The Existing and Emergent State of UAV/RPAS/Drones Surveillance Capacities and Law Enforcement

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Disclaimer

This report was commissioned by the Office of the Information and Privacy Commissioner of Ontario (IPC) and is intended as a review of the existing and emergent state of UAV/RPAS/drones surveillance capacities and law enforcement. Research was completed in September of 2024. The report is for informational purposes only and it should not be relied upon as a substitute for the legislation itself or as legal advice. The views reflected within the report are not necessarily those of the IPC. It does not bind the IPC, which may be called upon to independently investigate and decide upon an individual complaint or appeal based on the specific facts and unique circumstances of a given case. For the most up-to-date version of this report, visit the IPC's website at **www.ipc.on.ca**.

1. Executive summary

A historical review of the literature will, in nearly every instance, identify the work of drones as being directed towards the three Ds — tasks that are dull, dirty, or dangerous. This focus, however, is quickly changing in an environment where drone use in law enforcement is shifting from spontaneous responses to specific type of incident uses, to now routine deployment in everyday policing. Within this report, the terms remotely piloted aircraft system (RPAS) or drone will be used. This is to be consistent with Transport Canada classifications, regulations, and policies, though the industry is inconsistent in their terminology — somewhat complicating regulation, research, and oversight. RPAS are defined generally as remotely controlled aircraft without an onboard pilot, capable of differing levels of autonomy. Though trends in current uses and innovations within the field suggest these technologies should now be considered as a part of a larger, increasingly integrated, increasingly centralized, data-collection-centric strategy of police work.

Current capabilities for law enforcement

Police services in Ontario employ the use of at least four types of RPAS, the most popular being the FLIR SkyRanger and the DJI Matrice 30 series. These RPAS are considered by the industry to be small or micro in size, measuring between 58.5 cm and 1.35 m, with both employing the quadcopter design. In understanding the capabilities of RPAS, the crucial distinguishing factor is that of payload. Here, payload refers to the amount of weight in cameras and other material that can be carried, and for what period of time flights can be maintained. Payloads for RPAS deployed in Ontario are between 30g and 3.5 kg, with flight lengths of approximately 24-hours when tethered to a power source on the ground, and between 36 and 59 minutes without a tether. This payload size enables each to carry highly detailed zoom cameras as well as thermal cameras, allowing for a range of theoretical detection of individuals and objects from a distance of up to four km and the positive identification of individuals up to 457 m away. Weather and atmospheric conditions, however, greatly impact these distances, with real-world testing suggesting approximately 60 per cent of these distances being readily achievable (detection: 2.5 km and identification: 289 m). The capabilities of the thermal cameras are considerably shorter, with a theoretical maximum distance for detection of approximately 300 m. The DJI Matrice 30 series also includes a laser for measurement, as well as onboard artificial intelligence (AI) for the labeling and tracking of objects in real time. One mini RPAS is currently deployed in Ontario, with this much smaller model allowing for flight into and within buildings.

Five-year development and current innovation for law enforcement

In interviews, police personnel reported that RPAS will shape all areas of policing, and that their applications are only limited by designers' imaginations. Awards and industry reports on innovation, however, provide a clearer picture of how technology is progressing and will most likely be implemented in the next five years, following this publication. The need here is to distinguish between imagined futures, technologies in the testing phase, and current applications with institutional momentum. Where historically, innovations focused on the utility of having a camera take photographs from novel or dangerous viewpoints. Current developments and RPAS narratives now have largely shifted to command-and-control applications and unmanned aerial vehicles (UAVs) flying across cities in response to service calls. Moving forward, RPAS are being conceptualized as a central tool for collecting large

amounts of data from multiple sources and providing ranking officers in command centres with real-time augmented reality displays of what is happening on the ground. Innovations here include:

- one-to-many flying, where multiple RPAS are piloted by a single individual and are able to use multiple data collection points to render 3D visual displays drone as first responder (DFR), where new policy requires RPAS to be deployed from a central location, fly independently in response to service calls, and arrive at a scene before officers on the ground
- AI identification, where AI are trained to automatically identify specific individuals, or kinds of individuals (those in distress or suspicious for example), within crowds or as part of investigations
- AI tracking, where a moving target can be "locked on" and its movements will automatically be followed
- drone-in-a-box, technology where flight paths and data gathering are fully automated and driven by AI modeling
- nesting, where RPAS are placed and housed at strategic locations across a city
- live annotations, or the ability to highlight objects or areas of interest for mission management and distribution to other team members
- 5G connectivity, which allows for streaming video, communication over the internet, transmission across an array of devices, and the ability for an RPAS to act as a Wi-Fi hotspot for data collection about suspects and their internet use.

Each of these innovations opens up new spaces for policing but are widely presented as contributing to a reorganization of RPAS police work. The trend is moving away from spontaneous, single-pilot-focused applications to RPAS becoming a routine part of command-centric, situational-awareness-focused data collection models.

Small to mid-sized RPAS in military use, today and in five years

In Armed Forces applications, there is an extension of current technologies that have largely been adopted by police services in North America. In particular, procurement documents outlining the capabilities of RPAS to be purchased by the Department of National Defence (DND) identify sensor packages similar to those used in law enforcement, including:

- electro-optical and infrared cameras (EO/IR), which are very similar to the cameras used by police services but provide approximately 405 times greater image resolution
- synthetic aperture radar (SAR), which functions similarly to light detection and ranging (LiDAR) technologies used by policer for surface mapping and, though it uses microwaves, making it less impacted by weather and atmospheric condition
- signals intelligence (SIGINT), which includes additional sensors used to capture cell phone, internet, and other electronic communications data, which is similar to, but much more extensive than police- used cell-site simulators, international mobile subscriber identity (IMSI) catchers, and digital receiver technology (DRT) boxes

In application, a logical next step is for law enforcement to be influenced by the Armed Forces' pattern of life analysis (POLA), an AI-assisted means of sifting through an incredibly high volume of data to determine the routine patterns of movement, social connections,

communications, and data use that make up people's daily lives. This approach enables the detection of individual versus group pattern anomalies, as well as anomalies in an individual's specific actions versus their own routine patterns.

The Ukraine-Russian conflict also continues to influence Class 1 RPAS technological development and innovations in application. Although Ukraine battlefront data indicates that the majority of casualties remain the result of human-to-human combat rather than RPAS use, it has been shown that RPAS are playing a different and much expanded role when compared to previous conflicts. Both off-the-shelf drones and military-grade RPAS are being deployed, including models used by police services in Ontario. On the Ukrainian side alone, more than 10,000 drones a month were destroyed and needed to be replaced in 2023.

In regard to the impact of this tremendous demand on the industry, it is expected by experts in the field that RPAS will become smaller, faster, cheaper, and have greater processing power. As a result of these industry pressures, the decreased cost and increased availability of RPAS could lead to easier adoption of these technologies across Ontario for law enforcement. The Class 1 RPAS applications from the Ukraine-Russian conflict that are most relevant to law enforcement include streaming battlefield data directly to soldiers on the ground and using RPAS-collected data for media messaging and perception management.

New and emergent privacy risks

In reviewing the literature on current and innovative RPAS applications, five technologically distinctive privacy concerns stand out as challenges moving forward.

Normalized use and DFR as first responder

The normalized use of RPAS has quickly outpaced past privacy guidance literature. Many existing privacy protection recommendations assume that a flight plan, reason for the flight, and data collection practices are known in advance, and that notifications can be made to the general public. The frequency and integration of RPAS use into everyday police work requires new privacy solutions. Additionally, policies like DFR — in place in other jurisdictions — require RPAS deployment for every service call, flying directly from the police station to the call location. Here, there are new emergent privacy concerns. As a result of past solutions no longer fitting police practice, these changes present a serious risk of over-collecting personal information in transit to or from a call.

RPAS patrols and hot spots

Police services now deploy RPAS not only in response to calls for service but also to conduct routine patrols of communities identified as hot spots or those areas considered more prone to crime. Unlike patrol duties performed by officers in cars, RPAS patrols have elevated viewpoints, and their array of sensors enable a capacity to capture not only the personal information of members of the general public but also the daily movements and associations that make up the fabric of their private lives.

Media narratives and perception management

Police services have begun producing their own content for news outlets, as well as producing in-house videos and podcasts about true crimes. This creates an emerging privacy risk because RPAS are able to capture large amounts of personal information about Ontarians and these media products may contain personal information without an individual's consent or prior knowledge.

