AN APPLICATION OF AERIAL DRONES IN ZONING AND URBAN LAND USE PLANNING IN CANADA

A Preliminary Review of Current Policies, Restrictions and Planning Direction for Aerial Drones in Canadian Cities

By

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ABSTRACT

The rapidly changing technology of Unmanned Aerial Vehicles (UAV), or drones, has potential uses in many aspects of urban life, including in the planning profession. Compared with current alternatives, UAVs could potentially provide a superior low cost, adaptable and accurate data gathering tool for planners. Presently however, government regulations on the use of UAV's in Canada, especially in urban areas, are very loosely defined with a general focus on safety rather than fostering innovation towards a more efficient system. Urban planning professionals need well-reasoned, flexible, UAV- specific regulations that will address the complex issues related to the urban use of drones, in order to derive the maximum public benefit from use of this technology in planning.

Key Words: Unmanned Aerial Vehicle, Drone, Aerial Survey, Municipal Zoning Bylaws, Aerial Photography, Remote Sensing, Urban Design, Privacy, Public Safety

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Introduction

Unmanned Aerial Vehicles, or UAVs, are unique to the field of mechanical aviation. They have the ability to fly through the air without a human operator on board, and perform complex and unconventional aviation tasks. UAVs come in a vast array of sizes, can hover in midair, do back flips, spins and spirals. They can accurately locate objects, navigate smoothly and precisely through small spaces; and in addition, they can do all this while carrying an array of other technologies, like a video recording apparatus, on board. Their versatility is what makes them a viable option for a number of different tasks, and is what is making them a desirable alternative to manned flights.

UAVs have been used as weapons by the military, as sophisticated data-collection instruments by scientists to help in their advanced research, as helpful aids to humanitarian workers, and as tracking and surveillance devices for law enforcement. UAVs are no longer exclusively for military use, and with innovations in cellular modular technology, they are more widely accessible and affordable than ever before. They are constantly evolving into tools that could be used in many civilian applications across Canada, and in Canada's urban areas. Many international planning authorities have adopted some form of UAV-lead operational assistance in the past few years, with limited instances in Canada. However, their use is steadily on the rise, and in addition to their use by public and private sector organizations they are increasingly becoming available to individual Canadians.

UAV technology used in urban areas raises important questions and concerns about public safety, privacy, and the potential implications of public and private utility and use. There is a gap in specific regulations to address issues related to purpose and the specific, but multifaceted, implications of their use, especially in urban areas.

The purpose of this research report is to explore the emergence and implications of UAV technology in Canada's urban areas, planning for UAV use, and provide insight into how urban planners can apply these aerial tools in new and innovative ways. The main study methods involved review of the current state of UAV technology, uses in many areas of the world, and potential applications in the planning realm. Two UAV planning-specific applications will be discussed: planning for urban UAV flight zones and planning with data and information gathered by UAVs. Examples include using UAV atmospheric sampling to replace static ground sampling stations and using UAVs to assess tree canopy cover for urban sustainability targets, respectively.

Chapter 1 of this report provides an overview of what UAVs are and where they came from. Chapter 2 sets out to discuss the roles of players and concerned parties in the use of UAVs. Chapter 3 provides a sense of the possibilities drones can have on the planning of urban areas and the planning profession. Chapter 4 emphasises the government's legislative and regulative role in fostering drone innovation. Chapter 5 discusses ideas for drone urban management traffic systems, and proposes a municipal aerial zoning ordinance system. Chapter 6 provides an overview of possible safety and privacy concerns with the adoption of drones in an urban setting. Chapter 7 provides a basic overview of current legislation and regulations pertaining to drones. Finally Chapter 8 concludes with a summary of what is needed in Canada's current legislation and policy to facilitate the integration of drones into urban areas for the future.

Figure 0.1 Aerial Permitted Use Zoning for Drones (Sipus, 2014)

Chapter 1

1.0 Brief Overview of UAVs

1.1 A History of UAVs

The origin of Unmanned Aerial Vehicle (UAV) technology can be traced to its lack of physical connection to a controlling source. In many ways radio control was the primary enabler in the early innovations in UAV technology, and correspondingly its ability to act autonomously.

1.1.1 Radio Control

Radio control implies that an object is being controlled remotely using radio wave signals from a transmitter. The transmitter sends a control signal to the receiver using radio waves, which then drives a motor, causing a specific action to occur.

Radio control (RC) has a history of just over 115 years. In 1898, scientist Nikola Tesla designed, built and patented a pair of radio controlled boats for an Electrical Exhibition at Madison Square Gardens. Tesla stated to the disbelieving crowd, foreshadowing things to come, "The world moves slowly, and new truths are difficult to see" (Tesla, 2007; Turj, 2014). Using a small, radio-transmitting control box, he was able to maneuver a tiny ship and flash its running lights on and off without any physical connection between the boat and controller. This was the first time radio control had been demonstrated. However, other inventors were quick to match Tesla's success.

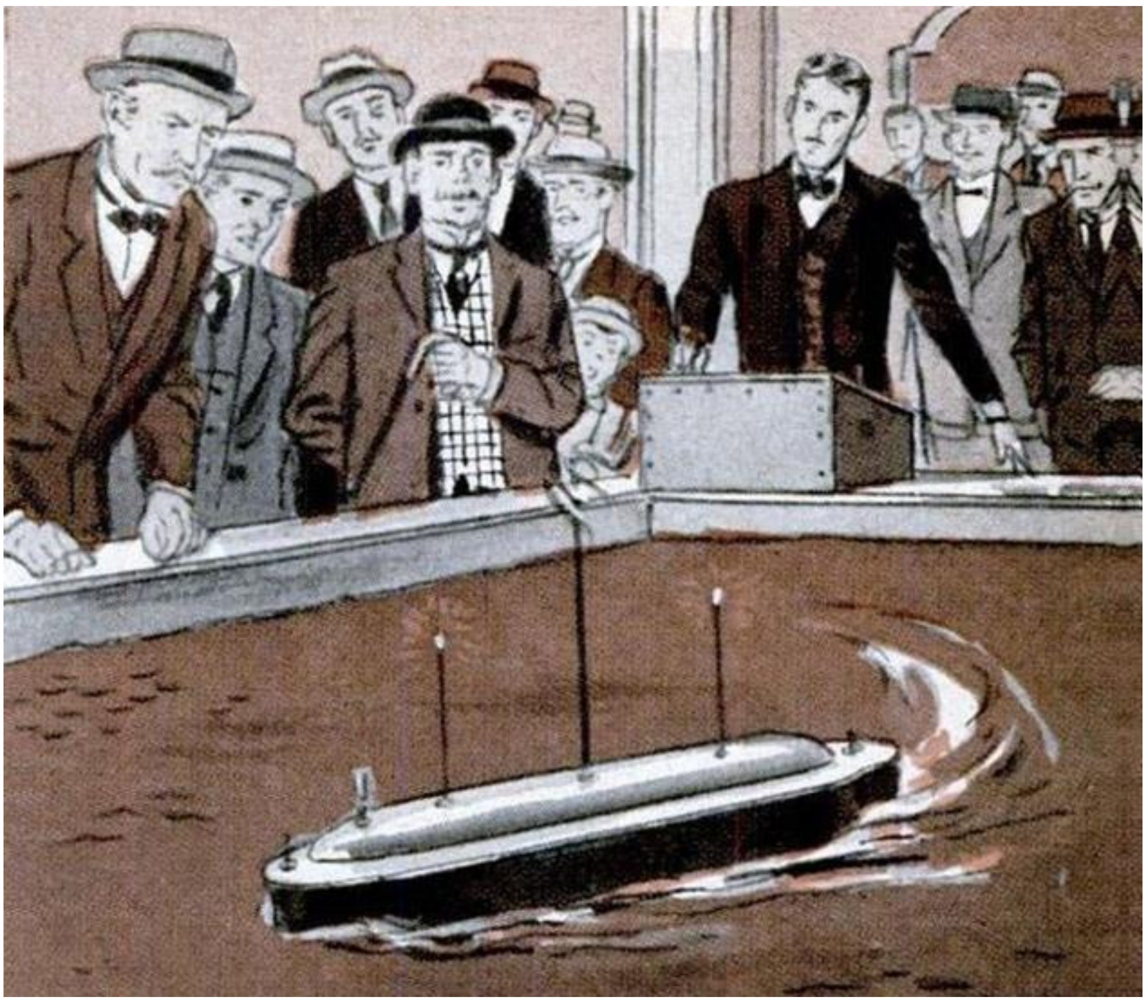


Figure 1.1 Tesla's RC Boat, 1898 (Turj, 2014)

In 1903, the world's first RC controller apparatus was created by Leonardo Torres Quevedo at the Paris Academy of Science (Kalif, 2013). Quevedo demonstrated the apparatus's ability to remotely control various robots via electromagnetic waves causing it to execute various commands. Although these demonstrations were benign in nature and the start to recreational hobbyism for many, interest quickly arose regarding its potential in military applications.

1.1.2 Military Applications

In the year following Quevedo's demonstration, the worlds first radio controlled torpedo was remotely tested, and in 1917 radio control was used successfully in an airplane by Archibald Low. Toward the end of World War I, the United States and the United Kingdom's Royal Flying Corps used previous works on radio transmission technologies to develop aerial torpedoes like the Kettering Bug (Nicolao, 2012). The Kettering bug was essentially the forerunner of what today is considered a UAV or a cruise missile. Due to the troubled times of military conflict at the start of the 20th century, much time and many monetary investments were made in radio controlled innovations to assist in military applications. Military leaders were always striving for technologies which could reach their targets from the greatest distance, with the fewest operational casualties possible. This has always been the primary driver behind development of the UAVs forerunner technologies.

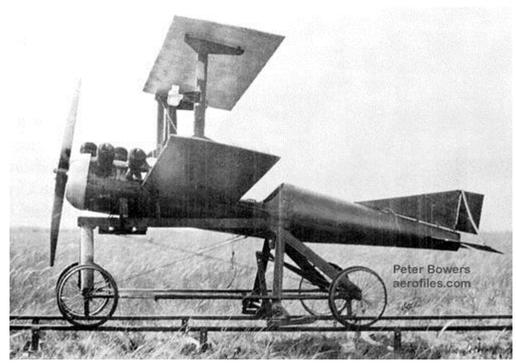


Figure 1.2 Kettering Bug (Nicolao, 2012)

During World War II military efforts had focused on developing rocketry, given the difficulties in building full-scale pilotless airplanes. However, it wasn't until the late 1950s when guided rocketry had made it to the point where they could essentially fly like a plane over great distances utilizing wings (Sifton, 2012). These Cruise Missiles were, in a sense, proto-UAV, miniature versions of what Archibald Low had attempted in 1917. They could be dispatched and guided in flight; some had cameras; and, in some incarnations, could even change target midflight (Sifton, 2012).

Cruise missiles were limited in their utility as they could not linger over a battlefield in the manner of a holding pattern, nor could they return to location or land. So in the 1960-70s, military engineers, primarily in the U.S., continued to tinker with unmanned aircraft—in particular for use in surveillance flights for the U.S. Central Intelligence Agency (CIA) (Sifton, 2012).

Figure 1.3 CIA Predator Drone (Ungerleider, 2010)

Later improvements in computing and electronic controlling technologies in the 1980s and 1990s lead to increased maneuverability, accuracy, and flight duration of proto modern surveillance UAVs. In 2001, following the September 11th terrorist attacks, the CIA announced its intention to utilize its surveillance UAVs for armed military engagements in the Middle East. This lead to a heightened degree of both governmental and private investment in supporting drone technology advances.

A decade ago fewer than 5% of U.S. military aircraft were unmanned: now 40% are drones with no pilot. It is predicted that military manufacturing companies like Lockheed Martin and Northrop Grumman will stop development of any new piloted aircraft within the next decade, as global militaries will become entirely drone centred (Reed, 2012; CCUVS , 2015a). This inevitably will lead to billions of dollars annually devoted to future innovations in drone technologies.

1.1.3 Cellular Phone Influences

The present day UAVs may have been based on innovations in military radio control applications in the past century, but the scale of proliferation in smaller and more cost effective sizes is primarily attributed to technology innovations from their cellular, mobile phone cousins. Over the past ~30 years cellular phones, or "cell" phones, also utilizing radio transmissions, have developed progressively smaller processors, batteries, transmitters, and gyroscopic censors. The cell phone industry has also helped spur advances and investments in Global Positioning Systems (GPS) technologies which use satellites to track a phones defined geographic location, also integral to modern UAV flight operations.

The cellular device industry has made phones so small they can fit into your pants pocket and move around with you the whole day on one battery. The cellular industry has made cell phone devises so affordable that in 2013, 27.9 million Canadians actively used them in their day to day lives (CRTC, 2014). Assuming that represents roughly one cell phone per Canadian, in 2013, four out of every five citizens used a cell phone. This investment in the small wireless gadget industry, by industry and the public, has had a spillover effect into UAV production and affordability. Cellular “smart phones” can often act as a controlling device for many civilian drones, further encouraging consumer adoption of drones. As public and private demand for UAVs proliferates, production and innovation in technology are bound to grow.

1.2 Description of UAVs

Present day Unmanned Aerial Vehicles (UAV), also known as Unmanned Aerial Systems (UAS), are aircraft either controlled by “pilot operators” from the ground or increasingly, autonomously following a pre-programmed mission. The most generally phrased, colloquial, term for these vehicles by the lay public is the “drone,” a catch-all term for any vehicle operating on the surface or in the air without a control person on board (Office of the Privacy Commissioner, 2013).

In the industry, and across different regions, drones are also called Unmanned Air Vehicle (UAV), Unmanned Air System (UAS) or Remote Piloted Aircraft Systems (RPAS). The International Civil Aviation Organization (ICAO), a United Nations specialized agency headquartered in Montreal, Canada, has set a new definition referring to drones as RPAS, which will soon become the recommended term internationally as ICAO moves towards developing worldwide standards. The following are definitions associated with the various international drone terminologies:

- **UAVs (Unmanned Air Vehicle) -** UAV is a “power driven aircraft, other than a model aircraft, that is designed to fly without a human operator on board.” (Department of Justice, 2014)

- **UAS (Unmanned Air Systems)** – A UAS is an unmanned aircraft (UA) and all of the associated support equipment, control station, data links, telemetry, communications and navigation equipment, etc., necessary to operate the unmanned aircraft. (FAA, 2015)
- **RPAS (Remote Piloted Aircraft Systems)** - A newly emerging definition that highlights the fact that the systems involved are not fully automatic but always have a pilot in command responsible for the flight. RPAS describes a “remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the design”. (Council of the European Union, 2012)
- **Model Aircraft** - is an aircraft, the total weight of which does not exceed 35kg (77.2 pounds) that is mechanically driven or launched into flight for recreational purposes and that is not designed to carry persons or other living creatures, capable of sustained flight in the atmosphere, and flown within visual line of sight of the person operating the aircraft. (Department of Justice, 2014)

While the previous descriptions only present minor variations in definition, UAV, UAS and RPAS can essentially be used interchangeably to refer to unmanned aircraft and the systems that connect them to their pilots on the ground. However, model aircraft are distinctly different from UAVs in the fact that they are used exclusively for recreational purposes, and thus not covered by Canadian regulation. This paper will use the terms UAVs, UAS and RPAS interchangeably or refer to them commonly as “drones”.

1.3 Classification of UAVs

At present there lacks a defined international classification and ranking descriptive system for drones and their uses. This is anticipated to become more defined in the immediate future as drones rapidly develop in their form and application.

Drones can range in size and form and are typically described according to weight, endurance, purpose of use, and altitude of operation. Some look like traditional airplanes with fixed wings, others are like mini helicopters, and some even look like birds or other animals and move around similarly to these creatures. The size of drones can range from being as large as traditional manned aircraft, being small enough to fit in a backpack, or even smaller, to land on a finger nail. Large drones can fly at high altitudes, the upper atmosphere, and some can even remain airborne for several days and travel great distances. When considering basic parameters as take-off weight and range drones may be classified as: (Zakora & Molodchik, 2014)

- Micro and mini UAV close range (take-off mass of 5kg, a range to 40km)
- Lightweight UAV small range (take off mass of 5-50kg, range of 70km)
- Lightweight UAV medium range (takeoff weight of 50-100kg, range of 150km)
- Average UAV (take off weight 100-300kg, the range of 1000km)
- Medium heavy UAV (take off weight of more than 500kg, range of 300km)
- Heavy, medium range UAV (take off weight of more than 500kg, range of 300km)
- Heavy UAV, large deration of flight (take off weight of more than 500kg, range of about 1500km)
- Unmanned Combat aircraft (BBL) (take off weight of more than 500kg, range of over 1500km

Further specific classifications exist for military drones, which lies outside of the scope of this paper.

There are hundreds of different types of drones (Wikipedia, 2015a). When simplifying drone types, the following categories provide a helpful description of some of the different forms they can take. (Stanley & Crump, 2011)

- **Large Fixed-Wing Aircraft**: The largest UAVs currently in use, such as the Israeli-made Eitan, are about the size of a Boeing 737 jetliner. The Eitan's wingspan is 86 feet, it can stay aloft for 20 hours and reach an altitude of 40,000 feet (Homeland Security Newswire, 2010). The United States military "Predator" drone, was the first-ever weaponized UAV, and has been used to gather intelligence and carry out targeted strikes in overseas operations. It can fly up to 25,000 feet for up to 40 hours. The "Global Hawk" drone is used primarily for surveillance and is not armed. It is capable of staying aloft for up to 35 hours, transmitting video to ground stations during its flight. It is also used by NASA as a "Hurricane Hunter." These types of large fixed-wing drones are the most similar to manned aircraft in their size design and function (Northrop Grumman, 2015). Their size and range of flight enables these UAVs to be configured with a range of different payloads.

