditions (§101.7), do not require additional operational safety review. Standard operating conditions for ICAO include operations that are conducted within visual line of sight (VLOS) of the pilot, are operated at or below 120m (400 ft), and are not operated within 30m of a person measured horizontally. Part 102 addresses RPAS operations using aircraft that exceed 25kg or weigh less than 25kg but do not adhere to Part 101 requirements. Part 149 promotes the use of an Approved Aviation Organization, which refers to an organization that has been certified by the national regulatory authority to perform specific operations. This allows for more expeditious authorization of future operations, thus reducing administrative burdens of review and authorization for the regulatory authority (ICAO, 2023). These model regulations provide a general framework that regulatory authorities can draw from when developing RPAS regulations.

### 4.1.4. Performance-based or Prescriptive Regulations

There are two broad approaches to regulatory language: performance-based or prescriptive. Performance-based regulations are framed around achieving a desired outcome by describing the result that is expected; alternatively, prescriptive regulations

are framed around describing how compliance should be achieved specifically (ICAO, 2023). For example, a performance-based regulation would require an RPAS operator to possess a safety manual, while a prescriptive regulation of the same nature would indicate how the safety manual should be developed or what components it should have. ICAO notes that there can, and perhaps should, be a balance between performance-based and prescriptive regulations, as prescriptive regulations can be useful for establishing minimum safety standards or for determining special authorizations for higher-risk operations. On the other hand, performance-based regulations put less strain on stakeholders to achieve compliance and are more adaptable to constantly evolving best practices. ICAO recommends that each state should determine its regulatory approach based on oversight, compliance, enforcement, and financial or administrative impact on stakeholders (ICAO, 2023). Although this paper does not recommend on regulatory language specifically, this consideration highlights the importance of working with stakeholders to produce reasonable and achievable compliance expectations.

## 4.2. European Union Aviation Safety Agency (EASA)

EASA is one of the global leaders in the development of RPAS regulation. EASA follows a risk-based categorization framework, reflective to ICAO recommendations, by developing three broad categories of RPAS regulation: the Open category, the Specific category, and the Certified category. National aviation authorities that are part of the European Union are required to follow EASA regulations, but may have enacted other regulations specific to their national airspace that are separate from EASA requirements.

### 4.2.1. Open Category

The Open category addresses low-risk or leisure drone activities and is limited to smaller drones. It sets out the foundation of the regulatory framework for all other categories, which are primarily based on the size of the aircraft, complexity of the operation, and level of risk. EASA has created three subcategories under the Open category that are scaled based on risk:

1. A1, where flight above people is allowed but not over assemblies of people, and where the max weight of the drone is 250g or 500g.

2. A2, where flight close to people is allowed (at least 50m away, measured horizontally) and where the max weight of the drone is less than 2kg.
3. A3, where flight operations must be conducted far away from people or urban areas, and where the max weight of the drone is less than 25kg.

Additionally, starting from January 1, 2024, EASA will require operations in the open category to be conducted with a drone bearing a C0 to C4 class identification label. These labels provide a standardized system of drone classification that is based on the size of the drone and the operations it is meant to conduct, which will allow the technology to become more commercially available. C5 and C6 drone classifications also exist for drones conducting higher-risk operations (EASA, 2023).

### 4.2.2. Specific Category

The Specific category is for riskier operations that are not covered under the operational limits of the Open category. Examples of the Specific category include operations that use drones which are less than 25kg, which fly higher than 120m above ground, occur BVLOS, or operating a drone less than 4kg in an urban environment. If the risk of the operation is higher than these limitations, it will fall under the Certified category (EASA, 2023).

Operations carried out under the Specific category require authorization from the applicable national aviation authority where they take place. However, EASA has developed other pathways to authorization to streamline the authorization process: Standard Scenarios (STS), Risk Assessment of Intended Operation, Predefined Risk Assessment (PDRA), and the Light UAS Operator Certificate (LUC) (EASA, 2023).

#### *Standard Scenarios (STS)*

STS are scenarios that contain established operating limitations. Operators are not required to obtain authorization to conduct an operation covered by an STS. If an operation can be accommodated under an STS, then the operator need only submit a declaration to their applicable aviation authority. As of December 2022, EASA has published two STS: one for VLOS operations over a controlled ground area in a populated environment, and another for BVLOS operations with Airspace Observers over a controlled airspace. At this time, EASA has invited operators to propose new STS

for their operations, however, since STS are codified under law, the process could take a long time (EASA, 2023).

### *Risk Assessment of Intended Operation*

A drone operator may also submit a risk assessment of their intended operation by using a methodology known as Specific Operational Risk Assessment (SORA), which is an internationally recognized risk assessment process developed by the Joint Authorities for Rulemaking of Unmanned Systems (JARUS). An equivalent methodology that is accepted by the applicable national authority can also be used. If the applicable national authority is satisfied with the information submitted in the risk assessment, the operator would receive authorization for their activity (EASA, 2023).

### *Predefined Risk Assessment (PDRA)*

A PDRA is an operational scenario for which EASA has already carried out a risk assessment for and has been published as an acceptable means of compliance. The PDRA is a type of checklist that the operator can fill out and submit to the applicable national authority, which streamlines the authorization process and replaces the need for the drone operator to conduct their own risk assessment. EASA intends on publishing more PDRAs for the most common operations in Europe in the coming years, and EASA has already published five PDRAs in the field of agricultural work and surveillance (EASA, 2023). The PDRA is an innovative, operations-focused regulatory approach that streamlines certification; this may be a useful strategy for Canada to draw from to expedite certification for specific RPAS operations, such as package delivery and air taxis.

### *Light UAS Operator Certificate (LUC)*

The final pathway for authorization in the specific category is the LUC, which can significantly speed up the authorization process. If issued by the applicable national authority, the LUC allows the operator to self-evaluate the risk of a particular operation in the specific category and begin that operation without needing authorization. In this process, the national authority will assess the operator and their organization to determine their capability to self-evaluate the risk of their operations, typically based on the maturity of the organization. It is recommended by EASA that when considering

granting a LUC, national authorities should monitor the activity of the operator, their understanding of the regulatory framework, and its level of safety culture (EASA, 2023).

### 4.2.3. Certified Category

The certified category addresses operations with the highest level of risk. In regard to size, if the drone has a characteristic dimension of 3m or more, and is designed to be operated over assemblies of people or to transport people, it must be certified before use. As such, the aircraft being used, operators, and pilots working under the Certified category will always need to have the proper certifications, with the recognition that with increasing autonomous technology, even pilots may not be required in the future. Due to the high level of risk, EASA expects that the process for safety assurance will be similar to those used in traditional manned aviation scenarios, and thus is expected to require the amendment of all aviation regulations. To approach this task manageably, EASA is focusing on three types of operations in this category:

1. International flight of certified cargo drones, where take-off and landing occur at an aerodrome.
2. Drone operations in urban or rural environments using pre-defined routes, including operations such as passenger-carrying air taxis or package delivery services delivered directly to a home; and
3. Operations as in type 2 above but conducted using an aircraft with a pilot on board, which is expected to cover the first type of air taxi operations before the aircraft becomes remotely piloted in a later phase of development (EASA, 2023).

**Notice of Proposed Amendment: Air Taxis in Cities**

EASA has published a Notice of Proposed Amendment (NPA) in June 2022 on the introduction of a regulatory framework for the operation of drones, focused on the technical domains of airworthiness, air operations, flight crew licensing, and rules of the air. This NPA would make EASA the first aviation regulator in the world to release a comprehensive regulatory framework for operations of Vertical Take-Off and Landing (VTOL)-capable aircraft, expected to offer services such as air taxis. The NPA was closed for public consultation on September 30, 2022 (EASA, 2022). This is a strong indication that progress into complex RPAS operations in urban areas is up-and-coming and provides urgency for TCCA to act.

## 4.3. United States Federal Aviation Agency (FAA)

The FAA's current RPAS regulatory framework requires comprehensive certification of first the aircraft itself, then the operations it is meant to conduct. In this way, the FAA's regulatory framework is rather explicit and reliant on industry stakeholder cooperation when compared to recommendations from the ICAO or EASA.

### 4.3.1. Urban Air Mobility Concept of Operations

In June 2020, the FAA published Version 1.0 of its Urban Air Mobility (UAM) Concept of Operations (ConOps), which is meant to "describe the envisioned operational environment that supports the expected growth of flight operations in and around urban areas" (FAA, 2020). This ConOps is part of a collaborative initiative between the FAA, National Aeronautics and Space Administration (NASA) and aviation industry stakeholders "to develop an air transportation system that moves people and cargo [in] places previously not served or underserved by aviation using revolutionary new aircraft," drones (FAA, 2020). The ConOps recognizes the growing market for air taxis and package delivery, and the societal and economic benefits of drones. They note that increasing commute times for ground traffic is a driving factor for an air taxi market, which is currently inaccessible due to the lack of safety regulations (e.g., air traffic conceptions that are incapable or insufficient for responding to drone air traffic) and infrastructure (e.g., landing zones for passenger-carrying aircraft) (FAA, 2020).