Visual and aural covertness

RPAS are following a trend in which their physical sizes are decreasing while their capabilities to collect data are increasing. This trend threatens Ontarians' understanding of RPAS use in their communities, while also working to disrupting the vital role, established in the legislation, that the general public plays in detecting potentially improper data collection.

POLA

This is a technique used for the development of intelligence, the identification of people, and sorting them into populations of interest. It involves developing a detailed understanding of the habits and behaviours of an entire community of individuals by collecting large quantities of data, including streaming video that enables the tracking of individual movement across cities for extended periods, as well as cell phone, digital communications, and internet data. The data is analyzed with the aid of AI. Once daily-life patterns are established for those under surveillance, analysts can detect anomalous individual behaviours against a group norm or an individual's own normal behaviours. Police services already have programs representing each of the key pieces of this application:

- High-resolution cameras are capable of capturing all an individual's daily movements across a city for up to 30 days.
- Tethered small RPAS can gather data 24-7 over a portion of the city and later stitch it together with data from other RPAS.
- AI, with capabilities for identification and machine learning, is built into the RPAS models in use in Ontario by law enforcement.
- Through digital data collection, police services continue to test cell phone and internet data capture through RPAS sensors.

2. Introduction

For many Canadians, the practice of police using RPAS in their communities for real-world applications would be largely unknown and would perhaps instead bring to mind depictions of some distant futuristic society. The capabilities that Canadians may believe to be science fiction, however, have most likely already been surpassed and may have even become routine and part of daily practice in many police services in western countries.

In Canada, the use of RPAS for military applications was first developed at scale in the late 1950s with the development of the Canadair CL 89 reconnaissance drone.[1] The armed forces application of fully networked RPAS for intelligence and reconnaissance was tested for the Canadian environment as early as 2001.[2] RPAS were first used in domestic policing to monitor protesters in Canada at the 2002 G8 summit in Kananaskis, Alberta, as part of

1 Flight International 1964 "Canadair CL-89" June 25, 1964.

2 Babcock, Sandy (2004) "Canadian Network Enabled Operations Initiatives." Department of National Defence Ottawa Directorate of Defence Analysis. Accession Number: ADA466127. http://www.dodccrp.org/events/9th_ICCRTS/CD/papers/001.pdf.

the Royal Canadian Mounted Police's (RCMP) Operation GRIZZLY.[3] The first police adoption of RPAS for photographing crime scenes occurred in Kenora, Ontario, by the Ontario Provincial Police (OPP) Forensic Identification Unit in 2007.[4]

The Canadian Police Research Centre investigated the utility of RPAS for routine police work in 2009,[5] with the RCMP asserting in 2012 that flight operations had already been conducted by their organization for "forensic identification, major crimes, search and rescue," and to assist "their dive team."[6] In southern Ontario, RPAS with thermal infrared sensors were used by the Halton Regional Police Service in 2012 to identify cannabis grow-ops.[7] The RCMP reported that search and rescue officers used an RPAS in Saskatoon, Saskatchewan, in 2013 to save a person's life.[8]

Given that these milestones in the use of RPAS within Canada date back well over two decades, with many police services having fully dedicated RPAS units as early as the mid-2010s, understanding the current uses of RPAS technologies requires answering several key questions:

1. What are the current capabilities and applications of RPAS technologies in use by police?
2. How is innovation and technological development in this sector trending?
3. What capabilities and innovations exist outside law enforcement?
4. What potential privacy concerns arise from current and developing RPAS applications?

After a brief overview of the methodology used for this literature review, the remainder of this report is separated into eight sections, including the current capabilities and applications of RPAS in Ontario policing, innovations occurring in Ontario and internationally regarding RPAS use, and what new practices may become normalized over the next five years, as well as potential emerging risks to privacy that could develop as a result of these innovations.

This report was commissioned to conduct a literature review of materials relevant to the capabilities, practices, potential privacy concerns, and the five-year development of RPAS technology used by police services in Ontario, with a focus on medium-to-small craft

3 Canadian Forces Experimentation Centre, Experiment Report IICE – 001/2002: Uninhabited Aerial Vehicle Concept Development and Experimentation (Department of National Defence Canada: Ottawa, 2003): 113.

4 Forberg, Sigrid "Emerging Trends: Taking to the Skies – New Tool Facilitates Investigations." The Gazette 74(1) (2012), https://publications.gc.ca/collections/collection_2012/grc-rcmp/JS62-126-74-1-eng.pdf.

5 Hamilton Spectator, "Watch Out: Halton Police Have an Eye in the Sky," December 13, 2012. https://www.thespec.com/news/hamilton-region/watch-out-halton- police-have-an-eye-in-the-sky/article_3c6883d9-2958-5767-8053-37ce130a0a2c.html.

6 Forberg, Sigrid "Emerging Trends: Taking to the Skies — New Tool Facilitates Investigations." The Gazette 74(1) (2012), https://publications.gc.ca/collections/collection_2012/grc-rcmp/JS62-126-74-1-eng.pdf.

7 Hamilton Spectator, "Watch Out: Halton Police Have an Eye in the Sky." December 13, 2012. https://www.thespec.com/news/hamilton-region/watch-out-halton- police-have-an-eye-in-the-sky/article_3c6883d9-2958-5767-8053-37ce130a0a2c.html.

8 CBC News, "Aerial Drone Locates Sask. Man Injured in Rollover Crash." May 9, 2013. https://www.cbc.ca/news/canada/saskatchewan/aerial-drone-locates-sask-man-injured-in-rollover-crash-1.1398942.

In this report, the terms RPAS or drones will be used. This is to ensure alignment with Transport Canada and current Canadian legislation,[9] though police services in Ontario and internationally currently lack an agreed-upon nomenclature for how to refer to these aircraft. Various terms are used almost interchangeably, including unmanned air vehicle (UAV), uninhabited aircraft vehicle (UAV), unmanned airborne vehicle (UAV), unmanned aerial systems (UAS), unmanned aircraft vehicle system (RPASS), remotely piloted aircraft (RPA), unmanned combat aerial vehicles (UCAV), and unmanned aircraft (UA). For this report, RPAS will refer to remotely controlled aircraft without an onboard pilot, capable of employing various levels of autonomy.[10]

To determine law enforcement capabilities, a Google search was conducted for each active police service in Ontario to identify which services deployed RPAS technologies. This was triangulated with a search of news media to provide a secondary information source regarding if, and what kind of RPAS were in use by police in Ontario. These searches provided details about the types of RPAS that were deployed, as well as the applications of these technologies in the field. With the RPAS types in hand, an online search was conducted for the manufacturers, with an emphasis on finding the technological specifications, handbooks, manuals, or other training materials. These searches provided data on cameras, sensors, and other payload types, as well as their technological specifications. For innovations and future directions of RPAS technologies, online searches were conducted for all policing associations within Canada (such as the Canadian Association of Chiefs of Police), as well as international policing organizations in which Canadian police services participate. This search yielded a series of reports regarding RPAS use, policies, and future directions, while also identifying industry awards for innovative applications of RPAS technologies. A search of the relevant awarding agencies was then conducted, providing information about the winning police services and their technological or policy innovations. The Office of the Information and Privacy Commissioner of Ontario's documentation on RPAS was also reviewed and compared with the guidance documents, policies, and practices of other provincial privacy regulators and privacy-focused organizations in Canada. For armed forces applications and capabilities, this report focused on procurement requirement documents and reports, as well as industry advertising materials. Considering Canada has made two major RPAS procurements in 2023 and 2024, procurement data provides an outline of the projected needs of these aircraft over their lifecycle. Finally, a search of Google Scholar was conducted to provide additional context to the other findings of this report.

3. RPAS capabilities for law enforcement

When reviewing the early literature on RPAS use by police services, there is consistent citation of the three Ds — dull, dirty, and dangerous work — with a general focus placed by

9 Transport Canada. 2023. "Flying your Drone Safely and Legally." https://tc.canada.ca/en/aviation/drone-safety/learn-rules-you-fly-your-drone/flying-your-drone-safely-legally; *Aeronautics Act* – Canadian Aviation Regulations, SOR/96-433. Part IX – Remotely Piloted Aircraft Systems. https://tc.canada.ca/en/corporate-services/acts-regulations/list-regulations/canadian-aviation-regulations-sor-96-433.

