Electra Aero's eSTOL Hybrid Electric Aircraft

Advanced Air Mobility Comes to Toronto.

Exciting Opportunities to Improve Urban Mobility of People, Goods and Services Without Adding Roadways, Lane Miles or Service Vehicles

AAM White Paper Series
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Canadian Advanced Air Mobility Consortium

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VISION OF CANADIAN ADVANCED AIR MOBILITY (CAAM)

CAAM intends to facilitate development of airspace above Canada's cities and exurban areas, delivering advanced mobility options and benefits to society, especially residents, businesses, disadvantaged communities, Indigenous peoples, and emergency responders. The VISION for Advanced Air Mobility (AAM) will be to deliver equitable, inclusive, resilient, intermodal, and accessible transportation with Zero-Emission Aircraft. A centralized strategy is planned, nationally and regionally, with the inclusion of stakeholders across government, industry, academia, and the investment community.

ABOUT THIS PAPER

This paper is about new mobility options available to metropolitan areas of the world, making use of the underutilized airspace above cities, and their expected societal and economic benefits. It is also an exploration of how the Greater Toronto Area may become an early adopter of AAM in North America, with the opportunities and challenges involved in being among the first. Our question is: How should Toronto go about building an enhanced, sustainable, and safe transportation economy, with the goal of increasing accessibility and quality of life for all communities? Audiences are municipal and government agencies, transportation and social policy experts, the aviation and tech industries, research organizations, the media, universities, community leaders and, most significantly, residents of the Greater Toronto region.

SPONSORS

This paper was sponsored by the Canadian Advanced Air Mobility (CAAM) Consortium, a non-profit effort bringing together partners across government, academia, industry, and local communities, to lay the foundation for advanced air mobility in Canada, seeking to maximize public benefits for all.

FURTHER DEEP APPRECIATION

We express our deep appreciation to the more than 60 individuals and organizations, most in the Toronto area, contributing their time and perspectives to the preparation of this paper. Several companies and individuals are responsible for the research and preparation of this document. Researched and prepared by NEXA Advisors LLC, the team included transportation economists and experts in aerospace transportation systems. Thanks go to authors Eleanor Herman, Phillip Dyment, Chase Leeby, Benjamin Merran and Ian Anderson.

ACKNOWLEDGEMENT OF ANCESTRAL TERRITORIES

We acknowledge the land discussed in this paper is the traditional territory of many nations including the Mississaugas of the Credit, the Anishnabeg, the Chippewa, the Haudenosaunee and the Wendat peoples and is now home to many diverse First Nations, Inuit and Métis peoples. We also acknowledge that Toronto is covered by Treaty 13 with the Mississaugas of the Credit.

NOTE ON CURRENCIES

All currency amounts in this paper are expressed in Canadian dollars.

ON THE COVER

The Electra.aero eSTOL hybrid-electric aircraft will transport 7 passengers or 800 kg cargo over distances up to 800 km.

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Executive Summary

A revolutionary new form of mobility is coming to metropolitan areas around the world that, as part of a sophisticated, seamless, multi-modal transportation system, will improve personal mobility and help slow the growth of congestion. Mind-numbing traffic—the bane of prosperous urban areas—causes cities, their businesses, and residents to grind to a halt. Productivity and quality of life decrease; costs rise.[1] Cities such as Toronto spend billions on the well-targeted expansion of public transportation systems to reduce congestion, only to attract more home construction, more people, and more congestion in a never-ending cycle.

Figure 1 - Flying air taxi start-up Lilium is investing over $1 billion in vehicle development and infrastructure. All told, investors have committed some $12 billion in the OEM supply chain. Another $10 billion will likely follow in the next two years.

Advanced Air Mobility (AAM) will not spring forth in a vacuum but will be developed, supported, funded, and staffed by a complex ecosystem already in place. In this respect, the Greater Toronto Area offers a dynamic base of experience, investment, and education that could propel it to become an early AAM user. It boasts a strong and historic aerospace industry, one of the most vibrant tech sectors in the world, and one of the most robust financial sectors globally, in addition to an impressive educational system focusing on STEM, engineering, and aerospace—necessary to prepare the thousands of skilled workers required for the new industry.

In terms of traffic reduction, strategic use of AAM aircraft for delivery and cargo can remove from the roads thousands of trucks which often block entire lanes in rush-hour traffic. Cargo as diverse as heavy freight, depot-to-depot, retail packages, and just-in-time deliveries can be delivered in a variety of efficient aircraft traveling above traffic, saving carbon emissions, noise, and wear and tear on the roads.

Given the anticipated public acceptance of a new technology that will save lives, Toronto's world-class medical facilities will likely be the first users of this new form of aviation. AAM medical transport will

[1] According to the C.D. Howe Institute, in the Greater Toronto and Hamilton Area, the commonly used estimate is that congestion costs the economy about $6 billion per year (2019).

move patients, medications, defibrillators, blood, organs, radioisotopes for cancer treatment, and PPE. AAM vehicles have the ability to take off more rapidly than helicopters, and some designs may be able to land in a smaller space. Patients in the rural areas of the Golden Horseshoe suffering life-threatening emergencies will be transported more quickly and efficiently to distant trauma centers.

The healthcare system will save a great deal of money given the lower cost factors of AAM compared to helicopters, which charge tens of thousands of dollars per flight.[2] In some cases, patients, too, will save thousands. Not all Medevac costs are paid by insurance. Gaps exist in coverage and vary across Canada. For instance, visitors and residents without an Ontario health card and residents transported into Ontario are responsible for the full cost.[3]

Geographical Terminology

The Greater Toronto Area (GTA) is the most populous metropolitan area in Canada. With a total population of 6.4 million, it includes the City of Toronto and the regional municipalities of Durham, Halton, Peel, and York. In total, the region contains 25 urban, suburban, and rural municipalities. Combined with the city of Hamilton, the area is known as the Greater Toronto and Hamilton Area (GTHA). The GTHA combined with the Niagara Region form the core of the Golden Horseshoe.

AAM will open up new forms of Regional Air Mobility: convenient, carbon-free flights between city pairs whose distances are currently not commercially viable for airlines. Passengers will hop on short, quiet flights from Pearson International and Billy Bishop Toronto City Airports to places like Kitchener, Peterborough, Barrie, Buffalo, Rochester, Detroit, Pittsburgh, Syracuse, and Cleveland. In addition, AAM Airport Shuttles—operating in an environment already set up for air traffic and passengers—will whisk people from Pearson International Airport to downtown Toronto and other strategic locations. At scale, the new aircraft will serve as On-Demand Air Taxis; hailed on an app similar to ground-based Uber or Lyft, or helicopter operator BLADE, they will transfer passengers from vertiport (eVTOL takeoff and landing facility) to vertiport, accelerating intracity transit.

The Air Metro concept envisions larger aircraft holding a dozen passengers which could replace some train routes. With an average cost of $300 million per km of subway expansion in the Toronto area, thoughtfully chosen Air Metro routes could be introduced later on (the development of larger aircraft is further in the future) to complement public transportation and reduce ground transportation expansion costs.

AAM aircraft are Zero Emissions, a key benefit to help the province and the nation meet their goals in combatting climate change. Another significant bonus is that over the next 25 years this new form of aviation will create thousands of new jobs and tens of millions in tax revenues.

Many cities are planning to introduce AAM in the next few years, including Singapore, Munich, Paris, Dubai, and Dallas. If Toronto hopes to seize this new opportunity, it will need to start work now to reap

[2] https://www.focuspointintl.com/trending/travel-insurance/are-air-ambulances-covered-by-ohip/
[3] https://www.intrepid247.com/tips-resources/travelling-within-canada

what we call early adopter advantages: investment dollars, top aerospace talent, and timely orders for the most popular aircraft that will, we believe, soon be on a long waiting list.

Figure 2 - Simulated flight of a Horizon Aero Cavorite X5 over Miami Florida. Horizon is an Ontario aerospace company with ambitious plans to develop versatile eVTOL aircraft.

This paper is sponsored by the non-profit Canadian Advanced Air Mobility (CAAM) Consortium; its goal is to educate policy makers, journalists, city planners, and the public at large about the field and the potential opportunities. The paper explains what AAM is, where the rapidly transforming new sector stands today, and the obstacles standing in the way of its immediate implementation. We will explore the social, business, and economic benefits, and why Toronto is well suited to become an early AAM user given its congestion, affluence, world-class medical system, decarbonization goals, and strong technology and financial ecosystems.

This paper investigates the various uses of these aircraft to transport people and cargo. Some Remotely Piloted Aircraft Systems (RPAS, often known as drones) are already in operation delivering supplies to remote communities, monitoring infrastructure, and assisting first responders. These will serve as a base to build upon with larger, more complex piloted and remotely piloted aircraft, many with passengers.

Figure 3 - Drone Delivery Canada will deploy its RPAS delivery platform to help deliver healthcare-related cargo.

Perhaps most importantly, we will discuss our interviews with some 60 stakeholders in the Greater Toronto Area—in aerospace, business, government, transportation, economic development, real estate, cargo, academia, and healthcare, individually and in focus groups. These leaders in their fields described their vision for AAM and its many benefits to government, businesses, universities, and residents throughout the region.

What is Advanced Air Mobility?

Advanced Air Mobility is a concept of air transportation that moves people and cargo between places not conveniently served by surface transportation or underserved by aviation—local, regional, intraregional, urban—using revolutionary new aircraft that are only just now becoming possible. AAM covers a wide range of manned and unmanned aircraft including electric Vertical Takeoff and Landing (eVTOL) aircraft, electric Short Takeoff and Landing (eSTOL) aircraft, fixed-wing electric aircraft, and Remotely Piloted Aircraft Systems (RPAS). The passenger aircraft will be powered by hybrid electric systems, batteries or, at some point further down the road, hydrogen fuel cells.

Figure 4 - Purely electric and hybrid vehicles such as the Bell NEXUS will be flight tested in the coming years.

While batteries currently limit flight times and require long charging times in between flights, hydrogen fuel cells—such as those that will be used in aircraft developed by Alaka'i Skai in Massachusetts and ZeroAvia in California—should offer long-range flight capabilities as well as fast refueling. Their only local emissions are water, and there are ways to develop these aircraft in a green and sustainable fashion.

Until quite recently, this new aviation technology was referred to as Urban Air Mobility, a name that reflects its intended uses in a congested urban environment. However, it is becoming apparent that its benefits will not be limited to cities. These aircraft may range far and wide, bringing accessibility to geographically distant, underserved communities.

While many new AAM designs are making rapid progress—some of them flying in evaluation scenarios—we must point out that none of them have received certification yet. Passenger carrying aircraft will undergo the most rigorous safety assurance, whereas aircraft used for movement of cargo or inspections may not require the same level of certification for commercial use. However, we can be confident of certain attributes of the new aircraft. Using composites, they will be lighter and more

efficient than traditional aircraft. Additionally, it has been demonstrated that they can be far quieter than traditional helicopters. All factors point to enormous cost savings in terms of their purchase, maintenance, and operation. And, given their propulsion systems, they will be far more environmentally friendly.

An emerging view of the next 25 years is that highly automated flight, with less reliance on pilots, will be necessary to improve the reliability and thus the safety of this new market sector. Highly automated systems will augment pilot capabilities while enhancing safety, enforce see-and-avoid rules, and safely separate all aircraft, including eVTOLs and RPAS. They will also reduce the cost of operations and permit greater aircraft access to city centres. Automation is the "Inflection Point"—expected in the early 2030s—where the cost structure of the entire industry will be dramatically reduced in synchronization with the expansion of aircraft and airspace capacity. However, before that happens, the industry needs to develop a robust system of automation that demonstrates that can produce the level of safety we expect of current aviation or better. Until that time, piloted aircraft will be required and necessary to ensure all people in the air and on the ground are able to enjoy the benefits of this new technology.

Metropolitan Areas Around the World Have a Vision for AAM

Stakeholders have varying visions for AAM and its mobility value consequences. Most agree that an important early use case worldwide will be emergency response to assist critically sick and injured individuals: transporting first responders to the site to support the patients and subsequently transporting them to local emergency centres. Smaller and possibly safer than helicopters, eVTOLs could provide transport to improve survivability by as much as 85% by getting the injured to emergency facilities within the "golden hour" after an accident.

Figure 5 - Electric Vertical Take-off and Landing Aircraft will serve densely populated areas with quiet, safe mobility options.

Some view AAM as a version of highways in the sky that mirror ground vehicle traffic. These visions come in the form of piloted air taxis picking up passengers on request as part of an on-demand urban network. Passengers will be able to book flights using mobile app technologies, have the nearest on-grid aircraft sent directly to a convenient pickup location, and be fully integrated with other mobility modes such as airports and train stations.

Others see AAM as a carefully targeted option to reduce subway construction costs and improve the transit experience for those far from their destination is by creating an Air Metro—flights on a regular schedule, similar to that of buses—at the furthest subway stations and near major bus transit centres.

All predicted models of AAM implementation boast significant societal benefits in environmental impact, new services for underserved and vulnerable communities, economic productivity, and job creation.

A Rapidly Transforming New Sector

In the past two years, the Advanced Air Mobility industry has undergone a transformation from a place of questions and hypotheses to one of dramatic non-stop developments in technology, partnerships, and investments. This industry has been taking shape exponentially in recent months, with new announcements on an almost daily basis.

Some 400+ companies around the world—from start-ups to aerospace giants—are developing AAM aircraft or the systems they will be relying upon for flight. Industry experts have estimated the cost of certifying an eVTOL aircraft at anywhere between $300 million to $1 billion. Recently, substantial progress has been made to overcome this obstacle. As of September 2021, corporations, private equity funds, and Special Purpose Acquisition Companies (SPACs) have committed some $12 billion in Advanced Air Mobility aircraft development funding for several AAM aircraft manufacturers. A further $10 billion is expected to follow the OEM (Original Equipment Manufacturer) supply chain over the next two years. For example:

- California-based Joby Aviation plans to launch air taxi services by 2024 in its effort to be one of the first to commercialize eVTOL aircraft for passenger use in the United States. Joby is developing a four-passenger, emissions-free aircraft, which can travel up to 150 miles at speeds up to 200 miles per hour. The company is beginning construction on a 450,000 square foot manufacturing facility, designed in conjunction with Toyota, to take advantage of automobile manufacturing processes.
- In March 2021, Lilium, based in Munich, announced that its first serial aircraft, the seven-Seat Lilium Jet, is expected to be produced in the next few years. The aircraft has a maximum range of 155 miles and a cruise speed of 173 mph, with zero operating emissions. Lilium aims to commercialize its electric aerial ride-sharing services in cities across the globe by 2025.
- In 2017, California-based Wisk (Figure 6) became the first company in the U.S. to successfully fly a highly automated eVTOL aircraft designed for passenger use. A partnership between Boeing and Kitty Hawk, Wisk has remained committed to the safe integration of highly automated aircraft systems into existing airspace.

Figure 6 - Wisk, a Joint Venture of Boeing and Kitty Hawk, will introduce fully autonomous aircraft within five to eight years. Pictured is the Wisk Cora.

- Another AAM leader based in Germany, Volocopter, expects certification by early 2023 for its two-seater, piloted VoloCity aircraft, a multicopter with 18 rotors, carrying a pilot and one passenger, with a range of 21 miles at speeds up to 68 mph. The company has tested its aircraft in France, Helsinki, and Singapore and expects to launch commercial air taxi services before 2024.
- In April 2021, Blade Urban Air Mobility, a services provider, announced a commitment to purchase up to 20 ALIA aircraft from BETA Technologies in Vermont, for delivery in 2025. The aircraft is envisioned to carry five passengers plus a pilot. A month later, Blade ordered 30 eVTOLs from Wisk.
- In July 2021, United Airlines ordered 200 ES-19 electric fixed-wing aircraft from Swedish electric aviation startup Heart Aerospace. The ES-19 is a regional airplane that seats 19, can fly up to 240 miles, and runs on batteries and electric motors instead of traditional jet fuel. United is just one of many airlines ordering eVTOL and electric fixed-wing aircraft. Orders for some 1,200 AAM aircraft have been placed by Virgin Atlantic, British Airways, UPS, RAVN, Qantas, and others.

Figure 7 - Beta Technologies' eVTOL in UPS livery.

AAM is also not just about new aircraft. Critical infrastructure needs to be readied to support urban operations: takeoff and landing facilities and air traffic control systems. Regional assets such as heliports, highways, and airports must be mapped. The likely economic impact of AAM implementation must be quantified. Numerous projects are underway along these lines. To name a few:

- In late 2020, the Vancouver area, through a CAAM initiative, developed a blueprint for the introduction of commercial services using electric flight. A business and economic feasibility study was completed that points to a new $2 billion industry making use of existing ground-based infrastructure provided by 54 regional heliports and 12 airports.

- In the Spring of 2021, to launch AAM in a leading role, Ohio became the first U.S. state to finalize an ArcGIS mapping of its entire area with tens of thousands of data points including roads, bridges, fire stations, warehouses, airports, heliports, manufacturing facilities, logistics centres, etc. for full-scale AAM implementation. An expected bump to its GDP by about $15 billion will follow development of AAM, with over 15,000 permanent full-time jobs forecasted.

- The state of Arkansas has commissioned an economic impact study and statewide mapping of airports, health care centres, roads and highways, manufacturing centres, shipping facilities, etc. Plans are afoot to use AAM to bridge the urban-rural divide and provide remote, rural areas with much improved healthcare.

What are the Central Social Benefits?

A wide range of social benefits are derived from the implementation of AAM which include the following:

For the environment:

- Decarbonizing, over time, transportation with Zero-Emission aviation using clean electric and hydrogen fuel cell technology.
- Reducing noise pollution. The quieter aircraft should prove to be a boon, particularly for Billy Bishop Toronto City Airport near the heart of downtown Toronto.
- Monitoring wildfires.
- Monitoring the health of bodies of water.
- Improving agriculture and minimizing fertilizer and pesticide use through prescriptive farming techniques.
- Delivering retail goods to residences, thereby reducing the number of trucks—including their noise and polluting exhaust—from neighborhoods.
- Eliminating other pollutants such as volatile organic compounds, particulate matter, sulphur dioxide, nitrous oxides, and unburned fuel.

For public health and safety:

- Taking injured and critically ill patients to hospitals more efficiently and quietly than Medevac helicopters (Figure 8).
- Allowing lower-income groups and/or physically distanced groups, such as Indigenous communities, easier access to centres of economic activity and healthcare, such as obstetrics or dentistry.
- Providing crucial supplies, medicine, and transportation to underserved communities in the north of the province that are difficult to serve with conventional fixed-wing aircraft.

Figure 8 - Ornge is a provider of air ambulance and critical care land ambulance services to all 13 million Ontario residents.

- Delivering medical supplies, blood, organs, and plasma quickly to and between hospitals.