The ConOps also sets out a framework and expected timeline for the evolution of UAM operations, starting with Initial UAM Operations, then to ConOps 1.0 Operations, and finally reaching Mature State Operations. The ConOps sets out key indicators to determine the maturity of UAM operations, including:

1. The density, frequency, and complexity of UAM operations.
2. The structure of UAM airspaces and infrastructure.
3. The need for regulatory changes.
4. The evolving community-based rules (CBRs) that are developed by industry stakeholders.
5. The level of automation for the aircraft.
6. The location of the pilot in command.

Initial UAM Operations are expected to occur at a low frequency and complexity, which would be conducted by certified UAM aircraft and conventional helicopters in accordance with existing rules, regulations, and helicopter airspace structures. Next, ConOps 1.0 Operations would see a rise in frequency and complexity of operations to the point that regulatory changes are needed, and CBRs developed by industry are used to support the necessary regulatory evolution. ConOps 1.0 Operations would also begin to transcend current helicopter airspace rules and infrastructure and towards the use of 'UAM Corridors', or specific airspaces developed for UAM operations. Lastly, Mature State Operations see an even greater increase in frequency and complexity of operations, further driving evolution in other indicators such as regulations, airspace rules, and infrastructure. Mature State Operations is when pilots are expected to be mostly remote and automation levels may allow for 'Human-over-the-Loop' passive piloting, with minimal monitoring and pilot intervention (FAA, 2020).

The FAA's approach to the rise of civil and commercial drone use is an "evolutionary developmental" approach that begins with low-complexity, low-frequency operations that builds towards an environment of higher frequency and complexity that require new regulations, rules and infrastructure. The FAA is planning to continuously and proactively engage with industry stakeholders to not only ensure compliance, but also to facilitate comprehensive analysis and information sharing. This evolutionary developmental approach allows for current regulatory structure and capabilities to be utilized for lower complexity operations before undertaking full-scale regulatory and operational infrastructure development (FAA, 2020).

### 4.3.2. Certification Structure

The FAA defines three types of certifications relevant for drones: type certification, production certification, and airworthiness certification. Type certification is the approval of the design of an aircraft and all its components; production certification is the approval to manufacture duplicate products of a type-certified aircraft design; airworthiness certification is the authorization to conduct operations beyond Part 107 (which only covers low-risk operations with small drones), or without an exemption (FAA, 2022).

Airworthiness certification is then divided into two kinds of certifications: standard airworthiness certification, and special airworthiness certification. Standard airworthiness certification is the authorization of a type-certified aircraft to conduct operations, which allows the aircraft to be operated with minimal restrictions. Since type-certification is a prerequisite for a standard airworthiness certificate, most drones do not meet the requirements for this certification. Alternatively, a special airworthiness certificate covers a wide variety of aircraft in multiple categories. The most common category of special airworthiness certificates for drones are those in the experimental category. The experimental category is for aircraft and operations for purposes such as research and development, showing compliance with regulations, air racing or exhibitions, and more. Compared to the standard airworthiness certificate, the special airworthiness certificate often severely limits the use and operation of the aircraft (FAA, 2022).

### *Advanced Operations Certification*

In an effort to provide a more defined pathway to airworthiness certification of drones, the FAA has begun publishing proposed airworthiness criteria that will be used to issue type-certificates for drones under the ‘special class’ category. From a regulatory perspective, the special class category is contained under Title 14, Part 21.17 of the Code of Federal Regulations, whereby the FAA will use existing airworthiness criteria to gauge the airworthiness of “special classes of aircraft”, including drones (National Archives and Records Administration, 2022). This defined pathway for type certification of drones is a key enabler for more complex operations such as package delivery that bypasses the need to publish comprehensive regulations; by approaching certification on a case-by-case basis, the FAA is more quickly allowing for complex drone operations to occur in the United States without having to develop a comprehensive new regulatory framework (FAA, 2022).

When gauging whether to issue a type-certificate under the special class category, the FAA uses a ‘durability and reliability’ (D&R) process, whereby the applicant must develop a ConOps that describes the intended missions of the drone, and its design and manufacturing criteria. The applicant must then conduct flight test demonstrations to ensure that the drone can operate reliably (FAA, 2022; Stoltz, 2021). This process is facilitated through a Notice of Proposed Airworthiness Criteria, where the applicant provides the materials to the FAA, to which the FAA responds to and provides

clarity on requirements, followed by requests for additional comments from industry stakeholders or interested parties. As of January 2023, the FAA has published 21 Special Class Notices of Proposed Airworthiness Criteria, including submissions from Amazon and other package delivery companies (FAA, 2022).

### *Part 135 Air Carrier (Package Delivery) Certification*

The FAA has also supported drone package delivery by working closely with industry, state, local, and Indigenous (referred to as “tribal” in the United States) governments to issue certificates for operators under the Part 135 air carrier certification. From 2017 to 2020, the FAA facilitated the Unmanned Aircraft Systems (UAS) Integration Pilot Program (IPP), focused on testing and evaluating the integration of civil and public drone operations. This work continues today under the UAS BEYOND program that focuses on the remaining challenges for drone integration, including BVLOS operations and economic and societal benefits of drone operations. The participants of these programs are among the first to prove their concepts and receive Part 135 air carrier certification, and the FAA continues to focus on reviewing certificate applications from these participants (FAA, 2022).

Part 135 air carrier certification is the only path for a business to use drones to carry the property of another BVLOS. Businesses must go through the full five phases of the certification process like any other operator or aircraft, although the FAA has adapted the process by granting exemptions for rules that do not apply to drones, such as the requirement to carry the flight manuals on board the aircraft. The least restrictive certification category under Part 135 is the Standard certificate, which has no limits on the size and scope of operations that can be conducted if each type of operation has been authorized. This is in contrast to more restrictive categories below the Standard level, which limit the number of pilots, aircraft, and the size of the aircraft to varying degrees. To date, the FAA has issued four certifications for drone operators under Part 135, including Amazon, who is the first company to operate a drone larger than 55lbs (25kg) under this certification, as well as Joby Aviation (FAA, 2022; Joby Aviation, 2023).

### *National Environmental Policy Act (NEPA) Records of Decision for Drones*

The FAA is required by the National Environmental Policy Act to ensure that environmental considerations are factored into its decision-making process. NEPA

reviews are completed for actions that could cause effects on the human environment. As of January 6, 2023, the FAA has completed 15 environmental reviews for drone operations, many of which are for package delivery services, and were found to have no significant impact (FAA, 2023). This gives confidence to industry that complex drone operations are on the horizon and can work to improve public acceptance.

## 4.4. Lessons Learned

### 4.4.1. RPAS Regulations Address Levels of Risk Based on Size and Complexity

A common criterion for the development of RPAS regulations observed in all three jurisdictions is the focus on the size of the drone and the level of complexity of the operations it is intended to conduct. These criteria indicate the level of risk associated with the aircraft and operation. It is understood that as the aircraft gets larger or heavier, the safety risk associated with the aircraft also increases, since a heavy aircraft will have more kinetic energy and cause more damage to people or property in the event of a malfunction, accident, or disaster. Likewise, as the complexity of an operation increases – for example, by flying in densely populated urban areas – the safety risk also increases, since damage to persons or property is more likely. The increase in the level of safety risk is what warrants a comprehensive regulatory framework for RPAS, because more safety measures must be in place to ensure that the level of risk remains at an acceptable level to allow the operations to occur.

This is consistent with TCCA's current understanding of RPAS regulatory development. Low-risk operations with small RPAS conducting non-complex operations, such as photography in a forest, are supported within current regulatory frameworks; the task for most regulatory authorities now, including TCCA, is to begin development of a regulatory framework that can respond to the high level of risk associated with large drones conducting complex operations in urban areas.

### 4.4.2. Complex RPAS Operations May Require Brand New Concepts

Regulatory authorities are beginning to recognize the unique challenge of integrating UAM into the national airspace, which may require the reconceptualization of

traditional aviation understandings. This is most visible in the FAA's UAM ConOps and EASA's notice of proposed amendment (NPA) on air taxis, where concepts of air traffic management, infrastructure, and the roles and responsibilities of the pilot are being challenged. For example, the FAA notes that for Initial UAM operations, existing helicopter infrastructure and air traffic rules can be used to support RPAS, but for Mature State operations, new infrastructure or traffic rules/regulations may need to be developed based on lessons learned and industry feedback. Both the FAA and EASA have specifically mentioned the significant regulatory undertaking associated with UAM and how it may require completely new regulatory concepts.

