ONTARIO SOCIETY OF PROFESSIONAL ENGINEERS

Growing the Drone Industry in Ontario

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Ontario Society of Professional Engineers (OSPE)

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Contributions

Research and Innovation Task Force

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Executive Summary

Ontario is facing a critical juncture in the development of its drone industry. Drones, or Remotely Piloted Aircraft Systems (RPAS), can provide services to key industries in Ontario by capturing high quality data from the skies. With Canada's largest economy, government funding programs, and a strong research ecosystem, Ontario is the ideal location to develop this emerging industry. First, obstacles such as international competition, scaling, and the problems arising from day to day adoption of drones must be solved.

Drone services could benefit industries that contribute over $600 billion to our national GDP. Ontario's drone policy should focus on three key pillars to ensure we lead a future global industry set to be worth over $20 billion by 2020:

1. **A roadmap for the integration of autonomous aircraft in our airspace:** Transport Canada has one of the most progressive drone regulatory frameworks in the world. Next, they must work with stakeholders in industry, academia and provincial government to develop the future of drone regulation. Drone technology's true value will only be unlocked once fully autonomous RPAS operating beyond visual line of sight (BVLOS) are authorized and integrated in our national airspace. The FAA has a 5-year timeline for this regulatory realignment, Canada must step up and do the same.

2. **Bridging the gap in RPAS technology transfer from research to industry**: Currently, most of our research on drones is never applied for commercial purposes. RPAS must be represented in programs such as Ontario Centers of Excellence (OCE), the Next Generation Manufacturing Supercluster (NGen) and the Downsview Aerospace Innovation and Research (DAIR) hub. Ontario's strong network of colleges must be leveraged to integrate drone technology for client industries.

3. **Ontario taking a position of leadership in drone commercialisation:** Ontario must lead drone commercialization by setting standards for commercial operations, with the help of local industry, and developing pilot programs to lead collaborative efforts towards advanced drone operations in delivery, inspection, and automation.

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1. Drone Technology: An Opportunity for Ontario

1.1 Drone Technology

Remotely Piloted Aircraft Systems (RPAS), also known as drones, represent an emerging trend in the development of aircraft and the use of our nation's airspace. While the basic technology of teleoperated flying devices has existed since the early 20th century [1], advances in electronic hardware, robotics software, and data analysis have created the drones we see today. Removing the need for a pilot, RPAS can be built in a much smaller form, allowing it to be dedicated to carrying payload or collecting data.

Multi-rotor RPAS can tightly navigate around infrastructure or remain stationary for the purpose of data collection, while fixed wing RPAS can collect data or transport goods over large distances. In both cases, the typical critical systems for a RPAS include the aircraft, its propulsion system, a flight controller to automate the control of the aircraft, a suite of flight sensors (GPS, altimeter, Inertial Measurement Unit (IMU) among others), a communications link to transfer data and send command & control (C2) instructions, and a Ground Control System for the remote pilot. Together, these systems enable a new class of aircraft able to collect valuable data and operate without any crew on board.

1.2 Benefits & impact

The development of RPAS presents a significant market opportunity due to their unique value. RPAS allow for the automation of aerial operations, while drastically reducing the required weight and complexity of aircraft by removing any crew. This can significantly reduce the cost of an aerial operation and enable new commercial services that would have previously been unprofitable. In addition, advances in camera sensors, LiDAR, and the development of robust data analysis and machine learning (ML) provide data only obtainable from the sky, creating new value for a customer.

In 2016 over 110,000 drones were sold for commercial use, and the commercial drone technology and service industry was valued at $6.6 billion USD globally [2]. Goldman Sachs Research estimates that by 2020 the commercial drone industry will grow to over $13 billion worldwide [3]. While currently Canada does not rank in the top markets for this emerging industry, there is widely untapped potential in providing services for the agricultural industry ($40 billion market), natural resource industries ($144 billion market), infrastructure and utilities ($220 billion market), construction & heavy industry ($143 billion market), as well as a host of other industries such as insurance, media, and public safety [4].

1.3 Key applications and addressable markets

Construction & heavy industry

Value of industry in Canada: $143 Billion, Value of global RPAS service market: $11 Billion

RPAS systems can collect timely data for construction projects and heavy industrial operations such as aluminum and oil refineries. This includes site surveys, monitoring infrastructure and personnel, volumetric calculations of large deposits of material, and environmental data collection [9].