10 Jackman, Anna 2023. Police Drones: Uses, Challenges, Futures Research Report. University of Reading: Berkshire, United Kingdom. https://research.reading.ac.uk/drone-geographies/wp-content/uploads/sites/271/2023/09/Police-report.pdf.

police services on time and cost savings in traffic reconstructions for highway accidents.[11] New innovations and the significant expansion of both the technological capabilities of RPAS and their applications over the past decade have shifted RPAS from limited, specialized, or even test-case operations to a reality where many police services now have full-time teams of staff dedicated only to the use of these technologies. The police use of RPAS has become normalized in Ontario and, within a growing number of police services internationally, RPAS deployment has not only become routine but is required for ensuring officer safety and command oversight. When determining the capabilities of RPAS, the largest distinguishing factor is payload — or what the aircraft can carry, how much it can carry, and for how long. This, in turn, provides a foundation for understanding the forms and qualities of data collection, as well as the implications for individual privacy.

3.1 Current RPAS capabilities in Ontario law enforcement

Ontario's policing landscape includes 43 municipal police services, the OPP, the RCMP, and 9 First Nations and Treaty regional police services.[12] A site search of these police services' websites identified that 26 (60.4 per cent) of municipalities currently use RPAS,[13] while two (4.7 per cent) others are in the process of procuring these technologies.[14] The remaining 12 municipal police services did not report having a program or deploying RPAS, and none of the 9 First Nations and Treaty police services reported having or deploying RPAS (see Table 3.1-1). To complicate accurate data collection, two (4.7 per cent) services identified that they pool resources with neighbouring police services to deploy RPAS, while one service reported contracting a private operator. These conditions make it difficult to definitively state whether RPAS have been deployed in a community without reviewing police flight logs.

Table 3.1-1. Known police service deployment of RPAS in Ontario, 2024

Police service RPAS use	Municipal	First Nations and Treaty
Active program or use	26 (60.4%)	-
No known program or use	12 (27.9%)	9 (100%)
Application/attempting to purchase	2 (4.7%)	-
Pooled resource use	2 (4.7%)	-
Contracted private operator	1 (2.3%)	-
Total:	**43 (100%)**	**9 (100%)**

NB: This table was tabulated based on a site search of all municipal police services in Ontario, as well as a media search of these police services. The numbers above do not include the OPP or the RCMP, which both have active RPAS programs.

11 See for example Bracken-Roche, Ciara, David Lyon, Mark James Mansour, Adam Molnar, Alana Saulnier and Scott Thompson. 2014. Privacy Implications of the Spread of Unmanned Aerial Vehicles (RPASs) in Canada: A Report to the Office of the Privacy Commissioner of Canada, Under the 2013-2014 Contributions Program. https://web.archive.org/web/20231012040048/https://www.surveillance-studies.ca/sites/sscqueens.org/files/Surveillance_Drones_Report.pdf; Parsons, Chris and Molnar, Adam. 2013. Watching below: Dimensions of Surveillance-by RPASs in Canada. Block G Privacy and Security Report.

12 Government of Ontario, "Policing in Ontario" https://www.ontario.ca/page/policing-ontario#section-2.

13 In addition to the OPP and RCMP, the following municipal police services have active RPAS programs as of 2024: Aylmer Police Service, Barrie Police Service, Belleville Police, Brantford Police Service, Cobourg Police Service, Durham Regional Police Service, Greater Sudbury Police Service, Guelph Police Service, Halton Regional Police Service, Hamilton Police Service, Kingston Police, London Police Service, North Bay Police Service, Ontario Provincial Police, Ottawa Police Service, Peel Regional Police, Peterborough Police Service, Royal Canadian Mounted Police, Sarnia Police Service, South Simcoe Police Service, St. Thomas Police Service, Stratford Police Service, Thunder Bay Police, Toronto Police Service, Waterloo Regional Police Service, Windsor Police Service, Woodstock Police Service, York Regional Police.

14 Evidence was found that the Owen Sound Police Service and the Timmins Police Service are in the process of testing or attempting to purchase RPAS.

With regard to applications, the site search data identified 14 different applications for RPAS reported by municipal police services in Ontario and the OPP. The most commonly stated use was missing persons and search and rescue, mentioned by all 27 of the police services self-identifying as having RPAS programs. Other top uses included motor vehicle collision reconstruction (81.5 per cent) and collecting evidence at crime scenes (74.1 per cent), with the remainder falling under 50 per cent of reported uses (see Table 3.1-2).

Table 3.1-2. Current RPAS applications identified by police services in Ontario, 2024

Stated applications			
Missing persons/search and rescue	27 (100%)	Public demonstration	3 (2.7%)
Motor vehicle collision reconstruction	22 (81.5%)	Dive team	2 (1.8%)
Collecting evidence at crime scenes	20 (74.1%)	Intelligence gathering	2 (1.8%)
Tactical	7 (25.9%)	Training	2 (1.8%)
Disaster/emergency response	7 (25.9%)	Crisis/mental health	1 (0.9%)
Suspect apprehension	6 (5.5%)	Traffic enforcement	1 (0.9%)
Large gathering/event monitoring	5 (4.6%)	Other	1 (0.9%)

NB: This table was tabulated based on a site search of all municipal police services in Ontario, including the OPP, as well as a media search of these police services.

Data on the frequency of the types of RPAS flights mentioned above are not publicly available. Only two police services identified how many flights they conducted, with only one stating the purposes of those flights. In that one case, the Barrie Police Service reported conducting a total of 39 flights, with:

- 25.6 per cent for missing persons responses
- 20.5 per cent related to crime scene data collection
- 17.9 per cent for suspect apprehension
- 17.9 per cent for training operations
- 5 per cent for public demonstrations on how RPAS technology works
- 2.6 per cent for motor vehicle collision reconstruction
- 10 per cent for all other applications[15]

A Canadian Broadcasting Corporation (CBC) report on Hamilton Police Service RPAS flight logs from 2022 showed a greater emphasis on collision reconstruction (46.5 per cent) of flights, with 13.9 per cent being for search and rescue, and 39.5 per cent for all other applications, which the police service has stated would include: collecting evidence at crime scenes, monitoring large gatherings, and investigating crime.[16] The academic literature on this matter is, unfortunately, significantly older and less specific to Ontario, with a 2011–2013 analysis of flight logs in Canada showed a breakdown of police operational tasks related to RPAS use as follows:

- 31.9 per cent for missing persons
- 23.2 per cent for major crimes investigations
- 14.5 per cent for suspect apprehension

15 Barrie Police Service, "2022 Annual Report." https://www.barriepolice.ca/wp-content/uploads/2024/06/Barrie-Police-Service-Annual-Report-2022FINAL.pdf.

16 CBC "Eye in the Sky" April 23rd 2023 https://www.cbc.ca/newsinteractives/features/police-drones.

- 11.6 per cent for grow-op searches
- 2.9 per cent for motor vehicle collision reconstruction
- 2.9 per cent for tactical operations
- 2.9 per cent for train derailment responses
- 2.9 per cent for black bear searches
- 17.4 per cent for unspecified operational tasks[17]

3.2 Current types of RPAS used by Ontario law enforcement

It is important to note that not all RPAS are the same; they vary considerably in their capabilities to carry payloads, mount equipment, and complete missions. The site search analysis of police services identified four distinct RPAS systems in use in Ontario:

- technology developed by Aeryon Labs/FLIR Systems,[18] including the SkyRanger[19] and Aeryon Scout[20]
- DJI Technologies' Matrice 30T[21]
- the DraganFly X4,[22] developed by DraganFly Innovations
- the DJI Technologies' Mini 3 Pro[23]

All these RPAS follow the quadcopter design and are considered small or micro RPAS, ranging from 36.2 cm to 1.35 m, with payload capacities between 30 g and 3.5 kg. In addition to their use by police services in Ontario, two of these RPAS are also used in military applications. The Aeryon Scout has been used by Defence Research and Development Canada (DRDC) and deployed in theatre by the Libyan National Liberation Army. Additionally, 800 SkyRanger R70s were scheduled for donation by the Government of Canada to support the war in Ukraine.[24]

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17 Saulnier, Alana, and Scott Thompson. 2016. Police RPAS use: institutional Realities and Public Perceptions." Policing 39(4): 685.

18 FLIR Systems, Inc. (NASDAQ: FLIR) purchased Aeryon Labs in 2019 (see Teledyne FLIR 28 Jan (2019) "Press Release." https://www.flir.ca/news-center/press-releases/flir-systems-acquires-aeryon-labs-for-$200m/.

19 Teledyne FLIR "SkyRanger R70" https://equipnor.com/media/3843/skyranger-r70-brochure-us.pdf; Teledyne FLIR "SkyRanger R70 Manual" https://drive.google.com/open?id=1L61esMvD8p1lWTEyPgWbx6x9AwVdFUQ2.