Figure 1.4 Global Hawk (Northrop Gruman, 2015)

- **Small Fixed-Wing Aircraft**: Aircraft such as the Boeing ScanEagle can stay aloft for more than 24 hours and can fly at 19,500 feet. These types of aircraft are becoming more popular domestically in the U.S. for use by local law enforcement and some private resource companies (Boeing, 2015).

Figure 1.5 ScanEagle (Boeing, 2015)

- **Micro-UAVs**: Sometimes colloquially regarded as a "Backpack craft", they are relatively cheap and portable, designed to be carried and operated by a single person. While their price range makes them within reach for hobbyists, they have also been popular for law enforcement and other public service operations. (Micro UAV Example – Aeryon Labs "Scout" (Aeryon Labs Inc, 2015)

Figure 1.6 Aeryon Scout (Aeryon Labs Inc, 2015)

- **Biomimetic UAVs**: Drones that imitate naturally-occurring animals or plants (commonly birds, snakes, branches and insects), such as the Nano-Hummingbird, one of TIME Magazines 50 best inventions of 2011, capable of indoor and outdoor operation. The Hummingbird is designed to look like a hummingbird and perch on trees to avoid detection (AeroVironment, 2015).). The RoboBee, another biomimetic UAV, is a tiny

Figure 1.7 Nano-Hummingbird (AeroVironment, 2015)

robotic insect that hovers in the air like a fly, weighs just 80 milligrams and is the size of a penny (Chalcraft, 2013)

- **Blimps or Balloons**: As the oldest type of aircraft, and not highlighted by media outlets, these are often not immediately considered as drone crafts. Unmanned blimps or balloons can sit up in the sky in one place, observing for long periods of time. These types of drones are cheaper than there fixed wing counterparts; however, they do not have the same maneuverability and range. Example, Drone Aviation Corp.'s BiB 50, Blimp in a Box (DAC Corp., 2015).

Figure 1.8 BiB 50, Blimp in a Box (DAC Corp, 2015)

1.4 Types of Unique and Primary Data Retrievable by UAVs

As was highlighted in Section 1.2, drones are often increasingly regarded to as a desirable alternative to manned flights. This is largely due to their flexibility, unique capabilities and ability to reduce operation costs while increasing safety. Drones can be a persistent, highly targeted and cheap form of data collection. Drones can be deployed on demand and can generally stay in the air longer than manned aircraft. They are flexible in terms of the tasks they can perform, they can support high-resolution imagery and sensors, and the “plug and play” payload capability makes them easy to tailor to a specific flight purpose (Aeryon Labs Inc, 2015). Furthermore, they can cover vast areas in a timely manner. Some of the advanced data collection apparatuses and technologies that can be mounted on drones include:

- High-power zoom lenses that can collect information from a great distance.

Figure 1.9 Cannon SX50x Optical Zoom DSLR (Bell, 2012)

- Night vision, infrared, ultraviolet, thermal imaging, and LIDAR (light detection and ranging) that enables drones to detect and enhance nonconventional and imperceptible (by humans) detail.

Figure 1.10 LIDAR Topographic, Humber River Toronto (Brock University, 2013)

- Wind and atmospheric detection apparatuses which can be used for localized weather as well as long range climatic modeling of a region.

Figure 1.11 SHARP Fine Particulate Matter Air Quality Detector (China Daily, 2012)

- Distributed video, “collective conscious” whereby a number of drones work in concert with multiple video cameras.

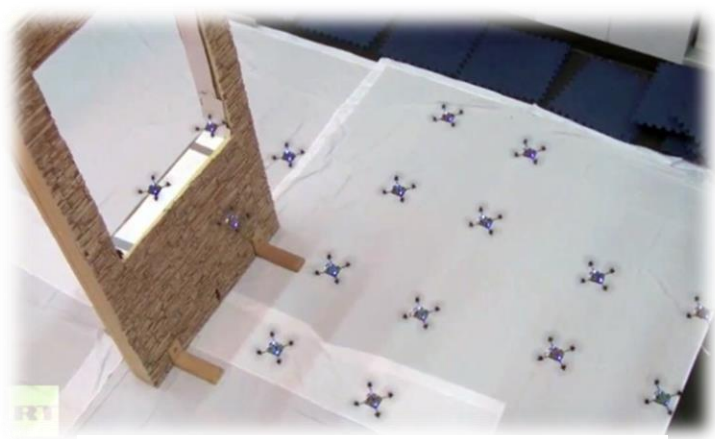


Figure 1.12 Swarm of Drones (RT, 2012)

- Radar technologies that can penetrate walls and earth enabling the tracking of objects even inside buildings, through cloudy conditions and through foliage.

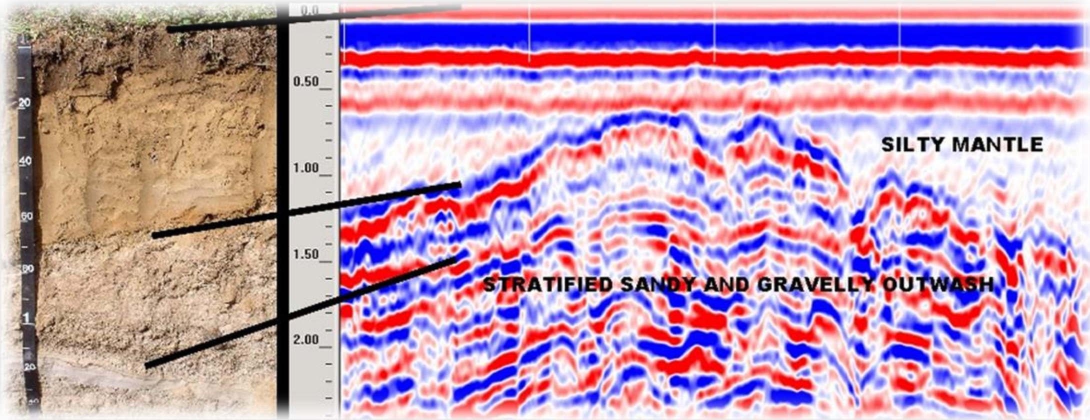


Figure 1.13 Ground Penetrating Radar (NRCS, n.d)

- Video analytics technology, which is improving rapidly and would be able to recognize and respond to specific people, events and objects, or even flag changes in routines to identify particular movement patterns as "suspicious". This could also include things like license plate readers. (Example drone police profiling)

Figure 1.14 Biometric Video Analysis Technology (Realizethelies, 2013)

- Facial recognition or other "soft biometric recognition" that enables the UAV to recognize and track personal attributes such as height, age, gender and skin colour.

Chapter 2

2.0 The Players and Concerned Parties in the Use of UAVs

Drones have matured to a point of sophistication, accuracy, utility and reliability so that they will almost certainly become a part of the future urban environment, unless legislated otherwise. In 2010, it was predicted that by the end of the decade there would be as many as 30,000 drones flying above the U.S. (another jurisdiction with similar economic trends to Canada) (FAA, 2010). Due to this anticipated presence of drones in Canada's urban areas, and associated investments in both the industry and in the cities, many players have equal stakes in the conversation about how to make drones work, for what reason, and where.

2.1 The Government

Figure 2.1 Canadian Flag & Drone (Kung, 2014)

The *Constitution Act, 1867* (originally enacted as *The British North America Act, 1867*) defined the principles under which the Canadian government should legislate in four words, with "peace, order and good government". All levels of government in Canada, and the courts, follow this phrase in order to properly review, regulate, and restrict certain freedoms for the public good, based from democratic precedent and legal justifications.

The Federal Government is mandated to plan for the nation of Canada, all its provinces and territories, and any concerns of national importance and scope; under Section 91 of the *Act.* Federal responsibilities include: (Constitution Act, 1867)

- defence
- criminal law
- employment insurance
- postal service
- census
- copyrights
- trade regulation
- external relations
- money and banking
- transportation
- citizenship
- Indian affairs

The Federal Government has an obligation to ensure that the safety, economic prosperity, and democratic right of Canada is preserved for all Canadians now and into the future. All federal concerns and decisions must meet these obligations while allowing second and third party governing accountability systems to ensure good government at all levels for all peoples.

The Provincial Governments are mandated to plan for matters of a local nature within their jurisdiction under Section 92 of the *Constitution Act, 1867*. These local Provincial matters and responsibilities include:

- property and civil rights
- administration of justice
- natural resources and the environment
- education
- health
- welfare

All Municipal Governments are "creatures of the Provincial Government" (Longo & Costello, 2013). The municipal planning of urban regions is required to conform to all provincial guidelines outlined in the Provincial Policy Statement, 2014 (PPS), issued under section 3 of the *Planning Act, 1990*. *The Planning Act* sets out the ground rules for land use planning in Ontario and describes how land uses may be controlled, and who may control them. *The Planning Act* is legislation passed by elected provincial representatives to:

- promote sustainable economic development in a healthy natural environment within a provincial policy framework
- provide for a land use planning system led by provincial policy
- integrate matters of provincial interest into provincial and municipal planning decisions by requiring that all decisions shall be consistent with the Provincial Policy Statement when decision-makers exercise planning authority or provide advice on planning matters
- provide for planning processes that are fair by making them open, accessible, timely and efficient
- encourage co-operation and coordination among various interests
- recognize the decision-making authority and accountability of municipal councils in planning

On March 31st, 2015, without Provincial guidance, Toronto City Council voted in favor of asking city staff to create a framework for how drones may work in the city of Toronto. This shows that the drone conversation has already started and that the issue is real for municipalities (City of Toronto, 2015).

Both the provincial and municipal governments have an obligation to ensure: the protection of property, adherence to justice, the integrity of the natural environment, and the welfare of its people, are protected in Ontario’s functioning civilization. Like the federal government, all provincial concerns and decisions must meet these obligations while allowing second and third party governing accountability systems to ensure good government at all levels for all peoples.

The Constitution also specified that every issue not mentioned as belonging to the provincial or territorial governments comes under the power of the Federal Government (Constitution Act, 1867). While drones and aviation are not specifically mentioned in the Constitution, their use falls under national transportation through the authority of Transport Canada. Transport

Canada is responsible for developing regulations, policies and services of transportation in Canada through air, on water, or land, under the *Canada Transportation Act, 1996* (currently under review).

Due to the use of drones falling under the authority of the Federal Government, all municipal and provincial uses and regulations pertaining to drones must conform to the federal transportation mandate and legislation. This however does not restrict the federal government from deferring aspects of local planning authority to provinces, or subsequently municipalities, in future.

2.2 The Courts

Figure 2.2 Gavel (Brock, 2014)

The concept of justice is fundamental to Canadian society. The role of courts in Canada is to help establish expectations of how we are treated by others by resolving disputes fairly and with justice, whether the matter is between individuals or between individuals and the state. The courts have an important role in defining the micro, case specific, 'grey areas' in Canada's laws surrounding the use of drones. Laws legislated by both provincial and federal levels of government are often challenged on their merits through the Constitution of Canada. In the subsequent process of "litigation", the courts interpret and establish law, set precedent, and raise questions that affect all aspects of Canadian society independently from government, and the associated herd mentality which often accompanies a democratic cast system of majority representation. This is why justice is often symbolized as a blindfolded figure balancing a set of scales, oblivious to anything that could detract from the pursuit of an outcome that is just and fair.

The Canadian courts and judiciaries roles are set out in section 96 of the *Constitution Act, 1867*. The Department of Justice helps the federal government develop policy and reform laws, with the Supreme Court of Canada constituting the highest-level court, and the final judgement on an issue of national importance.

2.4 The Private Sector – Companies, Commodities

Figure 2.3 Amazon "Prime Air" Delivery Done (Booton, 2014)

Due to progressively decreasing costs and rapidly rising public demand, drones have become a vanguard growth industry. It is anticipated that spending on drones will nearly double over the next decade, growing from current worldwide drone expenditures of $5.9 billion to $11.3 billion annually. These annual totals are projected to reach more than $94 billion in the next 10 years according to a study presented at the Association for Unmanned Vehicle Systems International (CCUVS, 2015a).

More drones are sold every three months than the entire US military uses in active operation (CBC, 2015). In Canada, Ottawa's ING Robotic Aviation and Kitchener-Waterloo's Aeryon Labs are both leading global agencies in this huge new business age, and this list is only expected to grow. According to industry estimates, in the U.S. alone, an estimated 50 companies, universities, and government organizations are developing over 150 different unmanned aircraft designs (Wood, 2013). From a cost, operational, infrastructure and safety perspective, this presents a number of challenges and opportunities to the private industry due to the diversity of aircraft, control stations, levels of autonomy, and communications methods.

A primary Canadian example of a corporation invested in the Canadian application of UAVs is the Canadian Centre for Unmanned Vehicle Systems (CCUVS). Formed in 2007, the CCUVS is a federally registered not-for-profit corporation with a mandate to facilitate and encourage sustained, profitable growth in Canada's unmanned systems sector with a focus on civil and commercial applications (Industry Canada, 2015a).

Services provided by CCUVS include drone training, regulatory assistance, consulting, and unmanned aircraft launcher services. In 2014, CCUVS received all the necessary approvals to manage a permanent area of "Restricted Airspace" for drone research, development and training near the village of Foremost Alberta (CCUVS, 2015b).

Figure 2.4 Foremost Drone Training Centre (CCUVS, 2015b)

This dedicated 2400 kilometres of airspace in rural Alberta provides CCUVS with unprecedented freedom to promote civil and commercial use of drone systems and work with the industry to help stimulate Canadian economic growth (Industry Canada, 2015a). Additionally, to provide an essential service within the unmanned systems sector, CCUVS owns and operates a Robonic MC2555LR drone catapult that is a turnkey solution for many companies and is available for lease throughout Canada and around the globe (CCUVS, 2015b).

Many companies globally have been developing drones for commercial application and have or will have a direct effect within Canada in the coming years. The Chinese company, DJI, recently released a wildly popular drone quad-copter, the Phantom, in January 2013, which has marked the emergence of a substantial consumer market in the mid-price range. While there were some Ready to Fly (RTF) quad-copter models in the market before the Phantom, DJI brought this category of products into a whole new market segment, something far beyond the hobbyists and tinkerers, with its low cost and ease of operation. This has essentially transformed the drone into a large market commodity.

Figure 2.5 Phantom Quadcopter (DJI, 2015)

Many private organisations have been developing this new drone industry by developing new and innovative ways that drones can be used in their operations. The following are examples:

- In Germany, companies use drones are used to inspect the blades on wind turbines (MicroDrones, 2015).
- Companies such as Bosys Technologies Inc., in Toronto, use drones to help farmers survey lands and tend to their crops (Bosystech, 2015).
- Oil companies use them to monitor pipelines and flare stacks. When FlameOut International identified a requirement for “on-line” flare stack survey and flare tip condition inspection of their Oil & Gas customers’ sites, they identified drones as being able to deliver. A company out of the United Kingdom, Microdrones, developed a microdrone which can perform these inspections with thermal imaging, gas leak detection and air sampling for PetroChem and Process Industries, improving safety and reducing costs (MicrodronesUAV, 2015).

Filmmakers from multiple companies put drones to use for cheap aerial footage to assist their journalists, civil engineers, realtors, and artists. For example, in Toronto real estate agents have started using drones as their “eye in the sky” to assess review and advertise for properties (Perkins, 2014).

Then there are the non-photographic implications. Internet shopping giant Amazon has stated its intention to deliver online purchases to a “large portion” of the U.S. population using drones (Booton, 2014). This service, Amazon Prime Air, aims to deliver packages to a purchaser within 30 minutes. However, due to the US federal government’s “lethargic approach”, with a national commercial drone ban, Amazon has moved its drone testing centre to an undisclosed location in British Columbia (Pilkington, 2015). Amazon has invested in six generations of carrier drones, signifying an obvious cost saving interest and an assumption of the ability to do so in future in Canada.

Figure 2.6 Google Project Wing (Preimesberger, 2014)

Google Inc. has been testing its own delivery drones, which have the ability to transform, performing like a plane for distance and speed of flight, while acting like a helicopter on the delivery stage, which involves lowering a package on a tether (Turner, 2014).