To increase efficiency, reduce the regulatory workload for national aviation authorities, and ease compliance burdens for industry stakeholders, a common strategy is to utilize exiting regulatory frameworks as much as possible. However, given the unique challenges of RPAS, particularly with high-risk aircraft and operations, aviation authorities may need to 'work from scratch' to develop a regulatory framework that can adequately manage the risks of this new and revolutionary aviation technology. It should be noted that concepts of RPAS operations are still in the early stages, and aviation authorities may be able to support complex RPAS operations with minimal changes to existing conceptions. As such, the need for new concepts should be regularly considered and developing one or multiple ConOps should be a priority for regulatory authorities like TCCA.

### 4.4.3. Importance of Industry Stakeholders & Regulatory Approaches

The US case demonstrates the benefit of working closely with industry stakeholders on developing regulations. In contrast to the ICAO and EASA, who approach RPAS regulations by developing frameworks for stakeholders to follow, the FAA puts the onus on industry to develop a ConOps, their own technologies, etc., and uses this type certification as the primary vehicle for developing a regulatory structure from the 'bottom up' instead of from the 'top down'. As a result, RPAS commercial industries are flourishing in the US as industry stakeholders pursue the path of certification at their own pace. On the other hand, EASA's top-down approach of establishing pre-determined paths to certification (e.g., PDRA, LUC certification processes under the Specific category) helps industry stakeholders in a different way: by doing the work of operational risk assessments or organization approvals, the regulatory

authority is helping stakeholders by reducing barriers and increasing accessibility for certifications. TCCA must take these considerations into account when developing a regulatory approach that is congruent with the Canadian context.

# Chapter 5.

# Multi-Criteria Analysis: Policy Options, Criteria, Analysis, & Recommendations

The following section formulates three policy options that TCCA may pursue to address the problems associated with the rudimentary regulatory structure for RPAS in Canada. Then, it establishes criteria and measures to analyze each option, and concludes with a recommendation and implementation considerations for TCCA.

## 5.1. Policy Options & Criteria

The following section provides a description of each policy option, rationalizations for the criteria used, a detailed overview of relevant stakeholders for TCCA to consider, and an overview of the scoring for each criterion. This establishes the context and considerations that will be employed in the multi-criteria analysis that proceeds in the next section. Note that more comprehensive implementation details and considerations will be discussed after the recommendation is made.

### 5.1.1. Policy Descriptions

#### *Option 1: Maintain Status Quo, with Minor Enhancements*

This option refrains from enacting any changes to the current situation beyond minor enhancements of existing efforts. TCCA will continue to receive applications for large RPAS or complex RPAS operations through the existing SFOC regulatory provision. TCCA will also continue its work on enabling BVLOS operations and establishing an ROC authorization process for RPAS operators that is reflective of the aircraft they use and their intended operations. As such, this option would not compel TCCA to undertake any new actions for RPAS regulations.

However, even when deciding to maintain the status quo, recommendations for some minor enhancements to the existing strategy are included. This is in response to the urgent need for progress on RPAS regulations and commercial certifications in Canada that have been justified throughout this analysis, particularly in the industry scan

which indicates growing economic potential and industry readiness. Fully maintaining the status quo without any minor enhancements would be ignorant of the research conducted in this paper, which has established that Canada's current framework is both rudimentary and inefficient. These minor enhancements would include:

1. Increasing the allocation of TCCA resources for review of SFOC applications, to accelerate the rate at which TCCA is authorizing RPAS operations that are not covered under the existing regulatory framework.
2. Increasing the allocation of TCCA resources for conducting consultation with key stakeholders and research, with the intent of gathering a rich foundation of technical research and consultation data that can be used to inform TCCA's RPAS regulatory development.

Accelerating the rate of SFOC application review is an important enhancement to make because it has the potential to fully authorize commercial operations such as package deliveries – although, given the rudimentary structure of the compliance expectations and lack of progress in this area in Canada, this would be highly unlikely. However, in theory, this would enable economic opportunity while also contributing to RPAS regulatory development by providing an example of a successful authorization of operations, which contributes to TCCA's knowledge and experience in this area. Successful commercial SFOC applications can then inform the development of regulatory provisions, structures, and relevant considerations for similar cases. As such, this minor enhancement suggests an increase in labour resources to review SFOC applications.

Similarly, increasing the allocation of TCCA resources for key industry stakeholder consultations and technical research can work to better prepare TCCA for RPAS regulatory development. Engaging in active and consistent consultation with industry stakeholders such as Amazon can go a long way to inform how TCCA may approach commercial RPAS operation certifications through the sharing of knowledge on common challenges, considerations, approaches, and successful strategies. Additionally, these consultations can also occur between TCCA and other regulatory authorities such as the FAA, for the same purpose of sharing knowledge and information. Technical research can also help inform regulatory development strategies by identifying best practices and technical challenges associated with RPAS regulations.

As such, this minor enhancement suggests an increase in labour resources to conduct research and consultations with key stakeholders such as industry leaders and other regulatory authorities.

**Expected Outcomes**

1. TCCA will gain time to better prepare its regulatory development strategy by gathering technical research and consultation data.
2. Canada will continue to rely on the SFOC regulatory provision, which is unpredictable for industry stakeholders and rudimentary in structure.
3. RPAS technology and complex RPAS operations will likely continue to flourish in other countries that can support it instead of entering the Canadian market.
4. Canada's international reputation on RPAS regulations will be negatively impacted through continued inaction, and regulatory inaction runs contrary to Canada's domestic regulatory priorities and commitments to ICAO.

### *Option 2: Reduce Regulatory Barriers & Provide Industry Incentives*

This option aims to reduce barriers and provide market incentives for RPAS industry stakeholders to provide commercial services or innovate their technologies in Canada. As mentioned earlier, the literature review, industry scan, and jurisdictional scan have consistently highlighted the importance of regulatory authorities working in collaboration with industry stakeholders. Regulations are also an economic enabler in the aviation industry, which further necessitates collaboration between regulatory authorities and industry stakeholders. Additionally, due to the typically high investment costs of providing commercial aviation services based on the need for advanced technologies, aircraft, and strict safety standards, regulatory authorities should support industry stakeholders in the early stages of business/service development. These points indicate that in the pursuit of reducing barriers and providing market incentives to motivate the adoption of commercial RPAS services in Canadian markets, TCCA should focus on strategies that simplify, streamline, or directly support industry stakeholders.

For reducing regulatory barriers, this option would recommend the following:

1. Reducing restrictions for foreign operators by amending the Canadian Ownership Requirement.

2. Providing a pathway for Canadian recognition of foreign regulations and RPAS businesses that have received foreign certification, to allow for the expansion of their services into the Canadian market, following the US-Japan example in Section 3.2.3.

Although amending the Canadian Ownership Requirement is a policy question that goes beyond the bounds of the considerations made in this analysis, it is worthy of consideration due to its potentially significant negative impact on this particular industry and market. As a reminder, this provision requires commercial air service operators to be 51% controlled by Canadians and requires the operator to obtain an economic license issued by the Canadian Transportation Agency. This requirement is likely meant to protect and support Canadian markets, service providers, and workers from foreign competitors. However, given the success of foreign RPAS operators such as Amazon in the US, and the global nature of commercial aviation services, TCCA should consider reducing or removing the Canadian Ownership Requirement for RPAS operators to reduce barriers for the transfer of these services from foreign markets into the Canadian market. A reduction to a 25% requirement or nulling the provision for a period of 5-10 years to 'jumpstart' foreign movement into Canadian markets are some implementation options to consider.

Similarly, providing a pathway for the recognition of foreign regulations and foreign-certified RPAS operators can reduce barriers for foreign service providers to enter Canadian markets. This can be done by reviewing and issuing approvals for certifications issued by foreign regulatory authorities, which would then allow foreign RPAS operators who have been certified outside of Canada to have their certifications recognized in Canada. While it may be necessary to adjust compliance expectations to fit the Canadian context and standards, these likely small adjustments will be worthwhile as the approval can be expected to remain valid in the long term or until the foreign regulations change.

For providing market incentives, this option would recommend the following:

1. Subsidies for businesses looking to provide commercial services using large RPAS and conducting complex operations, particularly for package delivery and air taxi businesses, to motivate the development of businesses and services in Canadian markets.

2. Grants for businesses or research institutions engaging in research, development, and manufacturing of large RPAS aircraft and relevant technologies to support technological innovation.