- Assisting firefighters and law enforcement personnel through RPAS providing no-risk early assessments of potentially dangerous situations.
- Inspecting bridges, high-rise buildings, and horizontal infrastructure (power/water/gas supply lines) safely and efficiently.
- Lower direct operating costs for all of the above.

For the region's residents and workforce:

- Providing local transportation of passengers and delivery of goods between such cities as downtown Toronto and Kitchener-Waterloo, one of the foremost tech hubs in Canada. A link between Kitchener-Waterloo and Toronto would allow for greater mobility of key businesspeople, materials, and products, connecting several technology company's headquarters to the economic hub and largest market in Canada.
- Providing regional transportation of passengers and delivery of goods between downtown Toronto to cities further afield without convenient travel options such as Peterborough, Kitchener, Barrie, Buffalo, Rochester, Detroit, Pittsburgh, Syracuse, and Cleveland.
- RPAS cargo drones can offer time-critical deliveries, such as just-in-time parts delivery, in support of Southern Ontario's significant manufacturing sector. As an example, in the automotive sector, drone delivery can support lean manufacturing processes by providing time-critical small component deliveries from local Tier 1 suppliers to the OEM vehicle assembly plants.
- Complementing and diversifying public transportation operations. For example, providing metropolitan transportation options for commuters between heavily populated suburban communities such as the Durham Region (Oshawa, Whitby, Ajax, Pickering), Halton Region (Oakville, Burlington, Milton), Peel Region (Brampton, Mississauga, Caledon), York Region (Markham, Vaughan, Newmarket,

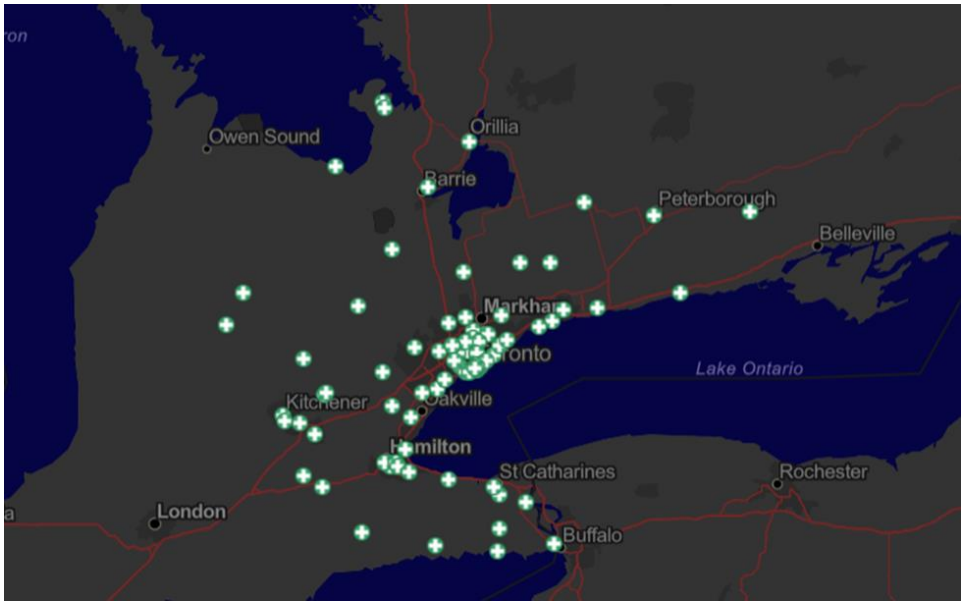

Figure 9 - Major healthcare facilities throughout the Greater Toronto region will be conveniently linked with new AAM services.

Richmond Hill), and Barrie. In addition to commuter benefits, business opportunities will be expanded to the outer reaches of the Golden Horseshoe; for example, tech giants in Kitchener-Waterloo will have much improved access to the Fortune 500 companies headquarters and other large companies in Canada's economic hub.

- Labor market pooling: As part of a multi-modal transportation system, AAM will open up new opportunities for those who live further out from major areas of employment. Currently, Toronto is undergoing a housing crisis due to a low supply of new homes, a crisis level of affordability, spiraling population growth, and a decrease in rental units, resulting in people moving further and further away from the city centre due to costs.
- Businesses, too, will benefit from a larger labor market and a better match of skill sets to the company's needs, resulting in increased economic efficiency and growth.
- One suggestion to improve transportation accessibility and equity with regards to AAM is setting aside up to [15%] of AAM capacity and flights to guarantee low- or no-cost access for the region's most vulnerable residents. These costs would be cross-subsidized through multi-tier pricing regimes developed in agreement, and in full transparency, among operators and local and provincial transportation authorities.

What are the Business and Economic Benefits?

NEXA Advisors/UAM Geomatics is currently preparing an Economic Impact Assessment (EIA) for the Greater Toronto Area as part of a CAAM initiative, the "Triple Bottom Line" exploration of the social, economic, and environmental benefits of AAM. NEXA's EIA will determine the following:

- Estimated AAM passenger demand through 2045 for five use cases: Airport Shuttle, Medical, On-Demand Air Taxi, Regional Air Mobility, and Business Aviation.
- Estimated economic activity resulting from AAM investment in cargo, logistics, and distribution.
- Resulting new business activity (direct activity) from investment in ground infrastructure, the variety of necessary air traffic management systems and infrastructure, aircraft acquisitions for eVTOL, eSTOL, electric fixed-wing aircraft, and RPAS; AAM operations; economic activity resulting from suppliers (indirect activity), and induced activity (when newly hired people spend their money on a variety of purchases.)

The investment required to introduce AAM can be arranged through the formation of public-private partnerships, largely or exclusively funded by the private sector. It is not likely governments will burden their taxpayers with these investments.

While the jobs and economic activity research on the Greater Toronto Region is not yet completed, we can provide figures for Vancouver, which we forecasted in our Fall 2020 paper, **"Economic Impacts of Advanced Air Mobility: New Air Mobility Options Will Benefit Greater Vancouver, Creating Jobs & Energizing GDP Growth."** In the initial two-to-three-year period, we forecasted 320 new full-time jobs. Between now and 2040, the total forecasted number of full-time permanent jobs is estimated at 2,000. AAM would produce some $2.1 billion in new business activity over the same period.

AAM productivity will be "greenfield" (absolutely new and not drawing away jobs or income from other industries) incremental revenue for Toronto and will drive an economically beneficial development phase that, over time, brings environmental, social, commercial, and even increased trade benefits. Our EIA study, to be finalized in November 2021, will estimate the same benefits for the Toronto region. The results are expected to be comparable to those of the State of Ohio for which we estimated 15,000 new full time permanent jobs and $15 billion in new economic activity.

Any transportation system, either new or an expansion of existing facilities, is expected to produce a wide range of economic benefits, and for greater Toronto, AAM will generate:

- GDP growth measured in the billions of dollars.
- New direct and indirect job creation, much of it in highly skilled disciplines.
- Tax revenues for local and provincial governments.
- Catalytic effects from increased trade and commerce.

Figure 10 - - Counties of the Greater Toronto Area, or GTA.

Who Will Pay for AAM Infrastructure?

AAM cannot be implemented without investment behind it. While the new aircraft, as mentioned above, are receiving billions of dollars of investment, most metropolitan areas do not have the tens of millions of dollars to spare for vertiports and RTM. Investment to fund the infrastructure will likely come in the form of Public-Private-Partnerships (PPPs), long-term contracts between a private investor and a government entity, for providing a public asset or service.

In the case of the GTA, it is likely that a PPP will consist of a consortium that includes metropolitan authorities, private financial institutions, commercial and government users and operators, and other stakeholders. The most senior member is the project sponsor, which could be the City of Toronto and its economic development organization, or the Province of Ontario, in granting a concession for construction of the vertiports and RTM systems to proceed.

Advanced Air Mobility must, within a few years, become economically viable to pay off investors as well as to support recurring costs such as equipment maintenance and upgrades, and employee salaries, and maintain public safety and convenience.

Figure 11 - Multiport concept developed for Uber Air (now Joby) represents a hub of the future.

What are the Current AAM Challenges?

Despite the excitement surrounding this new mobility sector, there is still much work to do before it takes off. Aircraft developers must finalize their designs, and aviation authorities (Transport Canada, the FAA in the US, and EASA in Europe, for instance) will build on existing regulations that have safeguarded air safety to create new airworthiness and operational certifications and regulations.

Figure 12 - NASA visualizes "Tunnels in Space" to ensure safe operation of aircraft in complex low-altitude urban airspace.

Another important challenge being worked on lies in the way we manage this increasing complexity of air traffic management. While many solutions have been proposed (see figure 12), each works well in certain cases and not in others. Building a comprehensive air traffic management system integrating eVTOLs, eSTOLs, RPAS, and traditional aircraft will require a mosaic of solutions that will enable the scaling of commercial AAM operations one solution at a time. Vertiports must be site selected, receive certification, and constructed to facilitate cost efficient and convenient passenger access. Routes must be planned, considering zoning, safety, privacy, noise and

security restrictions, and public opinion (Figure 12). Equity and accessibility must also be carefully weighed when planning routes and pricing. AAM must become part of a multi-modal transportation system for all who live and work in the Toronto Metropolitan Region.

The Global Advanced Air Mobility Industry

Advanced Air Mobility will require four supply chains to assemble and operate this new transportation system as shown in Figure 13. The ecosystem will need to provide convenient services to passengers at affordable prices where the sector itself finds an equilibrium, thereby becoming and remaining profitable.

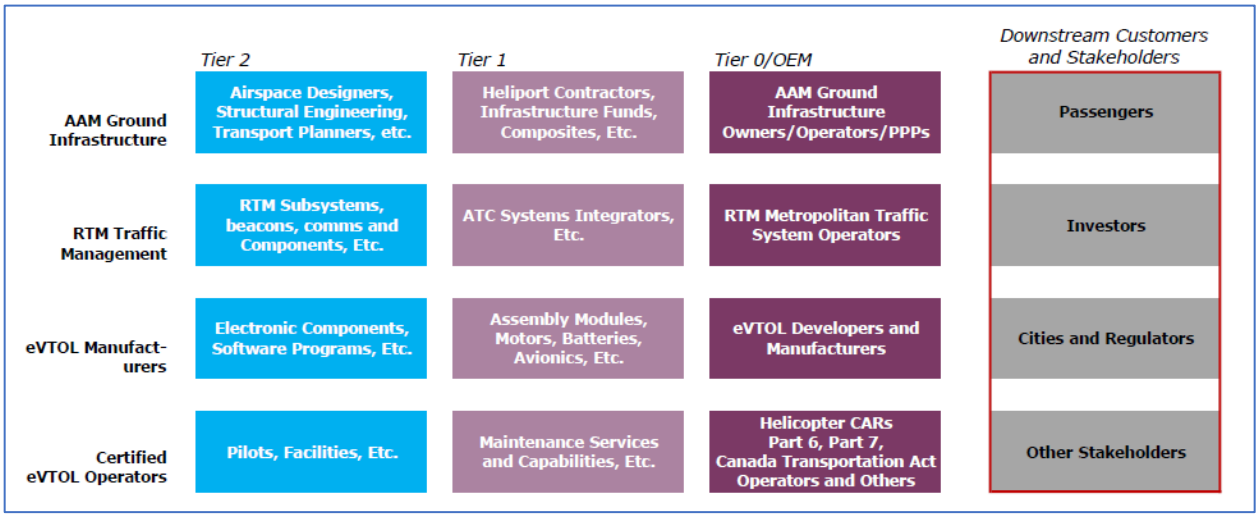

Figure 13 - Illustration of the four supply chains critical to the success of Advanced Air Mobility.

Supply Chain 1 - Developing and Manufacturing AAM Aircraft

Several AAM prototypes (eVTOL, eSTOL, electric fixed-wing, and heavy-lift cargo RPAS) around the world are either in or nearing advanced stages of development and operational trials of one kind or another. Designs vary widely in terms of number of passengers, number of rotors, and distance traveled before recharging (Figure 14).

Even those developers furthest along have not released certain details about their aircraft, but we believe they will be lighter, quieter, less expensive to purchase, maintain, and operate, and more flexible than helicopters. Nearly all AAM aircraft currently in development are designed to be piloted, at least initially. The next two decades will see increasing use of highly automated systems performing many functions traditionally performed by humans. With regulator approval, automation and autonomy offer the opportunity to reduce workload and enhance safety for critical aviation functions.

Aircraft noise is a key determinant defining the success and acceptance of eVTOLs and eSTOLs that will operate in areas of higher population density at low altitudes. Smaller AAM aircraft are expected to fall well within current noise guidelines, and noise-reducing technologies hold promise for larger aircraft to be good neighbors as well. The next two pages provide details on eight aircraft well along in their development.

- **Joby S4**
- Santa Cruz, CA, USA – www.JobyAviation.com
- 1+4 passenger eVTOL with 6 tilting propellers
- Safety features – Distributed Electric Propulsion
- Total funding – $1,600 million after SPAC investment
- Investors – Toyota Motor Group, Capricorn Investment Group, Intel Capital, JetBlue Technology Ventures, and Toyota AI Ventures, Reinvent Capital
- Range – 150 miles
- Speed – 200 mph

- **Hyundai S-A1**
- Seoul, South Korea – www.Hyundai.com
- 1+4 passenger eVTOL with 4 tilting propellers and 6 lifting propellers
- Safety features – Distributed Electric Propulsion, wings
- Total funding – $1.5 billion into UAM over next 5 years announced in Jan 2020
- Range – 60 miles
- Speed – 180 mph

- **CityAirbus**
- Marignane, France – www.AirbusHelicopters.com
- 4 passenger autonomous eVTOL with eight co-axial propellers.
- Safety features – Single failure tolerant architecture
- Total funding – Undisclosed
- Internal Airbus development
- Average range – 80 km
- Average speed – 120 kph

- **Wisk Cora**
- Mountain View, CA, USA – www.Cora.aero
- 2 passenger autonomous eVTOL with 12 lifting propellers and 1 pusher propeller
- Safety features – Distributed Electric Propulsion and Triple Redundant Flight-Computer, wings
- Total funding – Undisclosed
- Joint project with Boeing and Kitty Hawk
- Average range – 62 miles
- Average speed – 110 mph

- **Jaunt Aircraft**
- Dallas, TX, USA – www.JauntAirMobility.com
- 1+4 passenger eVTOL with 1 lifting rotor and 2 cruise propeller
- Safety features – Dual redundant electric systems
- Total funding – Undisclosed
- Joint partnership with Uber Elevate, now Joby
- Average range – 150 miles
- Average speed – 175 mph

Figure 14

- **Volocopter VoloCity**
- Bruschal, Germany – www.Volocopter.com
- 1+1 passenger eVTOL with 18 fixed-pitch propellers
- Safety features – multi-redundant propellers, batteries, motors, electronics, and displays, can function on 12 propellers
- Total funding – $390 M
- Investors – Daimler, Mitsui Sumitomo Insurance, MS&AD, TransLink Capital, Lukasz Gadowski and others
- Range – 22 miles
- Speed – 62 mph

- **Lilium Jet**
- Wessling, Germany – www.Lilium.com
- 5 passenger autonomous eVTOL with 36 ducted fans
- Safety features – redundancy with 36 independent engines, wings
- Total funding - $1,220M
- Investors – Tencent, Freigest Capital, Automico, LGT Capital Partners, QELL SPAC
- Range – 186 miles
- Speed – 186 mph

- **VEA Aircraft Inc. (Piasecki) PA890**
- Essington, PA, USA – www.Piasecki.com
- All-electric Slowed-rotor Winged Compound Helicopter with a three-bladed main rotor, a variable incidence wing, and swiveling tail rotor
- Safety features – highly redundant and reliable propulsion system
- Total Funding – Undisclosed
- Investors – Undisclosed
- Range – 280 miles
- Speed – 140 mph cruise speed

- **Beta Technologies**
- Vermont, USA – www.beta.team
- 1+4 passenger e/hVTOL with 4 lift propellers
- Battery electric aircraft
- Safety features – Distributed Electric Propulsion
- Total funding - $510 M
- Investors – Xavion, Martine Rothblatt
- Orders: UPS, BLADE
- Average range – 250 NM
- Average speed – Undisclosed

- **Archer**
- San Jose, CA, USA – www.flyarcher.com
- 1+4 passenger eVTOL 12 electric propellers: six tilt-propellers for forward and VTOL flight, and six fixed propellers for VTOL-only flight
- Safety features – Distributed Electric Propulsion
- Total funding – $1,120 M
- Investors: Atlas Crest, United Airlines
- Average range – Undisclosed
- Average speed – Undisclosed

Supply Chain 2 - Ground Infrastructure: Heliports, Vertiports and Multiports

Most of the first takeoff and landing facilities—called vertiports—will likely be reconditioned heliports. The basic elements of a heliport are clear approach/departure paths, a clear area for ground maneuvers, final approach and takeoff area (FATO), touchdown and liftoff area (TLOF), safety area, and a wind cone. This existing infrastructure can be updated for eVTOL/eSTOL aircraft by adding battery recharging stations and fuel stations for hybrid aircraft, as well as perimeter security, shelters, and other amenities. The region's power grid becomes an essential factor in determining vertiport locations.

The world is actually well populated with heliports and airports; however, fewer than half are in locations convenient for AAM applications. Ground infrastructure will require expansion into network configurations, with each node, or vertiport, carefully located and built to ensure passenger convenience and value.

The Golden Horseshoe area has 46 heliports. Twenty-six of the region's 92 hospitals and health centres have heliports. In addition, most of the area's 20 airports have one or more helicopter landing facilities. Depending on the convenience of their locations and local regulations, many of these will be upgraded to vertiports suitable for AAM aircraft. Small rural airports currently used for training, crop dusting, or business aviation can also be remediated to join a vibrant AAM network.

Globally, many cities have heliports that are rarely or no longer used. Helicopters are often seen as a nuisance by local communities due to their noise. Given the lower noise signature of eVTOLs/eSTOLs, it is likely that some of the unused or underutilized heliports may be renovated to receive the new aircraft.

At some point in the future, AAM aircraft will land and take off from multiports (Figure 11). These large, specially designed transportation hubs will be able to service several aircraft at once and may offer passenger amenities such as food, restrooms, and shopping.

Integrating an AAM aviation network with the existing system of public transportation modes requires detailed planning and analysis. With objectives of implementing the greenest, most cost-effective, and commuter-friendly transit system possible, planners must consider the needs of all users when locating vertiports to enable practical end-to-end solutions for passengers. The NEXA Advisors/UAM Geomatics study, **Urban Air Mobility: Infrastructure and Global Markets 2021-2045**, projected that by 2045 the Greater Toronto Area would need 56 vertiports (of which 20 would be unserviced vertipads), one of which would be an airport multiport, and two would be urban multiports, strategically placed throughout the region, in addition to those presently at hospitals. The combined estimated cost for these vertiports is $258 million. In 2045, it is estimated that on average each of Toronto's vertiports will provide service to some 470 people a day.