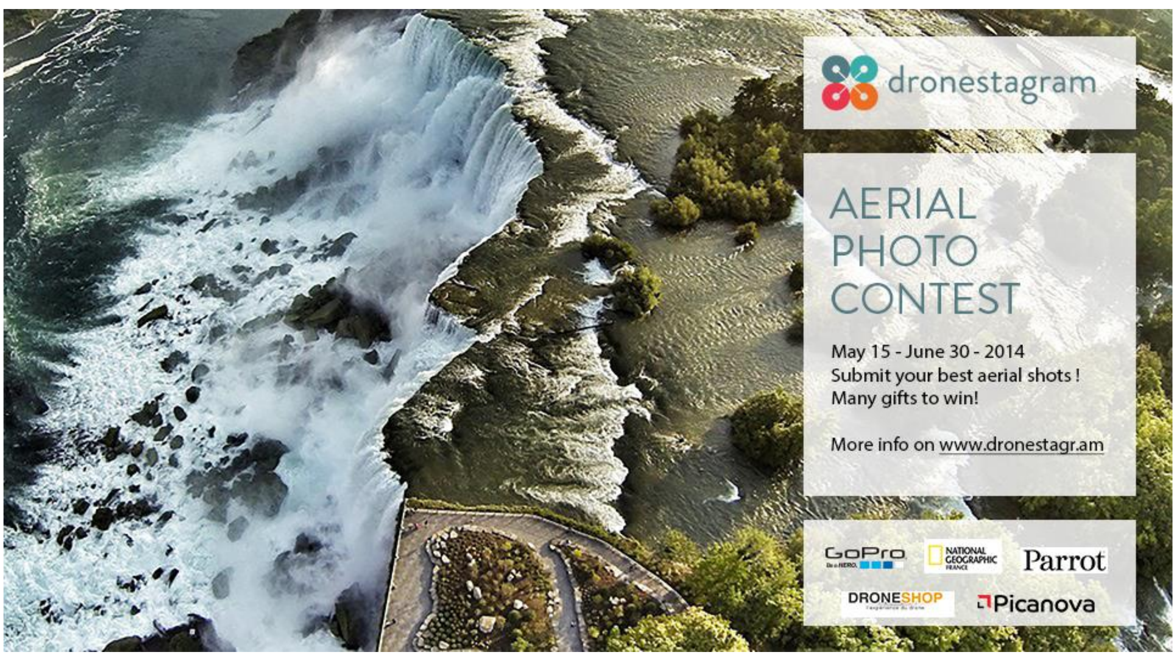


Figure 2.7 Dronestagram (Dronestagram, 2014)

A new drone enabled social networking company, Dronestagram, allows users to post their aerial pictures of Cityscapes, Countryscpaes, Industrialscapes and Sports as relatable categories for others to see and share (Fox News, 2013).

Canadian cultural icon and international entertainment company, Cirque du Soleil, has partnered with Verity studios and ETH Zurich University to develop a short movie performance using autonomous drone quadcopters. “Sparked” transforms 10 lampshades into airborne wonders that seem to come alive and "dance" with a human performer (Winston, 2014).

Figure 2.8 Sparked Cirque du Soleil, (Drita, 2014)

Craft brewing company, Lakemaid Beer, has developed a drone to deliver beer to ice fishing anglers in remote areas using cellular phone signals (Ehlke, 2014). In the San Francisco area a start-up company has been proposed, TacoCopter, to provide for the delivery of fresh tacos to nearby bohemian’s cell phones (TacoCopter, 2015).

Figure 2.9 Beer Drone (Thompson, 2014)

As the private drone examples become stranger and stranger, the limitless and unpredictable potential for drone use in industry becomes clearer and clearer. The private/innovation sector wants clear and malleable regulations and guidance in order not to limit potential innovation and investment. Without this guidance through regulation the industry is bound to fail due to its self-progression and conflicts with future legal precedent.

2.5 The Public

Figure 2.10 Manned Transport Drone (LaRive, 2013)

Under the *Constitution Act, 1982*, section 1, the Canadian Charter of Rights and Freedoms guarantees the rights and freedoms set out to Canadians, subject only to such reasonable limits prescribed by law. Specifically in relation to drone use in Canada, every Canadian citizen has "the right to life, liberty and security of the person and the right not to be deprived thereof except in accordance with the principles of fundamental justice" (Constitution Act, 1982). All free and law abiding citizens have the right to their freedom to use drones for leisure and livelihood in so much as it doesn't interfere with society's peace and order prescribed under the government and courts.

Canadians have the right to an accessible and open discussion surrounding the implications and uses of drones by themselves and others. This represents the role of "good governance" in the public's perception of the drone issue.

The public has already demonstrated a use for drones in their everyday lives in assistance with tasks. Self-photography and videography, prescribed item delivery and transport, and assistance with agricultural operations, are all presently being utilized by the public for their own isolated benefits. A farmer in Ireland has even started herding hundreds of sheep on his farm with his aptly named sheepdog replacement, "Shep the Drone" (Locker, 2015). The general public are bound to adopt the drone into their lives in many ways and the question remains, should they be restricted from doing so?

Chapter 3

3.0 Use of UAVs in Urban Planning

The ability to integrate technology into urban planning practices is generally becoming easier. In some part this is because of the number of options available for new tools, many of which are accessible directly by smart phones. Another important part of this adoption of technology for urban planning is the inspiration that can come from seeing something used in a recreational setting and recognizing its potential to be adapted for professional purposes.

Due to the adaptive and cost effective options of drone technologies today, the use of drones to assist in regional and municipal operations could potentially provide safer, cheaper, and more effective public services. Considering this, the utility and unique information provided by drones, highlighted in section 1.4, holds promise not just for urban planning but for many public agencies.

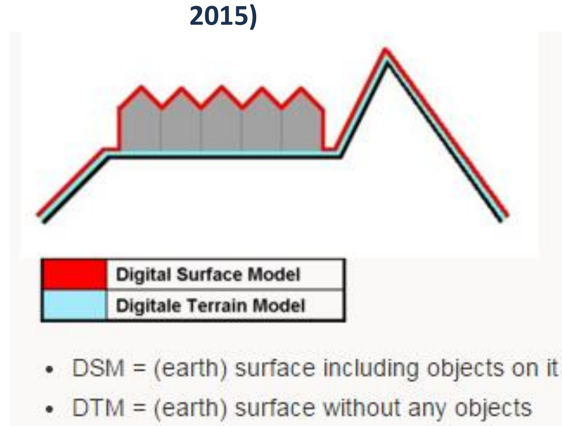
3.1 Practicality

Drones have steadily been declining in price with progressive increases in demand and technological advances. Professional domestic drones typically range in price from $12,000 - $50,000 and are easily to procure with many companies supplying a highly competitive market, while often developing drones to the specific needs of a client. When making an executive decision to utilize a new technology in operations, such as the planning of urban areas, it is important to assess the practicality, specifically the ease of operation for the technology.

In most cases drones can be flown completely autonomously along a pre-arranged operating regimen. However, this operating regimen needs to be programed and launched by a human operator, and often allows for direct in-flight control by this operator. En masse urban planning professionals are not trained on how to set and operate a drone in flight: we are potentially bad fliers. Drone companies have recognised this as a limitation to the professional adoption of their technologies and have been attempting to design more streamlined operation systems. Aeryon Labs Inc., based in Waterloo, Ontario, is one such company that has developed a drone operations interface for law enforcement agencies in Halton Region (Lamcja, 2015).

Figure 3.1 Aeryon Scout Backpack (Aeryon Labs Inc, 2015)

The Aeryon Scout is an easy-to-use drone that can be flown by anyone with only a few minutes of training due to its simple point-and-click navigation and camera control systems, with dynamic flight plans including Follow-Me flight protection and AutoGri mapping pattern modes. The Aeryon Scout can be folded, backpack deployed and airborne in seconds. The Aeryon Scout can be flown for any application that requires survey-grade accuracy orthomosaics, Digital Surface Modeling (DSMs) and point clouds from aerial or oblique imagery - and



seamless integration with Geographic Information Systems (GIS), Commuter-Aided Design (CAD), and traditional photogrammetry software; all standards in urban planning data usage (Aeryon Labs Inc, 2015).

Making all flight operations automatic greatly reduces the chance of pilot error. Halton police first purchased a drone to use in their investigations in 2009, when it was still a relatively new technology in law enforcement. Since then, it has been used in 50 police missions including search for missing persons, probing collisions, and investigation of an armed robbery and homicide (Aeryon Labs Inc, 2015).

Figure 3.2 Drone Goggles (Daily Mail, 2014)

Other companies have also developed automatic takeoff and landing systems, often the hardest part of operating a drone, and first person viewing apparatuses (goggles), which can help the operator see what the drone is "seeing" (ShadowView Foundation, 2015).

3.2 Drones for Good Award

جائزة الإمارات للطائرات بدون طيار لخدمة الإنسان
The UAE Drones For Good Award

The best thinking behind new ways to use technologies to support planning for the public good is often achieved through competition which drives innovation. In 2014, the Prime Minister of the

United Arab Emirates and ruler of Dubai started the worlds largest drone ideas and design competition called the Drones for Good Award to assist with planning related issues. The awards, for $1 million each, are segmented into three award categories of focus: International (global application), National (best use for UAE government services), and Government Entities (for the best government service using drones) (The UAE Drones for Good Award, 2015).

H.E. Mohammad Abdullah Al Gergawi, UAE Minister of Cabinet Affairs spoke to the reason for such an award, stating; "His Highness Sheikh Mohammed believes that technology should be used for the good of people and in the service of the people, and that governments should be the first to adopt the latest technologies. We want to reach to people before they reach us. We want to save time, to shorten distances, to increase effectiveness and to make country and city services easier" (The UAE Drones for Good Award, 2015).

A similar competition could really drive drone innovation towards Canada's urban planning issues. Several competitors had very inspirational ideas, many of which directly relate to the planning and servicing needs Canada's urban centres. Twelve have been selected for urban applicability (The UAE Drones for Good Award, 2014)

1. **Window Cleaning Drone, Marcus Fritzche** - A civil drone which is able to clean windows and surfaces autonomously at high altitudes.
2. **Fog Dissipation Drones**, Mouza Al Shemaili - Drones used to clear airport runways and other areas from fog.
3. **Drones For Power Grid Monitoring**, Geetha Thiagarajan - An aerial inspection Drone of power grid zones and for fault detection

4. **Site Inspector Drone**, Eman Obaid - Drones to monitor and inspect new construction sites.
5. **Fully Automated Paid parking system Drone**, Mohammed Darweesh - Paid Car Parking Drones to monitor car parks in designated areas and report car park violators.
6. **Project AMER, Autonomous Infrastructure Mapping and Evaluation Robot**, Johanna El Housseiny
7. **Coupling of Drones with Public Buses**, Hossein Tofigh Vahed - Integration of Drones with Public Transportation System with creation of a universal platform for use with different city wide government drone services
8. **UAE Falcon**, Feras Nazer - Usage of Drones to allocate accidents based on notification from road users and fly rapidly to assess damages of the accidents and resolve any dispute.
9. **Dronlife**, Tays Ferrer Gomez - A Drone used for organ transportation in emergency cases.
10. **Skynet Delivery Catchment System**, Clinton Burchat – Secure city wide package “mailbox” system integrating drone deliveries with a package catchment system to eliminate landing and tether mishaps.
11. **Drones for Planting 1 Billion Trees a Year**, Lauren Fletcher - The usage of drones to automate industrial scale reforestation.
12. **Waterfly**, Carlo Ratti - A drone designed to scan and probe lakes and rivers for emerging pollutants and threats with a goal to monitor, research and protect municipal water quality.

3.3 Construction Industry Uses with Potential Planning Implications

Drones have a unique set of attributes that set them apart from conventional construction machinery, the most apparent being that they are capable of flight, but aren't limited to working in specific areas and can potentially access spaces that simply aren't otherwise accessible. This could enable them to assemble structures in hard to reach places like between buildings or sites without access to roadways. Additionally, they have the ability to interact and collaborate on structures that cannot be built by single machines (like cranes that are limited to individual designed tasks) and can also move through and around materials during the process. However, it is difficult for drones to imitate existing construction processes due to the tools being so different. In future it is likely that how things are designed and built will be altered to adapt to new methods of architectural material designs.

Automated drones could soon be an everyday presence in the construction industry, with several groups, both private and academic, contributing to that reality. Eidgenössische Technische Hochschule (ETH) Zurich University is one of the world’s leading universities for technology and leading in drone research. Within ETH, the Institute for Dynamic Systems and Control lab, has been focusing on drone flight control systems and their programed stability, maneuverability, semi-independent command interpolation (artificial and collective intelligence), and interactions with their environments.

Researchers at ETH Zurich University are developing a prototype drone which can be 3D printed, detect other drones positions and self-assemble with them to create a larger flying machine (Andrews, 2013). Each independent module exchanges information with the others and uses sensors to determine how much thrust it needs for the array to take off and maintain flight. Researchers suggest that the technology could be used for construction systems or even transportation systems, stating that "The developed algorithms apply to any real system that needs to be scalable and distributed. One specific example could be a scalable mass transportation system, where one only adds so many modules that a certain payload could be lifted" (Andrews, 2013).

Another researcher, Professor Ammar Mirjan, the Chair of Architecture and Digital Fabrication at ETH, is particularly interested in the fabrication of tensile structures such as cable-net structures and three-dimensional suspension structures that could not be built with other fabrications methods They have created drones which can individually or collectively build complex rope bridges. The video demonstration can be accessed here: https://www.youtube.com/watch?v=_T0J5PB2av8&feature=youtu.be. These Weaver Drones can autonomously span a rope between two or more support points, then create and lay surface structures by using already placed ropes as new support points, essentially making a bridge. However, this is not ETH’s only drone construction related contribution.

Figure 3.3 Weaver Drone (ETH, 2014)

In 2012, Swiss architecture firm Gramazio Kohler Architects and roboticist Raffaello D'Andrea of ETH Zurich programed a fleet of drones to lift and stack thousands of polystyrene bricks to assemble a six metre-tall cylindrical tower, in a project called Flight Assembled Architecture (Mirjan, 2013). Their conclusion was that drones can be programmed just like an industrial robotic arm, but their greater freedom of movement means they can theoretically be used to build much taller and more complex structures faster than conventional methods (Mirjan, 2013).

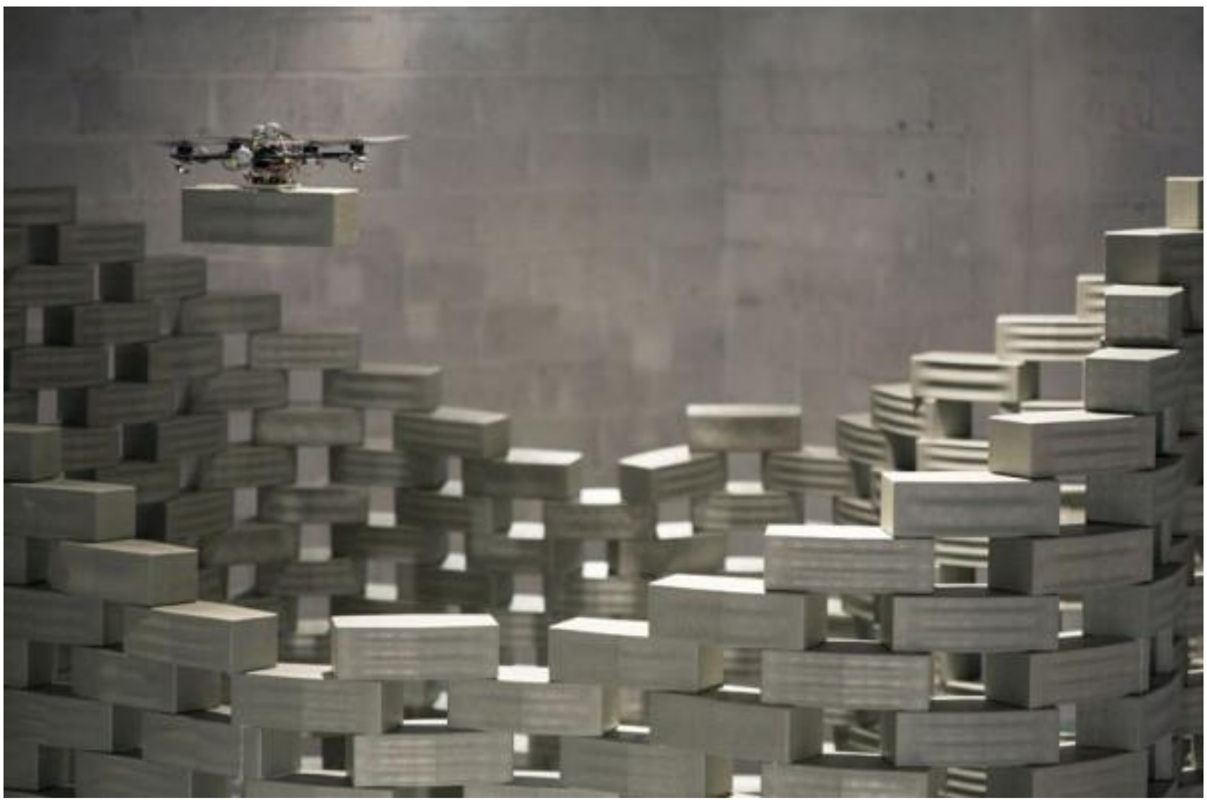


Figure 3.4 Drone Construction Tower (Laugin, 2014)

This finding has direct implications to urban planning as this action could directly affect the proposed development's construction building permit approval, building code, and the associated safety risks accompanying an automated drone building assembly. Theoretically these drones could be assembling basic finishes on buildings in Toronto tomorrow if a developer chose to use them with a Transport Canada permit. Municipalities could utilize these construction drones too, for example, to collect park trail materials (stone, wood chip, gravel) from a storage container and progressively build or resurface a path in an afternoon. The possibilities that drones have to the construction world are just starting, but so are the questions. What are the safely/privacy issues associated with drones in public parks? When can they fly? What should be their role? These are all important questions for Canadian planners and politicians to answer in the near future.

I say “near future” because on February 1st, 2015, a Japanese construction equipment maker Komatsu Ltd., initiated operations using unmanned aircraft, bulldozers and excavators to automate much of the early foundation work on construction sites in Japan (Nicas, 2015). The program, dubbed Smart Construction, is seen as necessary in the wake of a vast shortage of construction workers in that country due to the 2020 Summer Olympics in Tokyo.

Under Komatsu’s plans, Skycatch Inc.’s drones scan job sites from the air and build three-dimensional models of the terrain. Komatsu’s unmanned bulldozers and excavators then use those models to carry out design plans, digging holes and moving earth.