20 Drone User Manuals "Aeryon Scout Review" https://www.dronesusermanuals.com/aeryon/aeryon-scout-easy-and-reliable-professional-quadrocopter/.

21 DJI Enterprise Inc. "Matrice 30 Series Specs" https://enterprise.dji.com/matrice-30/specs.

22 Draganfly Innovations Inc. "Quadcopters and Multirotors" https://draganfly.com/products/quadcopters-multirotors/; Draganfly Innovations Inc. "Technical Specifications" https://draganfly.com/wp-content/uploads/2020/08/Commander-Technical-Specs-Final_20160603-1.pdf.

23 DJI Mini Pro. https://www.dji.com/ca/mini-3-pro/specs.

24 National Defence / Canada Armed Forces 2024 "Defence Minister Bill Blair announces Canadian donation of over 800 drones to Ukraine." https://www.canada.ca/en/department-national-defence/news/2024/02/defence-minister-bill-blair-announces-canadian-donation-of-over-800-drones-to-ukraine.html ; Homeland Security Technology. "Aeryon Scout Micro-RPAS." https://www.homelandsecurity-technology.com/projects/aeryon-scout-micro-RPAS/#:~:text=The%20Aeryon%20Scout%20can%20conduct,payloads%20in%20a%20normal%20environment (URL inactive); Financial Post. 2011 "Libyan rebels using Canadian- made reconnaissance drone." https://financialpost.com/technology/libyan-rebels-using-canadian-made-reconnaissance-drone

Table 3.1-2. Current RPAS applications identified by police services in Ontario, 2024

Technology	Number of police services	Maximum payload	Maximum flight time/ tethered	Maximum speed	Estimated maximum range / transmission range
FLIR SkyRanger	8	3.5 kg	59 min/24 h	50 km/h	48.8 km/8 km
DJI Matrice 30T	6	5.0 kg	41 min/24 h	82 km/h	56 km/7 km
DJI Matrice 210	2	1.45 kg	24 min/24 h	36 km/h	14.4 km/7 km
FLIR/Aeryon Scout*	1	1.2 kg	25 min/24 h	50 km/h	20.75 km/3 km
DraganFly X4	1	1.0 kg	18 min/ -	50 km/h	14.94 km/ -
DJI Mini 3 Pro	1	0.3 kg	51 min/ -	57 km/h	48.45 km/12 km
Private Contractor	1	-	-	-	-
Unspecified	11	-	-	-	-

*NB *Aeryon Labs Inc. was a Canadian company acquired by the U.S. company FLIR Systems Inc. (NASDAQ: FLIR) as of January 2019, making them the provider of both the SkyRanger and Aeryon Scout RPAS as of the writing of this report. DJI Enterprise is a Chinese company out of Shenzhen and DraganFly Inc (NASDAQ: DPRO) is a Canadian company with headquarters in Saskatoon.*[25]

Among the police services that disclosed their RPAS technologies, the most popular were the FLIR Systems' SkyRanger and Aeryon Scout (OPP, Toronto Police Service, Durham Regional Police Service, Halton Regional Police Service, Kingston Police, Peel Regional Police, Waterloo Regional Police Service York Regional Police), with DJI Matrice series RPAS being used by eight different police services (Guelph Police Service, Belleville Police Service, Greater Sudbury Police Service, Hamilton Police Service, North Bay Police Service, Ottawa Police Service, South Simcoe Police Service, St. Thomas Police Service),The DJI Mini 3 Pro being used by the North Bay Police Service, and finally, the DraganFly X4 is being flown by the OPP.[26]

3.3 Technological capabilities of RPAS in Ontario law enforcement

The most prevalent technologies currently in use by police services in Ontario is the FLIR/ Aeryon SkyRanger, with the second most prevalent being DJI Matrice 30T. These are both small RPAS, with the SkyRanger being the larger of the two at 1.35 m in total length and the DJI Matrice 30 being only 6.68 cm. The range of these RPAS are advertised as being

25 Teledyne FLIR. 2019. "FLIR Systems Acquires Aeryon Labs." https://www.flir.ca/news-center/press-releases/flir-systems-acquires-aeryon-labs-for-$200m/; DJI Enterprises. 2024. "About DJI." https://www.dji.com/ca/company; Homeland Security Technology. 2024. "Aeryon Scout Micro-RPAS." https://www.homelandsecurity- technology.com/projects/aeryon-scout-micro-RPAS/#:~:text=The%20Scout%20can%20fly%20for,motor%20powered%20by%20a%20battery (URL inactive) ; Teledyne FLIR "SkyRanger R70." https://equipnor.com/media/3843/skyranger-r70-brochure-us.pdf; Firehouse Technology. 2024. "DJI M30 Payload Delivery Kit w/ Emergency Lighting."https://www.firehousetechnology.com/store/p189/DJI_M30_Payload_Delivery_Kit_w%2F_Emergency_Lighting.html#:~:text=DJI%20M30%20drop%20release%20ca n,relatively%20conservative%2C%20leaving%20a%20margin. ; The Drone Pro Shop. 2024. "DJI Matrice 210 Specifications." https://www.thedroneproshop.com/blogs/product-info/dji-matrice-210-specifications (URL inactive) ; DJI Enterprise. 2024. "DJI Minni Specs." https://www.dji.com/ca/mini-3/specs; Teledyne FLIR. 2024. "SkyRanger R70 Datasheet." https://flir.netx.net/file/asset/58291/original/attachment (URL inactive)

26 DraganFly Inc. 2024. "About Us." https://draganfly.com/about-us/ ; Yahoo Finance. 2024. "Draganfly Inc. (DPRO)" https://finance.yahoo.com/quote/DPRO/?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAALNF9iG0GJFYwo1ddu1v-4ocLaeV3FCh3Sf2R6tfu4rnCpEjPO7KszTgchC2UnOvX56KiVCU1OOEmMcXHgEEVpmAY3YOILMrvsMmvmo4iLZ8TJcQv14VSljtPCA2CeSc3madRCZA9A-7YVmBBXDGOq-vFRRse9ZFLvGjmHIjxgqU.

between 1.2 and 8 km of horizontal movement, with maximum heights capable of 2.13 km to 7 km above mean sea level (MSL). The advertised flight times of these craft remain fairly short, with total flight times of 36 to 59 minutes — although there are tether kits available to link the RPAS to a device on the ground to provide sufficient power for continuous flight for up to 24 hours.[27] Both devices have primary cameras that can produce both video and still images. They also feature specialized day and night imaging and can capture both natural light and thermal imagery simultaneously.

3.3.1 Zoom, thermal, and smart low-light cameras

The FLIR SkyRanger and DJI Matrice 30T each employ fully stabilized multi-camera systems, allowing the user to switch between wide angle views generally used for flight maneuvering, zoom cameras (to take individual photos, which can then be stitched together multiple photographs for larger high-resolution images), and thermal cameras which display imagery based on the heat differential between an individual or object and the ambient environmental temperature.

Their range of image capture varies based on a large number of criteria, making it difficult to simply answer the question, "How far can they really see?" For example, the 20-megapixel sensor (5184 x 3888 pixels) of the SkyRanger's HDZoom 30 camera would allow for the maximum of an approximately 43.8cm x 32.9cm (11 x 17 inch) image to be printed at the 300dpi resolution, the current standard for printed photos. Advertising material, however, asserts its ability to locate objects at over 16km.[28] Additionally, the quality of the image faces technological limitations from the height of the RPAS, weather conditions, light levels, humidity, and other environmental factors. Within the surveillance camera industry, the DORI International Standard (IEC EN62676-4: 2015) has been adopted as a means of determining the effectiveness of a given camera. Importantly, it differentiates between a camera's ability to provide a minimum number of pixels across the face, and four levels of the visibility/utility of a collected image:

- detection – determines whether a person is present in a given space (4 px/face, 25 px/m)
- observation – identifies how many people are present and their characteristics, such as distinctive clothing (10 px/face, 63 px/m)
- recognition – confirms whether an individual has been seen before (20 px/face, 125 px/m)
- identification – the possibility to positively identify an individual based on facial features
- (40 px/face, 250 px/m)[29]

A DORI distance calculation can be conducted based on the camera's field of view and horizontal resolution, then calculating the number of pixels that would be captured across the area of an average face.[30] Based on the reported specifications for the RPAS primarily

27 Teledyne FLIR "SkyRanger R70" https://equipnor.com/media/3843/skyranger-r70-brochure-us.pdf.

28 Teledyne FLIR "SkyRanger R70" https://equipnor.com/media/3843/skyranger-r70-brochure-us.pdf.

29 Axis Communications (2022) "Pixel Density: Meeting Operational Requirements in Network Video." https://www.axis.com/dam/public/53/47/fd/pixel-density-en-US-364241.pdf.