Agriculture
Value of industry in Canada: $40 Billion, Value of global RPAS service market: $5.9 Billion
Existing RPAS technology has been demonstrated to deliver significant value to the agricultural industry. The collection and analysis of hyperspectral imaging data allows businesses to measure the health of their crops through key indicators (irrigation, leveling, vegetation index and monitoring for disease). Drones can also be used for precision agriculture, optimizing the use of pesticides and remotely applying them to crops. [5]

Infrastructure
Value of industry in Canada: $220 Billion, Value of global RPAS service market: $1.3 Billion
RPAS allow for regular and reliable monitoring of infrastructure, including utilities infrastructure, oil & gas platforms and pipelines, hydroelectric dams, nuclear power stations, wind power generators, telecommunications infrastructure, energy transmission lines, roads, and bridges [8]. RPAS can fly over these infrastructures for long distances and collect imaging data that can be analyzed to detect faults and other useful metrics (ex. heat loss, throughput).

Natural Resources
Value of industry in Canada: $220 Billion, Value of global RPAS service market: $100 Million
Sectors of the Canadian industry, such as mining and forestry, can benefit from the automation of surveying and prospecting operations. Drones can be used to efficiently collect geographical data on a large area through imaging and LiDAR [6], and integrate the data into geographical information systems (GIS) or analyze the data for surveying metrics (ex. Tree level, canopy height, and tree count for forestry applications) [7].

Note: Value of industry in Canada refers to the contribution to GDP of the entire sector (i.e. all agriculture in Canada), while Value of global RPAS service market refers to the estimated value of all drone services to this industry worldwide as of 2020 (i.e. all drone infrastructure monitoring drone)

Other Applications
- Hobby & Personal use
- Military & Defense, Security (patrol, surveillance, search & rescue)
- Delivery (rural & remote communities, ships & ports, last mile delivery, healthcare)
- Other data collection (journalism, film, insurance, weather, environmental monitoring, scientific research)

2. The RPAS Industry Today

2.1 The aerospace industry at large

Aerospace technology and manufacturing is one of the key industries critical to the economic success of the Province of Ontario, as outlined by the Ministry of Economic Development, Job Creation and Trade. The industry contributes over $5.3 billion to our GDP (direct and indirect), and Ontario accounts for 28% of the industry in Canada [10]. Ontario attracts over half of the world's top global aerospace corporations such as Airbus, Bombardier, United Technologies, Safran, Mitsubishi Heavy Industries, and others. These corporations are attracted by a highly skilled workforce, a diverse and established supply chain, and the research expertise of academic institutions such as the University of Toronto, Ryerson University, and Carleton University. The

success of aerospace has a markedly positive effect on the province, creating over 22,000 jobs, and annual research and development (R&D) spending of over $500 million [10].

Ontario has developed into an international hub in several fields such as landing gear, business jet aircraft, and avionics systems [10]. The growth of the aerospace industry in the province will be predicated on leveraging current R&D to create new clusters of expertise in emerging technologies.

2.2 Private drone companies & operators in Ontario

The same factors and ecosystem created for the traditional aerospace industry provide a major opportunity for the growth of the RPAS industry in Ontario. According to the Ontario Aerospace Council there are 8 member companies that serve the RPAS industry. Notable entries include Aeryon Labs, the Waterloo startup founded in 2007 which developed drone aircraft, payload, and services for the civil and commercial markets, and was recently acquired for $200 million by American technology firm FLIR systems [11]. At its heels, several new companies are emerging from Ontario's dynamic startup scene, leveraging new technologies to provide valuable services. These include companies such as ING Robotics, SkyX, and Drone Delivery Canada, which represent the future of the drone industry in Ontario.

Despite the sizable market opportunities, the highly developed aerospace sector, and a history of past success, the RPAS industry in Canada, and Ontario specifically, has not yet established itself as a market leader relative to other major hubs in the United States, France and Israel. It is critical for the continued growth of the Ontarian aerospace sector that it capitalizes on this technology and ensures the RPAS industry reaches its full potential.