This ambitious plan was formulated and granted through Japan’s National Robot Strategy, unveiled on January 23rd, 2015. The strategy was developed by the “Committee for the Implementation of the Robot Revolution,” which had its first meeting on September 11, 2014. Its membership includes partners representing business and all levels of government. 2015 has officially been declared to be “year one” of moving towards a “robot society” (DeWit, 2015).

3.4 Urban Design Tool

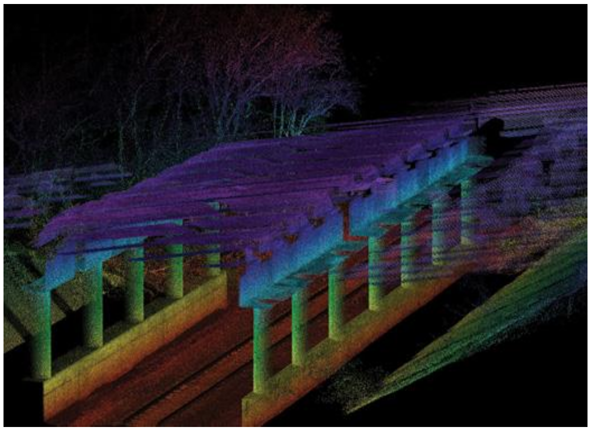


Figure 3.5 LIDAR Scan (Luccio, 2011)

With their ability to fly above properties and other urban spaces, and use in conjunction with cameras and more traditional forms of media for community engagement, drone imagery can help bridge the gap between two-dimensional, temporally-devoid satellite imagery and the more common ground-based conventional camera. Perhaps the most powerful use of the technology will be as a tool for both city and community governments and design and planning firms to aid in the public participation process required for any new development. Drones can provide an accurate sense of what is currently in place and can give timely and nearly instantaneous monitoring of site conditions. A drone can give both qualitative and quantitative observations of a site, the elevation, the diversity of housing types, the voids of underutilized open space, the complexities of traffic patterns, the flow of natural systems, the nodes of community activity, or the shadows cast over a neighborhood at sunset.

Projections of proposed designs or site analysis can then be integrated into the three-dimensional aerial video, adding a new level of spatial and temporal dynamics to the design process. Drones equipped with LiDAR (Light Detection and Ranging) scanners can produce accurate demonstrations of natural and built environments with amazing accuracy for details such as elevation, height, and other special dynamics, while software such as Autodesk's 123D Catch allows drone imagery to be stitched together to create a photo-realistic 3D model.

These techniques will help the public along the path of fully understanding complex problems and thus evoke more comprehensive and timely feedback. As Kevin Lynch stated in his book The Image of the City, this will help to "form the total scene, so that it's easy for the human observer to identify its parts and structure the whole." (Lynch, 1960)

The design of urban areas and public spaces is important for how people enjoy and use our civic space: it affects our quality of life and how groups of people interact. The urban design of a space directly relates to and affects the functionality, and in turn the land value and desirability of a property. Public, private, and planning groups are all interested in any tool which can aid in the process of public consultation and evaluation of a development conforming to municipal by-laws. Drones can potentially aid in these aspects of planning and can reduce the approval timeframe of municipal planning departments.

Canadian Urban planner Robert Vogt has developed a drone program with his planning team inspired by what they were seeing done with drones in the conservation and photography disciplines. The drone allowed them to take low altitude aerial photography for development sites, street corridors, natural areas, and the urban form of the communities that they were working with, giving an urban design perspective and access to sites that is unprecedented (Voigt, 2014). This is only the beginning of drones in urban design for Canada but it has been done elsewhere.

In Mexico City a private company, ConDatos, the Mexican Presidency and the City of Mexico have collaborated on a drone project coordinated through the Laboratorio para la Ciudad to use media and drone technology to revitalize neighborhoods and strengthen communities within

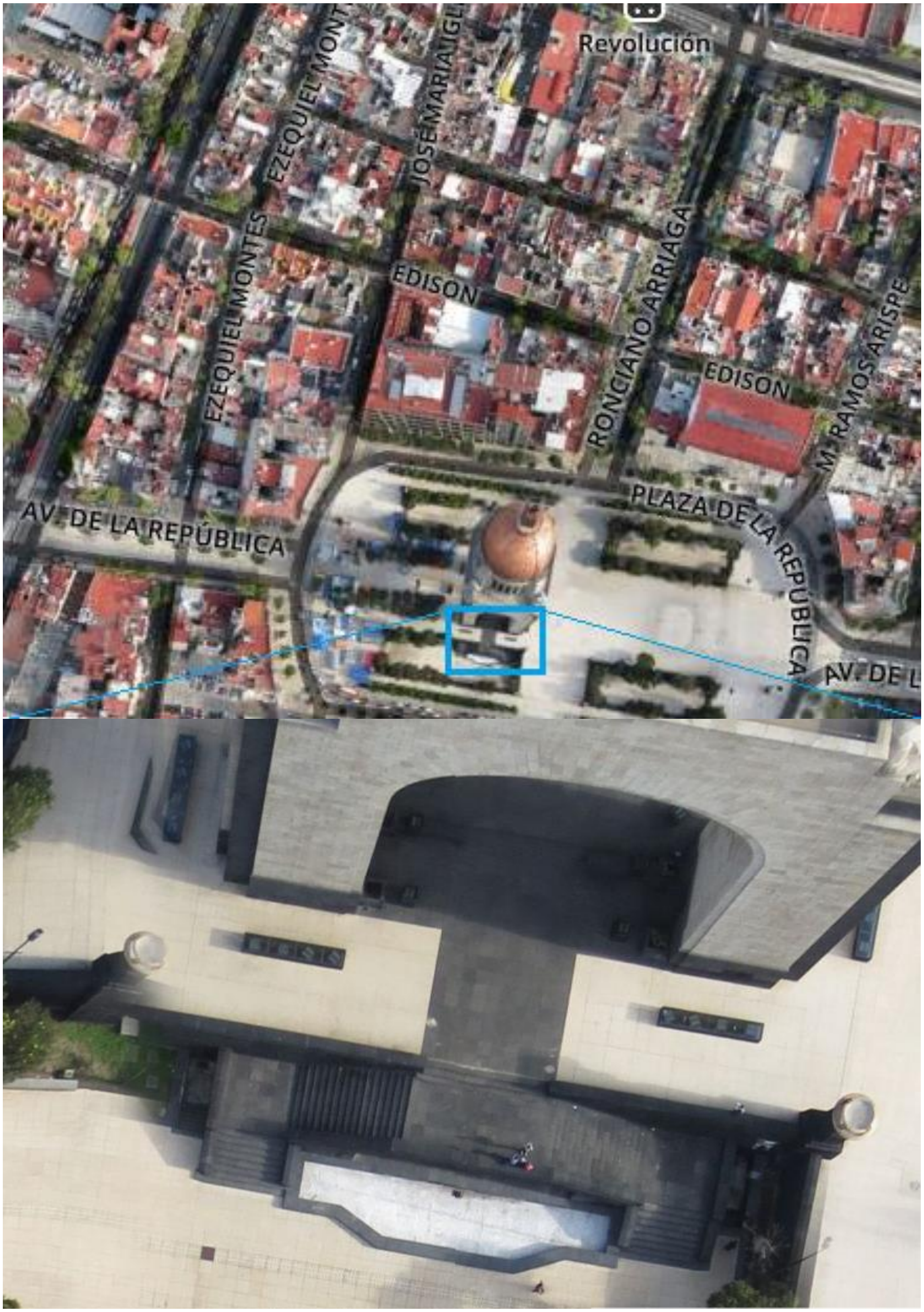


Figure 2.6 Mexico Laboratorio para la Ciudad (Goodman, 2014)

the city (Goodman, 2014). The Laboratorio para la Ciudad, or Laboratory for the City, is organized to facilitate interaction between citizens and government, to think of the city as a whole, creating a bank of ideas and solution; to build a city that supports and stimulates the imagination, a creative city (Espinosa, 2014). The Laboratory creates dialogues and collaborations between government, civil society, private sector and NGOs in order to reinvent, overall, some areas of city planning (Espinosa, 2014). Using a small E-Bee drone, ~$15,000 CAD, they demonstrated how drones can support urban planning and development through providing accurate and open data information for the public. In eight minutes they captured an area of 0.2 square kilometers at a resolution of 4.5 cm (Figure 3.6) (Goodman, 2014). This kind of large scale cheap, accurate and publically available information was unavailable to municipalities even three years ago.

3.5 Remote Sensing and Environmental Monitoring Tool

Figure 3.7 LIDAR Tree Canopy Cover (Imgarcade, 2012)

Urban planning is a highly complex process aiming at a conceptual anticipation of future situations. Thus it needs a balancing of advantages and disadvantages concerning all aspects at play in an urban system. The primary resource consideration when planning for future urban activities is knowledge: knowledge of the inhabitants of the city, the urban ecology and the physical urban environment as well as change over time. Remote sensing tools such as radar, RGB photographic sensors, multispectral, hyperspectral, and thermal imaging, as well as laser scanning tools (such as

LIDAR), have been used as successful and integral environmental monitoring and urban planning resources (Lucieer et al. 2015). However, due to the often high cost of information collection using satellites or fixed winged aircraft, implementation in urban decisions has usually been minimal and non-existent.

With the emergence of drones and their ability to carry remote sensing tools greater and greater distances, the advantages of drone technology are being increasingly recognized. While regulations may still hinder the broader use of drones, technological development, especially in miniaturizing sensors, has encouraged application to remote sensing. Drone capacity for near-continuous acquisition of ultra-high resolution imagery and seamless data has provided great opportunity for information collection about our urban areas. With this the basic question on "what" is "where" within the urban environment can be answered. The data retrieved by drones can be used quickly to provide up-to-date, area-wide and cost effective transformations of data (or images) into translatable information through a mapping of the urban morphology. Depending on available data sets, products vary from urban footprint level to a spatial level where individual objects are identified and often analysed spatially using GIS or Autodesk software (Lucieer et al. 2015).

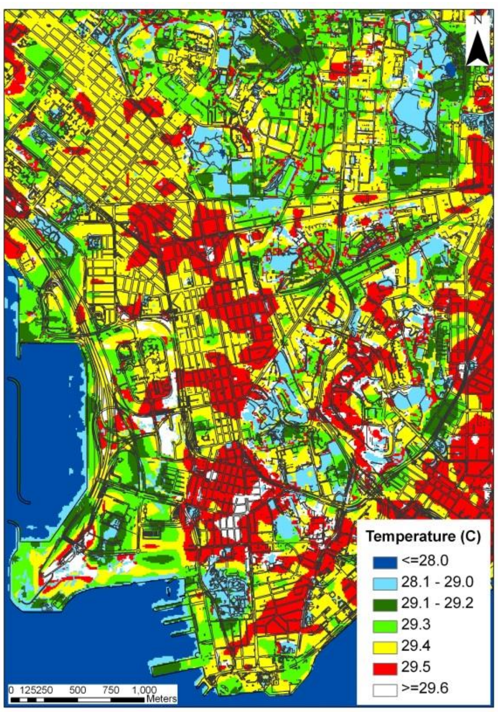
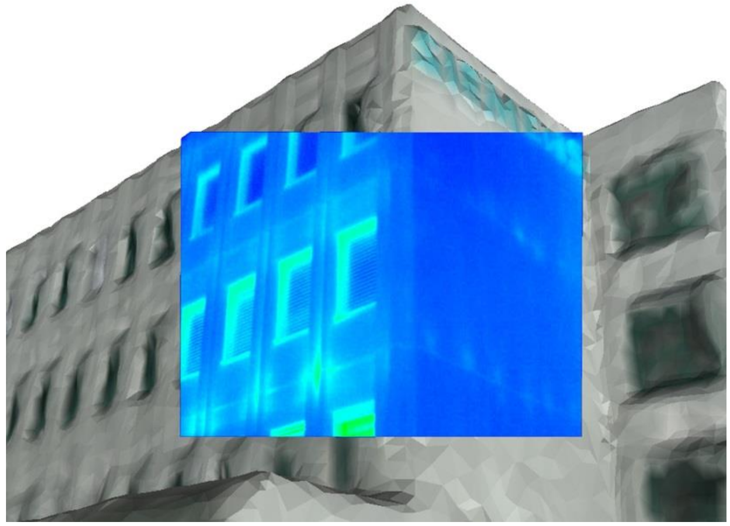


Figure 3.8 Urban Thermal Heat Map (Earthzine, 2015)



In February 2015 urban conglomerate Siemans announced a pilot project whereby aerial remote sensing data collected by drones combines with image processing software to visualize energy losses as thermal maps across urban districts (Siemens, 2013). This information can be helpful to both city planners and companies and private landowners as it provides them with a sense of the efficiency of a building.

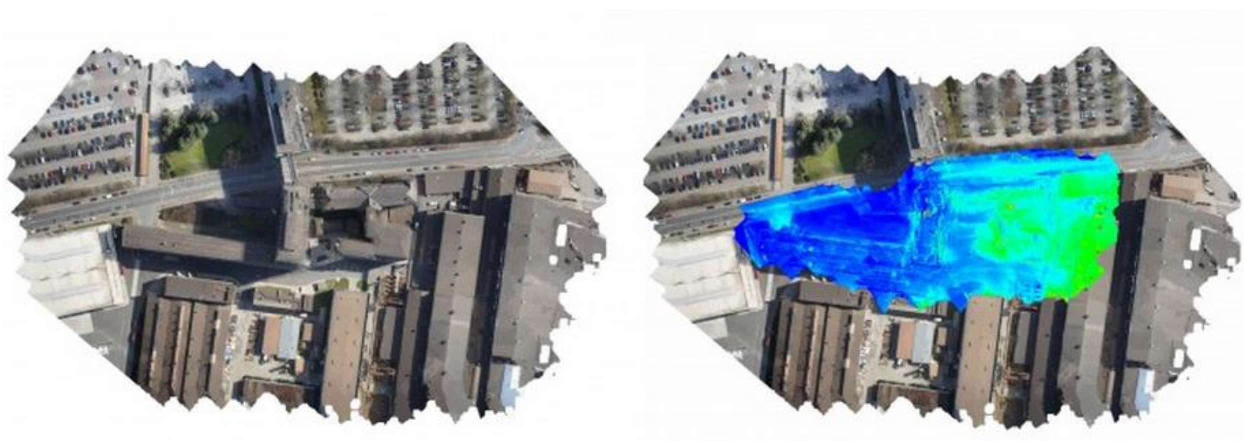


Figure 3.9 Siemans Inspector Drone (Lavars, 2015)

The literature exemplifying drone use in both urban and rural remote sensing applications has been growing over the past five years. The following represent recent examples of drones in action:

- University of Gottingen researchers in Germany, used drones to quantify special gap patterns in forests in order to emphasize the usefulness of drones to record forest gaps of a very small size (Getzin, 2014). They found that very small canopy gaps cannot easily be recorded with conventional aerial or satellite images, which calls for new and cost-effective methodologies of forest monitoring such as drones (Getzin, 2014).

- Similarly, another group of researchers, from the Chinese Academy of Sciences, has used drones for vegetation mapping in the Chaoyang District of Beijing. They used remote sensing to map urban vegetation using a mixture of "Random Forest" and texture analysis to reduce drawbacks of low cost, off the shelf digital drone cameras (Feng, 2014). They found that drones are "the ideal platform" to accurately differentiate land covers of urban vegetated areas, and retrieve data compared with feasibility of traditional methods of data collection (Feng, 2014).
- Researchers at Tufts University have also been using "off the shelf" drones to track and measure the effect of green algae in the rivers of Medford, MA. Their results indicated that optical remote sensing with drones holds promise for completing spatially precise and multi-temporal measurements of algae or submerged aquatic vegetation in shallow rivers (Flynn & Chapra, 2014).

All of these previous examples from the remote sensing scientific literature recommend and support data gathering utilizing drones, data collected on topics equally as significant to Canada's urban areas. For example, the City of Toronto's aquatic river systems, urban tree canopy, and the vegetation associated with land uses are all significant features to a healthy and functional city.

In 2013, Toronto City Council approved the continuation of an ambitious Strategic Forest Management Plan with the strategic goal of increasing Toronto's canopy cover to 40% by 2055

(Toronto Parks Forestry and Recreation, 2012); up from its 17-20% benchmark coverage in 2009 (Parks Forestry and Recreation, 2013). The 40% goal was based on analyses of forest condition in urban areas in different regions of the United States to determine what average cities could support (American Forests, 2009)(Nowak, 2012).

In 2008 Toronto Urban Forestry contracted the USDA (United States Department of Agriculture) Forest Service Northern Research Station to design and implement an urban forestry study for the City of Toronto; which lead to the publication of Every Tree Counts in 2009 (Every Tree Counts, 2013).