Supporting commercial businesses with subsidies can help to mitigate the often significant financial investments that are necessary to begin operations in the aviation sector, especially for RPAS which uses new and developing advanced technologies. Beyond relieving financial difficulties, subsidies can also develop a foundation of services and economic opportunity in the Canadian market – by supporting industry stakeholders, particularly new and budding businesses, Canada can build up its RPAS commercial market for the long term. These subsidies can be for RPAS operators of all different commercial services, however, the operator should need to provide proper documentation about the type of operation it is intending to conduct, the aircraft it will be using, and other safety and conceptual information in the form of an application that would inform the decision for TCCA to grant the subsidies – similar to the FAA's onus on operators to prove their concepts and conduct flight tests. It is important for TCCA to ensure that subsidiary beneficiaries have a reasonable business plan and a ConOps that is feasible – from an economic and regulatory perspective – to reduce the chance of resources being wasted. Additionally, the services that the business is looking to provide should include some societal benefits, such as improving delivery times or reducing greenhouse gas emissions. The amount of money that businesses would have access to should be based on the type of operation or service it is looking to provide and its economic and societal benefits, how expensive initial investments would be, and how long it would take for the business to become fully operable and/or profitable. This analysis will not suggest specific subsidiary amounts, as these calculations should be carried out on a case-by-case basis by financial and market experts who can make accurate suggestions based on more extensive economic research; however, in the interests of including figures to convey a general idea of costs, this option includes some subsidy calculations in the cost analysis section of the multi-criteria analysis.

On the other hand, TCCA can support technological innovation through grants to businesses or research institutions. Similar to the subsidies, grants can help support a foundation of research and development for RPAS technology in Canada. Given the novelty of RPAS industry and technologies, especially within the context of UAM, there is much work to be done for technologies: for example – although further along the

regulatory continuum – fully or highly automated drones have not yet been developed to a reasonably safe airworthiness standard. The benefit of grants for technological development comes in the long term through experimentation and exploration in these under-developed areas of technology. Again, these grants should be awarded based on a formal application process by the institution, who explains what they are developing and why it is important to RPAS advancements, and the specific financial calculations should be carried out by financial experts based on the organization's application and the economic context. Eligible applicants would include businesses looking to conduct commercial operations, such as Amazon, startups, or research institutions such as universities.

**Expected Outcomes**

1. RPAS businesses, particularly foreign ones, will expand into Canadian markets due to reduced barriers to providing commercial services.
2. RPAS businesses and technological innovation, particularly start-ups, will expand in Canada due to new industry incentives, providing a foundation of research and development for the future.
3. Canada will continue to rely on the SFOC regulatory provision for domestic certifications, which is unpredictable for industry stakeholders and rudimentary in structure.

### *Option 3: Develop Regulations to Certify Large RPAS & Complex Operations Using Large RPAS in Urban Areas*

Option 3 recommends the development of regulatory mechanisms focused on certifying aircraft designs on the one hand, and complex operations using those aircraft in urban areas on the other hand. The reason for this is to provide explicit pathways to certification and a clear separation of aircraft and operations certifications, which makes the regulatory task more manageable, among other benefits that will be explored throughout. Although the focus here is for large RPAS and complex operations in urban areas, as these are the most challenging and relevant regulatory hurdles for RPAS currently, these mechanisms can be applied to any aircraft or operation.

The first mechanism requires TCCA to develop Airworthiness Criteria for Large RPAS (ACLR), which would allow the certification of large RPAS designs, while the second mechanism requires TCCA to develop Pre-defined Risk Assessments for

Complex Operations Using Large RPAS in Urban Areas (referred to as 'PDRA' in this section). Following the establishing of the PDRA mechanism, TCCA would begin development of a PDRA for Package Deliveries Using Large RPAS in Urban Areas. These mechanisms together would establish a regulatory framework positioned to respond to the issue of UAM and the next generation of aviation challenges by separating aircraft certification from operations certification. This would improve regulatory predictability for stakeholders by providing an explicit pathway to certification, while improving efficiency through the PDRA approach, which establishes a single compliance checklist for a particular operation that streamlines future certifications for that operation. To summarize, this option recommends TCCA to develop the following:

1. Develop Airworthiness Criteria for Large RPAS (ACLR) designs that would certify large RPAS designs to be manufactured and submitted as the designated aircraft for operations certifications.
2. Establish a Pre-defined Risk Assessment (PDRA) system that streamlines certification for particular complex operations, such as package deliveries in urban areas, by conducting a risk assessment that results in a checklist of compliance requirements for the operation.
3. Develop a PDRA for Package Deliveries Using Large RPAS in Urban Areas to fast-track certifications for this highly anticipated commercial operation, and to pave the way for more complex commercial operations such as air taxis.

This option draws from the regulatory structures and provisions of the FAA and EASA, namely the 'durability and reliability' (D&R) process from the FAA on the certification of drone aircraft, and the Predefined Risk Assessment (PDRA) process from the EASA on the certification of operations using RPAS discussed in Sections 4.3.2 and 4.2.2 respectively. To review, the D&R process puts the onus on applicants to develop a ConOps that describes the intended missions of the drone, its design and manufacturing criteria, and then requires the applicant to conduct flight test demonstrations to ensure the drone can operate reliably. The D&R process was developed by the FAA to provide a more defined pathway to airworthiness certification of large drones, which utilizes existing airworthiness criteria to gauge certification. On the other hand, the PDRA process puts the onus on the regulatory authority to carry out a risk assessment for an operational scenario, which is then published as an acceptable means of compliance. TCCA already uses the Specific Operational Risk Assessment (SORA), which is a

methodology developed by the Joint Authorities for Rulemaking of Unmanned Systems (JARUS) (Transport Canada, 2020) – TCCA should continue to use this internationally recognized methodology as part of the PDRA process. After the risk assessment is completed and the PDRA has been defined, operators would then be required to complete and submit the PDRA to the regulatory authority, which is essentially a checklist establishing safety and procedural requirements for the operation to occur, in order for the operator to become certified for that operation. Although the PDRA is not intended for large RPAS in the EASA, the regulatory approach of streamlining certification for a particular operation is applicable in the context of supporting the adoption of commercial RPAS services.

For the development of ACLR, TCCA would develop a set of criteria that must be met by applicants in order for their proposed large RPAS design (greater than 25 kg) to be certified as safe and operable. Once certified, the applicant would be able to manufacture the approved design and use the aircraft in its applications for complex operation certification, which is the next component of this recommendation. To gauge airworthiness, TCCA would use a combination of existing airworthiness criteria for traditional aircraft, and new criteria developed through industry consultations and research on RPAS. These new criteria may include potentially necessary features, such as automated detect-and-avoid technology or visual aids such as an on-board camera to allow for BVLOS capabilities. The application process for this airworthiness provision should mimic the D&R process of the FAA: applicants would be required to develop a ConOps that explains the intended operations that this RPAS design is meant to conduct, and describes the design and manufacturing criteria of the RPAS. If approved, the next stage would involve flight test demonstrations carried out by the applicant to prove that the RPAS is safe and operable. By the end of the airworthiness certification process, TCCA should be confident in the safety and operability of the RPAS design, leaving only the question of the safety of the operation itself. An additional benefit of this approach is the ability for a business to engage solely in the design and manufacture of large RPAS, which can create a market for approved RPAS designs and manufacturing that can be purchased by aspiring commercial service providers.

The second mechanism, PDRA for Complex Operations Using Large RPAS, comes after a large RPAS design has been certified; a necessary prerequisite for approval of a PDRA would be to have a large RPAS that has the ACLR certification

described above. In short, this mechanism develops compliance checklists meant to streamline certifications for select complex operations, whereby an applicant would need to demonstrate that they understand and comply with the requirements established in the PDRA to receive approval to conduct that operation. This mechanism allows TCCA to conduct a risk assessment for any complex operation that is meant to be conducted using a large RPAS – for example, package delivery or air taxis – which then allows for applicants to understand and achieve compliance more easily, in addition to allowing for TCCA to fast-track the certification of specific, highly anticipated complex operations. This mechanism would feature a process for suggestions to be submitted to TCCA, where stakeholders would have the opportunity to make suggestions about which PDRAs should be pursued by TCCA in the future, and what technical considerations may be included in the PDRA. These suggestions have the potential to be highly detailed if they are submitted by industry experts, which can alleviate some of the burden on TCCA to do all the necessary research and analysis for a particular operation. In this way, this mechanism leaves the door open for close collaboration between TCCA and industry stakeholders who may already have established plans and conceptions for complex operations. However, development of the PDRA checklist would ultimately be the responsibility of TCCA, who would conduct technical research and consultation with industry stakeholders and subject matter experts.