While the technology is available to upgrade heliports to vertiports, Transport Canada has not yet developed the applicable standards. These regulations may be dependent on the types of aircraft selected, their footprint, weight, and electric or hydrogen charging requirements. CAAM is well positioned to collaborate with the Canadian government agencies to advocate the manufacturing and operation standards.

Although certain aspects of vertiports remain to be determined, it is safe to say that the development of infrastructure to support an eVTOL network has significant cost advantages over heavy-infrastructure approaches such as roads, light rail lines, bridges, and tunnels. Compared to the billions of dollars required to extend lines, for instance, the estimate for the 56 vertiports and three multiports projected to operate in the GTA by 2045 (a mix of remediating existing heliports and building new ones) is in the range of $256 million total.

Because eSTOL aircraft need a takeoff area about the size of a soccer field with no tall buildings nearby, converted heliports will not support them. However, airports and suburban/rural areas would have the necessary space.

Supply Chain 3 - Managing the Air Traffic Flow

An air traffic management system ensures the safe and efficient movement of aircraft. Airplanes and helicopters are guided through the airspace by air traffic controllers. RPAS and AAM passenger aircraft must also be safely and efficiently managed. The first passenger use cases will likely have strong oversight from NAV CANADA's existing air traffic management systems. NAV CANADA has recently developed a NAVDRONE system to help recreational and commercial RPAS operators fly safely. While future more complex aircraft operations may build on learnings from this platform, future aircraft will likely be operated frequently in much lower altitudes where even the best communication, navigation and surveillance systems have difficulty ensuring safety. Managing air traffic flow safely in these future conditions will require inputs from other entities such as telecommunications providers and other technology companies to ensure safe operations given the complexity of this effort. It's important to note that NAV CANADA has yet to publish their most recent RTM strategy which may outline who and how they expect to tackle some of the challenges mentioned in the following paragraphs. We recommend readers look out for this update in the near future to inform their understandings of future air traffic management.

Some Medevac operators, for instance, will transition from helicopters to eVTOLs; others will add eVTOLs to the mix for greater flexibility. The same is true for Toronto’s charter helicopter operators for tourism and business travel. eVTOLs, which will be less expensive to buy and maintain and will certainly offer a much lower carbon footprint, will be mixed into the existing fleet. Medevac and charter helicopter operators have the permits, the pilots, and the experience. Transitioning from one kind of aircraft to another will not be difficult nor will it greatly increase the load on Canada’s air traffic controllers.

It is unlikely, however, that the many new uses and new routes of eVTOLs, eSTOLs, and RPAS will rely on the traditional system of air traffic controllers for traffic management when volumes become challenging. NAV CANADA’s 1,900 air traffic controllers already manage 12 million aircraft movements a year for 40,000 operators in over 18 million square km, making it the world’s second-largest air navigation service provider (ANSP) by traffic volume. The addition of hundreds more aircraft movements a day in Toronto alone would put too great a strain on the system to ensure safe ooperations.

Advanced Air Mobility will need its own traffic management solution working in conjunction with the current air traffic control system. Human air traffic controllers may become airspace managers, focused

on supervising automated systems and aircraft oversight, safety, and security. At such a facility, a single controller could control many more aircraft movements than working in an airport ATC tower.

Figure 15 - Airspace layers help to organize traffic into manageable segments for Advanced Air Mobility to work harmoniously in today's aviation environment.

Various concepts of how the airspace could be managed are under review by NAV CANADA today. One is having a single authority for managing the urban airspace on a daily basis, with the RTM entity opening and closing routes, granting flight authorizations, and executing a single, integrated flow management plan. It would collect, analyze, and exchange airspace and flight information to support safe operations.

When an emergency or off-nominal situation arises during flight, the RTM entity would have human operators communicate with pilots and fleet operators to guide aircraft to safety. Other concepts allow for the coexistence of multiple RTMs that collaborate under a set of prescribed requirements.

A mix of transponder technology (cooperative surveillance) and radar sensor (non-cooperative surveillance) systems may monitor traffic and the location of aircraft in areas of the RTM entity airspace most likely to exhibit high traffic volumes. These surveillance systems may also interact with counter-RPAS (C-RPAS) systems to detect any unauthorized flights that may pose a threat to traffic. RTM equipment may include automation platforms capable of AAM air traffic management, resilient wireless communications systems, detect-and-avoid systems, augmentation of GPS through navigation beacons, and weather-related sensors.

The airspace of a given jurisdiction may be divided up horizontally, like the layers of a cake (Figure 15). At the highest level, where commercial aircraft currently fly, there is expected to be no interference from AAM aircraft. The middle level is where AAM passenger aircraft will likely fly. And the lowest level will most likely be the area most likely utilized by small RPAS. The most challenging operations may likely

be managing traffic as it transitions up or down through airspaces as well as merging traffic. Transport Canada, the department responsible for determining regulations and policies, must approve any changes to airspace or service levels recommended by NAV CANADA for this new industry. Transport Canada has not yet defined the standards for NAV CANADA to comply with. Current lower-risk regulation is still under development, a process that began in 2019 and is likely to take another 2 years to complete. From there, it will likely take several more years to develop general acceptance of Canadian standards in alignment with global standards and technological capability.

According to the NEXA Advisors/UAM Geomatics study, the estimated cumulative cost to build the GTA Advanced Air Mobility RPAS Traffic Management system will be in the range of $563 million between now and 2045. This amount includes the need for a fully manned Network Operations Centre or NOC, within the city's boundary. The NOC would be overseen by NAV CANADA.

Finding the right RTM solutions on a city-by-city basis will be necessary to unlock full market potential and requires increased collaboration and planning among all stakeholders. For Toronto and all of Canada, NAV CANADA is responsible for managing the airspace and, as an observing member of the Canadian Advanced Air Mobility Consortium, has committed to developing the air traffic management portion of the AAM ecosystem.

Supply Chain 4 - Operators of AAM Aircraft

Current helicopter operators are today's vanguard for eVTOL services (Figure 16). Charter helicopter companies such as Toronto Heli Tours at Billy Bishop Toronto City Airport, NovaJet Aviation in Mississauga, and ACS Charter in Etobicoke have excellent longstanding safety records, trained pilots, weather dispatching expertise and systems, and quality control and safety programs. They are also familiar with the regulations, terrain, and locations of the heliports and airports in the region. Some of these operators may expand to offer services using eSTOL aircraft for cities setting up AAM operations, such as Dubai.

Figure 16 – Corporate flight departments use fixed-wing aircraft and helicopters to move key personnel efficiently. Many are eager to transition to AAM aircraft for strategic mobility value.

RPAS operators can be independent individuals, small companies, and large players such as Amazon, FedEx, and DHL. Their missions are diversified, and range from healthcare (isotope delivery, vaccine delivery, COVID test kits, blood transport) to package delivery, agricultural purposes, bridge inspection, and other useful applications.

Factors Determining Toronto's Likelihood as an Early AAM User

There is no one-size-fits-all process for bringing AAM to a metropolitan area. Each region has a unique mix—almost a kind of DNA—consisting of GDP, population, congestion, current passenger and cargo transportation options, top industries, geography, public perception, the healthcare system, current airports and heliports, and equity and economic issues, among others. Let us examine the unique characteristics of the Toronto region.

The Greater Toronto Area (GTA), the fourth largest in North America, has more than 6.4 million people, a labor force of more than 4.7 million, and more than 800,000 businesses. Some 38% of Canada's business headquarters is located in the area, along with 18.5% of Canada's GDP. It is the second-largest financial centre in North America, with a regional economy worth $332 billion.[4]

By every measure, the city is remarkably international, with nearly 100,000 new immigrants arriving annually, and a diverse population of which some 51% is foreign-born, speaking 180 languages and major dialects, and belonging to 240 different ethnic groups. Toronto is centrally located with respect to large population centres, with some 130 million people within a 500-mile radius.

The City of Toronto is working to advance sustainable, equitable, inclusive, and innovative forms of transportation as per the Council-approved Official Plan. Toronto is working with neighbouring municipalities, the Province of Ontario, and Metrolinx (a Crown agency of the Government of Ontario that manages and integrates road and public transport in the GTHA) to address mutual challenges and to implement the Provincial framework for dealing with growth across the region. One goal is to focus urban growth into a pattern of compact centres, where residents live and work in close proximity, resulting in shortened trip lengths and overall reduced travel demand. Mobility hubs and corridors will connect the centres with a regional transportation system, featuring fast, frequent, direct, inter-regional transit service with integrated services and fares.

AAM Readiness Index: Toronto

NEXA has developed a Global Advanced Air Mobility City Readiness Index.

Toronto ranks highly out of 84 cities in the latest ranking, with an inertial element of 6. Factors include:

- P3 Consortium formation
- 25-year market opportunity
- Infrastructure in existence
- Public perception
- Current helicopter operations serving region
- Economic and business case opportunity
- Congestion and mobility challenges
- Investment Ratio: R/I

Go to www.nexa-uam.com for the complete index.

Toronto's Traffic Congestion and Its Causes

A key factor in determining whether a metropolitan area becomes an early user of AAM is its congestion. In 2019, Toronto drivers spent an average of 142 hours needlessly stuck in traffic, inching forward on some of the most congested roads in Canada. According to the TomTom Traffic Index, which ranks urban congestion in 416 cities around the world, it takes Toronto drivers 33% longer to arrive at their destination than it would without congestion. Delays increase to 56% during the morning rush and 68% during the evening rush.

[4] www.torontoglobal.ca

The C.D. Howe Institute estimates the annual cost of congestion in the Toronto-Hamilton area to be between $7.5 and $11 billion in lost time, productivity, and economic activity; wasted gas and wear and tear on vehicles; and the increased risk of car accidents, resulting in higher insurance rates.

Toronto's stunning success as a city—a prosperous, cosmopolitan business hub with countless cultural and recreational amenities for its population to enjoy—is responsible for its epic congestion. The root problem is population growth. The Greater Toronto and Hamilton Area had 3.8 million people in 1990; by 2020 that number had grown to 7.1 million and is expected to swell to 10 million by 2046.[5] In recent years, dozens of high-rise office buildings have gone up downtown, beacons attracting thousands of workers from far and wide. Many high-rise condo buildings have also been constructed in the optimistic but mistaken belief that these residents, being so centrally located, would not need cars. But most residents want the flexibility of a car. Those who don't own a vehicle use ride-share apps, still putting a car on the road.

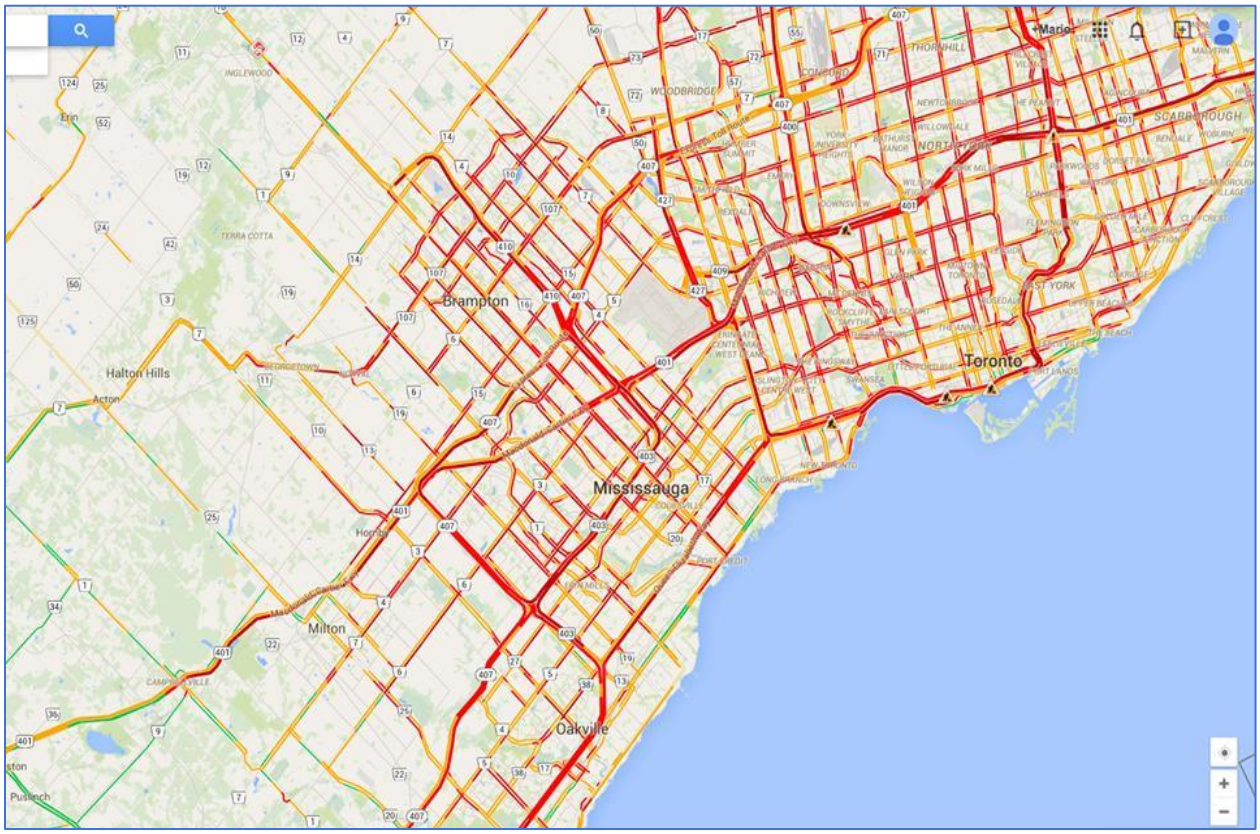

Figure 17 - Congestion plagues Toronto and is among the worse in North American metropolitan areas.

Construction of a new building requires taking a lane for equipment and safety purposes, often for months at a time. Due to extreme wear and tear, the roads themselves are in a constant state of

[5] www.ontario.ca

construction and repair. Moreover, the city suffers some 1,400 water main breaks a year, as some of the pipes date back to the 1870s, each one requiring a street to be blocked off and dug up.

Current Transportation Options

The Toronto Transit Commission (TTC) is the public transport agency that operates 1,200 km of bus, subway, streetcar, and paratransit services in Toronto, and the neighboring Peel and York regions. TTC owns and operates four rapid transit lines with 75 stations, over 149 bus routes, and 11 streetcar lines. The TTC is the third largest system in North America, after the New York City Transit Authority and Mexico City Metro. In addition, the Golden Horseshoe region is served by GO Transit, a public transit system of commuter rail trains and buses running from Kitchener in the west to Peterborough in the east, and from Barrie in the north to Niagara Falls in the south. In 2017, GO carried 68.5 million passengers.

On an average weekday in 2019, 1.69 million passengers made 2.76 million unlinked trips on the TTC, with the number of trips about evenly divided between the subways (1.34 million) and buses and streetcars (1.34 million). Some 1.86 million people traveled by car, many of them driving in from the suburbs of Barrie, Oshawa, and Hamilton, and 17.2% of all commuters spent more than 60 minutes to get to work.[6]

In 2019, the Province of Ontario announced a $28.5 billion transportation plan to build or extend four new subway lines: the Ontario Line, to open in 2027; the Yonge North Subway Extension, to open soon thereafter; the Scarborough Subway Extension, to start operations before 2030; and the Eglinton Crosstown West Extension, which will be delivered before 2031.[7]

While the region's bus system is extensive, buses are often late, stuck in the same traffic as the cars. The city's first dedicated bus lane opened in the Fall of 2020, with more to come in the next two years. In 2009, Toronto's City Council approved a plan to create a physical and cultural environment—including parks, public squares, and vibrant streets—where people would enjoy walking. In 2016, the council approved a ten-year cycle network update funding of $16 million a year to build and improve bike lanes.[8] There are currently some 500 km of bike lanes, which take cars away from the road (but also road away from the cars.)

In 2017, the TTC was named outstanding public transit system of the year by the American Public Transportation Association (APTA), recognition of the agency's diligent work to ease commutes. Yet the continuously burgeoning population, which relies heavily on cars, negates much of the progress. In 2020, the city announced a new $111.2 million plan called MoveTO which includes the installation of 500 smart traffic signals—which use cameras to react in real-time to traffic—at the most congested intersections between 2021 and 2026. Other suggestions to ease traffic include opening up paved

[6] https://dailyhive.com/toronto/toronto-car-commuters-stats-can-report-2019

[7] https://building.ca/government-of-ontario-unveils-28-5-billion-gta-transit-expansion-plan/

[8] https://www.cycleto.ca/get-toronto-moving-top-5-reasons-roll-out-bike-plan-soon-possible

shoulders to vehicles during rush hour and using RPAS to monitor accident scenes for a more rapid clearance.

Decarbonization Goals on the Local, Provincial, and Federal Levels

Local governmental authorities in the GTA are intent on creating transformational changes in how residents live, work, and commute. Toronto was a strong and early proponent of reducing greenhouse gas emissions (GHG) as shown in Figure 18. Between 1990 and 2017, overall emissions in the GTA were reduced by 37%, while the population increased from 3.8 million to 6.2 million, an astonishing success.[9] In 2017, some 55% of emissions came from homes, while 36% were generated by transportation, with 80% of those emissions coming from personal vehicles.

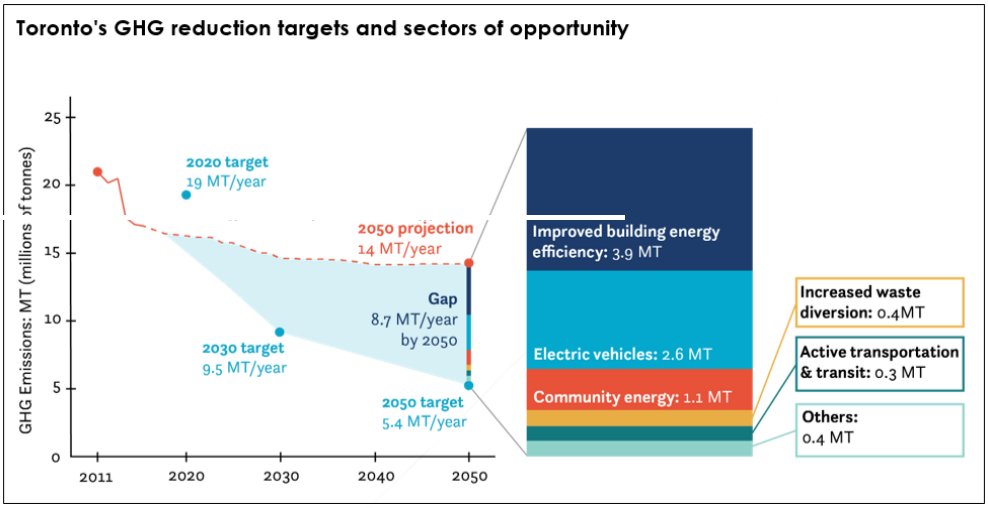

Figure 18 - Toronto is already a climate leader in many ways, but to reach its target it will have to take bold action immediately in key areas like reducing energy waste in buildings and electrifying transit (Source: TransformTO).