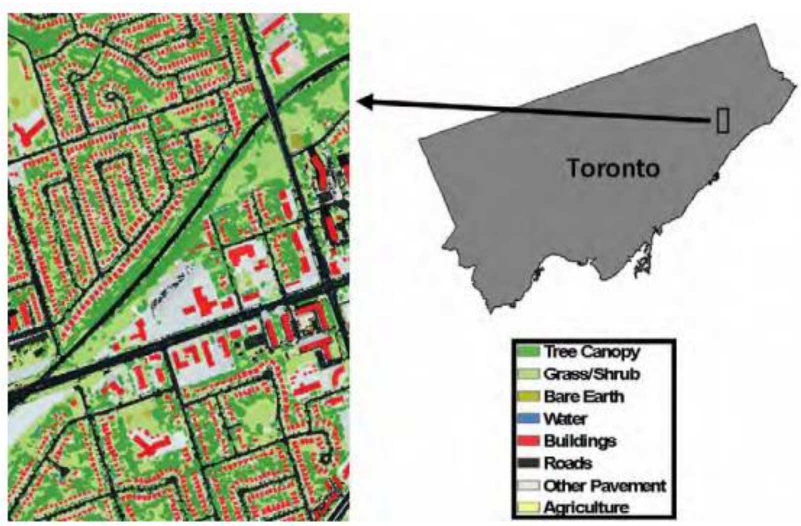


Figure 3.10 Every Tree Counts Monitoring (EveryTree Counts, 2013)

The study used the USDA Forest Service "i-Tree Eco model" (formerly known as Urban Forest Effects or UFORE)(I-Tree Eco, 2015) in conjunction with aerial imagery, city datasets and city street tree data to achieve the primary study objectives. The forestry study quantified the structure and value of Toronto's urban forest and provides baseline data for management decisions. The results were based on the analysis of field data collected from 407 plots in the City of Toronto as well as local weather, energy, land use and air pollution inputs. Land cover change assessment and tree canopy mapping were also important products of the study (Parks Forestry and Recreation, 2013).

Some key findings of the Every Tree Counts remote sensing assessment include: (Parks Forestry and Recreation, 2013)

- 60% of trees in the City are located on private property, 34% are in City parks and natural areas and 6% are in City road allowances.
- Land use affects both quantity and quality of the urban forest
- The urban forest provides the equivalent of more than $60 million dollars in ecological services each year, including benefits from energy savings and emissions reductions, air quality improvements and carbon storage and sequestration
- The structural value of Toronto's urban forest is estimated at $7 billion

The City of Toronto has a strong planning interest in keeping these natural infrastructural services healthy. Currently the i-tree Eco model is revaluated in four year increments to reassess how well Toronto is meeting its goal of 40% canopy cover. These data can be used for making effective resource management decisions, developing policy and setting priorities. The Toronto Strategic Forest Management Plan explicitly states in its "10 Year Vision" and "Strategic Goals .6" section that the City must "improve information management systems and enhance the ability to inventory, monitor and analyze the urban forest" (Nowak, 2012).

Drones are ideal to help with the environmental monitoring for the i-tree Eco model, including: site assessments, air quality and particulate matter monitoring, in a timely fashion with higher frequencies if needed (for example, following the Toronto Ice storm of 2013).

Environmental monitoring within planning districts like the Toronto Region Conservation Authority also occasionally involves wildlife population counts and physical collection of soil and aquatic samples. Drones can easily track and monitor wildlife from a safe distance in the sky using heat tracking cameras. However, physical water sampling and the data it provides is another matter. Recently a drone company, Quest UAV, has been developing an aquatic drone, the Quest UAV Aqua, that can fly to a location, collect a sample, or transmit results, then take off again. Quest UAV stated that they recognized the "significant demand for a marine-recoverable UAV that can operate over the sea and inshore waters," and developed one that will cost a buyer £24,995 (QuestUAV, 2015).

3.6 Benchmarking and Review Tool

All of the drone data- gathering tools and methods highlighted have the standard benefits as outlined in previous sections: safety, cost savings, flexibility, and time savings. However, the unique and accurate data drones provide is perhaps the biggest incentive for adopting the technology. Just like in the remote sensing section, drone collected data can be invaluable in establishing planning policy benchmarks reliably and affordably, while reviewing parameter data in a timely fashion.

For example, drones can greatly assist all Canadian municipalities in utilizing sustainability plans to receive Federal Gas Tax Funds. Since 2005, Canadian municipalities have been receiving Federal Gas Tax funding (FGT) to encourage municipalities to invest in sustainable infrastructure (Association of Municipalities of Ontario, 2008). In Ontario municipalities are required to prepare Integrated Community Sustainability Plans (ICSPs) in order to receive FGT funds. When it came time to renegotiate the FGT Agreement in 2010, municipalities had to be in a strong position to demonstrate they had made progress towards greater sustainability by strengthening Official Plans, enacting Environmental Management Plans, creating ICSPs and showing substantive, quantitative gains over established "real" benchmarks, or risk losing an important capital income asset.

The established utility of drones in data collection can only foster the establishment of "real", measurable sustainability benchmarks and ICSPs. Progress on sustainability goals set in the ICSPs can be frequently and reliably tracked and, if need be, adjusted and re-assessed to meet and exceed urban planning goals. Provinces or the Federal Government could require drones to be used, in order to receive FGT funds. If this were to happen, the prescribing government could provide specific drone varieties, and information guidebooks on how drones can be used to meet planning objectives. The Federal or Provincial Governments could then designate "hard" sustainability targets in ICSP's in order to provide incentive for action. This is all possible using drones as a catalyst for change.

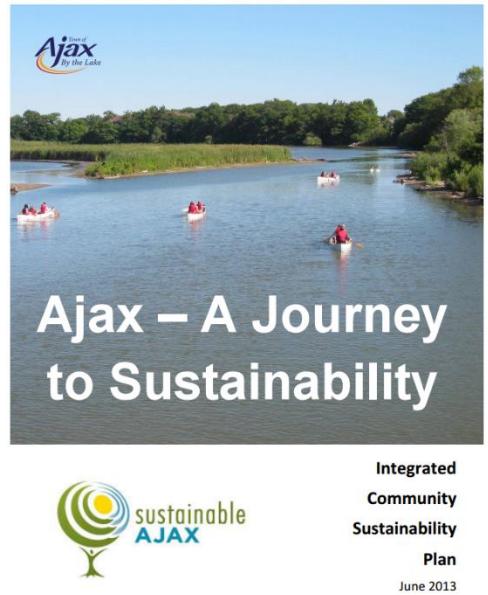


Figure 3.11 Town of Ajax ICSP (Town of Ajax, 2013)

Chapter 4

4.0 The Government's Role to Streamline Regulations and Guidelines

Governments have an important role in the future of drones. Legislators are integral in prescribing what is appropriate for Canadians and Canadian industries to ensure the country is livable and prosperous for current and future generations. Canadian Governments should be proactive in implementing streamlined, but adaptable, regulations and guidelines to foster the fledgling drone industry, before unbridled use and negative externalities cause unintended harsh limitations to the industry.

Since 2007 the Federal Aviation Administration (FAA), a federal branch of the U.S. government, banned use of all commercial drones in the country while limiting potential public use within current Model Aircraft guidelines (FAA, 2014). A commercial flight requires a certified aircraft, a licensed pilot and operating approval. To date (over 8 years) only one drone operation has met these strict criteria and was for a project in the Arctic (FAA, 2014).

U.S. President Obama has recently stated on the issue, that drones "may play a transformative role in fields as diverse as urban infrastructure management, farming, public safety…and disaster response." However, the President' would like to see drone specific policy directives take into account "not only our economic competitiveness and public safety, but also the privacy, civil rights, and civil liberties concerns these systems may raise." (McNeal, 2015a)

While the U.S. has the most complex air system in the world, and implementing changes takes time, new regulations are not coming fast enough. The opportunity lost in regard to drone industry innovation has been considerable, stagnating both private and educational interests (as educational institutions are considered to be exchanging a commercial service).

One example of the effect this has had on innovation comes from Massachusetts. An Associate Professor of engineering at Smith College has stated that, “Aircraft are being defined so broadly that it leaves no space for innovation. If you go to Walmart and buy a 15-inch remote-controlled helicopter and use it for fun, it’s a toy, but if you use it for education or research from 4 feet off the grass, it’s an unmanned aircraft system under federal law.” Voss has organised a protest letter signed by nearly 30 researchers, including professors from Boston University and Harvard (Meyers, 2014).

Currently in Canada drone restrictions have not been implemented to the same extent as in the U.S., but proper guidance towards a drone-enabled society is still lacking. Additionally, Canadian governmental roles in regards to drone use are not well defined with respect to the federal, provincial, and municipal governments.

The Canadian Federal Government is mandated to plan for concerns regarding Canada’s privacy, skies, and aviation transportation under section 91 of *Constitution Act, 1867*. However, due to their accessibility and their general integration into everyday persons’ livelihoods, drones fall under a grey area of policy. Drones can be considered the property of a person and thus can be ruled on in provincial courts. They can unintentionally affect aspects of the environment and can be considered part of a person’s health and welfare (tied to dependencies for accessibility, livelihood), all of these being constitutional responsibilities of the Provinces under section 92 of the *Constitution Act, 1867*. Additionally, provinces across Canada have delegated land use planning responsibilities to municipalities: in Ontario this is though the *Planning Act, 1990*. While land use planning responsibilities do not specifically relate to drone aviation, ownership and use, they do present complications towards municipal zoning practices.

Municipalities are mandated to create Official Plans which set out a municipality's general policies for future land use. Zoning by-laws prescribed under section 34 of the *Planning Act*, puts the plan into effect and provides for its day-to-day administration. Zoning by-laws restrict the use of the land by delegating specific types of land use as well as limiting appropriate height of a structure on a property. This is where drones present a conflict. With a future implementation of proper regulations, guidelines and enforcement for drones in urban areas, municipalities and planners will need to negotiate and prescribe appropriate land uses and building heights based on appropriate drone flight paths. This urban planning needs to be proscribed ahead of time in order to provide a long term future vision of urban design systems in a city.

The federal government could delegate a specific drone “aviation rights” regulation authority permission to municipal governments. Similar to the *Ontario Planning Act 1990*, municipal governments would be able to delegate drone specific aerial zoning rights to the airspace above municipalities with ‘respect to’ current zoning height restrictions embedded within land use zoning classifications. However, as municipalities are “creatures of the province”, in the ideal world, this federal delegation of regulating authority would have to be in collaboration with the Provinces to make a tri-level governmental planning partnership. Tri-level governmental planning partnerships have been effective at approaching complex planning delegation in the past.

Community based management could also be an option to start a discussion on drone use in local communities, where an individual could be challenged for their irresponsible behaviour by any other individual in the community. The enforcement of any regulations, which may come from provincial legislation, around aerial zoning, may require local management to ensure compliance in local communities.

The *Municipal Government Act* of Nova Scotia already provides a model to enable municipalities to assume the primary responsibility for land use planning. Part VIII Planning and Development, outlines a highly participatory process at the community level whereby residents determine for themselves land use by-laws and zoning in relation to environmental, social and economic considerations. While the province could legislate a municipal aerial zoning system, local municipal community based planning could define the limitations which would best protect those common rights. Community members would also then be more inclined to take responsibility for enforcing responsible use (Fawson, 2004).

An example of a proposed municipal aerial zoning system will be expanded upon in the following section of this report.

Chapter 5

5.0 Drone Urban Management Systems

With the demonstrated willingness by both private sector and public sectors to invest in and pursue use of drones, what methods can be used to guide and regulate use in urban areas such as Toronto? Urban areas represent the greatest potential for unintended harm to public safety and security due to more concentrated population and variations in built form. Several possibilities and considerations will be suggested to anticipate challenges to adoption of a future complex working urban management system for drones.

5.1 Designated Height Restrictions and Restricted Landing Zones

Certain varieties of drones are self-aware of their surroundings, monitoring for sudden changes in order to avoid collisions. However, the majority of drones are programmed to fly at a certain set of altitudes along a flight path and will be unaware of obstacles. In the City of Toronto, the elevation profile ranges from 74m above sea level (at Lake Ontario) to 211.5m (at Toronto's border with York Region); and structures in Toronto reach heights of 627m above sea level, notably the CN Tower. Numerous river valleys and ravines lace Toronto's landscape with high rise apartment blocks scattered throughout the city. These topographic and built form features present hazards for drone operation that need to be incorporated into every drone's flight plan.

While building height restrictions are a part of many municipal zoning classifications, zoning by-laws should aim to designate maximum possible height restrictions for all properties throughout the city; by-laws which are <u>not</u> easily changed except in special circumstances, for example a municipal secondary plan, the Growth Plan for the Greater Golden Horseshoe 2006, or Toronto's Avenues and Midrise Buildings Study with Toronto's Official Plan. Whenever a designated height restriction is increased, the information and maps pertaining to this increase must be openly accessible so that the public and businesses are aware of the change. While in many municipalities across Canada this is the case, it is even more important to ensure height restrictions are maintained in the age of the drone.

Size restrictions are another important consideration when deciding on the appropriate height and path of travel through a city. The majority of publicly-available drones are heavy enough to severely harm a bystander in case of a collision or loss of power or control. Size and weight restrictions for public hobby drones may be a central restriction in any new drone traffic system.

Online shopping company Amazon has expressed a willingness to limit its drone package sizes to 5lbs in order to reduce safety concerns and facilitate adoption of urban drone regulations (Brackett, 2014).

5.2 Designated Travel above Roadways and Public Spaces

Obvious comparisons can be made between potential drone routing systems and Canada's provincial highway systems, in both development and implementation. By definition road traffic control is the supervision of the movement of people, goods, or vehicles to ensure efficiency and safety.

The process by which the modern road systems we see today came about is a long and complex one starting over 2500 years ago in the Roman Empire. Roads were seen as physical infrastructure vital to the maintenance and development of the Roman state and key to its success through time (Rostovtzeff, 1926). As new forms of transport became available, the "road" changed and adapted to accommodate this transport, yet the intention stayed the same. The road is a linear connection to get from one place to another.

As automobiles were introduced and increased the speed of travel, roads became more dangerous and congestion increased on thoroughfares. People who could afford cars started drinking and driving, driving off the road, driving into trees, causing all sorts of chaos. When the Ford Model-T was introduced, these dangers escalated as more people could purchase an automobile. But clearly there many more benefits to travel by automobile than sticking to the old system. So instead of banning cars altogether, governments were reasonable in trying to develop traffic laws and infrastructure to support those traffic laws.

A road system, including traffic control, was needed to encourage the success of the automobile in urban areas. For example, the world's first traffic lights were installed near London's House of Commons in 1868 (Bellis, 2014). Since then speed limits have been imposed, coloured automatic traffic light systems invented, lane widths established, road sign and painting conventions adopted. The Province of Ontario's *Highway Traffic Act 1990* was first introduced in 1923 to deal with increasing accidents during the early years of the automobile. The *Act*, which regulates the licensing of vehicles, classification of traffic offenses, administration of loads, classification of vehicles and other transport related issues is similar to what is needed to help manage drones.

These systems were all implemented to make roads work more effectively but they didn't happen instantaneously. Drones present an unprecedented challenge because technological advances are proceeding so rapidly, along with increasing availability. Regulations and systems need to be developed quickly. Whereas automobiles (in parts of Europe at least) had long-established roads bisecting cities to drive on when they were first introduced, drones lack a similar established partner in the urban realm.

However, in the interim at least, drones could be required to fly above the linear roadway systems in order to reach their destination. A future theoretical on-board flight detection system would sense and reduce the likelihood of mid-air collision with other drones. Drones could be required to land at specific landing zones, similar to airports or could go to any specific property. Restricting drones to fly over public lands avoids potential privacy, and property damage concerns arising from collisions or crashes.

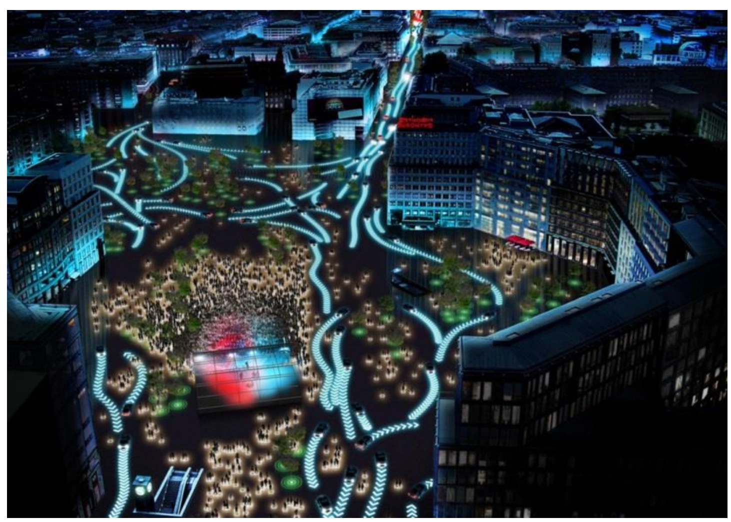


Figure 5.1 Audi Urban Future Award Design (Jordana, 2010)

The 2015 Audi Urban Future Award, a competition award that aims to stimulate new visions for cities and urban mobility, was given to BIG for their vision of a future driverless vehicle traffic system for urban areas (Jordana, 2010). The idea was that driverless cars could be controlled and guided using a “Smart Street” surface infrastructure that eliminates congestion and collisions in urban areas. Predictions by several major car manufactures claim that the first fully driverless car will be presented to the market in 2015 (Jordana, S., 2010). Could a driverless drone system follow a similar design and be developed in coordination with BIG's smart streets idea? It's a discussion worth having.

These are all theoretical drone system examples but the possibilities will be largely dependent upon future technologies, legislation, court decisions or innovative and creative municipalities.

5.3 Aerial Zoning Regulations for Drones

3.3.1 Where to use? When?

Despite federal flight restrictions around airports (discussed in Chapter 7), in July 2014 several planes flying into Toronto's Pearson international Airport had to divert their trajectory due to a civilian drone. Drones have also recently alarmed pilots over Vancouver, coming within 100 ft of a passenger jet, and Halifax where a drone was spotted flying higher than 19,000 feet, just above an Air Canada Jazz plane bound for St. John's (Reddekopp, 2014). Just last year pilots reported 14 incidents of drones appearing in their path, compared to just three in 2013, raising several increasing real concerns about safety and drone restrictions (Reddekopp, 2014).