2.3 Challenges and barriers to growth

There are several factors that have led to Ontarian RPAS service and technology industry being underrealized. As with many emerging technology markets it will require support and forward-thinking policy to overcome these challenges and ensure the industry's success.

- The consumer and hobby markets are the traditional drivers of economic value in this field, and the most lucrative markets were previously in the design and manufacturing of RPAS platforms. However, competition from abroad and the emergence of companies such as DJI, that have reached economies of scale, have reduced profitability and market opportunity [2]

- The core technologies that have propelled the growth of RPAS markets have matured, and today there exists strong international competition from startups and established players alike. Companies that do not develop an overwhelming market advantage through novel technologies and services, or find a profitable niche, will be hard pressed to grow beyond the size of a small to medium enterprise (SME).

- Despite this, the majority of potential markets (as described in section 1.3) remain untapped. There exists a lack of awareness in potential client industries of the capacities of drone technology and the value of specific drone services. On the other hand, RPAS technology companies lack the expertise in these potential markets to develop services and solutions with a clear value proposition.

- The SMEs and startups that make up the Ontario drone industry often lack the financial resources necessary for the required R&D, technology validation, and scaling required to service these new markets.

- RPAS are currently not fully integrated into the national airspace, a difficult undertaking requiring advances in technology, infrastructure and greater harmonization between key stakeholders [12].

- Further regulatory barriers exist for advanced operations such as beyond visual line of sight (BVLOS) flight, which could greatly expand the potential use cases for drone [13].

- As a result, a technical gap exists between the needs of potential clients and the capabilities of RPAS technology and service providers. There is no standardization or certification to ensure the value of these proposed services beyond the basic safety and operational qualifications. Given this gap, potential clients enterprises are not willing to take the financial and operational risk of adopting and integrating RPAS technologies.

3. Supporting & Growing the RPAS Industry

3.1 Research & Development

Canada benefits from a world class research ecosystem at the cutting edge of science and technology. Ontario is no exception to this, with several leading academic institutions, a highly educated workforce, and significant public and private investment in research and development. The development of several key technologies for RPAS is being led at research institutions such as the Centre for Aerial Robotics Research and Education (CARRE) at the University of Toronto Institute for Aerospace Studies (UTIAS) [14], the Carleton UAV Research Group [15], and the Ontario Tech University[16]. Ontario also boasts some of the world's leading research in machine learning and artificial intelligence through the Vector Institute [17].

In addition, these efforts receive strong government support, and the Canadian and Ontario governments have developed a multitude of funding programs to facilitate advanced research and development. Government agencies such as the National Research Council (NRC) and National Science and Engineering Research Council (NSERC) conduct collaborative research projects and provide funding opportunities for academic research labs. This confluence of expertise and resources have generated valuable research towards the future of RPAS.

If structured and supported by the government, this provides a tremendous resource to RPAS technology firms in Ontario. It is vital that a clear vision emerges for the future of the RPAS industry, and that the stakeholders involved in R&D can collaborate to follow a clear technology roadmap. This can mitigate the greatest structural issue with government funded R&D, namely the uncertainty and fluctuations inherent to administrations that are given finite mandates from our democratic system.

Industry led non-profits such as the Consortium for Aerospace Research in Canada (CARIC) help the industry come together and define research priorities, such as their 5-year vision for aerospace technology and corresponding roadmap towards enabling BVLOS drone operations [13]. Nonetheless, this is an area for improvement, as there is no standardized structure and common taxonomy for the key technologies for RPAS systems. These structuring efforts should consider the strengths of our research ecosystem, such as world class expertise in artificial intelligence and aerospace and drive the development of enabling technologies such as RPAS detect & avoid systems or drone data analysis. There are also opportunities to develop expertise in relevant technological niches, such as building on the Transport Canada initiative with RPAS company Arctic UAV to become leaders in drones resistant to cold temperatures and inclement weather [18].

3.2 Testing, integration & technology transfer

The academic research that Canadian institutions excel in, and the new additions Canadian research makes to the growth of RPAS technology, is only one part of the process of growing the industry. In order to convert academic research and technology design into real world solutions, the critical step is the transfer of technology to commercial industries. This requires validating the technology in real world settings and integrating it into existing systems.