Once the PDRA framework and suggestion system has been established, this option recommends TCCA to develop its first PDRA on Package Deliveries Using Large RPAS in Urban Areas. Doing so would fast-track certification for this highly anticipated commercial RPAS service through its targeted approach. As mentioned above, development of this PDRA would require technical research by TCCA, as well as consultation with key industry stakeholders such as Amazon and DDC. This PDRA would increase regulatory predictability and confidence in the adoption of package delivery as a commercial service, resulting in regulatory efficiency and economic opportunity in Canadian markets. It would also pave the way for future regulatory development of more complex operations such as air taxis.

The following paragraphs provide a practical example that demonstrates how this option would function in the case of package deliveries, from the perspective of an applicant, and provides some technical considerations for the reader to better understand why the process is necessary and what the process would be for TCCA.

First, the applicant must receive airworthiness certification for the RPAS it intends to use. For example, DDC may submit the Condor, which has a maximum take-off weight of 476 kg, for airworthiness certification. DDC would need to begin by developing a ConOps to explain what the Condor is meant to do (e.g., carry out package deliveries in urban areas), how it is meant to do it, and the design and manufacturing criteria for the Condor. Perhaps the Condor would need to integrate new technologies, such as an automated detect-and-avoid system, to gain full confidence from the TCCA on its ability to safely carry out package deliveries in urban areas.

Next, once airworthiness certification has been obtained by DDC for the Condor, DDC would then be eligible to apply for the PDRA for Package Deliveries Using Large RPAS in Urban Areas, which has already been developed by TCCA in this theoretical example. This PDRA sets out operational requirements that have been established by TCCA through research and industry consultations. For example, the package delivery PDRA may require the development of air traffic corridors or pre-defined aerial routes for package delivery aircraft to avoid collisions, or the designation of a package drop-zones of specific measurements for the safe delivery of the package to an urban destination. DDC would need to demonstrate to TCCA how it intends to achieve the checklist of compliance requirements, which may require further flight test demonstrations, for example to prove that the intended aircraft is able to fly in precise air traffic corridors. During this process, other challenges such as gaining a commercial license would be identified and integrated into the approval process.

Once DDC gains this PDRA approval, they would then be fully certified to use the Condor to conduct package deliveries in urban areas, and TCCA would be confident that these operations would be conducted safely. Additionally, other industry stakeholders such as Amazon would be able to view the airworthiness certification for the Condor, as well as the PDRA on package deliveries, and decide to pursue certification based on a clear understanding of compliance expectations for both the aircraft and the operation, thus increasing regulatory predictability. Lastly, TCCA would be able to utilize its findings and experience from developing the PDRA on package deliveries for future PDRAs such as air taxis – this is especially advantageous when considering the long spectrum of potential commercial operations using large RPAS in urban areas, which will consistently benefit from previous PDRAs based on similar considerations about the aircraft or conducting operations in an urban area.

Under this option, the existing intentions of TCCA to establish an ROC for less complex operations would be able to continue separately from these provisions, which are meant for large RPAS and complex operations. These efforts being developed in parallel can even be advantageous, as they will be based on similar considerations and will thus provide a diversity of perspectives and correlated regulatory provisions.

**Expected Outcomes**

1. Predictability and efficiency of Canadian RPAS regulations will improve via explicit pathways to certification, thus encouraging industry stakeholders to acquire certifications for their operations and services in Canada and allowing for their integration into Canadian markets.
2. The new regulatory structure will position TCCA's regulatory provisions to expand into other types of aircraft and operations in the future.
3. The PDRA approach allows TCCA to provide streamlined approval processes for operations that may be highly anticipated, which provides TCCA with the power to fast-track specific operations that are common and anticipated such as package delivery.
4. Canada's international reputation on RPAS regulations will be positively impacted, as Canada will be able to position itself as a leader in the development of UAM regulations that are currently underdeveloped across the globe by integrating lessons learned from other jurisdictions, thus becoming an example for other national regulatory authorities.

### 5.1.2. Criteria Selection Rationale

The following section describes and justifies the criteria used for the multi-criteria analysis. In particular, distinctions are made between key and secondary criteria, which are reflected in the score-weights assigned to each criterion. This section also provides an in-depth identification of relevant stakeholders for the analysis.

#### *Key Criteria: Economic Impact & Stakeholder Acceptance*

Economic impact and stakeholder acceptance are identified as being key criteria in this analysis, and thus have their point-weightings doubled compared to secondary criterion. This is due to TCCA's role as a regulator for commercial aviation services and

operations, where TCCA plays a significant role in the enabling of commercial aviation services in Canadian markets. As such, a policy option's ability to enable RPAS commercial services, streamline regulations, improve services, or otherwise encourage economic opportunity and innovation, is a significant factor in this analysis. Stakeholder acceptance is also a significant factor, particularly industry stakeholders, due to the importance of economic development and the market role played by industry stakeholders providing aviation services. The prioritization of these criteria is supported throughout TCCA public documents and consultation processes, as well as the jurisdictional scans and industry scans conducted in this paper.

#### *Secondary Criteria: Cost to Government & Implementation Timeline*

Cost to government and implementation timeline are identified as secondary criteria in this analysis. Monetary costs of the policy options will play a considerable role in decision making to ensure that the cost of policy options are reasonable. Implementation timeline is another important consideration, as RPAS are an emerging and disruptive technology that seeks a timely response from aviation authorities.

### 5.1.3. Stakeholder Identification & Analysis

Before conducting the multi-criteria analysis, an identification and description of key stakeholders will provide the necessary context for analysis of this criteria. Industry stakeholders are the most important for TCCA, followed by foreign regulatory authorities. The general public is the final stakeholder of consideration, which plays a lesser role in the scoring due to a lack of focus on them throughout the literature and research.

#### *Industry Stakeholders*

Businesses responsible for providing services in the aviation industry are the most critical stakeholder for TCCA. As mentioned previously, regulations are an enabler for commercial companies to conduct operations and expand their businesses to Canadian markets. As such, TCCA must continue or enhance efforts in conducting interviews, developing surveys, and pursuing other consultation and collaboration methods to better understand regulatory barriers, needs, and expectations of industry stakeholders in the Canadian context. Strong consultation and collaboration with industry stakeholders such as DDC, Amazon, and Joby Aviation will support the

development of regulatory solutions that are an accurate reflection of the needs of industry and the nature of their operations. Consultation is especially necessary across different types of industry stakeholders, for example, manufacturers and service providers, as they will have different regulatory needs and expectations based on the nature and complexity of their operations, as well as the size of the business. Additionally, the regulations that are enacted by TCCA must be cognizant of how they will be received by industry stakeholders – it is in the best interests of TCCA to enact regulations that are accessible, easy to understand, and easy to implement and achieve compliance for. This is supported throughout the literature and jurisdictional scans conducted in this paper.

### *Foreign Civil Aviation Regulatory Authorities*

The regulatory authorities of other countries or regions are an important stakeholder for TCCA, due to the global and transnational nature of aviation. Since industry stakeholders may provide services in multiple jurisdictions and would thus be transporting goods or people between countries, it is important to maintain regulatory congruence with foreign regulatory authorities to streamline compliance and reduce regulatory complexity for industry stakeholders. In particular, the US FAA is a primary stakeholder for TCCA, given the geographic closeness and deep economic partnership between Canada and the US. As such, developing congruent regulations that provide easy-to-understand, accessible requirements for aviation industry stakeholders, who may be operating in multiple jurisdictions, is an important consideration for TCCA – especially since the FAA is ahead of TCCA in RPAS regulatory development. If TCCA were to publish regulations that contain vastly different compliance requirements compared to other jurisdictions, it would act as a barrier for industry stakeholders who may need to develop new aircraft or operating procedures to meet Canadian regulatory requirements. Additionally, differing regulations would put pressure on industry stakeholders to learn Canadian regulations anew, thus disincentivizing economic expansion to Canadian markets while also increasing the risk of noncompliance due to the increased difficulty for industry stakeholders of understanding multiple compliance expectations.

### *General Public*

The general public is the final consideration under the stakeholder criterion. This facet of stakeholder acceptance plays a lesser role in the overall scoring of this criteria, due to the lack of focus on the general public throughout the literature. Additionally, as mentioned in section 1.2.5 of this analysis, public acceptance concerns typically arise when considering operational or implementation realities, such as noise levels or ethical privacy concerns. Although these considerations are important to note, they are less relevant for this stage of policy and regulatory consideration, which is again reflected throughout the literature.