Building on points made in Chapter 4 regarding potential municipal zoning by-law regulations, real substantive rules and regulations prescribing and restricting aerial uses must be established in some form. Local governments could play a valuable role in the regulation of drone activity. Provinces have long delegated substantial regulatory authority over land use and comparable activities to municipal entities through the *Planning Act, 1990*, and similar statutes. Many municipalities thus regulate a whole host of uses, ranging from the heights of buildings to the raising of backyard chickens, things that impact neighbors but are unlikely to affect those living outside of the municipality.

Spatial zoning bylaws in planning have long been a powerful means of limiting negative externalities and promoting synergies between various uses of a community's land and resources. Like the raising of backyard chickens, operating drones is not inherently disruptive but can be very disruptive at certain locations or times. Drone zoning ordinances could provide a public framework for these locations and time differences.

Urban designer Mitchell Sipus with Carnegie Mellon University has proposed one such framework for Chicago's waterfront (Figure 0.1, 5.2). His system would let cities plot out volumes of space where drones are okay to fly, places where there are restrictions, and places where they're forbidden without special approval (Sipus, 2014). For his concept, he used the familiar colors of traffic lights: green areas for free-use, yellow and orange maintain various restrictions according to the time of day and day of week, while red areas are restricted at all times (Sipus, 2014).

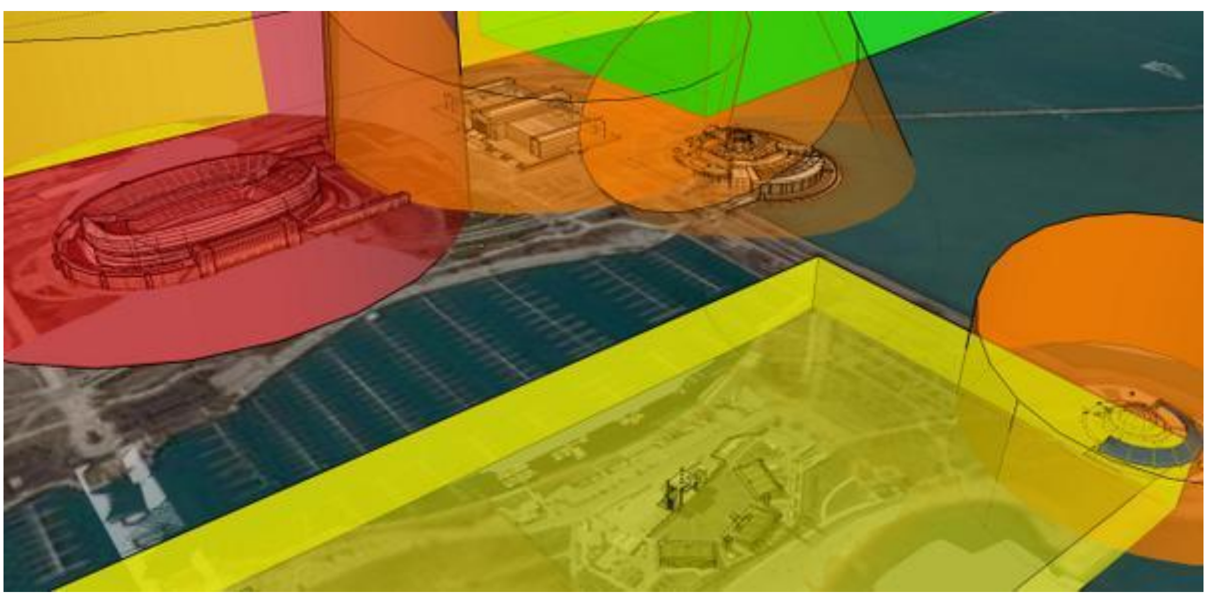


Figure 5.2 Chicago Done Zoning (Sipus, 2014)

Allowing widespread use of drones in dense urban areas, in the “green zones” could prove highly valuable as a means of delivering items over the top of traffic congested roads, for example. In such green spaces the expectation is to reduce the likelihood of losing the drone or disrupting others in the event of an accident. Additionally, the privacy invasion costs the drones might impose on landowners in these places might be acceptable so long as there were rules requiring delivery drones to constantly continue moving until they reached their destination so they didn't hover outside high-rise windows.

Restricting drone use in certain areas, in the yellow zones, at certain times of day or year is due to concerns regarding large public gatherings, sightlines for sports games whose viewing rights are often owned by sports clubs or agencies, or due to environmental concerns such as weather.

Fully restricted zones, the red zones, relate to areas for which drones may severely harm or impact sensitive buildings, areas near airports, or areas where local residence or BIA’s (for example) have decided drones should not be above their backyard “NAMBYs” (Astor, 1998).

5.3.2 Mega-Regions and Provincial Zoning for a Prosperous Integrated Region

Professor Richard Florida of the Rotman School of Management at the University of Toronto has theorized an interesting idea that applies in many ways to the drone zoning discussion. Florida has published several papers and books, The Rise of the Mega Region in 2007, and The Great Reset in 2010, on the idea of the “Mega-Region” and its emphasis on regional economies. According to Florida the Mega-Region is a “polycentric agglomeration of cites and their lowerdensity hinterlands" (Florida et al. 2007). It represents a new, natural economic unit that emerges as metropolitan regions not only grow upward and become denser but grow outward and into one another, sharing specializations and workforces for the benefit of all in the region (Florida et al. 2007).

In his book The Great Reset, Florida surmises that we are entering the third "Great Reset" of the past century, emerging from a great recession where the structure, and functions of our current cities undergo great innovative changes to adapt to a new economic reality and to stay competitive (Florida, 2010). These new innovations are tied to new technologies and forged together into bigger and better systems. This coincides with public and private collaborations on: energy, transportation, and communication infrastructure, to give the broad skeleton of a new economic landscape; an economic landscape with potential to look to the global economy for trade and further innovation. These create a new spatial fix that is more closely in sync with the improved productive capacities of the underlying regional economy (Florida, 2010).

In many ways Toronto has had experience with a form of mega-region (Metro-Toronto, 1954) and is progressing towards a new economic region under the provincial Big Move, Growth Plan for the Greater Golden Horseshoe and *Greenbelt Act 2005*. While not the "Tor-Buf-Chester" Mega-Region Florida proposed as the

Figure 5.3 Tor-Buf-Chester Mega Region (Florida et al. 2007

greatest potential; the Greater Toronto and Hamilton Areas seem to be developing regional, transportation, economic, and demographic policies which emphasise the region through connecting its parts.

Drones are a technology which has the potential to greatly increase the region's prosperity by facilitating travel, trade, and connectivity by reducing economic congestion, improving the flow of goods and services. In some ways municipal aerial zoning by-laws do not go far enough in facilitating this regional potential due to political boundaries. A multiregional streamlined aerial zoning by-law system is essential to facilitating streamlined trade and travel between regions. This would most likely be organised through the provincial governments as they have a regional economic planning interest and can most easily facilitate this collaboration. While current battery performance still limits the distance smaller drones can travel, they are getting smaller and more efficient every year.

Chapter 6

6.0 How to Use a Drone: Systems and Regulations to Addressing Safety and Privacy

Drones have the ability to gather unique and specialized data of our surroundings, and transport items in new and unique ways. However, drones also have unique and unprecedented safety and privacy concerns that have already evoked heated debates and have the potential to obstruct future progress in utilizing drone innovations. This section will try to identify the potential safety and privacy concerns associated with widespread use of drones in urban areas.

6.1 Drone Safety Hazards in an Urban Setting

6.1.1 Collision Hazards

As was mentioned previously, the majority of drones are presently unable to detect their surroundings and are preprogramed to a specific set of flight coordinates before take-off. This can cause issues during flight if the pre-flight operator was unaware of potential trees or buildings in the designated flight path.

Figure 6.1 Downed Drone (Senese, 2015)

One of the award-winning recipients of the 2015 United Arab Emirates (UAE) “Drones For Good” award has gone to Patrick Thevoz for developing a drone which has the unique ability of being able to collide on obstacles without losing its stability and of being safe to fly in contact with humans (Thevoz, 2014). This is thanks to its geodesic design, and could act as a safe design for drones in urban areas.

Researchers at ETH Zurich University have developed a safeguard against drone collisions that might result from a propeller failure (ETH Zurich, 2013). They have developed a control algorithm that allows copter drones to continue to fly with a failed propeller by initiating a full drone concentric spin motion to cause the drone act like a propeller, spinning safely to the ground. However, spinning copter drones may still collide with other drones in flight.

Occasionally drones may collide in mid-air with other drones or even larger aircraft. A civilian drone has not collided with an aircraft yet but it is almost certain to happen. The closest “near miss” for a drone and airplane took place in December 2014 when a civilian drone came within 20 feet of an Airbus A320’s engine coming in for landing at Heathrow airport, UK (Pollock, 2014). What made this even more troubling was that drones of that size cannot be picked up on radar, leading to the reality that both aircraft pilots and others are flying blind. There is presently no national or international requirement for drones to be in contact with any aircraft control tower.

On January 26th, 2015 a small civilian drone crashed onto the Whitehouse lawn after its operator lost sight of, and control of their drone (Figure 6.1)(Senese, 2015). What is to stop a nefarious individual from arming a drone with an explosive and flying it into a sensitive building like the Whitehouse or 24 Sussex Dr. in the future? Unfortunately there is currently no answer to this potential issue in Canada.

However, one such solution for both airports and sensitive restricted zoned airspace is to shoot them down. The government of China has developed a highly accurate laser weapon system that can shoot down small drones within five seconds of locating the target and to a distance of 1.2 miles. The Chinese cite the system as “playing a key role in ensuring security in urban areas”, for that country (Presse, 2014).

6.1.2 Environmental Hazards

Drones are creatures of the atmosphere. They fly amongst the birds and may even harm some, but this is a very rare occurrence as birds can easily maneuver around most drones. But like the birds, drones have to be able to handle variable wind speeds and inclement weather on a regular basis, which is especially an issue for copter drones. Urban aerial zoning by-laws can aim to restrict operation of drones at certain wind speeds for varying classes of drones.

6.1.3 Transmission and Interference Hazards

As drones are often transmitting location stabilizing information to satellites with Global Positioning System (GPS) technologies, and to operators using RC wave transmissions, surrounding transmission hazards become a serious concern when operating a drone. Wi-fi transmitters, radio and cell phone transmission towers, microwaves, among other common signal interfering technologies can all effect a drones flight through urban areas, which often have the highest concentration of interference. The Canadian Radio Spectrum Allocation chart, seen below, is a very complex allocation system for permitted signalling frequencies and devices across Canada. Unfortunately the majority of civilian drones operate at a very narrow range on the spectrum. (Industry Canada, 2015b)

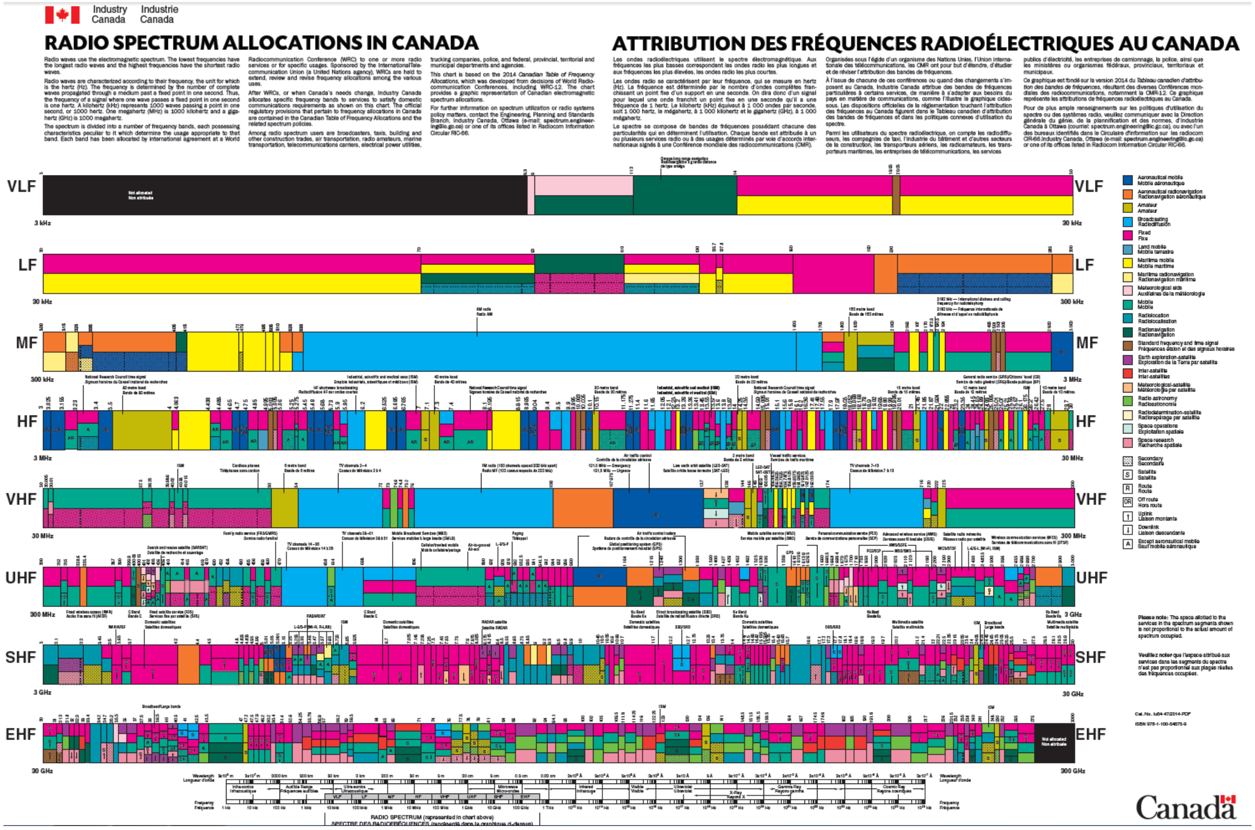


Figure 6.2 Canadian Radio Spectrum Allocation Chart (Industry Canada, 2015)

A drone's operator is usually transmitting on and around 2.4Ghz, and 5Ghz which is the same frequency used by other common public signal technologies and can cause a loss of aircraft control. If the drone were to land on, and damage, a house due to a loss of connection with the drone who would be at fault? This is still an unanswered question in the courts, but part of the blame could fall on the government for not instituting an easy-to-understand municipal aerial zoning by-law system to avoid these concerns. Municipal planners know where a fair number of the signal generating infrastructure is within the urban area and should help advise the public, for the safety of the public.

6.1.3(A) Intentional Hazards

Figure 6.3 GPS Signal Jammer (JammerFromChina, 2015)

This identified conflict between common drone transmissions and that of others in a localized area can potentially lead to nefarious intentions. Individuals unhappy with drones, or just out to cause trouble could purchase a strong transmission system around their house to block any signals which drone might use flying through the area. This is the type of issue several areas in the U.S. have been recently having, causing the Federal Communications Commission (FCC) to step in. In 2014, the FCC issued its largest fine ever - $34.9 million against a Chinese company that makes and sells signal jammers. The company even sells a 100 watt GPS jammer, capable of disrupting global positioning signals more than a half mile away (Schroyer, 2014).

6.1.4 Safety Benefits

Drones also have the potential to greatly improve the safety of many aspects of urban land use within urban areas. In the future, the construction industry will realize aggregate benefits such as a much better safety record and fewer projects that are off budget. Drones also have the side benefit of allowing construction companies to save on expensive safety equipment.

The application of drones can also increase the rate and ability for an exhaustive review of a buildings structural condition, for building inspections. An Australian firm, Soto Consulting Engineers, is using drones to monitor heavy industry and mining sites, scoping out large concrete structures, boilers and skyline conveyers to identify hard-to-spot structural problems such as corrosion (Lavars, 2015).

This will not be expanded on but it is important to highlight the fact that drones have also been used around the world by police, search and rescue, hospitals, disaster relief teams, and fire departments to increase the safety of urban areas.

6.2 Privacy Concerns

Perhaps the biggest obstacle to the adoption of drones lies in the public's perception of privacy surrounding drones. Drones can be a tool which provides a sometimes unintended perspective on people and their private spaces that was not available previously. The built form of many homes were not designed with privacy barriers to the sky. People then feel defenceless against the capture of their personal moments on video, which can then be distributed to the world through the internet. The rise in appearance of the drone has been so sudden and pervasive that the reaction in some circles has been one of fear--fear over what is allowed and what the they could do about it if there were a problem.

Some parallels can be made between the privacy concerns over the drone and the Kodak Brownie camera in 1888. When the Brownie snapshot camera was released it became popular very quickly. Many in the public thought there should be a ban on Brownies in public as there candid moments could be captured for others to see (Lindsay, 2000). However, people soon fell in love with exactly what they had feared initially. The Brownie's candid photos captured a fun aspect of everyday life and people eventually ignored and accepted its everyday presence. Drones have given people a view of themselves and others that they are unaccustomed to and many fear the broader implications. Who's taking the drone video/photo and do they own this information, the capture of a person's personal space?

Today, with many police forces in major cities in Canada now using drones, concerns have been growing over privacy and surveillance. The Halton Regional Police, who use drones for a variety of reasons, say they are very cautious about the use of its drone given those concerns. "We don't just sort of fly over homes at random. Well, we can, and we don't" (Lamcja, 2015).