A standard framework for this process is the technology readiness level (TRL) scale, developed by NASA for its R&D programs [19]. Universities often operate at the low to mid end of the scale, developing & analyzing novel technology designs, performing experimental proof of concepts, and validating technologies in a laboratory environment. Technology transfer requires further R&D to advance a technology on the TRL scale, namely:

- Prototype system validation in an appropriate operational environment
- Qualification of the technology through testing and demonstrations
- Successful deployment of the technology in an operational setting

The federal and provincial government supports several initiatives to bridge this critical gap. Central to this are well designed funding mechanisms that foster collaborative research projects between academia and industry. Government agencies and industry lead nonprofits have developed programs such as the Alliance Grants (NSERC), Maturing Technology Grants (CARIC), Mitacs, and the Ontario Centers of Excellence (OCE) Vouchers for Innovation and Productivity, supporting public private partnerships between multiple stakeholders. These also include cost sharing agreements to reduce the financial burden of R&D on industry partners. These programs are structured to support SMEs and prioritize specific technologies vital to the drone industry.

However, the RPAS industry has not yet been identified as a strategic priority in Ontario, and there lacks specific programs and representation in agencies such as OCE. Large scale initiatives such as the DAIR hub, NGen Supercluster, or Vector Institute, that could further propel the transfer of RPAS technology to industry, are also missing. The participation of the RPAS industry in a centralized Ontario aerospace hub, such as DAIR, presents an opportunity, as it could integrate the SMEs of the drone industry with academia, government, and the traditional aerospace industry.

This could yield collaborative projects for RPAS technology transfer and help the shared development of infrastructure necessary for the validation of new services, such as testing sites with controlled airspace and ground based RPAS monitoring capabilities. Furthermore, the participation of college institutions in aerospace R&D, such as Centennial College's central role in the DAIR hub initiative, signals an opportunity to leverage colleges to fill the gap in high TRL R&D for RPAS technology. Crucially, this could propel the technology from exciting research into a valuable product or service.

3.3 Commercialization

Despite Ontario's well-established traditional aerospace industries and strong research ecosystem, the commercialization of RPAS technologies remains limited, which results in many of the market opportunities previously outlined being underserved.

There exist today several government policies and initiatives beneficial to commercialization through their support of startups and SMEs. The Toronto and Waterloo tech startup scenes have emerged as some of the most dynamic and promising in North America. Large incubators such as the Creative Destructive Lab, Ryerson DMZ, and Communitech, receive government support, enabling them to foster new promising startups in the field of RPAS, such as Vertical AI, DreamQii, AirMatrix and Avidrone. Successful government initiatives to support start-ups include FedDev Ontario's regional innovation ecosystems grant [20], OCE's SmartStart Seed funding [21], and CARIC's Acceleration Innovation program [22], which is focused on aerospace technology companies.

Funding for startup and SMEs is particularly critical for the field of drone technology. Currently, there are few mature drone service markets, with notable exceptions including real estate photography and film. Startups represent an opportunity to leverage new technologies and enable new business models.

Much of the variation in the adoption of technology comes down to the fundamental gaps between client enterprises and RPAS service providers. However, forward thinking policies focused on the drone industry could help reduce friction and kickstart commercialization efforts in the industries with the most untapped potential. The Ontario government, through OCE, could create channels to connect drone technology providers and potential client industries, which has been shown to be effective by groups such as Association for Unmanned Vehicle Systems International (AUVSI). AUVSI hosts forums, conferences and networking events, and have outreach efforts to potential industries such as construction, energy and utilities [23].

To this end, government supported pilot programs have demonstrated value in validating integrated approaches to leverage drone technology in fields such as infrastructure monitoring, delivery, and supporting police work. These projects have been attempted by Transport Canada [24] and the Federal Aviation Agency (FAA) in the US [25], and by the government of Ontario to promote the use of these technologies in the province.

In addition, norms and standards are an effective way of reducing the operational risk of the commercial services enabled by RPAS technology. There is a demand for an agency that can qualify and certify standardized commercial operations from the perspective of the client industry, enhancing operational and safety certification by Transport Canada.

With support from the Ministry of Transportation or Ministry of Infrastructure, Ontario could become the first to set a standard on the use of drones for infrastructure inspections, and become a leader in drone commercialization, growing the demand for such services in Ontario and creating revenue for Ontario drone companies.