**Table 5.1. Multi-Criteria Analysis Scorecard**

| Criteria | Description & Measure | Rating Scale (Higher Points is Better) |
|---|---|---|
| ***Economic Impact** | The degree to which the policy option encourages or facilitates economic opportunities, such as increased business, services, or technological innovation. Also considers the economic impact of increased opportunity | *Low (+2), Medium (+4), High (+6)<br>Low: minimal economic opportunity<br>High: maximum economic opportunity |
| ***Stakeholder Acceptance** | The degree of acceptance or support of the policy option from stakeholders | *Low (+2), Medium (+4), High (+6)<br>Low: minimal stakeholder acceptance<br>High: maximum stakeholder acceptance |
| **Implementation Timeline** | The expected timeline for the policy option to be fully implemented | Long (+1), Medium (+2), Short (+3)<br>Long: slow implementation timeline<br>Short: fast implementation timeline |
| **Cost to Government** | The monetary cost of the policy option for TCCA to develop and implement | High (+1),Medium (+2), Low (+3)<br>High: high monetary costs<br>Low: low monetary costs |

*Key criteria with doubled points-weighting

## 5.2. Multi-Criteria Analysis

The following section applies the criteria established above to each policy option and provides analysis and interpretation. The scores of each option are summarized in the table at the end of this section.

### 5.2.1. Option 1: Maintain Status Quo, with Minor Enhancements

#### *Multi-Criteria Analysis*

**Economic Impact**

*(RATING: LOW)*. RPAS businesses will be discouraged from conducting operations in Canada due to regulatory unpredictability and longer certification approval times. Simultaneously, RPAS businesses will be incentivized to conduct operations elsewhere, such as the US, where there is more regulatory predictability. The

acceleration of SFOC application reviews, research, and industry consultations is not expected to result in an increase in motivation to enter Canadian markets or the adoption of commercial services on a scale large enough to warrant a rating higher than 'low'. Additionally, this option would not produce any significant positive economic impact as the level of action is low and not expected to generate a high level of economic opportunity or movement.

**Stakeholder Acceptance**

*(RATING: LOW)*. Industry stakeholders are expected to express low support because the barriers to RPAS operators will remain the same. Foreign regulatory authorities are expected to express low support because Canada will not be contributing to global efforts to develop a regulatory framework for drones, and foreign regulations may be unrecognized by Canadian authorities. This option has low or no impact on the general public, as it does not produce operational outcomes that will affect the public, such as noise levels.

**Implementation Timeline**

*(RATING: SHORT)*. TCCA will have little to nothing new to implement. Minor enhancements can be expected to take 1-3 months to train new hires and begin enhancement efforts.

**Cost to Government**

*(RATING: LOW)*. TCCA will have minimal increased costs. Minor enhancements will incur small costs through the hiring of additional analysts.

The following is a brief calculation of expected costs:

- Two EC-4 (Economic and Social Services) Analysts at $80,000/year ($160,000 over one year)
  - One analyst for the review of SFOC applications; one analyst for increased consultations and technical research
- *Total Expected costs: $160,000/year, ongoing and subject to adjustments*

### 5.2.2. Option 2: Reduce Regulatory Barriers & Provide Industry Incentives

#### *Multi-Criteria Analysis*

**Economic Impact**

*(RATING: MEDIUM)*. Foreign drone businesses will gain increased access to Canadian markets with the bypassing of the Canadian Ownership Requirement, or through the recognition of issued foreign RPAS certifications. Financial incentives such as subsidies for businesses providing commercial services using large RPAS, or grants for organizations engaging in research and development, will support RPAS industry and innovation in Canadian markets. The focus on supporting commercial RPAS services and technological innovation is particularly effective for this criterion given the parameters of this policy problem.

**Stakeholder Acceptance**

*(RATING: MEDIUM)*. Industry stakeholders are expected to express support due to reduced barriers for market entry and increased financial support. Foreign regulatory authorities are expected to express support due to regulatory streamlining through the recognition of their certifications. The general public may begin to gain more substantial interest in these issues under this policy option, as it begins to introduce the possibility for operational realities such as increased noise levels when commercial operations are implemented.

**Implementation Timeline**

*(RATING: MEDIUM)*. It is expected to take 1-2 years for regulatory amendments and business incentives to be analyzed and brought into force (1 year for initial research, any necessary consultations, and initial development, then another year for regulatory drafting and implementation).

**Cost to Government**

*(RATING: HIGH)*. TCCA is expected to incur relatively high administrative and labour costs through the drafting of amendments, analysis of incentives, and any consultation or outreach that may be warranted. The cost of financial incentives provided by TCCA for RPAS businesses can vary based on market analysis and

recommendations for an appropriate amount, however, the incentives will likely need to be significant in order to provide sufficient motivation for RPAS businesses to start operations in Canada, given the typically high price of novel technologies.

The following is a brief calculation of expected costs using hypothetical incentive amounts that are subject to adjustment based on pending financial research to be conducted by TCCA:

- Six EC-4 (Economic and Social Services) Analysts, 2 years of employment at $80,000/year ($960,000 over 2 years)
    - Two analysts for regulatory amendments; two analysts for business incentives analysis; two analysts for outreach and general support;
- Financial subsidies or grants at $100,000 per approval, with 10 approvals per year (up to $2,000,000 over 2 years);
- *Total expected cost: up to $2,960,000 over 2 years, subject to adjustments based on financial research informing incentive amounts.*

### 5.2.3. Option 3: Develop Regulations to Certify Large RPAS & Complex Operations Using Large RPAS in Urban Areas

#### *Multi-Criteria Analysis*

**Economic Impact**

*(RATING: HIGH)*. Highly anticipated commercial RPAS services such as package delivery will be fast-tracked into Canadian markets through predictable, explicit regulatory structures and certification processes. This will act as a ‘green light’ for industry stakeholders looking to provide package delivery or other commercial services that require the use of a large RPAS. Additionally, the increased efficiency provided through the PDRA approach that streamlines the certification process is expected to improve the rate of approvals for other operations in the long-term, while also encouraging stakeholders to take up operations that have a pre-defined approval process completed. This Option also helps develop a foundation of information and data that can be used for future airworthiness certifications or PDRAs, which can streamline approval criteria for different aircraft and operations in the future, such as air taxis. Lastly, the economic impact of this Option can be expected to enhance existing services

such as package delivery, thus improving efficiencies related to the transportation of goods.

**Stakeholder Acceptance**

*(RATING: HIGH)*. Industry stakeholders are expected to express high support for an explicit regulatory framework, as it will provide a predictable path to certification. Foreign regulatory authorities are expected to express high support as they will be able to learn from and potentially employ the regulatory structure that Canada develops, while also contributing to international harmony of RPAS regulations. The general public must also be consulted during the regulatory development/consultation phase of this Option, as this explicit framework is expected to bring about operational concerns such as noise levels or privacy concerns.

**Implementation Timeline**

*(RATING: LONG)*. It is expected that it will take at least 3 years for the new regulatory framework to be fully developed and implemented. This is assuming reasonable workflow and minimal disruptions. Unforeseen obstacles could extend this implementation timeline to roughly 5 years; likewise, efficient workflow may reduce it below 3 years.

**Cost to Government**

*(RATING: HIGH)*. TCCA would incur high administrative and labour costs through the rigorous analysis, regulatory drafting, and consultation with various internal and external stakeholders that is warranted for the development of these new regulatory mechanisms.

The following is a brief calculation of expected costs:

- Twelve EC-4 Analysts, 3 or 5 years of employment at $80,000/year ($2,880,000 over 3 years, or $4,800,000 over 5 years)
  - Nine analysts for analysis, regulatory drafting, and development of guidance materials; three analysts for consultation and general support;
- Four EC-4-equivalent Inspectors for conducting compliance inspections and general enforcement at $80,000/year ($240,000/year, ongoing)

- *Total expected cost: minimum $2,880,000 over three years, then $240,000/year after regulations are implemented, ongoing and subject to adjustment. Costs may reach up to $4,800,000 over five years based on the potential for unforeseen challenges or delays during the regulatory development process.*

### 5.2.4. Summary of Multi-Criteria Analysis Ratings

**Table 5.2. Multi-Criteria Analysis Overall Ratings**

| Criteria | Option 1: Maintain Status Quo, with Minor Enhancements | Option 2: Reduce Regulatory Barriers & Provide Industry Incentives | Option 3: Develop Regulations to Certify Large RPAS & Complex Operations Using Large RPAS in Urban Areas |
|---|---|---|---|
| **Economic Impact** | Low (+2) | Medium (+4) | High (+6) |
| **Stakeholder Acceptance** | Low (+2) | Medium (+4) | High (+6) |
| **Implementation Timeline** | Short (+3) | Medium (+2) | Long (+1) |
| **Cost to Government** | Low (+3) | High (+1) | High (+1) |
| **Total Score** | 10 | 11 | 14 |

## 5.3. Recommendation

Based on the multi-criteria analysis above, this paper recommends **Option 3: Develop Regulations to Certify Large RPAS & Complex Operations Using Large RPAS in Urban Areas**. This is based on the ability of this option to provide strong outcomes for the key criterion, and its effectiveness at addressing the specific gap and problems discussed throughout this paper.