There also exists government surveillance drones (in the U.S.), ARGUS-IS with Solar Eagle, which can monitor half the size of New York City, and everybody in it, in real time, for up to 5 years (Szoldra, 2013). With Canada's recently proposed Bill C-51 and the broad "tools" given to

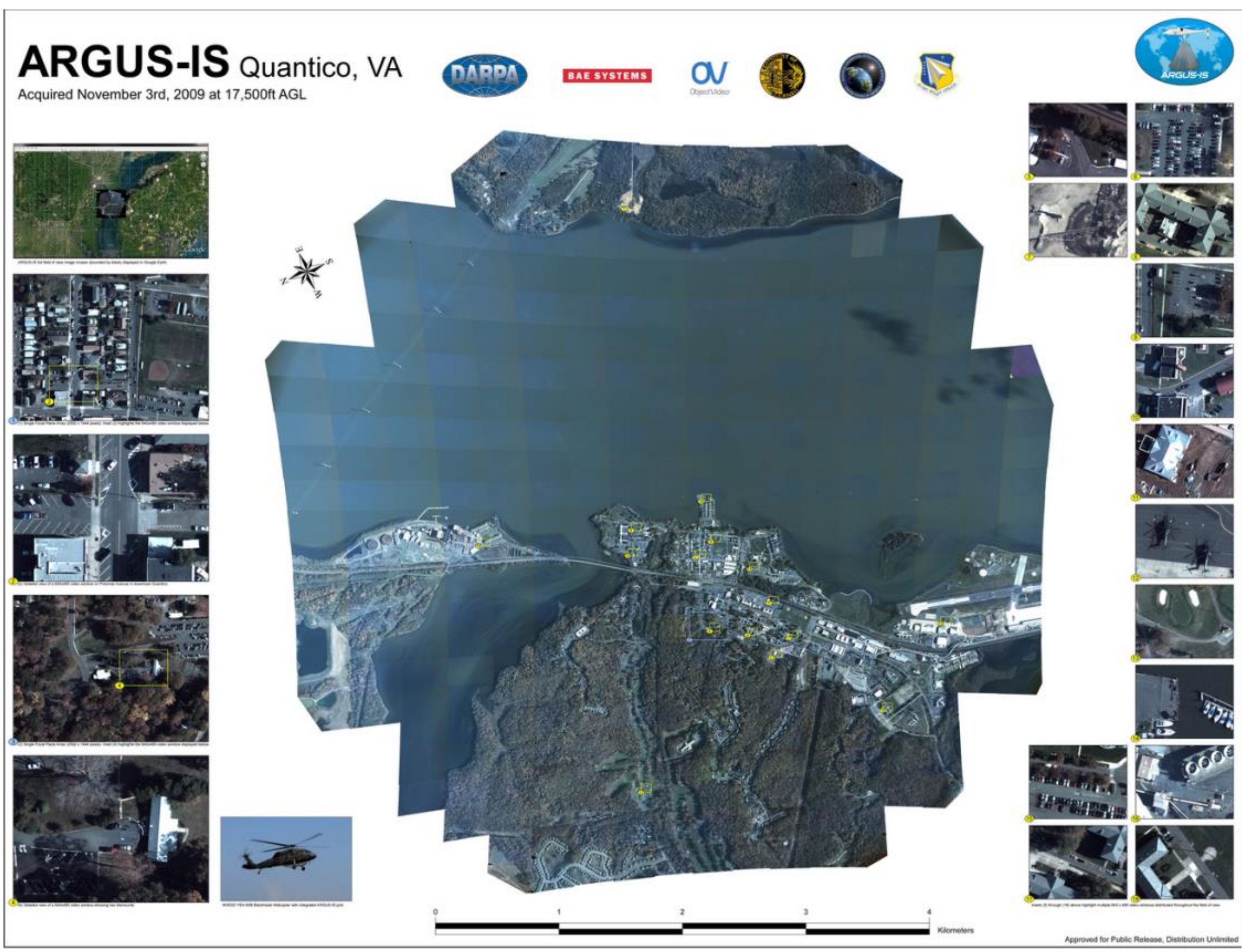


Figure 6.4 ARGUS-IS Surveillance Drone (Szoldra, 2013)

Canada's Security Intelligence Service (CSIS), to combat terrorism by sidelining Canadian's Charter Rights and Freedoms, the public has some legitimate privacy concerns with the potential for government surveillance on Canadians (Kempa, 2015).

The Federal government of Canada is obligated to address public privacy concerns regarding both government and private use of personal information. The Office of the Privacy Commissioner of Canada (OPC) is mandated with overseeing compliance with both the *Privacy Act, 1985*, which addresses personal information held by the Canadian government; and the *Personal Information Protection and Electronic Documents Act, 2000* (PIPEDA), which addresses personal information held by the private sector.

In 2013 the OPC released a drone privacy report, entitled "Drones in Canada" to clarify the governments' current position on drones and privacy. The specific regulations will be covered in Chapter 7. However, concluding findings will be summarized. Drones present unique privacy challenges due to their unique abilities and flexibility in the way in which they may collect personal information, ranging from acute and persistent tracking of individual activities to systematic surveillance of a wide area. There is a strong argument that drones may be a surveillance game changer in three general areas: their attributes, payload technologies, and the manner in which they collect personal information (Office of the Privacy Commissioner, 2013). Drones are affordable and change existing practical limits on aerial monitoring due to their ability for pervasive surveillance.

The Canadian government and law enforcement agencies claim that the types of information they are collecting on Canadians have not changed, despite the quality of information increasing. However, drones represent a manifestation of how other spheres of privacy, such as spatial and physical privacy, continue to be challenged (Office of the Privacy Commissioner, 2013). In other words, the recording of an individual's movements in public space is allowed on cell phones with the expectation that under daily routines this information will not be recorded for later use. However, there is no direct government oversight to ensure this information is deleted. Location information can be collected and linked together in such a way that it is possible to create an increasingly holistic picture of an individual's activities, behaviours, and patterns of movement (Office of the Privacy Commissioner, 2013). Drones could potentially be a key source in this trend to collect location information.

It will only be a matter of time before the courts will have to consider the constitutional balance to be struck. Assessments about the "reasonableness" of drone surveillance, including reasonable expectations of privacy in public spaces, will be at the centre of the debate. The CPC's report goes on to state that the "reasonableness" of drone surveillance will likely be informed by three factors: 1) location of the search, 2) the sophistication of the technology used, and 3) society's conception of privacy in an age of rapid technological advancement (Office of the Privacy Commissioner, 2013). "Reasonableness" of government drone surveillance is currently generally interpreted to be when an individual is traveling in a public space or near a political border. Canada's privacy laws will, and do apply to drones deployed by public or private sector organizations to collect and/or use personal information about citizens (Office of the Privacy Commissioner, 2013).

6.3 Potential Safety and Privacy Regulative Precautions

Safety and privacy concerns need to be addressed before drones in urban areas can be fully realized and accepted by the public. A collaborative approach to this discussion with government, business and the public working towards this outcome is ideal.

The United Kingdom is currently attempting to implement a similar arrangement. A consortium of defence companies has been given £31 million to try and incorporate drones into British skies (ASTRAEA, 2015). The ASTRAEA (Autonomous Systems Technology Related Airborne Evaluation & Assessment) programme aims to enable the routine operation of drones in civil airspace for commercial purposes (ASTRAEA, 2015). A fundamental requirement of the programme is to ensure that UAS can be integrated into the existing manned aviation environment in an equivalent, safe and transparent fashion. Issues of legality, security and safety, will have to be addressed before drones will fly.

6.3.1 Collision Detecting Systems

Figure 6.5 Drone Collision Avoidance System (Aerialtronics, 2015)

Regulations requiring that all drones above urban areas have on-board aircraft collision avoidance systems, are needed to improve the safety of a drone traffic management system in the skies.

A masters student at Brigham Young University has proposed a “Sense and Avoid System” for drones using complex algorithms. The algorithms use a “Tree Branching Path Plan” to provide the aircraft with multiple possible evasive trajectories dependent on the movement of the other drone craft though time and space (Klaus, 2013). This is an on board detection system and would require regulations stipulating that every drone must be manufactured with a sensor system.

6.3.2 Drone Licensing

Requiring drone registration and licensing for drones which can operate out of field of vision is necessary. The Canadian Centre for Unmanned Vehicle Systems (CCUVS) is an example of a Canadian drone licensing agency. Drone licences are currently not required but clients usually come to be educated

The Canadian Centre for Unmanned Vehicle Systems (CCUVS) promotes the formation of drone systems growth through their ground school which increases awareness of and safety within the drone business sector (Unmanned Vehicle University, 2015). The drone training course is available across Canada and is practical for both civil and commercial operators. This course prepares its students with the information they need to safely fly and operate a drone in Canadian air space. This is the top UAS course in Canada having trained over 500 students through 2014 (Unmanned Vehicle University, 2015).

CCUVS also offers specialized assistance with writing and submitting Special Flight Operating Certificates (SFOCs) to Transport Canada for new clients and operators of small UAS.

6.3.3 Active Monitoring of UAVs to Enforce Restrictions in Urban Spaces

If municipal governments were to establish aerial zoning by-laws, drones could then be required and programmed to respond to sensors spread throughout the urban area, similar to telecommunication towers (would be a new form of necessary infrastructure). These towers would either grant them full access to select areas, or alternatively automatically redirect their paths when approaching restricted areas. This digital infrastructure mapped over three-dimensional airspace would be completely invisible but play a crucial role in the deployment of infrastructure such as “highways” for delivery drones and more open recreational spaces for civilian drones.

6.3.4 Privacy Regulations

6.3.4(A) Special Phone Call Line for Perceived Violation of Privacy and Personal Property

In situations where a person’s property has been damaged, their privacy invaded, or if they have been injured due to a drone, there should be a municipal or regional phone line to address public concerns in the drone issue.

6.3.4 (B) Privacy Speed Limits

Amazon, the online company who has invested in its Prime Air, 30 min drone service guaranty, has proposed potential minimum speed limits on drones in certain highly populated residential areas in order to encourage supportive regulation on drones (Brackett, 2014). The idea behind a minimum speed is that drones would travel too fast to cause privacy concerns and suspicions as they pass residential windows.

Chapter 7

7.0 Current Regulations and Legislations

This Chapter will provide a brief overview of the current regulations and legislation surrounding drones in Canada. It is important to recognize that current regulations are in a state of flux and are likely to be changed as drone technology and utility progresses month to month, and day to day.

Perhaps it is best to start this Chapter with the most recent sign of progressive optimism in Canada regarding drones, at Toronto municipal government. On March 31st, 2015, Toronto City Council passed a motion to address the governance of drones in Toronto's outdoor spaces by asking city planners to provide a framework and strategy for how to manage Toronto's skies. The staff report will include but is not be restricted to: (City of Toronto, 2015)

1. any current policies that can be leveraged to ensure the safety of Toronto's airspace;
2. any safety concerns or potential liability issues the City could face due to the use of drones on City of Toronto property;
3. investigating the need for possible restrictions on the use of drones and photography above City of Toronto outdoor recreation and park facilities;
4. the potential to permit the use of drones in designated spaces; and
5. restrictions on the types and/or models of drones that can be operated in the City of Toronto.

While this is not required of the City, it demonstrates good governance in facilitating the public discussion at the local level. The report is due back to City Council in September 2015, a month before a federal election.

7.1 Federal Restrictions and Guidelines

7.1.1 Transport Canada

7.1.1(A) Legal Requirements

In Canada, our laws use two terms: (Transport Canada, 2014)

- *"Model aircraft"* describes those usually used by hobbyists for recreational purposes.
- *"Unmanned air vehicle"*, or UAV, generally refers to more complex operations used for commercial purposes.

The aviation laws under the Civil Aviation Branch that govern the use of model aircraft and drone systems operated in Canadian airspace are the: Transport Canada, 2014)

a. *Aeronautics Act; and*
b. *Canadian Aviation Regulations*

Requirements for the operation of a drone fall under the Canadian Aviation Regulations (CARs). The CARs are essentially the "rules of the road" for all operations within Canadian airspace. The intent of the CARs is to reduce risk to airspace users as well as to people and property on the ground.

In addition, it is the responsibility of an operator to comply with all other Canadian laws that might apply such as the: (Transport Canada, 2015)

c. *Canadian Transportation Accident Investigation and Safety Board Act;*
d. *Charter of Rights and Freedoms,*
e. *Criminal Code of Canada;*
f. *Customs Act;*
g. *Environmental Protection Act;*
h. *National Parks Aircraft Access Regulations;*
i. *Personal Information Protection and Electronic Document Act;*
j. *Privacy Act;*
k. *Radiocommunication Act;*
l. *Transportation of Dangerous Goods Act; and*
m. *Trespass Act*

7.1.1(B) Regulative Drone Taxonomy

Transport Canada's regulative taxonomy for drones in Canada is fairly simple and straightforward (Figure 7.1). Any non-commercial drone under 35kg is considered a "model aircraft" under the law, and does not require any permission to operate, with the expectation that the operator will fly safely (Transport Canada, 2015). It is also expected that the operator will not fly close to airports, large groups of people, into others' private spaces, and over 90m in altitude (as 100m is the minimum altitude for other aircraft) (Transport Canada, 2015).

Commercial drones more than 25kg "must" apply for a Special Flight Operations Certificate, similar to any aircraft (outlined in the next section). As of November 2014, Transport Canada lifted some restrictions on commercial drones and now grant exemptions for any commercial drones under 25kg, with limited guidelines and requirements (Flitelab, 2014).

7.1.1(C) Special Exemptions for Commercial UAVs

Figure 7.2 outlines the special exemptions for commercial drones. To fly a drone that weighs between 2.1 kg and 25 kg without permission, the operator must be trained to understand: (Transport Canada, 2015)

- airspace classification and structure
- weather and notice to airmen (NOTAM) reporting services
- aeronautical charts and the Canada Flight Supplement Guidelines
- relevant sections of the Canadian Aviation Regulations

Additionally operators must supply Transport Canada with:

1. Your name, address, and phone number
2. Drone model and serial number
3. A description of the operation
4. And, the geographical boundaries of the operation

With the commercial special exemptions announcement the Minister of Transport, Honorable Lisa Raitt, announced that any drone must never: (Flitelab, 2014)

- Fly closer than 9 km from forest fires, airports, heliports, aerodromes, or **built-up areas**
- Fly over crowds or higher than 90 metres

Minister Raitt went on to state; “These exemptions mark an important milestone in drone safety. By easing restrictions for businesses, Canada is promoting growth and innovation in an important sector, while ensuring the continued safety of those on the ground and in the sky.”

However, Transport Canada has not specifically defined what “Built Up Areas” is to represent and presents a need for further clarification.

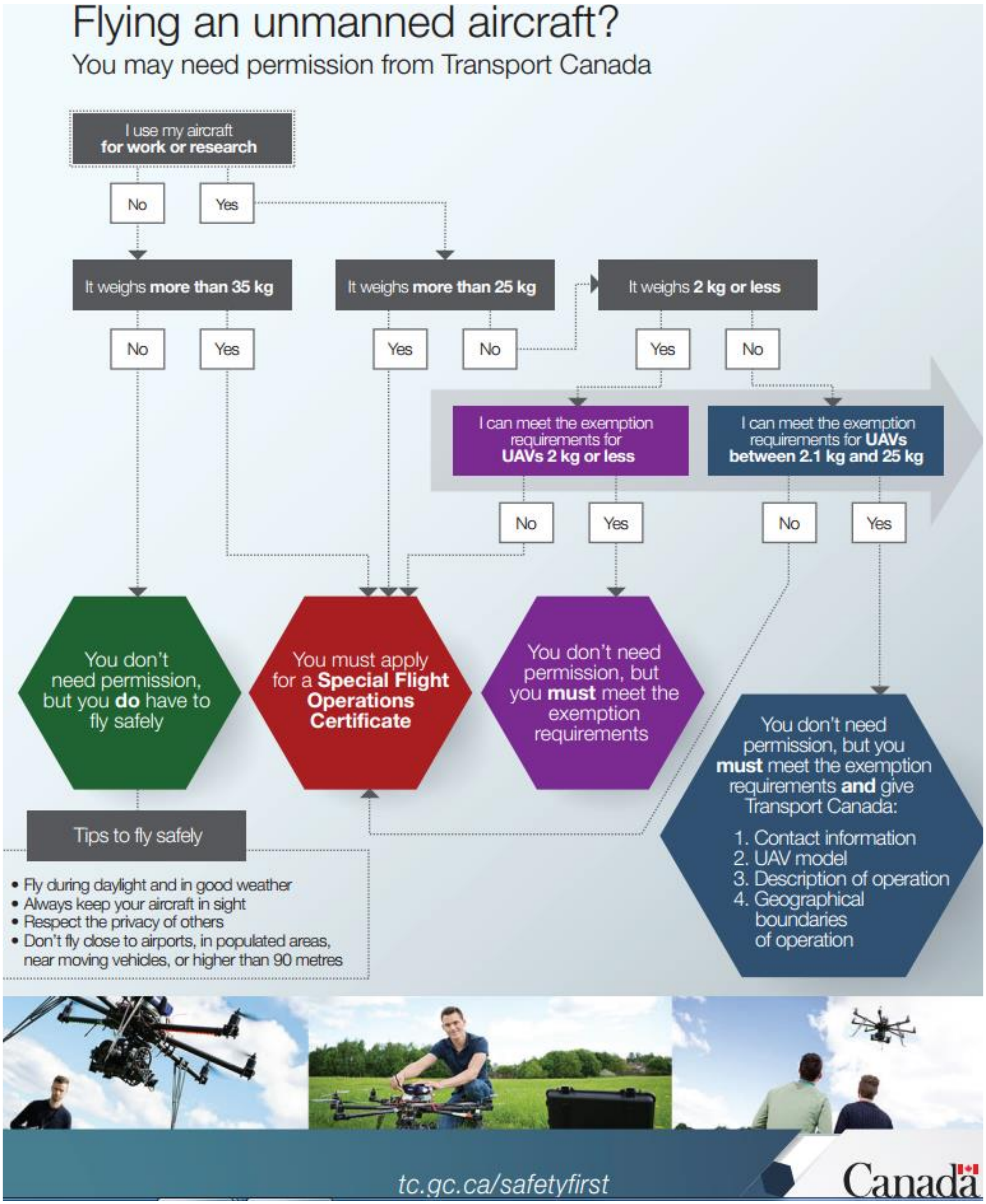


Figure 7.1 Transport Canada Drone Policy (Transport Canada, 2014)

Exemption requirements for operating UAVs without permission

THIS INFOGRAPHIC IS FOR EASE OF REFERENCE ONLY. YOU MUST CONSULT THE OFFICIAL EXEMPTIONS.