According to TransformTO, an ambitious net-zero climate strategy adopted by the Toronto City Council in 2017, by 2050 100% of transportation options should use low or zero-carbon energy sources.[10] Some 75% of trips under 5 km will be walked or cycled. The program envisages that in 2050 affordable, shared electric vehicles will be easily accessible for trips that are too complex for transit and too far for walking or cycling. As a result of the near total elimination of fossil fuels, public health will improve as Toronto's air will be cleaner.

The strategy aims to expand mobility options and embrace electrification while enhancing the local economy, reducing inequalities, and improving public health. It states, "Achieving our low-carbon goals hinges on transforming transportation in two ways: how we move around our city and between our city and the rest of our region; and what fuels our movement. What is required is a flexible, integrated set of options including robust public transportation with frequent service, increased active transportation

[9] Toronto's 2018 Greenhouse Gas Emissions Inventory, www.toronto.ca

[10] TransformTO: Climate Action for a Healthy, Equitable and Prosperous Toronto, 2015.

options supported by well-planned infrastructure to ensure public safety, shared mobility including shared commuting, auto-share and bike-share programs, and mobility hubs to allow seamless transition among different transportation options. At the same time, transportation options need to be electrified to drastically reduce GHG emissions."

The program plans on all new vehicles being electric by 2030 while the transit authorities will operate only electric buses by 2040 (it currently operates 60 such vehicles out of a fleet of 1,665), and all City-owned vehicles will be electric by 2042. Converting passenger, freight, and transit vehicles from gasoline to electric or low-carbon renewable fuels is a central element of the TransformTO low-carbon scenario as it would result in a near total elimination of gasoline by 2050.

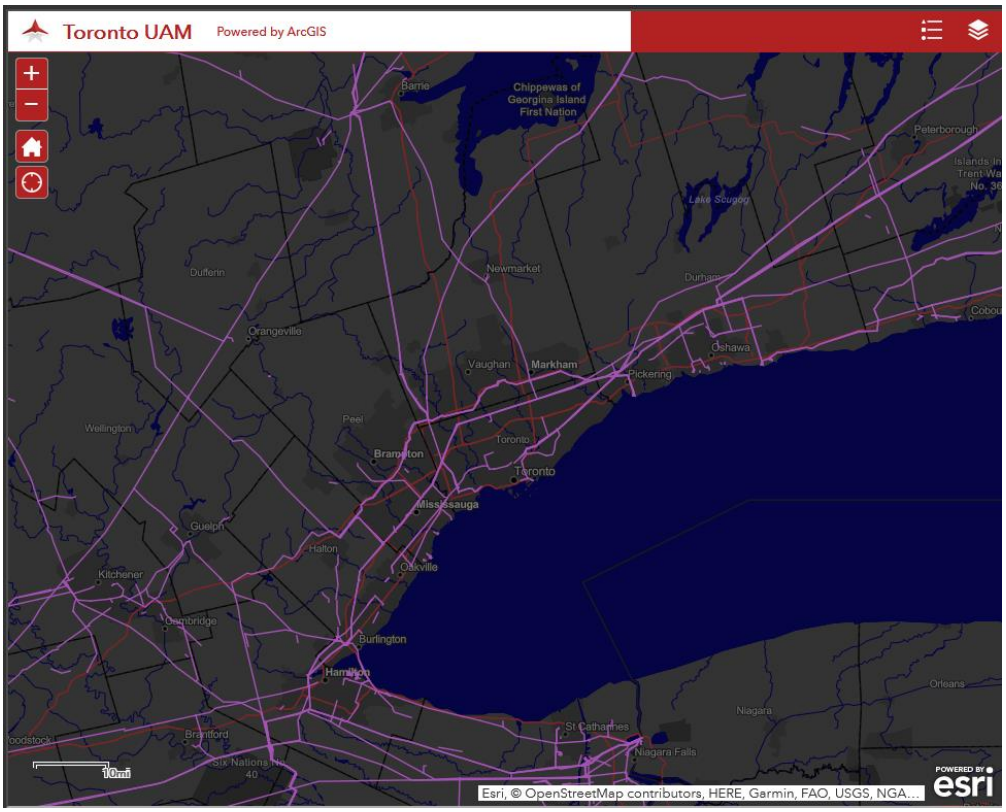

Figure 19 - Map showing high voltage power grid for the GTA, critical for establishment of eVTOL charging stations throughout the region.

The program sees mobility as electric vehicles, walking, biking, and convenient multi-modal public transportation at an affordable price at frequent intervals. Strategic use of AAM fits well with this strategy. For instance, TransformTO also recommends that regulations support innovation and economic development, while maintaining safety. Moreover, the program approves of the regulatory flexibility shown to RPAS to test specific technologies. In 2017, the budget provided $76.7 million for connected and automated vehicles and RPAS regulations, certification, standards, and testing. [11]

Despite these efforts, in 2018 (the last year for which data is available,) due to a colder winter and other factors, carbon emissions increased 7% in Toronto proper and 5.2% in the Greater Toronto and Hamilton

[11] https://tc.canada.ca/en/corporate-services/transportation-2030-green-innovative-transportation

area.[12] While it is safe to assume emissions dropped drastically during 2020 due to Covid, it is just as likely that they are rising again as the city reopens.

Ontario's Covid-19 economic recovery plans are focused on building roads and highways to generate jobs, which, while welcomed by traffic-weary commuters, will also increase greenhouse gases. In 2020, only 1.8% of new vehicle registrations in Ontario were Zero-Emissions vehicles (ZEVs), compared to 6.8% in Quebec and 8.4% in British Columbia. In October 2019, Toronto's City Council voted unanimously to declare a climate emergency and work harder to reduce emissions.[13]

Advanced Air Mobility and Aviation Greenhouse Gas Reduction Efforts

In 2018, commercial aviation's total global contribution to climate warming (including CO2 emissions, warming induced by aircraft contrails, and other pollutants) was approximately 5%. Passenger transport accounted for 81% of the emissions, while cargo produced the remaining 19%.[14]

Since 2005, the Canadian aviation industry has undertaken a strong climate action strategy. Current GHG reduction measures goals outlined in Transport Canada's 2018 report "Canada's Action Plan to Reduce Greenhouse Gas Emissions from Aviation" include fleet renewal with lighter, more efficient aircraft, the development of cleaner, sustainable aviation fuels, and more efficient air traffic management systems which reduce an aircraft's time in the air.[15]

Given these concerted efforts across the industry, since 2008 aviation has seen an average annual fuel intensity improvement rate of 2% (above the Action Plan's target of 1.5%). In 2018, Air Canada was named Eco-Airline of the Year by airline industry publication *Air Transport World*, who cited the airline's commitment to emissions reductions. Despite these impressive accomplishments, reduction targets are the victims of the industry's success. In 2018 alone, demand for Canadian air transport grew by 8.5%. To meet the demand, air carriers used 5% more fuel—to a total of 8.5 billion litres—effectively obliterating all the progress they had made and releasing some 22 megatonnes of carbon dioxide equivalent. Though air travel fell dramatically during the height of the Covid-19 pandemic, it is rebounding quickly as restrictions ease.

Both passenger and cargo aviation have a history of steady growth, and the trend will likely continue**.** Given the projected growth in both categories, according to the United Nations aviation body, the International Civil Aviation Organization (ICAO) headquartered in Quebec, using current technology by 2050 commercial aircraft carbon dioxide emissions could triple, rising from 900 million metric tons in 2018 to 2.7 billion**.** New research from the International Council on Clean Transportation in Washington, D.C., however, which analyzed some 40 million flights around the world, found that aviation emissions may be increasing 1.5 times as quickly as the UN estimate. By 2050, aviation could use up a quarter of

[12] The Atmospheric Fund, https://taf.ca/gtha-carbon-emissions/

[13] https://electricautonomy.ca/2021/04/23/canadian-ev-sales-data-2020/

[14] https://www.eesi.org/papers/view/fact-sheet-the-growth-in-greenhouse-gas-emissions-from-commercial-aviation

[15] https://tc.canada.ca/en/corporate-services/policies/summary-2018-annual-report-canada-s-action-plan-reduce-greenhouse-gas-emissions-aviation

the world's carbon budget, the amount of emissions permitted to keep global temperature rise to within 1.5 degrees Celsius above pre-industrial levels.

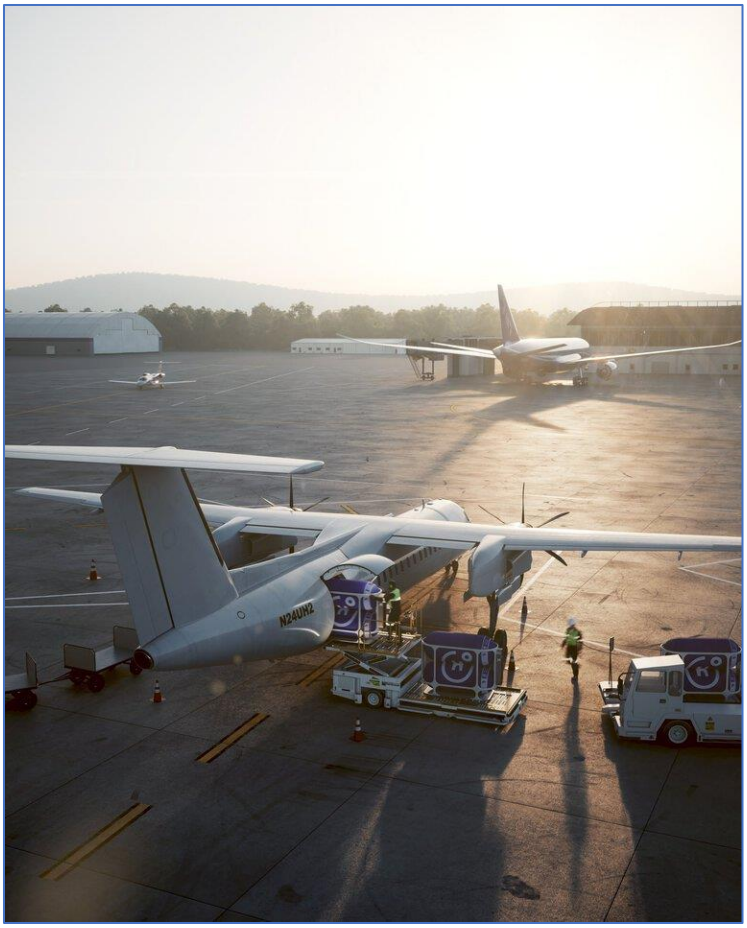

Figure 20 - A rendering of how the Universal Hydrogen modular fuel capsule would be loaded onto a Dash 8 turboprop.

While the primary reason for the development of electric, hybrid-electric and hydrogen fuel-powered fixed-wing aircraft is lower operating costs, these new forms of propulsion will reduce emissions to more acceptable levels and will, with the rapid increase in certification and fleet renewal in coming years, help the Canadian aviation industry make significant progress toward its goals. For instance, in July 2021, Pratt & Whitney Canada announced plans to advance its hybrid-electric propulsion technology and flight demonstrator program as part of a $163 million investment, supported by the governments of Canada and Quebec. The new hybrid-electric propulsion technology will drive significant improvements in aircraft efficiency by optimizing performance across the different phases of flight, allowing the demonstrator to target a 30% reduction in fuel burn and CO_2 emissions, compared to a modern regional turboprop airliner. An added advantage of electric fixed-wing aircraft is that they can operate in existing aviation infrastructure without the need for special vertiports.

The U.S. is moving in the same direction, even though aircraft are not certified and will probably not fly for three-to-five years. United Airlines has ordered 200 ES-19 electric aircraft from Swedish electric aviation startup Heart Aerospace, with the option to purchase up to 100 more. The ES-19 is a regional airplane that seats 19 and runs on batteries and electric motors instead of traditional jet fuel.

Heart plans to deliver the aircraft in 2026. The first routes will be short, such as the 118-mile distance between Chicago O'Hare International Airport and Purdue University Airport, and San Francisco International Airport to Modesto City-County Airport, which is 74 miles. Not only will the ES-19 reduce carbon emissions, but it will be far less expensive to purchase, operate, and maintain, Heart claims.

In terms of cargo, the U.S. major cargo and package transportation company UPS has ordered 150 Beta Technologies eVTOL aircraft, to be delivered starting in 2024 pending certification. At first the aircraft will be piloted, transitioning to remotely operations once the technology and regulations are in place. In September 2021, the U.S. Senate passed an infrastructure bill providing $25 billion to airports to reduce congestion and emissions and drive the adoption of low-carbon technology and electrification.

The Need for Improved Transportation Inclusivity and Accessibility

Figure 21 - Deliveries of the first ten Beta electric Vertical Takeoff and Landing (or eVTOL) vehicles begin in 2024, says UPS, which has an option to buy 150. They have a flying range of up to 250 miles per charge and can carry up to 1,400 pounds of cargo.

Any program reimagining how a city works must take into account residents of varying income levels and abilities. The city of the future must offer opportunities for all, not just the wealthy and well connected. When the Toronto City Council approved the long-term goal of transitioning to a low-carbon Toronto by 2050, they asserted that any changes should a) advance social equity; b) improve affordability, particularly for vulnerable populations; c) protect low-income residents d) contribute to poverty reduction; e) enhance and strengthen the local economy; f) maintain and create good quality local jobs; g) improve public health; and h) create resilient communities and infrastructure.[16]

Because of congestion, many workers forego jobs that would bring in higher salaries and greater satisfaction. Companies, too, lose out when the best qualified workers don't bother to apply. And shops, businesses, and theaters lose customers who decide that such a lengthy commute in bone-chilling traffic is simply not worth the effort.

With improved transportation opportunities, residents will have greater choice in both employment and recreation. TransformTO foresees mobility in 2050 as walking, biking, and a robust, affordable public transportation system providing frequent and dependable service. Mobility hubs will allow seamless transition from one kind of transportation to another: walking to biking, biking to electric shared rides, buses, and trains. Clean, green, Advanced Air Mobility, accessing the underutilized space above the city, would offer yet another mobility mode, taking passengers from heavily populated exurbs to subway stations furthest from the city centre, for instance.

City planners are dealing in real-time with creating a town of the future only 15 km from downtown Toronto. Northcrest Developments was established in 2018 to develop some 520 acres including Downsview Airport (Figure 22), which Bombardier and De Havilland Aircraft of Canada have used as an aircraft final assembly and test facility, and a neighbouring former Canadian Forces base.

[16] Toronto's 2018 Greenhouse Gas Emissions Inventory, www.toronto.ca

The goal is to transform the area into a sustainable, resilient, vibrant, healthy community, working in close consultation with local residents. The 291-acre Downsview Park will remain at the heart of the new development, surrounded by affordable housing, office space, and schools. Community feedback points to the desire for roads and transportation networks that are focused on people rather than cars. One of the development's central ideas is that the area will comprise "15-minute neighbourhoods," "where people live, work, shop, learn, and play within a 15-minute walk or bike ride."

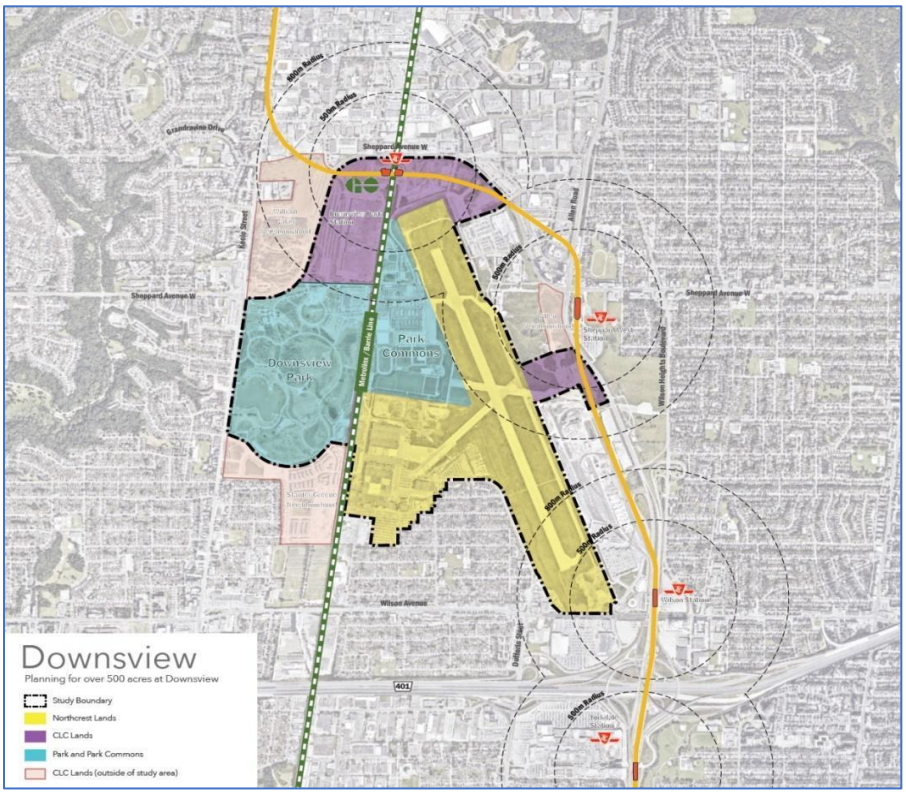

Figure 22 - Downsview Airport can become a central feature for AAM for the Greater Toronto Region.

The area is already well-served by public transit, with three subway stops and a GO train station nearby. A vertiport could serve residents in this densely populated area to the downtown financial district, Pearson Airport, Billy Bishop Toronto City Airport—which is just steps away from the city centre— or Hamilton.

Toronto's Strong Business and Technology Ecosystem

A strong base in technology, finance, aerospace manufacturing, and STEM education is crucial for any region looking to implement AAM. A city must have in place an ecosystem of businesses, investors, expertise, and skilled workers available to support the new industry.

A Thriving Tech Sector

The GTA boasts the third-largest tech sector in North America with the same amount of tech jobs as in the San Francisco Bay area. The region accounts for 26% of Canada's tech talent and employment, with some 290,000 skilled workers, making it one of the largest tech hubs in the world. Between 2015 and 2020, Toronto added more tech jobs than any place in North America, some 67,000 of them. More than three quarters of all Fortune 500 companies in the tech sector have representation in the Toronto Region, including Google, Twitter, and Microsoft. In 2018, *Inc.* magazine named the city "the next great startup hub." The tech website *Built In* calls Toronto "a hotbed of invention and disruption." (Figure 22).

A Flourishing Financial Sector

Additionally, Toronto is Canada's financial hub. The city's financial district is home to the headquarters of the Big Five Canadian banks, (RBC, TD, Scotiabank, BMO, and CIBC) which together hold over $2.2 trillion in assets under management. Toronto is an increasingly important player in the world of global finance, seventh largest in the world and second in North America to New York, though growing at a far greater rate. In fact, the city has the fastest growing financial sector of any in North America from 2011-2021, and the fifth-highest rate in the world.