## Implementation

### *Implementation Procedure & Considerations*

As described briefly during the policy description, this recommendation would see the implementation of two new regulatory mechanisms, one for the certification of large RPAS, and another for the certification of complex operations using large RPAS. Although this option requires airworthiness certification for an operator before their certification under a PDRA such as one for package deliveries, the regulatory development of these mechanisms may occur in tandem. On the one hand, analysis can be done by TCCA to establish the criteria for airworthiness, in consultation with key industry stakeholders such as Amazon or DDC. On the other hand, TCCA can develop a PDRA framework that establishes the PDRA for Complex Operations Using Large RPAS approach of streamlining operations certifications, then move on to developing TCCA's first PDRA – the PDRA for Package Delivery Using Large RPAS in Urban Areas – all the while assuming that applicants would have received airworthiness certification already. As such, there is no need to develop one mechanism before the other, and they can be developed in tandem.

However, there should be consistent communication between each team of TCCA analysts, as airworthiness requirements are reflective of the types of operations the aircraft is meant to conduct, and findings on compliance requirements for a specific operation may shed light on the necessary airworthiness requirements for the aircraft meant to conduct that specific operation. As such, there should always be consistent communication and collaboration between different teams of TCCA analysts developing regulations and industry stakeholders who are applying for aircraft and operational certifications.

As mentioned previously, there should also be an avenue for suggestions to be made to TCCA regarding future PDRAs. In establishing the PDRA approach as a regulatory structure – separate from the specific PDRA that this recommendation includes on package delivery – TCCA also gains the opportunity to hear from industry stakeholders or aspiring commercial service providers on the specific operations that would benefit from a PDRA. This suggestion process would need to contain prompts to gain the information necessary for TCCA to consider development of a new PDRA, such as a ConOps, societal or economic advantages, safety considerations, and so on. This

suggestion process would also establish a relationship with the relevant stakeholder through dialogue and the sharing of contact information, which allows for future consultation and collaboration between TCCA and the relevant stakeholder.

### *Other Regulatory Considerations*

Based on information from the jurisdictional scan, TCCA should keep the following objectives in mind when developing these new RPAS regulatory mechanisms: supporting international harmony on regulations, and conducting effective consultation with all key stakeholders. As mentioned previously, due to the global and transnational nature of aviation regulations, it is important for national regulatory authorities to harmonize their regulations with one another to support streamlined certification expectations from industry stakeholders. For the second objective of effective consultation with key stakeholders: through strong collaboration with industry stakeholders, TCCA can develop regulations that take into account the practical realities of RPAS operations while reflecting input from a variety of stakeholders whose operations differ in nature, complexity, and size. Consultation with foreign aviation regulatory authorities can also support international harmony of regulations and the development of regulations that reflect lessons learned from other jurisdictions. Lastly, TCCA should recognize the importance of continuing with the BVLOS NPA mentioned in Section 3.1.3, as BVLOS operations are a necessary step forwards in the introduction of complex drone operations in urban environments.

TCCA may also consider beginning with the development of a broad ConOps for RPAS operations in Canada. Much like the US FAA ConOps described in Section 4.3.1, a Canadian RPAS ConOps can set out the conceptual framework and expectations for the present and future of RPAS operations, technology, rules and infrastructure in the specific context of Canadian aviation and markets. A ConOps is an effective way to communicate plans and expectations to the public, industry, and other regulatory authorities, while also giving TCCA a chance to explore the role of RPAS and its practical adoption in Canada. This will be particularly helpful for the development of PDRAs for Complex Operations Using Large RPAS, which require a combination of conceptual and technical considerations.

### *Additional Implementation of Options 1 & 2*

It is possible for TCCA to also implement options 1 and 2 in addition to option 3, in part or in whole, as these options can still help to support the objectives set out in the multi-criteria analysis. The minor enhancements discussed in option 1 (increase efforts to review SFOC applications and conduct more research and consultations) can support the development of regulations. Ramping up industry consultations beyond what may normally be considered during regulatory development can be beneficial in the context of RPAS regulations, since enabling economic opportunity is the primary motivating factor for new RPAS regulations, with industry stakeholders playing an instrumental role as service providers, manufacturers, etc. Interviews, focus groups, workshops, and other collaborative working sessions are effective outreach methods that would likely be useful in generating valuable discussion and information to support regulatory development in this brand new area of aviation. Additionally, increased technical research on practical challenges, best practices, and other considerations will go a long way to prepare TCCA with a foundation of information to inform future developments.

Financial incentives discussed in option 2 (subsidies for RPAS businesses conducting complex operations, grants for businesses and RPAS technology development) would provide strong economic support for the Canadian RPAS industry once the new regulations are on the horizon. The other portion of option 2, in regard to reducing barriers from the Canadian Ownership Requirement, is likely unnecessary if TCCA is developing a new regulatory framework. However, the Canadian RPAS industry may still benefit from the recognition of foreign RPAS certifications, as long as these certifications are congruent with new regulations. As such, TCCA must first develop its own regulatory mechanisms before being able to make an informed decision on whether or not to pursue the integration of foreign certifications.

# Chapter 6.

# Conclusion

The rudimentary and inefficient Canadian RPAS regulatory framework, contrasted with the booming drone industry that is beginning to introduce complex operations using large drones where regulations allow it, such as package delivery and air taxis, indicates that TCCA must do more to enable the commercial adoption of this revolutionary aviation technology. In this pursuit, this report has consolidated relevant regulatory, scholarly, and industry background information, undertaken an analysis of RPAS regulations around the globe, and completed a multi-criteria analysis of regulatory policy options for TCCA to consider. The jurisdictional scan revealed the progress and implementation strategies on RPAS regulations by other regulatory authorities, which shed light on the global progress of drone regulations in contrast with Canada, relevant technical considerations, and potential strategies for TCCA to draw on in development of Canada's RPAS regulatory approach. These findings informed the options that were developed and analyzed through a multi-criteria analysis, which utilized criteria selected based on findings from the literature review and jurisdictional scans. Based on the findings of the multi-criteria analysis, this report recommends that TCCA develop regulations to certify large RPAS and complex operations using large RPAS in urban areas. This would support the introduction of new services and technologies into Canadian markets, which would not only support economic opportunity and technological innovation in a quickly growing drone market that has attracted billions of investment globally, but would also improve services such as delivery or taxi, providing societal benefits for the public and widespread positive economic impact.

# References


Alan Levin. “Delta Invests $60 Million in Joby, Seeking Air-Taxi Flights to NYC Airports”. *Bloomberg News*. October 11, 2022. https://www.bnnbloomberg.ca/delta-invests-60-million-in-joby-seeking-air-taxi-flights-to-nyc-airports-1.1830982.

Amazon. "Amazon Prime Air prepares for drone deliveries." June 13, 2022. https://www.aboutamazon.com/news/transportation/amazon-prime-air-prepares-for-drone-deliveries.

Amazon. “Amazon reveals the new design for Prime Air’s delivery drone – here’s your first look.” November 10, 2022. https://www.aboutamazon.com/news/transportation/amazon-prime-air-delivery-drone-reveal-photos.

BusinessWire. "Global Commercial Drones Market Opportunity Analysis and Industry Forecasts, 2021-2022 & 2030 - ResearchAndMarkets.com.” May 25, 2022. https://www.businesswire.com/news/home/20220525005498/en/Global-Commercial-Drones-Market-Opportunity-Analysis-and-Industry-Forecasts-2021-2022-2030---ResearchAndMarkets.com.

Cision. “Successful Canary Drone Parachute Testing.” September 28, 2022. https://www.newswire.ca/news-releases/drone-delivery-canada-provides-update-on-successful-canary-drone-parachute-testing-802412233.html.

Dalamagkidis, K., Valavanis, K. P., Piegl, L. A. “On Integrating Unmanned Aircraft Systems into the National Airspace System: Issues, Challenges, Operational Restrictions, Certification, and Recommendations”, 2nd edition. *International Series on Intelligent Systems, Control, and Automation: Science and Engineering*, Vol. 54. Springer, 2010.

Danny Kucharsky. “Drone deliveries: Coming soon to a property near you?” *Real Estate News Exchange*. January 29, 2021. https://renx.ca/cre-property-owners-drone-deliveries-spots.

Drone Delivery Canada. “DDC Issued Canadian Transportation Agency License.” July 27, 2021. https://dronedeliverycanada.com/press-releases/drone-delivery-canada-issued-canadian-transportation-ag/.

Drone Delivery Canada. “DDC Launches Dangerous Goods Transportation for UBC’s Remote Communities DTI Program”. August 4, 2022. https://dronedeliverycanada.com/press-releases/ddc-launches-dangerous-goods-transportation-for-ubcs-remote-communities-dti-program/.