3.3 Regulation

Despite the tremendous value RPAS technology is poised to provide to society through civil and commercial services, they present a host of new challenges in managing and mitigating safety risks in our national airspace. Automated aerial devices present collision risks to people, infrastructure and other aircraft, rely on additional complex technologies such as flight controllers and communication links, and inherently reduce direct human oversight of aerial operations. As such, it is in the interest of our communities that national regulatory bodies such as Transport Canada be given authority to control, certify and manage RPAS operations. However, a balance must be struck to ensure safety to the utmost degree while enabling commercial operations and providing operators with a clear path to compliance.

To this end, Transport Canada established the RPAS center of expertise in 2017 to develop regulations and standards for the industry [24]. This led to the establishment of an RPAS regulatory framework in 2019, ending a period of regulatory uncertainty for the industry. This involved formalizing the definition of basic and advanced operations, a qualification process for operators, and a certification process with an associated RPAS safety assurance standard for drone manufacturers. This framework covers operations within visual line of sight and for smaller scale drones. Transport Canada has also helped standardize the process for operations beyond this framework, such as BVLOS or heavy lift drones (more than 25kg) where completing an Operational Risk Assessment (ORA) and applying for a Special Flight Operations Certificate (SFOC) [26] is required.

These measures are some of the most progressive and well developed in the world, following best practices set by the Joint Authority for Rulemaking on Unmanned Systems (JARUS) and the International Civil Aviation Organization (ICAO). Their recommendations center around creating a standardized framework for low risk operations, with lower regulatory barriers, and establishing a safety assurance burden proportional to the risk for more advanced operations.[27] This provides lawmakers the flexibility to extend the standardized framework to cover more advanced operations in the future to keep pace with advances in technology.

While commercial operators today benefit from being able to conduct a basic set of operations without a significant regulatory barrier, a key issue for the future of the industry will be enabling BVLOS operations, operations in controlled airspace, and heavier drones with a high payload capacity, all which could greatly improve current drone service offerings. Regulators should develop a roadmap for the integration of these operations and the development of the requisite technologies, such as Remote ID capabilities, reliable Sense and Avoid (SAA), ground based positioning and enhanced cybersecurity. The FAA in the United States released a roadmap for the integration of drone technology in their national airspace in 2018 [28], and it is critical Canada builds a similar vision focused on the future of the industry to ensure it remains competitive on a global scale.

4. Conclusion and recap of key recommendations

Ontario sits at the cusp of a tremendous opportunity. A new industry of automated aerial operations is emerging, and with most key technologies already mature, there remains a significant gap in RPAS commercialization. The Ontarian drone industry is comprised of startups and SMEs who are not fully established, and yet there remain industries, such as agriculture, construction and natural resources, that could greatly benefit from drone technology who are underserved.

The problem of turning these potential clients into a sustainable market for Ontario drone technologies is complex. On the one hand, large corporations see significant technological and financial risk in RPAS, and oftentimes the core value proposition and return on investment is not sufficiently validated. On the other hand, the small enterprises that comprise the drone industry lack the capacity to invest in R&D to build the custom solutions these new industries require. In addition, Ontarian companies are pressured by international competition to quickly utilize the consumer market.

Ontario has several strengths that could one day make it a hub of RPAS expertise: world class academic research, a well-structured regulatory framework, and significant support and funding mechanisms for R&D. Nonetheless, the province must adopt a forward-thinking approach to policy in order to support this nascent industry. As such:

- Government and industry-led nonprofits must collaborate to build a shared vision focused on enabling the automation and increase in the capacity of RPAS.
- Research efforts in Ontario should be coordinated, and the various adjacent technological fields categorized and mobilized towards the future needs of the industry, building expertise in niches such as AI enabled data analytics.
- To further the technology transfer, RPAS should be better represented in province wide efforts such as the DAIR hub and OCE R&D programs.
- Ontario's strong network of colleges should be mobilized to bridge the gap in the validation and integration of maturing drone technology.
- Government-supported pilot programs should be developed to bring technology providers and clients together in developing advanced operations.
- Commercial operations should be better standardized and commercial operators qualified through a third-party with support from client industries and government.
- Regulators should share with industry and the public a clear roadmap for the integration of automated aircraft into our national airspace.

End Notes

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