Figure 23 - Toronto is quickly becoming one of North America's top start-up hubs.

The financial services sector is the largest private sector contributor to GDP in Toronto and provided more than $267 billion in credit to small and medium-sized companies in Canada in 2018. Its banking, pension, accounting, and insurance businesses employed some 400,000 people that year. Only Luxembourg and Singapore have higher concentrations of financial services employment. Toronto also has the most stable banking system in the G7.

An Impressive and Historic Aerospace Industry

Aviation began in Toronto back in 1910 with the Ontario Motor League aviation meet on an airfield on Tretheway farm, to the northeast of the corner of what is now Jane Street and Trethewey Dr. During the event, Count Jacques de Lesseps piloted the first distance flight (of twenty miles!) over Toronto. In 1928, de Havilland Aircraft of the UK established The de Havilland Aircraft of Canada Ltd. in Toronto, which manufactured thousands of aircraft and is still in business.

Figure 24 - Toronto has Canada's second largest aerospace sector after Montreal.

Since those early days, more and more aerospace firms have located to the area, creating a vibrant interconnected sector. Over half of the world's top 25 aerospace companies have operations in the Greater Toronto Area and adjacent regions, including Bombardier, Collins Aerospace, Airbus, General Dynamics, Honeywell, L3, Leonardo, Mitsubishi Heavy Industries, Magellan, Northrop Grumman, Pratt & Whitney Canada, PCC Aerostructures Canada, Raytheon, Safran, and Thales.

In 2018, Ontario had annual aerospace sales of over $6 billion, annual GDP impact of $4.4 billion (direct) and $6.4 billion (direct and indirect), and employment of over 25,200 direct jobs (such as systems engineering, equipment production, and integration) and 19,400 indirect jobs. The aerospace sector generates more than $1 billion in annual wages.

World-Class Medical Facilities and Health Care Programs

Given its social benefits, medical use of Advanced Air Mobility will probably be the first in the Toronto area. In 1977, Ontario was the first Canadian province to provide a helicopter-based air ambulance system to transport critically ill patients from on site to hospital and between hospitals. Subsequently, the entity became a non-profit organization—Ornge—incorporated under the federal Canada Corporations Act.

The Golden Horseshoe is home to a robust, publicly funded healthcare system with approximately 92 hospitals and healthcare centres of various levels in the Greater Toronto Area, and six in Hamilton. Many of these facilities are world class. The Sunnybrook Health Sciences Centre is the largest trauma centre in Canada. *Newsweek* rated Toronto General-University Health Network the #1 hospital in Canada in 2021. The Princess Margaret Cancer Centre is one of the top five cancer centres in the world, boasting a team of internationally recognized scientists researching all aspects of cancer and its treatment. And the Hospital for Sick Children, a teaching hospital affiliated with the University of Toronto, is the second-largest pediatric research hospital in the world.

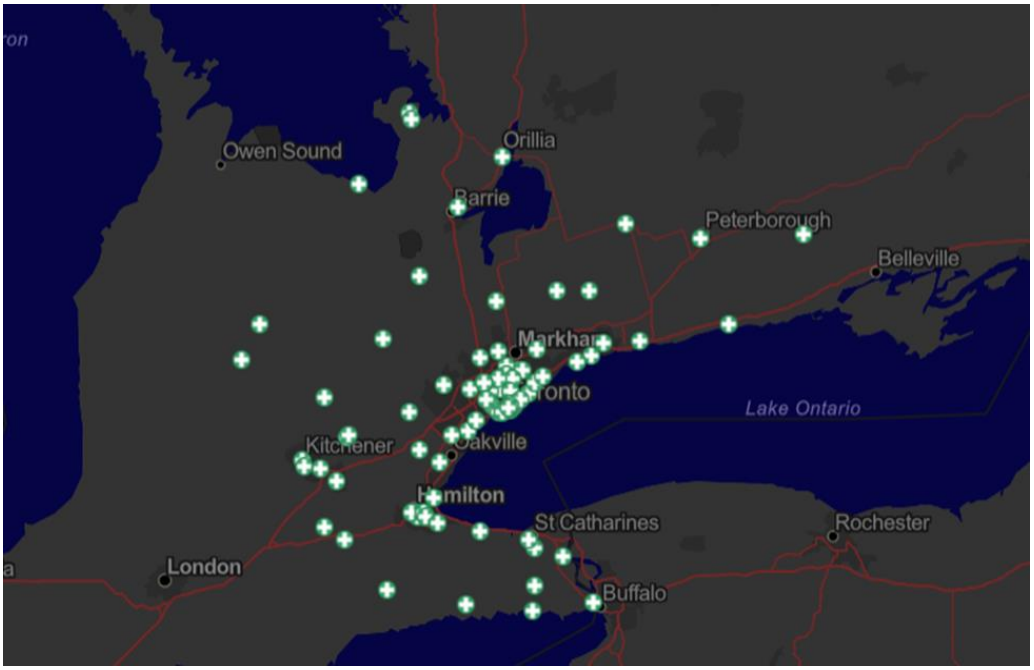

Figure 25 - The GTA has 92 healthcare facilities of various service levels serving over 8 million residents. AAM and healthcare mobility options will improve patient outcomes for residents.

As far as healthcare is concerned, the urban populations of southern Ontario are well-served. In 2019, total health expenditure in Canada reached approximately $265.5 billion.[17] The Ontario Ministry of Health (MOH) is projected to spend $74.1 billion in the 2021-22 fiscal year.[18]

Aviation and the Pandemic Response

Ornge, Ontario's provider of air ambulance and critical care transport services, has provided pivotal services during the pandemic. For instance, in February 2021, it headed up Operation Remote Immunity, a program initiated by Ontario's health authority, to provide both doses of the Moderna Covid-19 vaccine to 31 isolated First Nations in northern Ontario, transporting some 32,000 doses north. As a result, vaccine rates in those areas averaged 70 percent, with some communities up to 90 percent. Starting in May, Operation Remote Community 2.0 vaccinated some 5,000 Indigenous youth aged 12-17.

[17] https://www.cihi.ca/en/health-spending

[18] https://www.fao-on.org/en/Blog/Publications/2021-health-estimates

Throughout the pandemic, Ornge has made thousands of hospital-to-hospital transfers of Covid patients, transporting them from crowded facilities or those with lower levels of specialist care to hospitals with available beds and greater specialist care. Additionally, Ornge has flown thousands of Covid-19 tests from several northern communities to Toronto labs for rapid processing to prevent further outbreaks. We expect that Ornge and other air ambulance operators will make use of less expensive, Zero-Emission, quiet AAM aircraft once they come on line.

A Strong STEM Educational System

In terms of education suitable to prepare people for work in the AAM sector, the Toronto Region has 670,000 STEM degree holders, with some 25,000 new STEM graduates every year. The region places great emphasis on STEM education as a means of meeting today's global economy. Students start learning critical thinking skills in kindergarten and, as they get older, become adept in science, technology, engineering, and math in real world contexts.

The region has five world-renowned universities and six internationally recognized colleges. In terms of aerospace education in particular, in 2019, Centennial College opened its new $72 million Downsview Campus, which features Aviation Technician and Aerospace Manufacturing Engineering programs.

Across Ontario, sixteen universities offer engineering programs as well as degrees in applied aerospace, aviation, and space disciplines. The Ontario Manufacturing Learning Consortium offers an airframe assemblers program. Ryerson University in Toronto has an Institute for Aerospace Design & Innovation. Both Ryerson University and the University of Toronto, the latter ranked among the top 20 schools in the world and first among Canadian schools by the Times Higher Education World Reputation Rankings—offer Masters' and PhD programs in aerospace engineering. Seneca College in Toronto is one of Canada's premier airline pilot training schools.

In conclusion, then, numerous factors indicate that the GTA will be an early AAM user: severe traffic congestion, ambitious decarbonization goals, the need for improved transportation inclusivity and accessibility, strong business, financial, and tech sectors, a thriving aerospace ecosystem, world-class medical facilities, and a robust STEM educational system.

Potential AAM Use Cases

Looking ahead, a logical question is “How will AAM be implemented in the Greater Toronto Area over the next 25 years?” To answer that question, we will examine the two major sectors: passenger and cargo.

Missions and Services Moving People

AAM passenger operations will serve a wide variety of missions: from medical rescue and transport to airport shuttles to providing affordable supplies and reliable transportation to underserved, remote Indigenous communities, and more.

Emergency Services, Including Medevac and Critical Supply or Equipment Delivery

As we have stated, most likely the first use case of AAM aircraft will be emergency services. eVTOLs will likely complement existing air ambulance fleets in the near future. Furthermore, drone delivery is available in the near term as a solution for time-critical medical cargo delivery such as blood, plasma, organs and radioisotopes.

Figure 26 - Ornge Air Ambulance servicing patient at GTA hospital heliport.

Conventional Medevac helicopters take 10-13 minutes to prepare for takeoff, while eVTOL aircraft will take only about one minute, depending on the final designs. In the case of a critically ill or injured person, every minute lost before help arrives means there is a greater chance of death, brain damage, and other serious complications. With regards to cardiac arrest, for every minute the victim waits to receive defibrillation, their odds of survival decrease by about 10%.

Hospital centres in densely populated using Medevac services will likely transition to eVTOL aircraft due to lower purchase, maintenance, and operations costs, and lower noise levels—which the surrounding population will be grateful for.

Regional Air Mobility Including Trans-Border Services

Regional Air Mobility comprises those flights between city pairs that are not far enough apart to be commercially viable and, as a result, travelers are forced to make a time-consuming drive: Toronto to Peterborough (138 km), for instance. Most eVTOLs under development using batteries alone promise a

range of about 250 km. But other aircraft will offer longer ranges. Some AAM aircraft manufacturers are investing in hybrid aircraft that will use rotors, propellers or ducted fans to take off and land vertically at a vertiport under electric power, and transition to cruise flight on wings. Powering and recharging batteries using small diesel or jet turbine powered generators while at altitude, these aircraft have a longer range (400 km). Similarly, by the end of this decade, electric airplanes such as Heart's ES-19 will fly up to 400 km.

Additionally, electric Short Take-off and Landing (eSTOL) aircraft, such as the Electra.aero model, are expected to deliver a range of up to 800 km, more than twice the distance of most eVTOLs under development. The hybrid-electric nine-seater (eight passengers and one pilot) operates more like an airplane than a helicopter, requiring an ultra-short runway of about 100 meters. As a result, the aircraft does not use up a large amount of energy in a vertical lift, leaving more power for a longer flight range. While downtown vertiports could not be used by an eSTOL, airports would have the hundred-meter runway eSTOLs require.

A strong preference for short, inter-regional travel, such as Toronto to Peterborough (138 km), Detroit (301 km), Syracuse (270 km), Kitchener (108 km), Buffalo (159 km), Rochester (158 km), Pittsburgh (358 km), and Cleveland (300 km) will meet a demand that airlines do not adequately serve.

Ontario has 14 drivable border crossings along its international border with New York, Minnesota, Michigan, Ohio, and Pennsylvania. In 2019, some 10.5 million people crossed the border at the Buffalo-Niagara Falls crossing, many of them tourists, and the Ambassador Bridge in Windsor is the busiest crossing on the Canada–United States border. The four-lane bridge carries more than 10,000 commercial vehicles on a typical weekday. The Canadian end of the bridge connects to busy city streets in west Windsor, leading to congestion. The privately owned bridge carries approximately 25% of trade between Canada and the United States.

Figure 27 - NEXUS Kiosk Speeds Customs and Immigration.

One key aspect of AAM travel will involve using biometrics to ensure travelers are "trusted." Figure 27 shows a familiar NEXUS kiosk that would need to be utilized before a traveler embarks on a non-stop flight. Biometrics would speed the travel of cross-border Regional Air Mobility passengers.

Figure 28 illustrates one-way travel time between a residence in downtown Toronto to Syracuse, NY, and applying modes of travel: car, commercial flight (YYZ to SYR), and eVTOL/eSTOL. Driving will take more than three hours, while an AAM flight will be a third of that in total. By more closely and conveniently linking these cities through new AAM transportation options, enhanced mobility should guarantee greater trade opportunities.

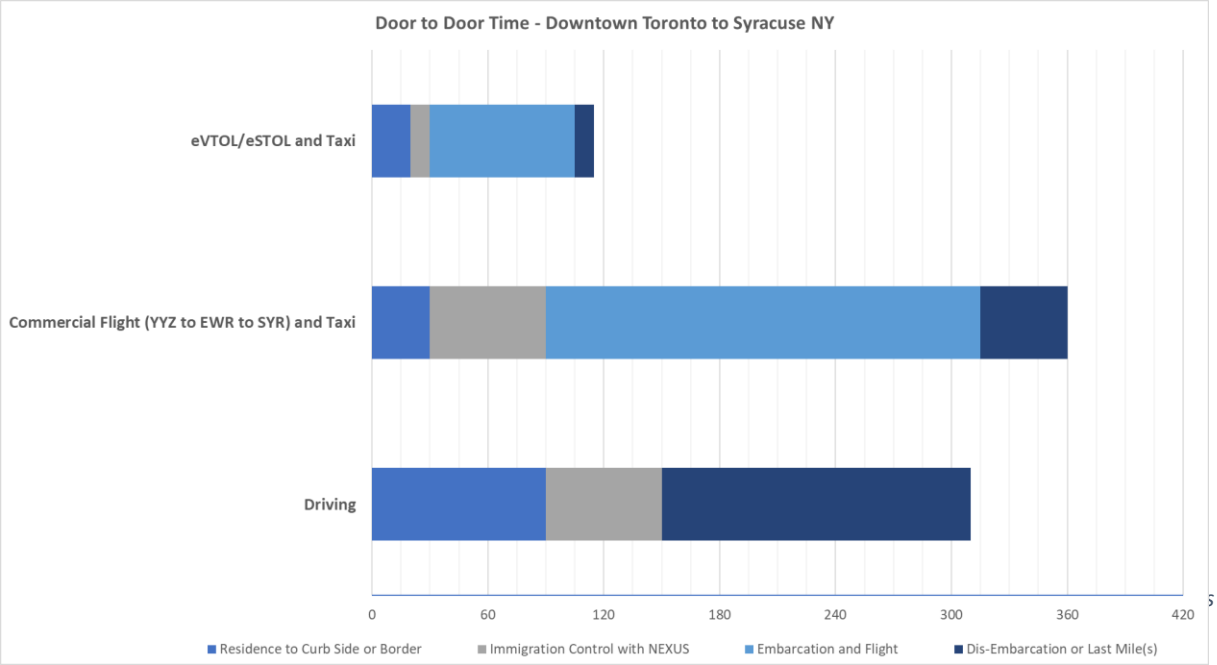

Figure 28 - Comparison of commute times between Toronto and Syracuse, NY with available options.

Airport Shuttle Services

Airports, already set up with runways, heliports, terminals, air traffic control centres, certifications, and passenger amenities, are well suited to be among the first AAM use cases. Airport shuttles will take passengers from a central, highly populated area such as downtown Toronto (eVTOL) or its major suburbs (eVTOL or ESTOL), directly to the airport.

The Golden Horseshoe is Canada's air traffic hub. As Canada's economic centre, the area is the final destination for large volumes of passengers and cargo, and it serves as the primary hub for people and cargo destined for other parts of the country. The Horseshoe is home to several of Canada's most important airports. Toronto's Lester B. Pearson International Airport (located just outside Toronto in Mississauga) is Canada's premier airport in terms of passenger and cargo traffic, boasting almost double the total passenger counts and 1.5 times the total cargo traffic of any other Canadian airport. In 2019, with more than 50 million passengers, it was the 30th busiest airport in the world and one of the top international gateways in North America.

The Billy Bishop Toronto City Airport, situated in the heart of downtown Toronto, is Canada's ninth busiest airport, serving 2.8 million passengers in 2019. The John C. Munro Hamilton International Airport, located 67 km southwest of Toronto, served nearly a million passengers in 2019. The Region of Waterloo International Airport is currently undergoing a $375 million, 20-year redevelopment plan. It is home to the Waterloo Wellington Flight Centre, one of Canada's largest professional flight training schools. There are also many rural aerodromes in the region, serving small aircraft for purposes such as pilot training and crop dusting. General Aviation airports are also common throughout the region (Oshawa,

Figure 29 - Hyundai has unveiled the world's first urban airport design for eVTOL traffic.

Niagara, Guelph, Burlington, etc.), and all reaches of the Golden Horseshoe are well served in all facets of aviation. AAM gives an opportunity for these airports to expand service by creating connections between regional airports and hubs.

Air Metro Services

Many Toronto commuters are living further and further away from their places of work due to skyrocketing real estate prices closer to the city. Municipalities in the region showing huge recent one-year population growth include Milton (+4.0%), Brampton (+3.4%), and Oshawa (+2.0%).

Kitchener-Waterloo has also shown consistently high population growth in recent years, fueled by its world-class tech industry and educational base with the University of Waterloo and Sir Wilfrid Laurier University. Waterloo is home to a number of large technology companies, including BlackBerry, Aeryon Labs, and Google's Canadian headquarters. It also has a strong start-up culture and attracts tech talent from all over the world. Kitchener-Waterloo is poised to continue its steady growth, reaching almost one million residents by 2051, a growth of about 37%.

Stats Canada shows that almost half of Toronto's commuters travel 20 km or more each way for work. Subway expansion in the GTA costs on average $300 million per km and, as in the case of Toronto's Relief Line, can swell to $1 billion per km. How far out can expansion continue?

A carefully planned Air Metro system—regular flights along designated routes something like buses—can provide at a greatly reduced cost metropolitan transportation options for commuters between heavily populated suburban communities such as the Durham Region (Oshawa, Whitby, Ajax, Pickering), Halton Region (Oakville, Burlington, Milton), Peel Region (Brampton, Mississauga, Caledon), York Region (Markham, Vaughan, Newmarket, Richmond Hill), and Barrie. In addition to commuter benefits, business opportunities will be expanded to the outer reaches of the Golden Horseshoe; for example, tech giants in Kitchener-Waterloo will have much improved access to the Fortune 500 company headquarters and other large companies in Canada's economic hub.