UAVs 2 kg or less

- Be safe, well trained and know the rules of the sky
- Be 18 years old, or at least 16 years old to conduct research under academic supervision
- Have at least $100,000 liability insurance
- Be alert—not tired or under the influence of alcohol or drugs
- Inspect your UAV and site before flight to ensure they are safe
- Get permission before you go onto private property
- Inform Air Traffic Services if your UAV enters controlled airspace
- Give right-of-way to manned aircraft
- Fly during daylight and in good weather
- Keep your aircraft in direct line of sight and always be able to see it with your own eyes
- Verify that radio frequencies/transmissions won't affect control of your UAV
- Have an emergency plan ahead of time
- Carry a copy of your UAV exemption, proof of liability insurance, contact information, and aircraft system limitations
- Follow the manufacturer's operating and emergency procedures, including those if the remote control loses contact with the aircraft
- Respect laws from all levels of government
- Operate only one UAV at a time, with a single remote control
- Immediately stop all operations if you can no longer meet the exemption requirements or if the safety of a person, property or other aircraft is at risk
- Stay at least 30 metres away from people, animals, buildings, structures, and vehicles not involved in the operation

UAVs between 2.1 kg and 25 kg

- Be safe, well trained and know the rules of the sky
- Be 18 years old
- Have at least $100,000 liability insurance
- Be alert—not tired or under the influence of alcohol or drugs
- Inspect your UAV and site before flight to ensure they are safe
- Get permission before you go onto private property
- Carry a copy of your UAV exemption, proof of liability insurance, contact information, and UAV system limitations
- Respect laws from all levels of government
- Keep your UAV in direct line of sight and always be able to see it with your own eyes
- Operate only one UAV at a time, with a single remote control
- Give right-of-way to manned aircraft
- Fly during daylight and in good weather (no clouds, snow or icy conditions)
- Create and follow procedures for landing and recovering your UAV and for contacting emergency responders and air traffic control.
- Have an emergency plan ahead of time
- Follow the manufacturer's operating and emergency procedures, including those if the remote control loses contact with the aircraft
- Verify that radio frequencies/transmission and eletronic devices won't affect control of your UAV
- Assess the risk of losing connection with the UAV and decide when to use the flight termination setting
- Have a fire extinguisher on site
- Inform Air Traffic Services if your UAV enters controlled airspace
- Follow the manufacturer's maintenance/assembly instructions
- Ensure the UAV does not have an emergency locator transmitter
- Report accidents to Transport Canada and stop operations until you have addressed the risks
- Immediately stop all operations if you can no longer respect the exemption requirements or if the safety of a person, property or other aircraft is at risk
- Stay at least 150 metres away from people, animals, buildings, structures, and vehicles not involved in the operation

DO NOT:

- Fly closer than 9 km from forest fires, airports, heliports, aerodromes, or built-up areas
- Fly over military bases, prisons or in controlled or restricted airspace
- Fly over crowds or higher than 90 metres
- Participate in special aviation events, air shows or system demonstrations
- Carry dangerous goods or lasers

Figure 7.2 Transport Canada Drone Special Exemptions (Transport Canada, 2014)

7.1.1(C,a) Special Flight Operations Certificate

It is Transport Canada's policy that large drones operating in Canada must meet "equivalent" levels of safety as manned aircraft. Section 602.41 of the CARs outlines specific standards for drones and states that no person shall operate an unmanned air vehicle in flight except in accordance with a Special Flight Operations Certificate (Transport Canada, 2014). Section 623.65(d)of the CARs outlines information that should be submitted when making an application.

Transport Canada has to be convinced that an individual can conduct their planned operation safely and is familiar enough with aviation regulations before an SFOC will be granted. Certificate holders need to be aware very early in the application process that they must subscribe for adequate liability insurance covering risks of public liability as outlined in section 606.02 of the CARs. (CCUVS, 2015b)

The requirement for an SFOC is intended to ensure the safety of the public and protection of other users of the airspace during the operation of the unmanned air vehicle. This requirement will be a condition in the SFOC. (CCUVS, 2015b)

Transport Canada has steadily issued more Special Flight Operations Certificates (SFOCs) each year, as drones grow in popularity. Between 2010 and 2013, they issued 1,527 approvals for drone operations. (Transport Canada, 2015)

7.1.1(C,a,i) Radiotelephone Operations Restricted Certificate

As part of the application process, applicants of an SFOC may be required to have possession of a Radiotelephone Operations Restricted Certificate, and that it may take up to 30 days to obtain radio frequency clearances, and/or radio licenses (Industry Canada, 2010).

7.1.2 Criminal Code of Canada – Drones

The Criminal Code of Canada outlines the ramifications of the dangerous operation of aircraft and endangering the safety of other aircraft (Canadian Criminal Code, 1985). A drone “aircraft” operator found criminally negligent can face prison terms of up to 14 years for manslaughter, and fines at the judge’s discretion, and with legal precedent.

7.2 What is the Public Domain?

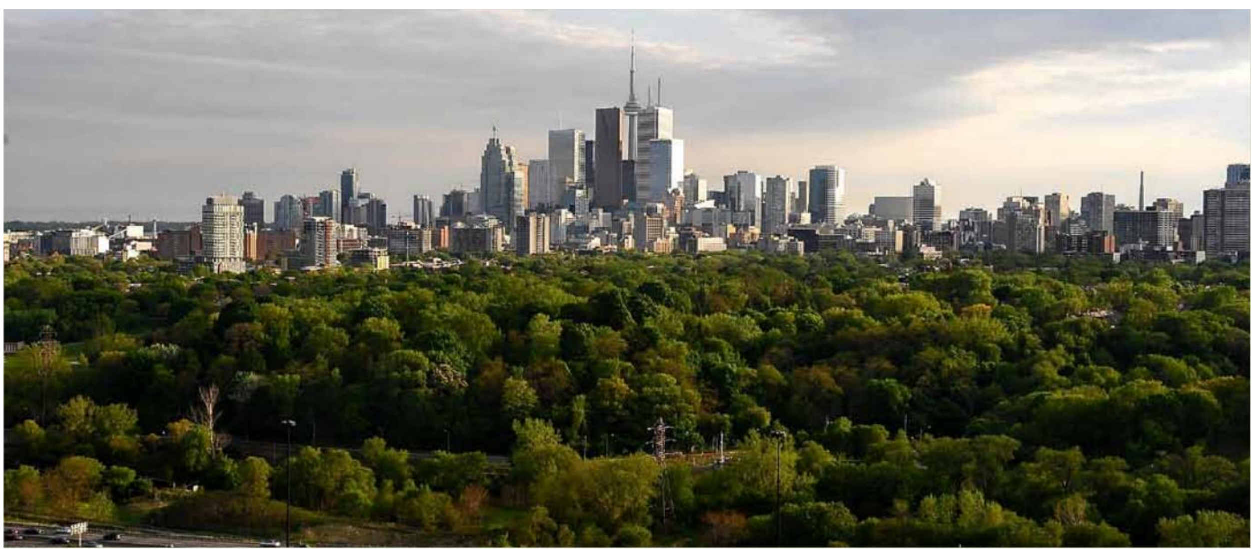


Figure 7.3 City of Toronto (Every Tree Counts, 2013)

The public domain is generally defined as the state of belonging or being available to the public as a whole. Canadian airspace is a public domain: it is not owned by anybody and is free and accessible to all Canadians who can use it. This potentially includes airspace above privately owned lands, leading to privacy and property rights concerns, which has not been clearly defined in Canadian law or in the courts.

7.2.1 Right to Roam

The freedom to roam, or everyman's right, is the general public's right to access certain public or privately owned land for recreation and exercise. Access is permitted across any open land, in addition to existing paths such as urban roads (Wikipedia, 2015b). This “right to roam” using a recreational drone could be constitutionally justified based on similar recreational allowances in the past. However there are still issues surrounding possible liability if someone or something may be damaged on private properties. These are real concerns and perhaps can only be dealt with by provincial legislation limiting liability for land owners. Compensation for landowners is another area where legislation can outline a mechanism to determine legitimate loss of land value to allow access for drone customary uses above the property.

7.2.2 Private Property Rights in Canada

Property rights have played a central role in the evolution of Canadian society and are also an essential part of British parliamentary democracy. These rights can be traced back to the year 1215, when the Magna Carta was signed (Siegan, n.d). In 1948, Canada signed the United Nations Universal Declaration of Human Rights, Article 17 of which reads: (United Nations, 1948)

1. Everyone has the right to own property alone as well as in association with others
2. No one shall be arbitrarily deprived of his property

Property rights are also recognized in the 1960 *Canadian Bill of Rights*, and the *Charter of Rights and Freedoms*, which affirms the right of the individual to the enjoyment of property and the right not to be deprived thereof except by due process of law.

Section 26 of the Charter stipulates that: "The guarantee in this Charter of certain rights and freedoms shall not be construed as denying the existence of any other rights and freedoms that exist in Canada." (Canadian Charter of Rights and Freedoms, 1982)

Therefore, there is a direct conflict between an individual's right to the enjoyment of their property and another individual's right to freely enjoy the public domain of airspace above that property (also a right in the Constitution). The courts or a revision of the constitution is needed to clarify this distinction in regards to privacy and a legalised nuisance for property owners.

While not in Canada, the case of *United States v. Causby*, established an air rights precedent which Canadian courts could emulate. The U.S. Supreme Court declared the navigable airspace to be "a public highway" and within the public domain. At the same time, the law, and the Supreme Court, recognized that a landowner had property rights in the lower reaches of the airspace above their property. The law, in balancing the public interest in using the airspace for air navigation against the landowner's rights, declared that a landowner owns only so much of the airspace above their property as they may reasonably use in connection with their enjoyment of the underlying land (Wikipedia, 2015c). There however needs to be a distinction made that Canadian's do not have the same Constitutional Property Rights as our U.S. neighbours, so a similar court decision may not be possible in Canada.

7.2.3 Urban Planning and Aerial Rights of Way

However, in the interim, drone “air road” rights of way can be established in urban areas for the public good. A right of way is a term used to describe "the legal right, established by usage or grant, to pass along a specific route through grounds or property belonging to another". A further definition is that it is a type of easement granted or reserved over the land for transportation purposes (Alberta Land Surveyors Association, 2015).

7.3 Privacy Legislation

Figure 7.4 Mosquito Nano-UAV (RT, 2012)

Drone operations that involve the surveillance of Canadians or the collection of personal information are subject to the same privacy law requirements as with any other data collection practice. Uses for commercial purposes are covered by the *Personal Information Protection Electronic Documents Act* (PIPEDA), where companies are not allowed to take your photo in a public place without your express permission (Office of the Privacy Commissioner, 2013).

Likewise, federal government departments intending to use drones have to ensure their program activities are carried out in accordance with the *Privacy Act, 1985*, and will have to ensure they undertake a Privacy Impact Assessment (PIA). Under a PIA there is an expectation that “organizations carefully evaluate, and demonstrate, that the initiative is necessary to achieve a specific and legitimate purpose, that it is likely to be effective in achieving that purpose, that the intrusion on privacy is proportional to the benefit to be derived and that no other less privacy intrusive alternative would achieve the same purpose" (Office of the Privacy Commissioner, 2013).

The general public's awareness around the use of drones is often minimal, and citizens often have few indications that drones are in use. The OPC has stated that even in a hypothetical case where someone has an indication that their privacy may be violated by the operation of a drone, it would prove challenging for individuals to produce sufficient evidence to support their complaint under the Privacy Act or PIPEDA, particularly when dealing with unmarked drones (Office of the Privacy Commissioner, 2013).

7.4 Where We Are

As this report has highlighted, compared with the U.S., Canada's drone regulations are fairly open in allowing for innovation in the drone industry and their possible uses. However, more stringent restrictions still exist across Canada's urban areas which limit the potential of drones as a resource in all aspects of Canadian life. While Transport Canada's basic drone regulations are in place to help manage drones, they are based on previous general aviation frameworks. A more systematic and streamlined approach needs to take place if drones are to become a part of the planned urban environment.

In many ways where Canada is now, in regards to drones, is not keeping pace with other countries around the world, particularly in Europe. The European Aviation Safety Agency (EASA), the European Unions (EUs) authority for aviation safety, has released a regulatory framework that calls for new drone specific regulations to be proposed by December 2015 (McNeal, 2015b).

The EASA has explicitly gone onto say that regulations must "not simply [transpose] the system put in place for manned aviation" but rather must create "one that is proportionate, progressive, risk based and…[expresses] objectives that will be complemented by industry standards" (McNeal, 2015b).

The European adoption of the vanguard drone industry far outpaces North American efforts. For a quantitative sense of this, in the EU there are 2,495 registered commercial operators of drones weighing less than 150kg (330 pounds), compared to the 2,342 operators flying in the rest of the world (with 2,000 of those sanctioned operations taking place in Japan) (McNeal, 2015b).

Chapter 8

8.0 Conclusion

8.1 Where We Go From Here?

8.1.1 The Planners Perspective

In planning for urban development and land uses the planner has an ethical responsibility to the public, to clients and employers and to the planners' profession. While the planner has to deal with immediate needs and challenges, they have at the same time a responsibility to future generations (CIP, 2015). Planners' responsibilities are not only confined to client-practitioner relationship-- they also need to work for the broader public interest in promoting a dynamic vision of the future.

According to the Canadian Institute of Planners (CIP) Code of Practice, planners' are responsible for preserving or advancing the public interest by respecting the diversity, needs, values and aspirations of the general public (CIP, 2015). The public interest involves a range of issues around political thinking, legal theory, welfare economics and mediation (Lloyd, 2006).

Professional standards guide the planner in dealing with complex meta-problems in the best interests of the community. The drone issue, in both its benefits and drawbacks, is a complex meta-problem affecting Canada's urban areas in need of framework for proper governance. It is a complex issue faced by governing bodies around the world.

8.2 What Planners Need From Government

Multiple stakeholders will be affected by the anticipated rules governing the use of drones. Certain aspects of the problem will need to be secured by government legislators before any planning specific applications can be fully realized. A revised legislative framework is needed for establishing and meeting the highest benefit for the public good.

Problems exist in the current general definition of drones as “aircraft” by Transport Canada, grouping them into an aviation framework which was not intended for such localised, agile, and readily available machines. Combining drones into the previously established framework, makes using a drone onerous for many municipalities to plan and review policies. For example the cost and difficulty for municipalities to meet the requirements for a Special Flight Operations certificate, despite recently been eased somewhat, is still a hindrance.

Planners and others need government regulations to provide a framework for drone use while addressing the complex issues, some of which have been reviewed.

Clarification of public privacy concerns in relation to drone operation, data collection techniques, transparency, oversight, and use of collected data is required before this tool can be justly and ethically utilised.

Drone safety concerns with respect to weight, propeller guards, temporal collision hazards (including bids and cranes), as well as nefarious hazards also need to be addressed. Noise concerns relating to drone operations, should also be reviewed, as this would represent a legalised nuisance for many. Additionally, an aerial drone traffic system, for permitted uses, drone types and flight trajectory is currently lacking and is needed to ensure in-flight incidents are avoided. This drone traffic system should aim to bring clarity in regards to drone safety concerns, including, licencing, and enforcement of drone traffic system by-laws in order for planners and others to safely utilize drones.

Planners are also lacking a means by which to integrate a potential aerial drone traffic system into current municipal land use control by-laws. Municipal zoning by-law tools such as building height, and permitted height is variable across land use classifications and needs an organized integration with drone flight systems in order for long term urban planning.

8.3 Drones as a Planning Tool

Drones are a highly adaptable technology that is constantly changing in innovative ways to provide greater utility. This tool provides planners with a source of unique aerial data by which they can better inform the client and public. Drones are also relatively inexpensive, providing access to data and information which was previously cost prohibitive for many planning tasks; such as with satellite technologies. Therefore, due to both the adaptability of the technology and the low cost of drones compared with alternatives, the utilization of drones in urban planning provides one of the most cost efficient data collection and transport task utility tools of our time. If Canadian legislators can progressively address the issues surrounding the 'growing pains' through the initial adoption of drones in urban areas then this technology can help plan for, and monitor progress towards, public policy objectives.

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