30 DORI distance calculators use the number horizontal pixels, along with the lens's shape impact on the field of view. With these measurements, the overall number of pixels within the field of view can be calculated at a given distance, which then can be measured against the size of the average male face at that distance and the number of pixels that would make up that face. That final number of pixels is then measured against the DORI standards. See Active Online "DORI Distance Calculator from Active Online." https://www.activeonline.com.au/free-dori-calculator/.

used by police in Ontario (SkyRanger and DJI Matrice 30T), applying the DORI standard would mean an estimated maximum capability for their more detailed zoom cameras of: detection from a maximum distance of 4,569.6 m, observation from 1,813.3 m, recognition from 913.9 m, and identification from 457 m. These distances are significantly lower for wide angle, thermal, and low-light cameras due to their wider lenses, designed to enable larger fields of view for greater piloting visibility while the craft is in motion (see Table 3.3.1-1).

Table 3.3.1-1. Maximum distances for police RPAS cameras based on the DORI standards, 2024

Cameras	Resolution	Field of view	Detect	Observe	Recognize	Identify
FLIR StormCaster-T	640 x 512	31° to 6°	47.3 m to 244.5 m	18.8 m to 97 m	9.5 m to 48.9 m	4.7 m to 24.4 m
FLIR StormCaster-L	4240 x 2832	39° to 11°	249.2 m to 883.4 m	98.9 m to 350.6 m	49.8 m to 176.7 m	24.9 m to 88.3 m
FLIR StormCaster-E	1920 x 1080	58.1° to 2.3°	75.7 m to 1,913.2 m	30.1 m to 759.2 m	15.1 m to 382.6 m	7.6 m to 191.3 m
FLIR Trillium HD40-XV	1280 x 720	60° to 2.1°	48.9 m to 1,396.9 m	19.4 m to 554.3 m	9.8 m to 279.4 m	4.9 m to 139.7 m
FLIR HDZoom 30	5184 x 3888	68.6° to 2.6°	173.2 m to 4,569.6 m	68.7 m to 1,813.3 m	34.6 m to 913.9 m	17.3 m to 457 m
FLIR EO/IR MK-II	4192 x 3104	58° to 32°	165.6 m to 300.2 m	65.7 m to 119.1 m	33.1 m to 60 m	16.6 m to 30 m
DJI Vue Pro 640	640 × 512	69° to 32°	21.3 m to 45.8 m	8.4 m to 18.2 m	4.3 m to 9.2 m	2.1 m to 4.6 m
DJI Thermal	640 x 512	64°	22.9 m	9.1 m	4.6 m	2.3 m
DJI Wide	4000 x 3000	84°	109.1 m	43.3 m	21.8 m	10.9 m
DJI Zoom	8000 × 6000	unspecified	-	-	-	289 m*
DJI FPV	1920 × 1080	161°	27.3 m	10.8 m	5.5 m	2.7 m
DJI Mini 3 Pro	8064 × 6048	180° to 82.1°	102.7 m to 225.4 m	40.7 m to 89.4 m	20.5 m to 45.1 m	10.3 m to 22.5 m
DraganFly Sony Nex5n	4912 x 3264	107°	105.2 m	41.8 m	21 m	10.5 m

*NB: Resolution refers to the horizontal and vertical measurements of the number of pixels captured by the sensor. Field of view refers to the optical lens of the camera only, as digital zoom does not add pixels and does not alter the number of pixels that make up a face. *Represents a real-world test of the DJI Matrice 30T, flying at 300 ft and 900 ft from the target.*[31]

It should be reiterated that the estimates above are best-case scenario capabilities of the cameras, as real-world weather and atmospheric conditions will impact the DORI distances on any given day. This is particularly true for thermal cameras, as their accuracy depends on measuring temperature difference between an object and its surrounding environment at a distance. A test of the DJI Matrice 30T's HD Zoom camera, conducted in 2022, demonstrated that in daylight, at a height of 300 ft (91.44 m), the horizontal identification distance was approximately 900 ft (274.32 m), making the IEC DORI identification distance (from the RPAS to the target) about 289 m. This result for IEC identification falls within the SkyRanger HDZoom 30 camera's estimated range but is about 160 m below its estimated maximum, making the real-world capability about two-thirds of the estimated maximum range.[32] Therefore, to answer the question of how far these technologies can currently

31 Steel City Drones "DJI Matrice 30 Comprehensive Review and Comparison." https://www.youtube.com/watch?v=oRuTZ-dhxTI&t=1811s.

32 Steel City Drones "DJI Matrice 30 Comprehensive Review and Comparison." https://www.youtube.com/watch?v=oRuTZ-dhxTI&t=1811s.

identify people using real-world tested numbers, consider the example of downtown Toronto. On a clear day, this would mean that if an RPAS was flying directly over the King Edward VII statue at Queen's Park at a height of about 91 m, looking past the War Memorial, it would be capable of identifying people (to the IEC identification standard — 40 px/face, 250 px/m) standing at the Museum station subway entrance, near the corner of Queen's Park Road and Charles Street West, about 270 m away.

With regard to the use of RPAS for the identification of individuals and the development of intelligence, an RPAS industry group recognized the OPP in 2016 for their success in this area, based on data recorded at two separate events involving outlaw motorcycle groups — the Friday the 13th event in Port Dover and the Hells Angels National Run in Ottawa.[33] The majority of news stories, meanwhile, discuss the use of thermal cameras by police to locate missing persons, persons in distress, or suspects trying to evade police, with the earliest known case made public by the RCMP in Saskatoon in 2013.[34]

3.3.2 Laser measurements, AI, streaming, hardware/software applications, and other technologies

In addition to cameras, law enforcement RPAS systems are continually expanding their capabilities, employing additional hardware and software that enable new applications to be carried out. Marketing materials for the two RPAS most commonly deployed by law enforcement in Ontario stress their capacity to use AI and to share data across platforms. Both support chemical, biological, radiation, and explosive (CBRNE) detection hardware, commonly known as "sniffer" technology. They also enable live video streaming and real-time data sharing across a range of devices. Reviewed marketing documents for both product lines identify nine applications and capabilities that are considered standard (see Table 3.3.2-1).

Table 3.3.2-1. SkyRanger and DJI Matrice 30T currently advertised applications and capabilities

Geo-pointing	The use of imaging to estimate the current geographical location of an object
User-defined object tracking	Allowing the user to select an object and have it automatically tracked across a 3D space.
Moving target identification	An automated means of discriminating moving targets from stationary objects (DJI Active Track)
Digital image stabilization	An automated means of shifting a viewed image (within a larger cropped image) to make it appear stable to the user
Target coordinates	An automated means to record the movement of an object or person identified by the user
AI-based people/vehicle detection and classification	A deep-learning-trained neural network to make predictions on new data, eliminating the system's dependence on a central server for image analysis, leading to lower latency, higher reliability, and improved security[35]
Live annotations	The ability to highlight objects, people, or areas of interest for mission management and the distribution of this information to other team members

33 Airborne Public Safety Association 2017 "Unmanned Aerial Systems Award." https://web.archive.org/web/20221129005947/https://publicsafetyaviation.org/2017-award-winners-scholarship-recipients.

34 CBC News, "Aerial Drone Locates Sask. Man Injured in Rollover Crash." May 9, 2013. https://www.cbc.ca/news/canada/saskatchewan/aerial-drone-locates-sask- man-injured-in-rollover-crash-1.1398942.