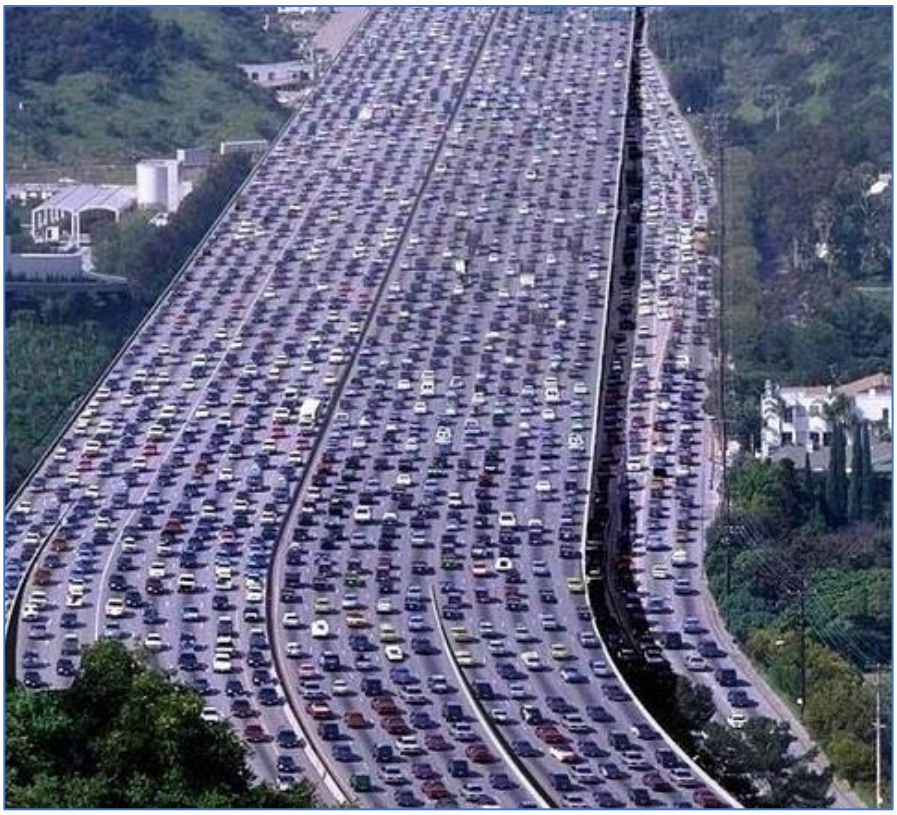

Figure 30 - Congestion in the GTA is legendary and, in interviews for this paper, was cited most often by stakeholders as a key catalyst for introduction of AAM.

It is likely that Air Metro will be an AAM mission that comes after the introduction of new aircraft for emergency and airport shuttle use. eVTOL aircraft capable of lifting off vertically in a dense area, and big enough to carry some dozen or so passengers, will not likely be in production for several years due to the technological limit of the weight of existing batteries. eSTOL aircraft, however, are capable of carrying more weight than the earliest eVTOLs, as they take off more like a conventional airplane and, as a result, do not use up a great deal of energy in a vertical lift. The short runways required by eSTOL of about some 100 meters and the lack of tall buildings around them would be available in suburban settings.

Currently, GO Transit, a commuter rail system with Union Station in downtown Toronto as its hub, carries passengers from all over the Golden Horseshoe, removing countless cars from the road. AAM routes that increase access to the outer reaches of the GO Transit system could improve access to the region's economic hub, Toronto. As of now, the GO Trains travel as far as Oshawa to the East, Hamilton and Kitchener to the West, and Barrie to the North, with seasonal service to St. Catharines and Niagara Falls. AAM Metro routes could bring people from the outer reaches of the Golden Horseshoe to these outer stations, connecting places like Peterborough, Orillia, Kawartha Lakes, Kingston, etc. AAM Metro routes could also take some pressure off of the GO Transit system entirely, whisking passengers from these outlying areas straight to Toronto.

There are also benefits for the other cities with their own commuter streams: Kitchener/Waterloo, Oshawa, Hamilton, and others in the region represent smaller employment centres with their own commuters. Establishing AAM Metro in the region would improve accessibility and allow the Golden Horseshoe to grow as a larger region, improving the connectedness in the area.

Figure 31 - Yonge Street has particular inefficiencies that make a commute along its route painful. Snow in winter and parked delivery trucks year-round create a hazard for both drivers and pedestrians.

On-Demand Air Taxi

On-demand air taxi services—hailing an AAM aircraft on your phone to meet you at the nearest vertiport, rather like hailing an Uber—have the potential to radically change urban mobility.

The former Uber Elevate was a strong, early proponent of on-demand air taxi and ride sharing. Now the Elevate unit of Joby, it is working toward transforming cities through aerial ridesharing at scale. In July 2021, Joby said it was on track to have its six-rotor design certified by the Federal Aviation Authority in 2023 and plans to carry paying customers by 2024. In July 2021, Joby completed the longest test flight of an eVTOL to date: Its remotely piloted, unnamed full-sized prototype aircraft concluded a trip of over 150 miles on a single charge.

Corporate and Business Aviation

Business aviation is a global industry, and business aircraft are tools that strengthen or leverage the impact of a company's intangible assets, including key employee talent. Companies everywhere have long benefitted from business aviation, as demonstrated by a host of studies, surveys and other types of analysis. For example, a 2017 study from NEXA Advisors measured the effects of business aviation on shareholder value creation of the S&P 500, for which over 450 companies operate aircraft. The report found that business aircraft make a substantial difference in how a company performs its mission, in many cases generating significant gains in shareholder value. Increased mobility was at the core of these gains—satisfying management's need for greater organizational agility, knowledge integration and transaction speed.

Existing heliport infrastructure, particularly outside of commercial and general aviation airports, provides eVTOL business aviation users with access to highly convenient urban destinations. Many current heliports have the operating certificates and access to airspace to begin stationing eVTOL aircraft immediately, though, depending on as-yet-to-be-determined regulations, some heliports will need to undergo modification to offer recharging stations, hybrid aircraft refueling, passenger shelters,

and other amenities. We estimate the cost to retrofit a simple landing pad into an eVTOL vertiport to be between $1.26-2.5 million.

Figure 32 - Corporate flight department hangar, showing an eHang multi-rotor eVTOL parked but available to service the company's mobility needs.

Tourism and Sightseeing

Toronto offers tourists not only the sophistication of a world-class city, but Ontario also offers plenty to do for tourists from camping and hiking to mountain biking, fishing, and exploring the region's wineries. The use of quiet, environmentally friendly eVTOL/eSTOL aircraft could greatly benefit this large portion of the province's economy by providing better access to remote tourist destinations.

Niagara Falls, located about 130 km from downtown Toronto, is Canada's most famous tourist attraction, attracting 14 million visitors annually. For many visitors, getting to Niagara from Toronto can be quite frustrating. Options include renting a car and dealing with the city's notorious traffic, using public transit that doubles the trip time, or buying an expensive VIA Rail ticket. AAM passenger operations to Niagara could provide fast pass access to the nation's most popular tourist site with ticket prices comparable to renting a car for the day.

Ontario's border stretches nearly halfway across the U.S., offering the province unparalleled access to nearly 130 million people within a day's drive (800km) in major cities like New York, Boston, Chicago, and Detroit. Internationally recognized tourist attractions such as Niagara Falls, Algonquin Provincial Park, Bruce Peninsula National Park, the Niagara Escarpment UNESCO World Biosphere Reserve, Blue Mountains, Manitoulin Island, and the Rideau Canal provide year-round activities for the province's tourists, who spend nearly $40 billion annually on tourism-related goods and services.

Ontario's access to international markets isn't its only strength; domestic tourism is a proven market and continues to grow. Ontario accounts for 86% of overnight stays across Canada, and 74% of overnight stays are Ontario residents traveling within their own province.

AAM Services for Underserved Northern Communities

Well before the advent of COVID-19, Canada's Indigenous and remote communities suffered from substandard housing and healthcare, and a lack of accessible transportation opportunities for both people and supplies. There are 637 First Nations on what is now known as Canada, as well as two other culturally distinct Indigenous groups, the Inuit and the Métis. Ontario is home to 23% of all Indigenous peoples in Canada—with some 133 distinct groups located throughout the province, representing at least seven major cultural and linguistic groups.

Figure 33 - Airlines such as United are solidifying plans to buy hundreds of small electric airplanes to serve regional markets.

These communities are located from Windsor in the South to the Northern shores of Hudson Bay. Five of the 20 largest bands in Canada are located in Ontario, with Mohawks of Six Nations being the largest. Over 30 First Nations in Ontario are considered remote, accessible only by air year-round or ice road for much of the year. There are more remote First Nations in Ontario than any other region. Urban centres with significant Indigenous populations living off-reserve are found in Thunder Bay, Sudbury, Sault Ste. Marie, Timmins, Ottawa, and Toronto.

Many of the communities are difficult and even impossible to reach with trucks or rail. Some can only be accessed by conventional aircraft or ferries. Others depend on ice roads in the winter—though these are no longer dependable due to climate change; routes that were solid ice are now more likely to be dangerous slush. As a result, in these communities basic food and hygiene items—whether orange juice or toilet paper—are usually many times what they cost in better-served areas.

Because of systemic inequities and discrimination, many Indigenous people have suffered disproportionately from illnesses such as diabetes and tuberculosis, resulting from poverty and lack of access to a healthful diet. Medical treatment in these communities is often far below the standards of city hospitals. Many nursing centres are underfunded and understaffed, lacking equipment, PPE, and medications.

Air Canada Cargo has recently entered into a 10-year agreement with Drone Delivery Canada to work on a number of projects commencing in 2020 designed to provide remote communities and Indigenous peoples with better access to medical supplies—such as vaccines, PPE, syringes, and medications—and essential goods such as food, hygiene products, and building materials.

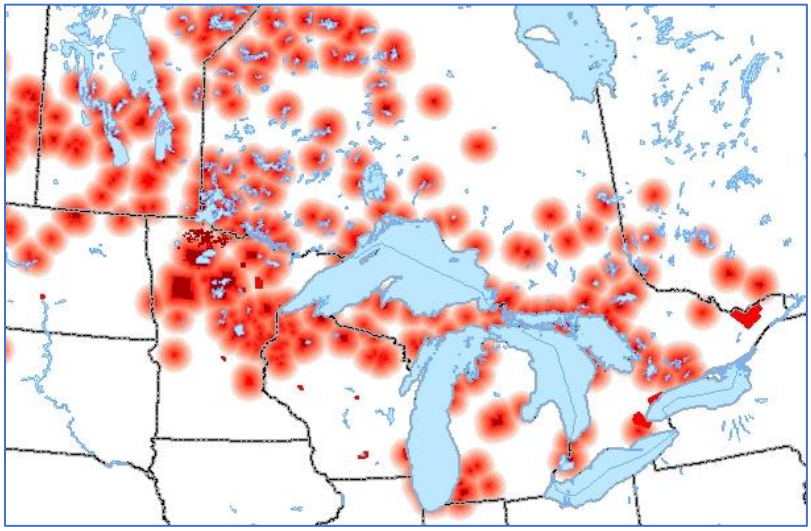

Figure 34 - In addition to other issues shared by First Nations recognized by the Canadian government and other aboriginal peoples in Canada, the Anishinaabe of Manitoba, Ontario and Quebec have opposed harmful energy and transportation projects.

AAM aircraft could transport critically ill patients from these communities to trauma centres at a fraction of the price of Medevac helicopters. For routine healthcare, while telehealth has gained popularity during the pandemic—and is especially helpful in rural areas—there is truly no substitute for a physician physically examining a patient. Specialized AAM medical aircraft could fly among remote communities—perhaps several in a single day—where doctors could personally examine their telehealth patients.

Remote communities also need reliable and affordable non-emergency transportation. Those individuals who want to visit a dentist in town, or a relative, or go shopping, should not have to wait until spring, or spend a small fortune and several hours to get there. Additionally, low-cost eVTOL/eSTOL aircraft will transport supplies to these communities at a much lower cost than current means of transportation. A network of regularly scheduled AAM flights for cargo and passengers throughout underserved communities would go a long way toward reconciliation and social equity.

Missions Involving Transport, Logistics, and Cargo

Advanced Air Mobility not only offers new mobility options for passengers but will also more efficiently move cargo and freight. According to the Toronto Board of Trade, over $3 billion worth of goods are trucked through the region every day, adding to the congestion and straining the capacity of existing highway infrastructure. On average, congestion increases the price each household pays for its goods by $125 a year, or as much as $650 million to residents in the GTA, as trucking companies pay more for gas, insurance, salaries, tolls, fines, and parking tickets.[19] The increasing shipment of goods is a positive sign of economic prosperity, but the downside is that delivery vehicles play a prominent role in traffic congestion. Deliveries skyrocketed during the peak of Covid-19, when far fewer commuters were on the road. Now that roads are once again jammed, deliveries remain high. Apparently, many residents have

[19] Toronto Region Board of Trade, "Policies to Improve Goods Movement," February 2018.

become accustomed to the convenience of ordering products and food online rather than going to a shopping centre, and having restaurants deliver food rather than dining out.[20]

Figure 35 - Major cargo/logistics corridors in the Golden Horseshoe, as well as important major manufacturing facilities and distribution centres, will need the improved mobility and logistics solutions that AAM will offer.

In addition to increasing congestion on the roads, trucks often block entire lanes as drivers—unable to find a legal place to park—make deliveries. A good example is Yonge Street in downtown Toronto, notorious for this problem. Many major thoroughfares should be four lanes in rush-hour traffic yet can be reduced to half that capacity as delivery trucks park on both the right and left lanes. Those truck drivers who don't block lanes often cruise around the block until they can find a legal space to park. A 2019 study in *Transport Policy* found that in downtown Seattle 28% of the driving time of trucks and other delivery vehicles was spent in circling the block.

Additionally, when a large truck has an accident, it can block an entire road or highway for hours. For instance, on December 8, 2020, a tractor-trailer full of trash caught fire on Highway 427, necessitating the use of a fire ladder, closing the road for hours, and stranding thousands of commuters.

[20] https://nielseniq.com/global/en/insights/analysis/2021/the-bright-future-of-e-commerce-in-canada/

Cargo businesses are rapidly expanding in the GTA to meet demand. DHL Express is expanding its facility at the Hamilton International Airport four-fold, to 800,000 square feet, at a cost of $100 million.[21] Amazon Canada is currently building a new 855,000 square-foot facility there with the promise of 1,500 new jobs.[22] Both facilities are set to open in 2021. In addition, Amazon has a new 50,000 square-foot delivery station in Hamilton where packages arrive from various Amazon fulfillment and sortation centres and are then loaded onto trucks for delivery to customers. Using RPAS, delivery companies could send packages to their destinations from launch pads strategically placed around the region and from a central downtown location, thereby reducing rush-hour congestion by removing significant numbers of trucks.

Figure 36 - DHL Express recently announced a $100 million expansion of its logistics facilities at Hamilton International Airport to serve the GTA and the rest of Canada.

Cargo forwarding and logistics firms are already using RPAS for small cargo deliveries in the Greater Toronto Area. DSV Air & Sea Canada, part of Denmark's DSV Panalpina which is the world's third largest logistics firm, has been using Drone Delivery Canada's RPAS service to deliver healthcare goods from DSV's customer logistics facility in Milton, Ontario to a local customer starting in 2020.

It is likely that aircraft without passengers will receive approvals before passenger eVTOL/eSTOL aircraft which will, for safety reasons, require far more restrictions and regulations before implementation. Carrying goods before passengers would also allow operators and OEMs to have the necessary demonstration flight hours and data to more easily navigate the Transport Canada certification requirements for air taxi operations.

Transport Canada takes a very cautious, risk-based approach to certifying aviation operations, and for good reason. For cargo RPAS or eVTOL/eSTOL operators, a "crawl, walk, run" approach has been adopted. A logical first start would be to focus on serving rural populations or business-to-business operations outside of major metropolitan areas. Flying over densely populated areas has greater risks,

[21] https://www.globenewswire.com/en/news-release/2019/10/29/1936933/0/en/DHL-Express-invests-100-million-CAD-to-expand-its-existing-gateway-at-John-C-Munro-Hamilton-International-Airport.html

[22] https://press.aboutamazon.com/news-releases/news-release-details/amazon-announces-plans-create-more-2500-full-time-jobs-greater

but flying over waterways, railroads, or undeveloped land with small payloads mitigates the risks to persons on the ground and would therefore be more likely to be approved by Transport Canada.

As mentioned above, light-payload RPAS operations such as medical deliveries are underway in Ontario today, but larger RPAS or heavy-payload eVTOL will be certified in the future as Remote Traffic Management (RTM) develops to ensure the safe operation of these larger aircraft. The GTA receives a significant portion of Canada's total cargo traffic, and total freight movements in the region are only expected to increase as populations swell. Utilizing the space above highways, waterways, railroads, or rural areas for cargo transportation will be essential to "Get Toronto Moving."

Airport Air Cargo Services

Drone delivery can be the logical extension of air cargo services currently provided by airlines at the leading hub airports in the region, as well as secondary airports in Southern Ontario and from remote airports in Northern Ontario. Drone delivery is applicable as a "final mile" delivery solution for smaller cargo loads to remote, hard-to-reach locations from airports (which may be impossible or uneconomical to service with conventional aircraft) or in instances where time is of the essence and schedule reliability is of prime importance (such as avoiding road traffic delays).

Figure 37 - Many private companies are using RPAS aircraft to perform inspections of bridges, high-rise buildings, residential rooftops, and critical power/water/gas supply lines, which can be done safely and efficiently. RPAS are already in daily use in the GTA.

While there are currently restrictions for drone delivery into densely populated urban areas, Canada's current regulatory environment does permit drone delivery operations into suburban warehouse zones and to rural and remote areas. At busier hub airports, drone delivery operations need to be integrated into the airport control zone traffic mix through coordination with NAV CANADA. This is already happening in Alberta, where Drone Delivery Canada is implementing drone delivery service at Edmonton International Airport, Canada's fifth busiest airport, with two courier/final mile firms (Apple Express Courier and Ziing Final Mile) as the users of the new service linking the airport area with the adjacent business zone in Leduc County. As experience is gained with the service, new delivery routes over greater distances from Edmonton International Airport using larger drones are anticipated. It is logical to assume that this type of drone delivery service can be replicated at airports in Southern Ontario, including major GTA airports such as Toronto Pearson International, J.C. Munro Hamilton International and Billy Bishop Toronto City Airport.

What Stakeholders Told Us

To gauge the missions, obstacles, concerns, and overall potential of Advanced Air Mobility in the GTA, our team interviewed some 60 individuals in aerospace, business, government, transportation, economic development, real estate, cargo, academia, and healthcare, individually and in focus groups. Many of the CAAM consortium observers and members contributed (Page 2 of this report, and Figure 38).

The general consensus was that the GTA has an aerospace, financial, and technical education ecosystem in place and ready to start immediately implementing AAM. As far as AAM missions are concerned, our group rated them in order of importance:

- Medical delivery
- Cargo
- Regional Air Mobility
- Airport Shuttle
- On-Demand Air Taxi

Our stakeholders agreed that the rapid introduction of medical delivery AAM will win public support and save lives and healthcare costs. Cargo delivery promises to reduce street congestion by removing a portion of the trucks and deliver high-priority packages speedily and efficiently.

Regional Air Mobility would provide new time-saving transportation options to locations not currently served by aviation. Airport shuttles will take passengers from strategically chosen locations—downtown, for instance, and exurbs beyond the last subway lines—to the airports and vice versa. Air Taxis would be a convenient new form of mobility that would likely be implemented after the other, more public-minded missions are firmly in place.