Drone Delivery Canada. “Our Story”. https://dronedeliverycanada.com/about-us/. Accessed March 28, 2023.

Drone Delivery Canada. “Technology.” https://dronedeliverycanada.com/technology/. Accessed March 28, 2023.

Dronegenuity. "A Comprehensive List of Commercial Drone Use Cases (128+ And Growing). June 18, 2020. https://www.dronegenuity.com/commercial-drone-use-cases-comprehensive-list/.

European Union Aviation Safety Agency. "Certified Category – Civil Drones”. https://www.easa.europa.eu/en/domains/civil-drones/drones-regulatory-framework-background/certified-category-civil-drones. Accessed March 28, 2023.

European Union Aviation Safety Agency. "EASA publishes world’s first rules for operation of air taxis in cities”. June 20, 2022. https://www.easa.europa.eu/en/newsroom-and-events/press-releases/easa-publishes-worlds-first-rules-operation-air-taxis-cities.

European Union Aviation Safety Agency. "Light UAS operator Certificate”. https://www.easa.europa.eu/en/domains/civil-drones-rpas/specific-category-civil-drones/light-uas-operator-certificate-luc. Accessed March 28, 2023.

European Union Aviation Safety Agency. "Open Category - Civil Drones”. https://www.easa.europa.eu/en/domains/civil-drones/drones-regulatory-framework-background/open-category-civil-drones. Accessed March 28, 2023.

European Union Aviation Safety Agency. "Predefined Risk Assessment (PDRA)”. https://www.easa.europa.eu/en/domains/civil-drones-rpas/specific-category-civil-drones/predefined-risk-assessment-pdra. Accessed March 28, 2023.

European Union Aviation Safety Agency. "Specific Operations Risk Assessment (SORA)”. https://www.easa.europa.eu/en/domains/civil-drones-rpas/specific-category-civil-drones/specific-operations-risk-assessment-sora. Accessed March 28, 2023.

European Union Aviation Safety Agency. "Standard Scenarios (STS)”. https://www.easa.europa.eu/en/domains/civil-drones-rpas/specific-category-civil-drones/standard-scenario-sts. Accessed March 28, 2023.

Federal Aviation Administration. “Certification.” *US Department of Transport*. Last updated July 20, 2022. https://www.faa.gov/uas/advanced_operations/certification.

Federal Aviation Administration. “Certification for Advanced Operations Unmanned Aircraft Systems (UAS).” *US Department of Transport*. Last updated October 5, 2022. https://www.faa.gov/uas/advanced_operations/certification/criteria_special_classes.

Federal Aviation Administration. “National Environmental Policy Act (NEPA) and Drones”. *US Department of Transport*. https://www.faa.gov/uas/advanced_operations/nepa_and_drones. Accessed January 9, 2023.

Federal Aviation Administration. “Package Delivery by Drone (Part 135)”. *US Department of Transport*. Last updated June 21, 2022. https://www.faa.gov/uas/advanced_operations/package_delivery_drone.

Federal Aviation Administration. "Urban Air Mobility (UAM) Concept of Operations v1.0." *US Department of Transport*. June 26, 2020. https://nari.arc.nasa.gov/sites/default/files/attachments/UAM_ConOps_v1.0.pdf.

Forbes. "Drone Explosion: $5B Investment In 2 Years, 129 Startups, 170 New Craft." February 7, 2022. https://www.forbes.com/sites/johnkoetsier/2022/02/07/drone-innovation-check-up-5b-investment-129-companies-170-craft/?sh=25b2b6ba38f6.

Global Newswire. "Drone Market Size, Share [2022-2029] | Insights and Forecast Research | Growth Rate, Demands, Trends, Key Players, geographical Segmentation, Sales, Price, Revenue and Gross Margin Analysis | Market Reports World." June 17, 2022. https://www.globenewswire.com/en/news-release/2022/06/17/2464627/0/en/Drone-Market-Size-Share-2022-2029-Insights-and-Forecast-Research-Growth-Rate-Demands-Trends-Key-Players-Geographical-Segmentation-Sales-Price-Revenue-and-Gross-Margin-Analysis-Mark.html.

Government of Canada. “Canada and the International Civil Aviation Organization.” September 27, 2010 (Archived webpage). https://www.canada.ca/en/news/archive/2010/09/canada-international-civil-aviation-organization.html.

Grand View Research. "Commercial Drone Market Size, Share & trends Analysis Report by Product (Fixed-wing, Rotary Blade, Hybride), By Application, By End-use, By Region, And Segment Forecasts, 2021-2028." https://www.grandviewresearch.com/industry-analysis/global-commercial-drones-market. Accessed March 28, 2023.

Insider Intelligence. "Drone market outlook in 2022: industry growth trends, market stats and forecast." April 15, 2022. https://www.insiderintelligence.com/insights/drone-industry-analysis-market-trends-growth-forecasts/.

International Civil Aviation Organization. "Development of UAS Regulation". https://www.icao.int/safety/UA/UASToolkit/Pages/Narrative-Regulation.aspx. Accessed March 28, 2023.

International Civil Aviation Organization. “ICAO: Frequently Asked Question: What does ICAO audit?” https://www.icao.int/about-icao/FAQ/Pages/icao-frequently-asked-questions-faq-5.aspx. Accessed March 28, 2023.

International Civil Aviation Organization. "Introduction to ICAO Model UAS Regulations and Advisory Circulars." https://www.icao.int/safety/UA/Pages/ICAO-Model-UAS-Regulations.aspx. Accessed March 28, 2023.

International Civil Aviation Organization. “Unmanned Aviation 2022 Symposia and Webinars.” https://www.icao.int/safety/UA/Pages/Unmanned-Aviation-2022%20Events.aspx. Accessed March 28, 2023.

Jakee Stoltz. “Durability & Reliability – The New Path to Ops Over People”. *Advanced Drone Operations*. August 5, 2021. https://www.advanceddroneops.com/news/oops-pt4-category4.

Joby Aviation. “Home”. https://www.jobyaviation.com/. Accessed November 3, 2022.

Joby Aviation. “Joby Applies for Japan Aircraft Certification”. https://www.jobyaviation.com/news/joby-applies-for-japan-aircraft-certification/. Accessed November 3, 2022.

Joby Aviation. “Our Story”. https://www.jobyaviation.com/about/. Accessed November 3, 2023.

National Archives and Records Administration. “Title 14”. https://www.ecfr.gov/current/title-14/chapter-I/subchapter-C/part-21/subpart-B/section-21.17#p-21.17(b). Accessed December 29, 2022.

Northern Ontario Business. “Cargo drone heading to market in 2021.” October 30, 2020. https://www.northernontariobusiness.com/industry-news/transportation/cargo-drone-heading-to-market-in-2021-2836862.

Robert Glenn Olsen. “Paperweights: FAA Regulation and the Banishment of Commercial Drones.” *Berkely Technology Law Journal*, 2017, vol. 32, Annual Review (2017), pp. 621-652. https://www.jstor.org/stable/10.2307/26490257.

Statista. “Drone package delivery system market size in Canada from 2018 to 2030.” April 13, 2022. https://www.statista.com/statistics/1278414/drone-package-delivery-system-market-size-canada/.

Transport Canada. “2020 to 2021 Integrated plan for regulatory framework and oversight.” March 2, 2021. https://tc.canada.ca/en/corporate-services/transparency/open-tc/2020-2021-integrated-plan-regulatory-framework-oversight#toc-4.

Transport Canada. “Canadian Aviation Regulations (CARs)”. *Government of Canada*. https://tc.canada.ca/en/corporate-services/acts-regulations/list-regulations/canadian-aviation-regulations-sor-96-433. Current to October 18, 2022.

Transport Canada. "Notice of Proposed Amendment: Remotely Piloted Aircraft Systems Lower-Risk Beyond Visual Line-of-Sight." *Government of Canada*. April 2020. https://upac.ca/wp-content/uploads/2020/06/2-NPA-droens-BVlos-RDIMS-16275943-v9-NPA_-_LOW_RISK_BVLOS_.pdf.

Transport Canada. “Permanent Mission of Canada to the International Civil Aviation Organization.” August 5, 2022. https://tc.canada.ca/en/corporate-services/policies/permanent-mission-canada-international-civil-aviation-organization.

Transport Canada. "Transport Canada's Drone Strategy to 2025." 2021. https://tc.canada.ca/sites/default/files/2021-03/TC223-Drone-Strategy-ENG-ACC.pdf. Accessed November 3, 2022.

Vertical Magazine. “DDC-Sparrow-696x484.” https://verticalmag.com/press-releases/drone-delivery-canada-achieves-compliant-uav-status-transport-canada/ddc-sparrow-696x484/. Accessed March 28, 2023.