35 Teledyne FLIR 2019 "How to Build a Deep Learning Classification System for Less than $600 USD" https://www.flir.ca/discover/iis/machine-vision/how-to-build-a-deep-learning-classification-system-for-less-than-$1000/; DJI Enterprise. 2024. "AI Module." https://www.dji.com/ca/ai-module/faq#:~:text=Yes.,run%20AI%20recognition%20algorithms%20offline

Live streaming and cloud mapping	The ability to connect and integrate data across multiple devices and other RPAS, over the internet (Amazon Web Services — ISO/IEC 27001 security certification), as well as stream high- resolution video to multiple devices and device types
Team communication	To transmit information such as team position, drone status, mission details, and other information across multiple device types

NB: The data and wording are drawn from advertising materials for the SkyRanger and DJI Matrice 30 Series RPAS.[36]

Technologically, both SkyRanger and DJI Matrice 30T use AI to allow machine learning for object detection and classification, while also employing dedicated computer vision cameras to aid autonomous flight, including within GPS-denied environments. Both enable data sharing across platforms and with command centres, with the SkyRanger's EO/IR Mk II employing software that captures video, geolocation, and additional metadata in the STANAG 4609 format.[37] This is a standard for motion imagery developed as part of the North Atlantic Treaty Organization (NATO) to ensure a common format for geospatial information across systems and platforms. Marketing materials describe this capability as enabling the onboard development of augmented reality visualizations and overlays across 2D and 3D maps, with embedded location identifiers and tagged objects (including the capacity to identify and calculate the heading and speed of tagged objects). The system can then contribute these data, along with those from other sources, to command centres in real-time.[38]

Alternatively, DJI's Flighthub software enables cloud-based solutions for interoperability, with the capacity to livestream UAV data over multiple devices (2,000 minutes of total viewing per month). It allows for 500GB of data storage and the ability to apply map annotations and overlays. As part of this application, DJI partners with Amazon Web Services (AWS) to facilitate communication across devices connected to the internet, transferring and storing data to the ISO/IEC 27001 security certification standard.[39]

Alternative off-the-shelf SkyRanger sensor packages include three CBRNE onboard testing payload options:

- a chemical sniffer sensor (MUVE C360) capable of detecting carbon monoxide (CO), chlorine (CL2), nitrogen dioxide (NO2), sulfur dioxide (SO2), and a lower explosive limit (LEL) detector
- a biological sniffer sensor (MUVE B330) able to detect spores, bacteria, viruses, and toxins, within the 0.7 to 10 microns range

36 DJI Enterprise 2024 "Matrice 30 Series" https://enterprise.dji.com/matrice-30/ ; DJI Enterprise 2024 "FlightHub 2." https://enterprise.dji.com/flighthub-2; Teledyne FLIR. 2024. "SkyRanger R70 Ecosystem." https://equipnor.com/media/3843/skyranger-r70-brochure-us.pdf.

37 Teledyne FLIR 2021 "EO IR Mk II — High-Fidelity Infrared & High-Definition Daylight Imaging Payload." https://www.flir.ca/products/eo-ir-mk-ii/.

38 North Atlantic Council 2008 "NATO Unclassified STANAG 4609 (Edition 3)." https://archives.defense.gouv.fr/content/download/552732/9407966/file/4586eed3draft.pdf; Teledyne FLIR 2021 "Resolving Border Security Threats with Integrated Solutions." https://www.flir.ca/discover/government-defense/resolving-border-security-threats-with-integrated-solutions/ ; Teledyne FLIR 2021 "EO IR Mk II — High-Fidelity Infrared & High Definition Daylight Imaging Payload." https://www.flir.ca/products/eo-ir-mk-ii/; Aeryon Labs Inc. 2016 "Aeryon Expands Imaging Portfolio with Real-time Video Processing and Next-Generation EO/IR Payload" https://www.prweb.com/releases/aeryon_expands_imaging_portfolio_with_real_time_video_processing_and_next_generation_eo_ir_payload/prweb13757979.htm.

39 DJI Enterprise. 2024. "DJI Flighthub 2." https://enterprise.dji.com/flighthub-2.

- a radionuclide detecting sensor (MUVE R430) employing an energy-compensated Geiger Müller (GM) tube[40]

The DJI Matrice 30 is compatible with six separate sniffer sensor packages (Sniffer4D Mini2, AAM1, AAM2, AAM3, HAZMAT, Oil & Gas, and Landfill), allowing for the detection of hydrocarbons, a capability not available with the SkyRanger model.[41] Other attachments allow the SkyRanger and Matrice 30 RPAS to be fitted with:

- a tether that provides power and communication to the RPAS up to a distance of almost 100 m (328 ft)
- searchlights and broadcast systems (loudspeakers)
- a hook (SkyRanger only) for small package delivery up to 3.49k g (7.7 lbs)[42]

No publicly available information was found that could determine if any of these additional sensor configurations are used in Ontario by law enforcement, though RPAS use for CBRNE testing is identified in a now-archived 2012 report on developing RPAS emergency response programs, written by officers of the Saskatoon Police Service, the OPP, and the DRDC Centre for Security Science.[43]

The DJI Matrice 30T is also equipped with a laser module capable of measuring objects with an accuracy of ± (0.2 m+ distance × 0.15 per cent), with a minimum of 20 per cent reflective surfaces at a distance of 1.2 km.[44] Again, if deployed at Toronto's Queen's Park King Edward VII statue, for example, and aimed past the War Memorial a height of 91 m, its measurement and tracking capacity would almost reach the Davenport and Avenue Road intersection, about 1.1 km away. This distance represents a technological limit, as atmospheric conditions impact laser degradation. Additionally, the accuracy of the measurement decreases as it travels through the atmosphere (the advertised measurement accuracy would be approximately ± 1.85 m at the 1.1 km distance). In application, the Thunder Bay Police Service applied this kind of measurement and mapping in two publicized highway enforcement blitzes in December 2022 and August 2023. In these cases, RPAS technology enabled analysts to measure distances between vehicles and capture photographs of vehicles traveling between two painted lines on the highway. The two instances resulted in more than 50 tickets being issued for following too closely and speeding, while RPAS video footage was also supplied to news media to demonstrate the effectiveness of this kind of enforcement.[45]

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40 Teledyne FLIR. 2024. "SkyRanger R70 Ecosystem." https://equipnor.com/media/3843/skyranger-r70-brochure-us.pdf.

41 Volatus Drones. 2024. "Resources for Government Sniffer4D Mini2." https://volatusdrones.ca/products/sniffer4d-mini2.

42 Teledyne FLIR. 2024. "SkyRanger R70 Ecosystem." https://equipnor.com/media/3843/skyranger-r70-brochure-us.pdf; Volarious. 2024. "V-Line Pro DJI M30 Smart Tethered Kit." https://www.volarious.com/vlinepro-tethered-drone.

43 Engele, Jerome, Marc Sharpe, and John Evans. 2012. Guidebook for Integrating a Micro Unmanned Aerial System (UAS) into Police and Emergency Operations. Defence R&D Canada. https://www.publicsafety.gc.ca/lbrr/archives/cnmcs-plcng/cn25278-eng.pdf.

44 DJI Enterprise 2024 "Matrice 30 Series: Specs" https://enterprise.dji.com/matrice-30/specs.

45 TBNewsWatch 2023 "Thunder Bay Police use Drone to Conduct Traffic Blitz." https://www.youtube.com/watch?v=KJo9aOgNVo0; Thunder Bay Police Service 2023. "TBPS and MTO Conduct Traffic Enforcement Along Dawson Road." https://www.thunderbaypolice.ca/news/tbps-and-mto-conduct-traffic-enforcement-along-dawson-road; Net News Leger 2022 "Thunder Bay Police Go High Tech on Dawson Road." https://www.netnewsledger.com/2022/12/23/thunder-bay-police-go-high-tech-on-dawson-road/ ; TBNewsWatch 2023 "Nearly 50 transport truck drivers ticketed for following too closely." https://www.tbnewswatch.com/local-news/nearly-50- transport-truck-drivers-ticketed-for-following-too-closely-7829891.

4. Innovations and future directions for law enforcement over the next five years

RPAS are no longer simply flying cameras, but they are not yet capable of doing everything, everywhere, all at once. That is, micro and mini RPAS have limited weight carrying capacity and battery power, requiring specialized payloads, and choices still need to be made about what will be carried on a given flight. For example, the SkyRanger can be fitted for small package delivery but at the cost of removing its high-powered HD Zoom Camera.[46] This limitation will diminish as technological advances reduce the size and weight of sensors and tools, however it is important to keep in mind that many of the innovations listed below require specialization. Moving forward, knowledge of an RPAS specific payload is crucial in understanding its capabilities and implications for privacy.

4.1 Developments in other jurisdictions and RPAS awards

To get an understanding of cutting edge and innovative practices in policing using RPAS, this report sought out police services, individuals, and companies that have been given industry awards for innovative practices. The reason for this focus was to separate the expansive imagined possibilities for RPAS use[47] from technologies that have already been tested and are likely to see larger scale implementation over the next five years. RPAS innovation awards were analyzed, with a focus on the International Association of Chiefs of Police (IACP), the DRONE RESPONDERS international organization, the Amazon Web Services Responders X event, and the international Airborne Public Safety Association. Overall, 36 award recipient agencies were reviewed, and several key innovative developmental directions were identified (see Table 4.1-1).