*Figure 38 - CAAM **AAM Members** and Observers.*

Almost every respondent commented on the appalling traffic congestion in the Toronto area. They agreed that the goal of AAM is to complement existing transportation options as part of a multi-modal system. AAM cannot compete with current public transit, siphoning off revenues, but must be blended in with the existing framework in a highly strategic fashion.

Focusing on the Business Case and Quantifiable Benefits

Our stakeholders believe that while equity, affordability and accessibility are important, they are dependent on having a business case. Taxpayers will likely not pay for AAM infrastructure; investors will, and they will be expecting a return on their capital over a reasonable amount of time. Part of the

business case is proving to government and transportation authorities that AAM will create a substantial number of new jobs and tax revenues.

The stakeholders emphasized that in order to acquire government and public support for the introduction of AAM, the industry must make very clear the *quantifiable benefits*, such as life-saving medical missions, reduced travel time and emissions, greater efficiency, less congestion, and avoiding heavy, expensive infrastructure such as new highways and subways.

Aerospace, Tech, and STEM Educational Ecosystems Already in Place

The interviewees pointed out that Ontario's highly skilled aerospace workforce should attract and support AAM in the region. "OEMs should come into Canada… We know how to build airplanes," said one, pointing to the available workforce from Bombardier and other companies located throughout the region, including Hamilton, Peterborough, and Mississauga. The area has a strong base in maintenance, repair, and avionics manufacturing.

They also pointed to the many tech-focused educational opportunities in the area which offer dedicated faculty for aerospace engineering, aerial robotics, and aerospace education, collaborative industry work and placement for students, and student projects focused on development and applied research.

Figure 39 - STEM learning can help students develop critical thinking and collaboration skills. AAM is already strongly supporting women in science and technology with associations in place to ensure gender equity in this new industry.

We repeatedly found that the Toronto business community is excited about the advent of AAM because it is "greenfield investment"—something completely new, bringing new jobs, revenues, and economic productivity to the area. Toronto Global—a not-for-profit investment attraction agency that supports the expansion of foreign-owned businesses to the Toronto Region—supports the idea. Another

supporter is the Ontario Aerospace Council, an industry trade association representing 200 members of aerospace organizations across supply chain.

Respondents pointed to the city of Hamilton—80 km from Toronto—as a potential centre for early AAM implementation. Hamilton is a regional hub for healthcare, with five major hospitals. Hamilton's McMaster University has a small nuclear reactor located on its campus and is one of the world's leading providers of medical radioisotopes used for cancer treatments. Hamilton International Airport is the busiest expedited cargo airport in the region and #3 in all of Canada. It has seen increased expansion and development, with both DHL and Amazon currently building 800,000 square foot facilities there, and Mohawk College has established a new avionics campus on the site. The airport has no curfew, unlike Pearson International and Billy Bishop Airport, but offers 24/7 access. It is also a port of entry with a Canada customs facility for international cargo.

Figure 40 - Innovation Factory, Hamilton's regional innovation centre, has launched the Centre for Integrated Transportation and Mobility (CITM) to help Ontario companies develop solutions for connected and autonomous vehicles.

Hamilton is the home of the $10.5 million Centre for Integrated Transportation and Mobility (CITM), which helps Ontario companies develop solutions for connected and autonomous aircraft. The Centre, part of Ontario's Autonomous Vehicle Innovation Network (AVIN), provides business and technical advisory services and resources to Ontario-based startups and small- and medium-sized enterprises (SMEs) to accelerate the development of connected and highly automated, multi-modal and integrated mobility technology solutions and business models.

Our stakeholders expressed optimism that the Downsview Airport site would be a centre for Advanced Air Mobility manufacturing and testing. Currently being phased out as an aircraft manufacturing and testing facility for Bombardier and de Havilland Aircraft of Canada, the 520-acre site with a 2,100- meter runway currently awaits redevelopment. One thing is certain: aerospace will continue to play a vital role on the site. Centennial College recently celebrated the opening of its Centre for Aerospace and Aviation there, and a consortium of aerospace companies and post-secondary schools from across the Greater Toronto Area are developing the Downsview Aerospace Innovation & Research (DAIR) hub on the property. It is quite likely the site will attract aviation and transportation industry as well as high-tech light manufacturing. Downsview, according to our interviewees, has the potential to become a new regional hub for mobility development.

The respondents saw the obstacles to AAM in need of solutions as follows:

- Regulatory gridlock: There must be new government-approved standards, aircraft and air traffic management certifications, airspace regulations, infrastructure permitting, route planning, and other aspects of AAM. How quickly will new regulations, standards, certifications, and approvals be developed and promulgated?
- Technological issues, though that hurdle seems to be diminishing rapidly with the billions of dollars of global investment in aircraft development. However, there remain some challenges in developing certain technologies, such as detect and avoid systems.
- Public Acceptance: Will a significant percentage of the public perceive eVTOL/eSTOL and RPAS aircraft as intrusive, noisy, and dangerous?
- The perception that this new form of aviation is only for those who can afford it and not for others who might also benefit greatly from it. While the business case is paramount, equity is also an important consideration.
- Current lack of landing spots for charter helicopter operators. Heliports, if located strategically, will be the first AAM vertiports after remediation, and outside of hospitals, the area does not have many of them.
- The current pilot and maintenance technician shortage, which will only be exacerbated by the introduction of eVTOL and eSTOL aircraft.
- Weather: It is not yet known how Ontario's climate will affect AAM aircraft currently in development, and how often they will be grounded due to wind, rain, and snow.

Summary

Across the board, our respondents are optimistic about the introduction of AAM in the GTA, although much work remains to be done. They believe certain specific, public-oriented missions such as medical transportation will be first while other use cases will develop more slowly. If strategic use of AAM reduces traffic congestion by even a small amount, they foresee it becoming quite popular. The stakeholders emphasized repeatedly the major cargo distribution facilities, aerospace manufacturing, and STEM educational ecosystems already thriving in the area as a logical base to support this transformational new mobility option.

Next Steps

Now that we have explored the potential AAM has to offer the Greater Toronto Area, let us examine what steps should be taken for this new sector to move forward. This section provides specific, achievable, and practical goals for stakeholder groups supporting the introduction of AAM throughout the Greater Toronto area.

Canadian Advanced Air Mobility Consortium Actions

CAAM will continue in its leadership role, including:

- Funding and delivering important "Triple Bottom Line" analyses for the GTA, an exploration of the social, economic, and environmental benefits of AAM.
- As part of the above, delivering the Economic Impact Analysis (currently underway by NEXA Advisors), with a special focus on direct, indirect, and induced job creation. AAM will bring many thousands of new jobs to the GTA, a vital benefit, along with GDP growth and, through a widened tax base, increased federal, provincial, and local tax revenues.
- Securing sources of long-term funding for engineering studies, feasibility studies, and airspace design work necessary to attract infrastructure funding for the GTA, and to ensure the proper stand-up of a dedicated CAAM team for Toronto and the GTA.
- Bringing all AAM stakeholders in the GTA more permanently together to foster greater understanding and cooperation with other players and further connect requirements and needs.
- Investigating those catalytic impacts arising from AAM that can fuel further economic growth and related benefits. For example, we anticipate catalytic effects from Regional Air Mobility leading to increased trade and commerce throughout the region and with the U.S. In addition, CAAM will work with the GTA regional governments and medical professionals to evaluate in greater depth the immediate as well as long-term public benefits of RPAS and eVTOL/eSTOL use in medicine, public health, emergency medical services, and COVID-19 amelioration.
- Joining the Open Mobility Foundation by December 31, 2021. Governed by cities, the Open Mobility Foundation brings together public and private sector stakeholders to develop and promote technology used by commercial mobility service providers and governments that manage the public right-of-way.
- Informing the public perception, a crucial factor for the introduction of AAM to succeed. CAAM will develop an effective short-term communications strategy to articulate a message that AAM and RPAS missions will deliver tremendous long-term benefits—economic and environmental—for the greater Toronto region and its stakeholders (see below for further detail).
- Sending this paper, and the Economic Impact Analysis that will be available soon, to stakeholders including individuals in the Ontario and federal ministries tasked with transportation, public health, and decarbonization issues, to inform them of the social and economic benefits Advanced Air Mobility will bring.
- Recommending that the provincial government implement a mandatory requirement for all departments to ensure that at least 5% of their contracts by dollar value are held by or benefit Indigenous businesses.

Identifying and Prioritizing Environmental Benefits of Advanced Air Mobility for the GTA

Reducing dependency upon hydrocarbon fuels for aviation, at the same time reducing noise pollution and increasing public acceptance, are some of the most important benefits of AAM. Next steps include:

- Organizing study teams under CAAM to perform this work.
- Recognizing that one of the main public concerns of AAM will be noise. A group of stakeholders led by the Toronto Aerospace Community [and including Crown/HMMH, companies who conduct such studies] should undertake noise studies to support AAM deployment for the good of residents and to better understand public perceptions of these new transportation systems and technologies.
- Implementing three-dimensional visualization tools to support noise analysis and advance public awareness.
- Developing environmental targets and goals for AAM to eliminate net greenhouse gases through electric aircraft and limit greenhouse gases to only water vapour for hydrogen-based aircraft.
- Encouraging GTA-based companies with hydrogen fuel cell-based eVTOLs (hVTOLs) under development to participate in demonstration projects.
- Developing flight testing regimes with emphasis on Zero Emissions to demonstrate the benefits of electric flight to local stakeholders.

Actions for Municipal Governments of the Greater Toronto Area

The Greater Toronto Area comprises ten major municipalities anxious to ensure that AAM provides services, jobs, and social benefits to their communities. Public transportation authorities at the municipal, provincial, and federal levels should be encouraged to develop policies and procedures for the location, construction, and operation of more extensive vertiport networks within the region, capable of better serving the mobility needs of the public. Next steps include:

- Obtaining support from the City of Toronto Mayor's Office, Economic Development Division & Culture, Transportation Services, City Planning (transit network and transportation plans) Toronto Building (building code) and other relevant divisions.

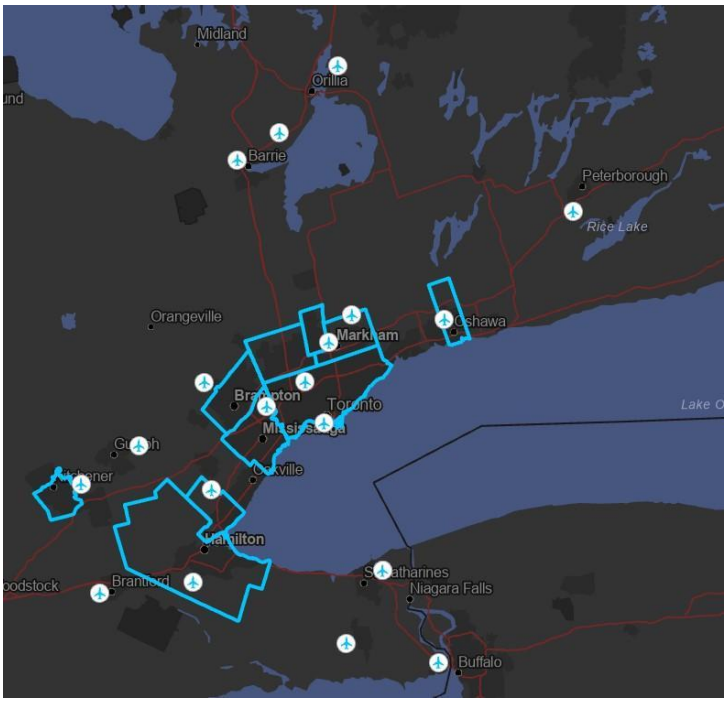

Figure 41 - 10 metropolitan areas of the GTA showing airports that provide passenger and cargo services.

- The City of Toronto staff should engage in processes by the federal, provincial, and/or regional governments/bodies regarding air mobility governance and regulations pertaining to safety and sustainability, and relevant city staff should monitor potential use cases such as emergency medical services for AAM.
- Forming the GTA AAM Municipality Consortium ("GAAMC") and Task Force by November 30th, 2021.
- Completing affiliated CAAM membership process with GAAMC by December 31st 2021.
- Launching GAAMC task force designed similar to the Los Angeles Mayor's Office and Urban Movement Labs by March 31st 2022.
- Signing a strategic partnership with World Economic Forum's AAM Cities and Regions Coalition Charter by December 31st 2021.
- Launching Digital Policy for Advanced Air Mobility project with Open Mobility Foundation by March 31st 2022.
- Securing a $150,000 annual budget to GAAMC task force by March 31st 2022.
- Publishing a preliminary roadmap for integrating public transportation and AAM, similar to TransLink's Transport 2050 with Metrolinx and the Toronto Transit Commission, by June 30th 2022.
- Seeking public comment by August 31, 2022.

Actions for the Provincial Government of Ontario

One traditional role of the Provinces of Canada is to ensure that transportation policies for all modalities are promulgated for the benefit of citizens. Next Steps Include:

- Policy development: For provincial government funding, policy work will be necessary to build regulations and incentives for Zero-Emission AAM in Ontario similar to the policy, regulations, and incentives seen in the Zero-Emission ground vehicle sector.
- Inviting extra-territorial governments to join in AAM development of the GTA through flight testing and commercial programs. Cross-border trade authorities should consider developing cooperative programs with cities in New York state and Ohio to ensure that cross-border considerations are made early; ODOT comes to mind.
- Developing legislative themes to assist with advancing AAM at the level of the Province of Ontario.[23]

Actions for the Government of Canada, Federal/Crown Corporations, and NAV CANADA

Public policy is considered strong when it solves problems efficiently and effectively, serves and supports governmental institutions and policies at all levels, and encourages active citizenship. Next Steps include:

[23] CAAM Notes: Funding, policy work to build regulations and incentives for Zero-Emission AAM into Ontario similar to the policy, regulation and incentives seen in the Zero-Emission ground vehicle sector, provincial government could implement a mandatory requirement for all departments to ensure that at least 5% of their contracts by dollar value are held by Indigenous businesses.

- Encouraging policy and regulatory support. Federal mandates could require Zero-Emission AAM aircraft operations for low altitude flights made by eVTOLs/eSTOLs.
- NAV CANADA activities: Airspace and air traffic control analysis. NAV CANADA should develop an analytical framework and program to design and validate GTA airspace for safe operation of RPAS, eVTOLs, eSTOLs, and conventional aircraft and create standards and regulations for vertiports.
- Transport Canada activities: TC must facilitate completion of the Canadian Aviation Regulations to accommodate all practical AAM use cases by drafting detailed Concept of Operations documents and supporting the development of new regulations, standards, and guidance material.
- Launching Advanced Air Mobility Federal Task force similar to what is called for in the U.S.: Advanced Air Mobility Coordination and Leadership Act (legislation promulgated in August 2021).
- Appointing SMEs (Small to Medium Enterprises) from GTA stakeholder groups to work closely with TC and NAV CANADA to ensure steady progress.

Ontario Aerospace Sector Actions

Many jobs will accrue to the Ontario aerospace sector, and as such the leadership of this industry will be crucial to move AAM forward. According to NEXA Advisors and UAM Geomatics, Inc. research, Metro Toronto has billions of dollars of revenue related AAM activities to look forward to, much of which will accrue to aviation and aerospace markets. Next steps for the aerospace sector include:

- Further confirming industry market research. Industry sectors including aviation and aerospace must better understand and act upon market opportunities in the AAM space for the GTA and nationally.
- Developing a concise inventory and map for the four critical AAM supply chains, with emphasis on Ontario's existing aerospace sector:
    - Aircraft OEMs developing electric aircraft
    - Existing and future potential eVTOL/eSTOL operators
    - Suppliers capable of developing and implementing ground infrastructure such as vertiports
    - Suppliers capable of implementing RPAS
- Forming an industry coalition between aviation and aerospace stakeholders, perhaps led by the Ontario Aerospace Council, who can then work together to identify further revenue-generating use cases, partnering with real estate developers, airports, and eVTOL/eSTOL OEMs, to attract capital investment.
- Determining best fit with Downsview Aerospace Innovation & Research (DAIR) Centre and future attractiveness for eVTOL/eSTOL OEMs, and future GTA AAM planning.

Ontario's Healthcare and Medical Logistics Sector Actions

From feasibility work being performed globally, it is becoming abundantly clear that RPAS and passenger AAM aircraft will enable dramatically improved remote care and will close the rural/urban divide. Next Steps include:

- Further physical integration of the 92 hospitals, health care centres, and labs presently serving GTA communities with improved AAM services.
- Undertaking studies to more fully integrate electric aircraft with existing Medevac services offered by Ornge and other providers.
- Evaluating and further studying organ delivery benefits derivable from AAM for GTA citizens, working hand in hand with Trillium Gift of Life Network.

Actions for Academia

Government authorities and industry should partner with universities and high schools to emphasize STEM, engineering, and technical education. Educating the broader community on the benefits and societal value of AAM will be critical for public acceptance and for the advancement of STEM education. To achieve this, Next Steps include:

- CAAM is calling for an AAM "STEM Summit" to promote the new AAM ecosystem to colleges, universities, and high schools, and identify skills needing further development in the GTA and the rest of Canada.
- Planning and building an innovation hub for Small to Medium Enterprises to begin to leverage newfound CAAM network/collaboration momentum, thus allowing low Technology Readiness Levels (TRLs) to move to commercialization, a key strategy toward this ecosystem's successful maturity.
- Emphasizing, through a public awareness campaign, the importance of public understanding of the science behind noise and the actual impact of eVTOLs/eSTOLs on their daily exposure. Urban design disciplines will become essential.
- Ensuring that RPAS and eVTOLs/eSTOLs provide access to educational opportunities for Indigenous communities.
- Seeking federal funding for university and college-based research across all relevant STEM disciplines.
- Placing vertiports and drone-ports at participating campuses.

Investment and Capital Formation Actions

In terms of long-term capital investment, transportation authorities should examine the full range of Public-Private-Partnerships that can be utilized to attract private capital to fund AAM ground infrastructure and needed RTM facilities and services. Studies performed by NEXA Advisors have already made a strong business case for AAM CAPEX investment for GTA. Next steps include:

- Identifying the 25-year roadmap for capital formation and investment, with timing on returns to investors.

- Holding a series of investment webinars and seminars explaining the investment requirements of AAM and how the business case comes together for private capital markets. The audiences will include public and private infrastructure funds in Canada and internationally.
- Developing a series of White Papers, within P3 constructs, examining:
    - Regulated versus unregulated assets
    - Buy versus build decisions
    - Venture stage investment versus real asset ownership
    - Investment risks

Executing a Strong Communications Strategy

An effective communications strategy will be developed by CAAM with steps to include:

- Articulating a message that AAM passenger and RPAS missions will deliver tremendous long-term benefits for the region and its stakeholders.
- Providing early emphasis on use cases such as Medevac, emergency services, first responder needs, COVID-19 response, traffic congestion reduction, and related services for disadvantaged communities.
- Pointing to other cities currently in the advanced AAM planning stages (Vancouver, Singapore, Seoul, Dallas, Munich, Los Angeles etc.)
- Providing stakeholders with additional value in the form of high-quality content. As a practical matter, develop a series of white papers that are researched, referenceable, and articulate on the most critical topics by today's vision: safety, environmental benefits, noise abatement, public perception, and public benefit delivery.
- Stressing affordability and accessibility over time, with a focus on Air Metro aircraft and services, and the fact that AAM will not be a premium service.
- Ensuring benchmarks and an evaluation process designed to measure commitments delivered and success along the way.

Though, as we can see from the many action items listed above, there is much work to be done, the Greater Toronto Area stands poised to derive numerous social and economic benefits from the implementation of Advanced Air Mobility and is in an excellent position to become an early user.

Timeline for Introduction of AAM Within the Greater Toronto Area

A schedule below presents the macro phases involved with bringing the GTA both to, and beyond, day one revenue services.

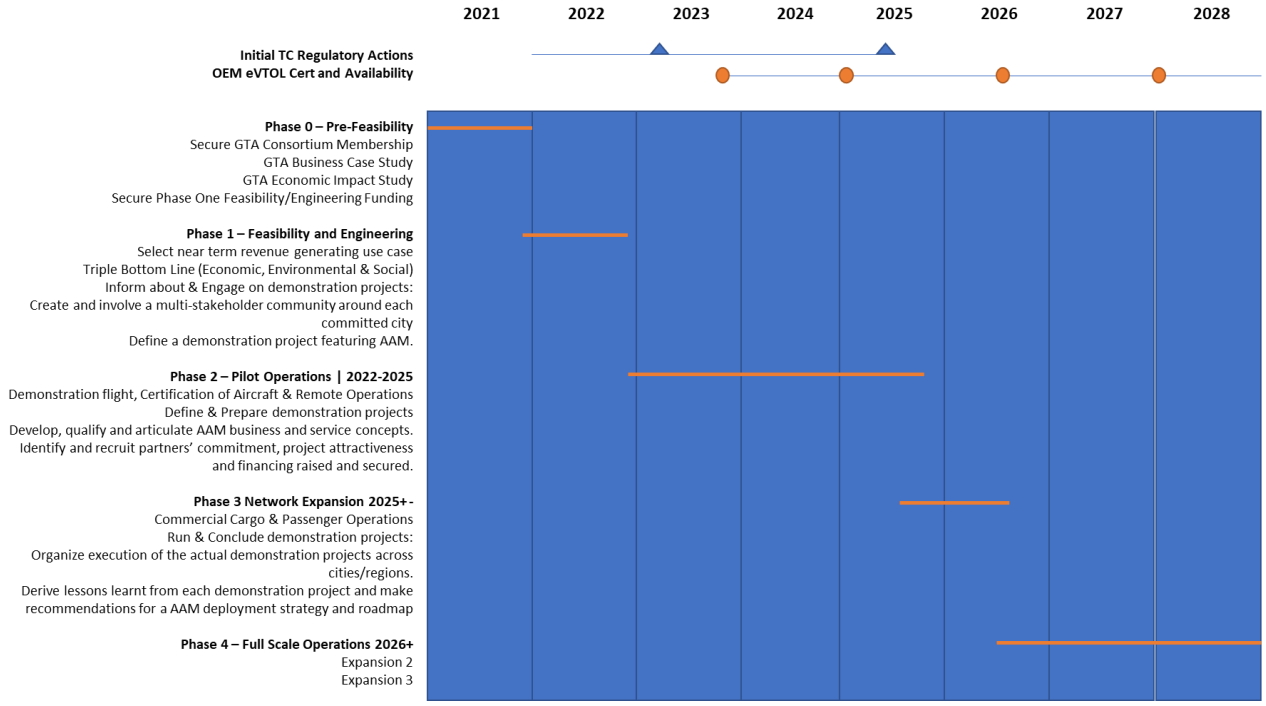

Figure 42 - A proposed schedule of the Toronto regions development of AAM.

From this schedule, it can be seen that certain early emphasis placed upon feasibility, engineering and pilot operations will lead to increased confidence by community groups in these new AAM services. Generally speaking, the project will stress pilot programs that can demonstrate economic and social benefits, while at the same time satisfying stringent regulatory frameworks being developed today by Transport Canada and other regulators in partnerships with OEMs and operators.

Appendix – Additional RPAS Use Cases

While the focus of this paper has been passenger aircraft and cargo, there are many additional use cases of Remotely Piloted Aircraft Systems that will benefit the Greater Toronto Region.

Retail, Restaurant, Grocery, and Medication Delivery to Individuals

Home delivery of a variety of items, which skyrocketed during the pandemic, shows no signs of abating. In late 2019, retail e-commerce sales of physical goods across Canada came to almost $31 billion. In 2021, that figure rose to $38 billion. By 2025, it is expected to reach $50 billion.[24]

In 2020, the Canadian grocery giant Sobey's reported online orders soaring by 241% compared to 2019.[25] Metro's online grocery service has tripled since 2019. Loblaw's online food sales went up by 250%. These and other firms have greatly expanded deliveries, some of them testing self-driving vehicles—and putting far more trucks, cars, and cyclists on the road.

Figure 43 - Retailers and grocery giants are moving forward with RPAS delivery for high-value commodities to homes and businesses.

RPAS could easily replace deliveries of some percentage of trucks and cars. Test programs are underway in cities around the world such as Mobile, Alabama; Canberra, Australia; and Reykjavik, Iceland for RPAS deliveries of food, medications from pharmacies, and small packages.

Short-range package delivery is a major potential mission for RPAS weighing up to 25 kilograms carrying packages of up to five kilograms. Due to aircraft payload limitations, it is expected that most flights will perform a single delivery before returning to their base of operation, but there may be cases in which the delivery comprises more than one package and multiple destinations within the nominal 20-km mission radius capability of the RPAS.

Delivery sites for these operations may be purpose-built or adaptations of existing facilities, such as shopping malls. The sites will include landing pads and facilities such as package drop chutes or lockers, and they may be designed such that the delivery aircraft can place the payload from a hover without landing on the ground. Launch sites will generally be fixed, but in some cases, RPAS may deliver packages from a warehouse to a truck situated close to the final destination; in other cases, it may be advantageous to launch RPAS from a truck to make the final delivery such as a residential backyard.

[24] https://www.statista.com/statistics/289741/canada-retail-e-commerce-sales/

[25] https://www.supermarketnews.com/retail-financial/sobeys-eyes-more-market-share-after-q2-sales-gains

Facilities for passenger AAM operations may also house designated delivery stations, or they may be collocated with package distribution facilities.

Operator, remote pilot, and aircraft certification regulations and standards will support safe operations and enable growth and integration of the RPAS industry with the rest of aviation. An approved RTM system will enable safe management separation of aircraft. The RPAS will fly at low altitudes and avoid interference with manned flight operations, but they may fly higher than 400 feet above ground level in areas devoid of manned traffic, including urban canyons or the rooftops of tall buildings. Package delivery operations will employ machine intelligence, automation, and sensor technology to safely operate BVLOS (Beyond Visual Line of Sight) between the remote pilot and the aircraft. Increasing levels of automation will enable a single remote pilot to manage multiple aircraft at a time. Flights are expected to operate in clear weather conditions until implementation of a traffic management system, the associated infrastructure, and aircraft designs that enable navigation in inclement weather and poor visibility. The diversity of aircraft types that support package delivery is expected to grow as various types of new delivery services are approved and implemented.

Figure 44 - Online retailer Amazon has RPAS delivery programs underway in over 10 countries, with regulatory approvals expected as early as 2022.

As improvements in electric propulsion, aircraft reliability, and automation enable increased range and density of operations and enhance market acceptance by reducing operating costs, the package delivery fleet population in the area is expected to eventually grow to number in the thousands, with hundreds of flights operating at any time. This volume of traffic may dictate a new class of low-altitude airspace replacing uncontrolled airspace in rural areas, as well as reallocation of controlled low-altitude airspace over urban areas.

Other Missions and Services of AAM Aircraft

Smaller RPAS can serve a variety of missions to inspect, monitor, and surveille anything from bridges to crime scenes to the migratory patterns of birds, fish, and moose.

Wildlife Tracking and Forestry Monitoring

Tracking and monitoring of endangered species is an important part of wildlife protection and conservation. Tracking and monitoring systems use photo traps, mobile phones, conventional cameras, and other methods to capture wildlife imagery. Although these methods are well integrated into the wildlife monitoring processes, there remains a desire for faster and more efficient image collection. Aviation, in the form of small aircraft flying at very low altitudes, has long been used to capture quality imagery for monitoring wildlife. However, this method is often dangerous and disruptive to the wildlife,

not environmentally friendly, and very costly. Advanced Air Mobility Aircraft can capture the same quality imagery as traditional aviation, but with greatly reduced impacts on the wildlife and environment and at a lower cost. These aircraft are playing a growing role in radio-tracking of tagged animals, poaching prevention, terrain mapping, multispectral vegetation analysis, and oceanic detection services.

Ontario is home to a diverse selection of wildlife, including four actively managed cervid species: moose, white-tailed deer, woodland caribou, and American elk. Cervids are a highly valued and unique species group of Ontario's wildlife heritage and an important component of the province's biodiversity. The Ontario Ministry of Natural Resources is responsible for the protection and management of Ontario's cervid species, and Advanced Air Mobility Aircraft could provide easier access to remote areas for herd migration and population growth monitoring. The Beluga whale, a native of northern Ontario's waters, is an "At Risk Species" of great interest to researchers. Conventional methods of tracking migratory patterns are limited to observations from a boat; however, AAM Aircraft technology allows observations of whales from the surface to as much as 10 m deep. This allows scientists to analyze the species searching for food, in coordinated travel, socializing, and other behavioral patterns.

Figure 45 - Digital Timber of North Bay Ontario makes use of high-end sensors and software to gather detailed tree inventory data, which clients can use to better manage their forests.

Advanced Air Mobility Aircraft can be deployed noninvasively from ad hoc locations with minimal infrastructure, and they can transmit live video and other sensor data while in flight. AAM-derived imagery has demonstrated far better quality, timeliness, and cost than traditional terrestrial collection methods. In Ontario, sophisticated AAM operating systems will offer highly automated flight and data capture options that enable more streamlined flight operations and post-flight data processing using onboard or ground station computers. Generating terrain and vegetation maps is another capability of AAM systems that can generate unique insight about the wilderness environment, particularly in difficult-to-reach areas.

Primary drivers for adoption by industry and researchers will be the ability to access difficult-to-reach areas; the need for accurate, timely, and reliable data; and savings in time and cost. Technology advances in battery efficiency and low-noise aircraft will address the challenges of potential disruption of wildlife from low altitude operations and the limited range and endurance capabilities of current small Advanced Air Mobility Aircraft.

Watershed Monitoring and Conservation

As the largest Canadian Province, Ontario borders on four of the five Great Lakes in addition to the Hudson Bay in the north. The lakes are the largest fresh-water system in the world and contain one-fifth of the world's surface fresh water. These bodies of water are vital to the health of Ontario's natural ecosystem as well as providing benefits for Ontario citizens such as drinking water, transportation, recreation, hydroelectric power, and economic opportunities. Accordingly, these bodies of water are actively managed and protected by the Canadian government in conjunction with the U.S. Environmental Protection Agency through the Great Lakes Water Quality Agreement. Canada and the United States are committed to restoring and maintaining the chemical, physical, and biological integrity of the Great Lakes ecosystem.

Figure 46 - Innovative drone technology can be used to monitor rivers and streams in remote corners of Ontario, improving research information and thus outcomes for water quality and other conservation goals.

Despite their size, the lakes are ecologically extremely vulnerable as less than 1% of their total water mass leaves the lakes each year. Contaminants can remain for many years, affecting the health of fish and fowl. Continuous monitoring is thus essential to assess and mitigate the effects of population growth, industrial waste, raw sewage overflows, mining operations, and agricultural runoff on the quality of the water and the Great Lakes ecosystem. Moreover, climate change allows invasive species to take hold, which foul beaches, harm fisheries, clog water infrastructure, and lead to the regional extinction of species. More than 180 non-native species have entered the Great Lakes, and a new species is discovered every 28 weeks on average.

Traditional monitoring methods are expensive and labor-intensive. RPAS in this role can quickly be deployed to cover long distances in a single flight and capture highly detailed data with a wide variety of interchangeable lenses. The aircraft can be particularly valuable by enabling safe and rapid assessment of areas with deteriorating or unstable conditions.

RPAS operations will take place largely in remote areas where traditional monitoring methods are inefficient. Additionally, regulations in rural regions are less stringent than in urban areas; operational limitations will not be a significant barrier except in fringe cases such as densely developed housing

areas or sensitive coastal nature preserves. The greatest regulatory hurdle will be posed by operation BVLOS, which requires operators to hold a Special Flight Operations Certificate as well as advanced operations certification. To simplify operations, Transport Canada has recently proposed an amendment which eases BVLOS restrictions in rural areas. Restrictions can be further mitigated for small RPAS by limiting flights to VLOS (Visual Line of Sight).

Adoption of small RPAS for this mission will continue to grow as sensors, aircraft, and analysis software become more capable and affordable and the impact of climate change on the Great Lakes and the Hudson Bay becomes more severe.

Rapid-Fire Dispatch for Emergency and Law Enforcement Response

Response time is critical for emergency responders to prevent or contain damage, treat injuries, and save lives. The Golden Horseshoe is a geographically diverse and expansive region, covering 31,561.57 km^2. It contains some of the densest urban areas in Canada as well as rural areas. The region is home to some of Canada's largest emergency response/law enforcement departments, including the largest fire department (Toronto Fire Services) and largest municipal police force (Toronto Police Service).

Figure 47 - Waterloo Regional Police recently unveiled a drone fleet to improve public services.

These emergency departments take calls on diverse situations, and a large portion of these are medical. In 2019, Toronto Fire Services responded to over 133,000 emergencies, 53% of which were medical—twice as many incidents as the Canada average. The key first step for emergency responders is to assess each situation and determine the capabilities that need to be deployed. Fire departments respond not only to fires, but also to events involving hazardous material, medical emergencies, maritime emergencies, motor vehicle accidents and fires, rescue calls, and other situations for which time is of the essence. Emergency responders will use AAM aircraft to surveille a situation to determine the necessary ground response and to provide a bird's-eye view to avoid the congestion and delays of surface traffic.

Initially, designated firefighters will be trained as RPAS operators, and small RPAS with appropriate sensors will be launched at the scene of a fire or other emergency to operate within visual line of sight. In the future, with appropriate communications and control of airspace, small RPAS may be operated BVLOS and from facilities such as fire stations or emergency control centres, or they may be parked at

various locations, such as atop buildings, to provide a rapid-response fleet across a region. Night operations will require special equipment, such as lighting or thermal imaging.

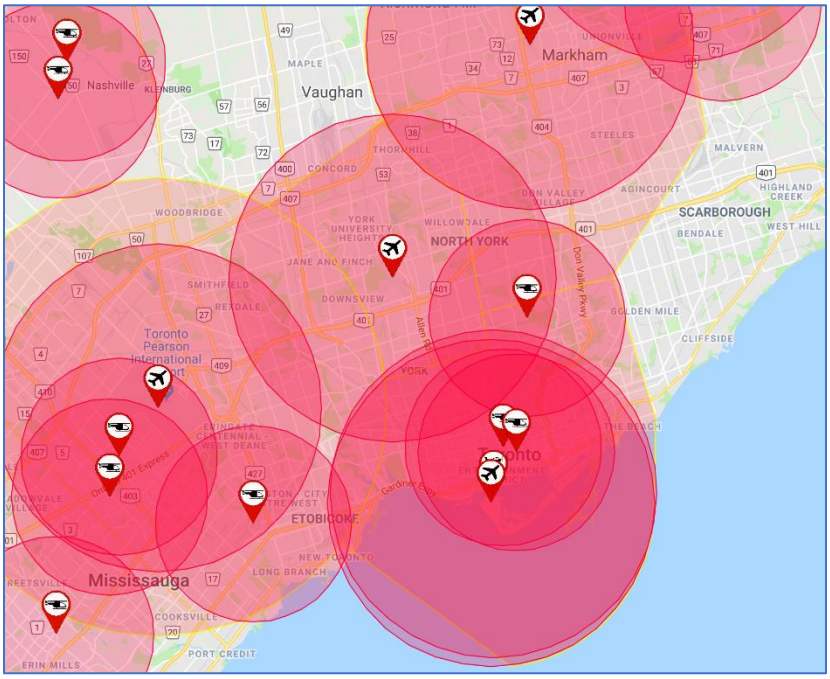

Figure 48 - GTA airspace is accessible to drones using Canadian Drone site selection tool. The NO Fly Zone Map is shown, requiring special clearance to operate.

Many emergency departments in the Golden Horseshoe have begun to employ RPAS: the fire departments in the City of Hamilton, City of Brampton, and Town of Georgina are among those adopting AAM technology. The remotely piloted aircraft employed by these departments are valuable for their ability to quickly cover great distances: large cities in the region like Hamilton and Brampton are geographically expansive, and these AAM aircraft allow quick and efficient assessment of a scene.

The South Simcoe Police Service and Innisfil Fire and Rescue Service recently partnered to utilize a new RPAS that will aid both departments in emergency response. Using RPAS technology cooperatively allows them to effectively assess emergency scenes to send appropriate personnel, locate missing persons more effectively, photograph/map scenes of accidents, and reach scenes that are inaccessible to humans (large fires, marine-based emergencies, etc.). The City of Hamilton has been using their RPAS primarily for operations at night, where thermal imaging helps to locate missing persons and suspects in the dark.

In Peterborough, an RPAS was recently used to locate three teens who had become lost in the woods during a hike. Police deployed the aircraft to aid ground crews in the search, helping them quickly locate the three missing boys and dispatch paramedics to the scene.

Remote pilots will control the RPAS within the existing regulatory framework. Initial operations will be limited to VLOS and altitudes well below conventional aviation. Future BVLOS operations will require regulatory permission, advanced pilot training, and approval from air traffic control to fly in controlled airspace. Operators may be accompanied by visual observers in some scenarios to reduce risk and improve situational awareness. Fleet size will start small, with units in the single digits in a metropolitan area growing to double digits within a few years of operations.

Infrastructure Inspections

The Ontario Society of Professional Engineers estimates that the value of the infrastructure industry in Canada is $220 billion, and RPAS are a large part of the future of the industry. These aircraft allow for

frequent and reliable inspection/monitoring of major pieces of infrastructure. Utilities, dams, nuclear power stations, telecommunications networks, bridges, etc., can all be monitored using RPAS and imagery data that they collect. These images can be taken via RPAS at higher frequencies than traditional monitoring methods, giving a better temporal resolution for inspections of key pieces of infrastructure.

Figure 49 - So-called "indoor drones" can be used to perform infrastructure surveys in areas difficult for people to access.