Table 4.1-1. Key innovations in RPAS first responder awards and policing industry reports, 2016 – 2024

Command and control/augmented reality	Innovation in this space focuses on enabling off-site commanding officers to direct decision-making during in-progress events. It includes live streaming data, data transmission over the internet, integrating data from multiple sources, digital identification and tagging of objects and individuals, and transmitting data from a command centre to officers on the ground across various devices.
Drone as first responder chemical identification/sniffer	This innovation is policy-driven and involves ensuring that a non-human drone is always the first to enter an unknown scene, particularly to enhance officer safety. The development of smaller technologies capable of detecting dangerous substances in the air allow for disaster response, HAZMAT operations, chemical spill management, and bomb squad deployments. Other payloads include military grade CBRNE kits.
Protest applications and media	Innovation is enabling officers to identify individuals, record activity, and collect images and video, particularly for public relations and perception management with media sources.
Large events/crowd observation	Innovation in this area involves the capacity to detect individuals in distress, whether physically or mentally, or those acting suspicious within large crowds.

46 BSS Holland. 2024. "Osprey – Package Delivery Payload – SkyRanger R70." https://bssholland.com/product/osprey-package-delivery/.

47 Jackman, Anna 2023. Police Drones: Uses, Challenges, Futures Research Report. University of Reading: Berkshire, United Kingdom. https://research.reading.ac.uk/drone-geographies/wp-content/uploads/sites/271/2023/09/Police-report.pdf.

One-to-many (OTM)	Innovations enable a single operator to pilot and collect data from multiple RPAS flying simultaneously. Canadian Aviation Regulations, section 901.40(2) currently allow one individual to pilot up to five RPAS.[48]
Nested deployment	The permanent housing of RPAS in "nests" or boxes across cities allows for faster deployment and more frequent access to city hot spots. Nests also allow for the quick battery swaps or the use of tethers, with advertising materials claiming this enables 24-hour, continuous operation of a single RPAS for up to 30 days.[49]
5G connectivity	The implementation of 5G technology greatly increases the quality and quantity of data transmission, enabling increased flight range, greater resilience to signal disruption, as well as the use of the internet for data transfer. Specifically, 5G offers technological benefits including: network slicing, or segmenting networks for dedicated uses to eliminate lag in areas with high network volume; multiple-input multiple-output (MIMO), or being able to use parallel streams from different sources to improve signal strength; beamforming, or focusing transmission on a smaller area to improve signal quality and distance; scalable waveforms (orthogonal frequency division multiplexing), which enables higher data-rate communication; and vehicle-assisted RPAS networking, where transmission occurs across multiple devices, like those in police vehicles, rather than relying on a single device.
AI	AI innovations have enabled the identification of specific individuals known to police while also detecting abnormal behaviours of individuals in crowds to identify those in distress or those deemed to be suspicious. AI has also been shown to enable the targeting or "locking on" of individuals or objects, allowing RPAS to automatically track movements and predict destinations.
Mood alteration (light and smell)	Current research indicates that the use of bright light and certain fragrances (the scent of oranges in particular) can help de-escalate violence within crowds by inducing a calming effect, and canisters or lights can be added to RPAS for deployment in these situations.
Wi-Fi hotspot	The inclusion of technology that enables a UAV to act as a Wi-Fi hotspot allows for the tracking of individuals across spaces while also capturing online activity.
Full automation	Technologies like Microavia's drone-in-a-box platform have been deployed internationally, enabling fully automated RPAS operations including deployment, flight plans, data collection, and incident response. These RPAS are also informed in their actions by AI training software.
Sonar	The addition of a sonar package that could be lowered into water allows RPAS to provide sound wave imagery in cases deemed too dangerous for officers to approach the scene.
3D mapping/LiDAR	This includes remote sensing using laser light to produce highly detailed 3D digital maps of spaces and objects.
Geofencing	The ability to identify the current location of an RPAS, an identified object, or person in relation to a known area of interest allows for alerts if they have crossed a threshold and moved into an area or to be aware if they are moving toward or away from that area.

NB: These data were produced through an analysis of RPAS awards presented to first responder organizations, including the International Association of Chiefs of Police, the Airborne Public Safety Association, the Drone Responders organization, and Amazon Web Services/Responder X Labs, as well as reports from the World Police Summit.[50]*

48 Canadian Aviation Regulations (SOR/96-433), Part IX — Remotely Piloted Aircraft Systems, Section 901.40 (2) https://tc.canada.ca/en/corporate-services/acts-regulations/list-regulations/canadian-aviation-regulations-sor-96-433.

49 Lockheed Martin. 2018. "Indago UAS – Dubai Police 10x Initiative." https://www.youtube.com/watch?v=cBBdCePjp0w.

50 International Association of Chiefs of Police. "IACP Leadership in Police Aviation Award." https://www.theiacp.org/awards/iacp-leadership-in-police-aviation-award ; Airborne Public Safety Association. "Past Award Winners & Scholarship Recipients." https://web.archive.org/web/20230127235445/https://publicsafetyaviation.org/recognition/past-award-winners-scholarship-recipients." https://www.droneresponders.org/public-safety-drone-program-awards; Aurora Illinois Police Department. "APD Drone Team honored with Protector Award." https://www.facebook.com/AuroraILPolice/videos/apd-drone-team-honored- with-protector-award/491136341643269/; World Police Summit. 2023. "Police Drones Report." https://rotormedia.com/wp-content/uploads/2023/09/WPS-2023-Drones-Report-6.pdf;

An analysis of award recipient agencies found a wider range of RPAS types in use compared to those being deployed in Ontario. Of note is the more widespread use of mini RPAS which can be flown inside buildings, as well as fixed-wing RPAS, which are capable of having longer flight times and slightly larger payloads. The RPAS types used by these organizations are dominated by products constructed by the Chinese company DJI,[51] in contrast with Ontario's approach — particularly that of the OPP — which focuses on U.S.- and Canadian-manufactured FLIR and Areyon RPAS.[52]

In reviewing the RPAS applications identified within these innovative first responders, there is a much greater focus on command and control and situational awareness. Within the awards and reports, over 20 per cent of recipients stressed the importance of the command-and-control application in their service. As described in these awards, command and control is described as enabling those in positions of authority to observe data collected by one or more RPAS, make decisions about how to approach a given situation, and then effectively communicate this information to those on-the-ground on-site.

In the awards documentation, this oversight and command is facilitated through streaming video of an event, using RPAS to develop 2D or 3D maps of key spaces outside and inside structures, and the transmission of streaming video, still images, annotated maps, or audio communications directly to all relevant staff at the scene via their phones, car computers, or other communications devices. Here, the ability of RPAS data to easily transfer across devices is crucial, with the DJI RPAS using primarily cloud technology and the benefits of network slicing or allowing busy networks to prioritize this communication over a given 5G network. This capability has been identified as greatly reducing or eliminating lag or delays in data transmission. Command and control is also enabled by the ability for several different RPAS to transmit data simultaneously, as well as by one operator's ability to direct multiple semi-autonomous RPAS to fully capture data from a scene. AI systems also benefits command and control with its capacity to identify a subject, lock on to them and track them, as well as overlay annotations or other crucial data onto maps or images, further enhancing command situational awareness and communication.

In practice, RPAS contributions have been described as "stream[ing] HD video back to the department's real-time operations center where the teleoperator, who is a trained critical incident manager, not only controls the drone remotely, but communicates with the units in the field to give them information and tactical intelligence about what they are responding to."[53] From there, authorized officers with internet access can receive streaming video and audio from the operations centre over the cloud.[54] Again, this centralized data collection and command-driven focus is distinctive from the single, specialized operator data collection

51 DJI Enterprises. 2024. "About DJI." https://www.dji.com/ca/company.

52 Airborne Public Safety Association 2017 "Unmanned Aerial Systems Award." https://web.archive.org/web/20210619124649/https://publicsafetyaviation.org/2017-award-winners-scholarship-recipients/2017-unmanned-aerial-systems-award; Teledyne FLIR. 2019. "FLIR Systems Acquires Aeryon Labs." https://www.flir.ca/news-center/press-releases/flir-systems-acquires-aeryon-labs-for-$200m/.

53 City of Chula Vista. 2024. "Drone as First Responder (DFR) Program Overview." https://www.chulavistaca.gov/departments/police-department/programs/uas-drone-program.

54 CAPE, Skyfire Consulting, and the Chula Vista Police Department. 2023. "Drones as First Responder: The Future of Public Safety." https://www.chulavistaca.gov/home/showpublisheddocument/19749/637084636048200000.

model, working on a static scene, that made up the core duties of RPAS law enforcement work in its early years in Ontario.[55]

Also of note is the use of RPAS in tactical operations in deploying mini RPAS with a capacity to enter and map buildings. A larger trend is the introduction of moving RPAS beyond operator line of sight, known as beyond visual line of sight (BVLOS) flights, along with the adoption of DFR policy. Reports from six institutions indicate that an RPAS was deployed to arrive at a scene first or be the first to enter an unknown or dangerous space.

In Chula Vista, California, their DFR program has fully integrated RPAS deployment into policing. Starting in 2018, the Chula Vista Police Department (CVPD) began to automatically deploy RPAS to all service calls within a three-mile (4.82 km) radius of the police station, aiming to provide commanding officers and dispatchers "the ability to see what is going on at an incident before emergency personnel arrive on scene."[56] Due to the success of the DFR program, a second RPAS launch site was added in 2019, and two more RPAS were added to the fleet in 2021. With additional approvals for BVLOS and one-to-many piloting, more than one RPAS can be deployed at a time from the operations centre.

The city falls within an area of approximately 83.6 km^2 (similar in size to Belleville, Ontario), but with two launch sites, RPAS can reach 30 per cent of the of the total area. As a result, RPAS were first on the scene in 70 per cent of priority calls for service, and had an average arrival-on-the-scene-from-the-time-of-dispatch of one minute and 51.15 seconds.[57] These response times are reported to be significantly faster than average patrol response times by over seven minutes for priority 2 calls and three minutes and 39 seconds for the highest priority calls.[58] In regard to privacy, program documentations assert that operators are prohibited from collecting data from locations where persons have a reasonable expectation of privacy, such as their backyards or within private buildings, except in emergency situations or where a judge has issued a warrant. Data retention and access to RPAS data follows CVPD policies on body-worn cameras, with data held in a cloud service and destroyed within a year if not part of an ongoing investigation. These policies around data use and retention, however, are complicated by the program's integration into the city's larger smart cities movement.[59] This use of RPAS in responding to all service calls, capturing data not only at a scene but en route, as well as routinely flying over certain areas of the city in transit to call sites, represent another significant shift in how police services are using RPAS and the potential collection of personal information.

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55 See for example Saulnier, Alana, and Scott Thompson. 2016. "Police RPAS use: institutional Realities and Public Perceptions." Policing 39(4): 685.; Bracken-Roche, Ciara, David Lyon, Mark James Mansour, Adam Molnar, Alana Saulnier and Scott Thompson. 2014. Privacy Implications of the Spread of Unmanned Aerial Vehicles (RPASs) in Canada: A Report to the Office of the Privacy Commissioner of Canada, Under the 2013-2014 Contributions Program. https://www.surveillance-studies.ca/sites/surveillance-studies.ca/files/Surveillance_Drones_Report.pdf.

56 City of Chula Vista. 2024. "Drone as First Responder (DFR) Program Overview." https://www.chulavistaca.gov/departments/police-department/programs/uas-drone-program; Chula Vista Police Department. 2023. "Drone As First Responder (DFR) Program Overview." https://www.youtube.com/watch?v=Hutu_uDI6Z4 57.

57 City of Chula Vista. 2024. "Drone as First Responder (DFR) Program Overview." https://www.chulavistaca.gov/departments/police-department/programs/uas-drone-program.

58 CAPE, Skyfire Consulting, and the Chula Vista Police Department. 2023. "Drones as First Responder: The Future of Public Safety." https://www.chulavistaca.gov/home/showpublisheddocument/19749/637084636048200000.

59 Chula Vista Police Department. 2023. "Unmanned Aerial Systems (UAS) Drone as First Responder (DFR) Program – Brochure." https://www.chulavistaca.gov/home/showpublisheddocument/26822/638308043120970000; City of Chula Vista. 2024. "Smart City." https://www.chulavistaca.gov/businesses/smartcity.

Table 4.1-2. Innovation awards by application for police and fire use of RPAS, 2016 – 2023

Command and control/ situational awareness	28 (20.4%)	Large events	3 (2.2%)
Missing persons/medical distress	19 (13.8%)	Live stream	3 (2.2%)
Tactical	13 (9.48%)	Bomb squad	2 (1.5%)
Disasters (natural, chemical, HAZMAT)	11 (8.02%)	COVID-19 social distancing*	2 (1.5%)
Locating suspects	10 (7.3%)	Efficiency of labour	2 (1.5%)
Traffic reconstruction	8 (5.8%)	Routine policing	2 (1.5%)
Officer safety/risk assessment	8 (5.8%)	Critical infrastructure	1 (0.7%)
Mapping (outside and inside structures)	6 (4.4%)	Fire	1 (0.7%)
Forensics	5 (3.6%)	Grow pp	1 (0.7%)
Protest management	4 (2.9%)	Media relations	1 (0.7%)
Intelligence gathering	3 (2.2%)	Nested deployment	1 (0.7%)
Major crimes	3 (2.2%)	Total**:	137 (100%)

*NB: *COVID-19 applications included the use of a loudspeaker attached to an RPAS to enable radio communications while maintaining social distancing. In the UK, a recording was played to individuals believed to be violating regulations.[60]*

***Several awards identify more than one application. These data were produced through an analysis of RPAS awards presented to first responder organizations, including the International Association of Chiefs of Police, the Airborne Public Safety Association, the Drone Responders organization, and Amazon Web Services/Responder X Labs.[61]*

Innovation in the use of multiple RPAS simultaneously by a single operator (one-to-many) was recognized in 2021, with the Michigan State Police becoming the first agency permitted to deploy multiple craft with a single operator.[62] Another larger trend was the expansion of the types of tools RPAS were designed to carry, with disaster applications receiving recognition for "sniffer" technology capable of detecting dangerous chemical components in the air as part of HAZMAT, chemical spill, bomb squad, and natural disaster work. Among the identified awards, three were allocated to police services in Ontario:

- the OPP in 2017 for their development of a training program and establishment of Canadian standards of use for UAV
- Peel Regional Police in 2019 for innovations in tactical deployment and command and control applications
- York Regional Police's Air Support Unit in 2022 for finding fleeing suspects and coordinating a multiple platform response

60 Jackman, Anna. 2023. Police Drones: Uses, Challenges, Futures Research Report. University of Reading: Berkshire, United Kingdom. https://research.reading.ac.uk/drone-geographies/wp-content/uploads/sites/271/2023/09/Police-report.pdf.

61 International Association of Chiefs of Police. "IACP Leadership in Police Aviation Award." https://www.theiacp.org/awards/iacp-leadership-in-police-aviation-award; Airborne Public Safety Association. "Past Award Winners & Scholarship Recipients." https://web.archive.org/web/20230627150310/https://publicsafetyaviation.org/recognition/past-award-winners-scholarship-recipients; Drone Responders. "Recognition Of Outstanding Public Safety Drone Programs." https://www.droneresponders.org/public-safety-drone-program-awards; Aurora Illinois Police Department. "APD Drone Team honored with Protector Award." https://www.facebook.com/AuroraILPolice/videos/apd-drone-team-honored- with-protector-award/491136341643269/.

62 Airborne Public Safety Association. 2021. "Unmanned Aerial Systems Award." https://web.archive.org/web/20230921085034/https://publicsafetyaviation.org/2021-award-winners-scholarship-recipients.

In relation to privacy, award applications related to protest monitoring, media relations, cannabis grow-op searches, efficiency of labour, large group/crowd management, and nesting RPAS. Several award-winning police services identified the importance of RPAS for the control of protests and protestors, with a focus on identifying participants, documenting criminal activity by key individuals, as well as establishing and presenting officer-driven narratives of events to media sources through the release of selected images and video.

In particular, the Cass County Sheriff's Department (North Dakota), Northeast Region UAS Unit, was recognized in 2018 for work related to the Dakota Access Pipeline protests.[63] In Ontario context, there would be normal privacy concerns related to section 2 of the Charter which protects the right to participate in peaceful demonstrations. However, the new levels of the detail in this collected data, and their purposeful use for the management of media narratives by police services, are somewhat novel, and certainly matters that will continue to develop. For Canadian examples see the Saskatoon Police Service Podcast on Kandrice Singbeil, the Calgary Police Service's Digital Service Unit's Cost of Crime web series, or TBNewsWatch coverage of the Dawson Road blitz.[64]

For large events and crowd management, innovations include the capacity to identify individuals in distress or who exhibit suspicious behaviour. Although not specified in these awards, RPAS AI tracking and identification software capabilities, in combination with the regular monitoring of large crowds, should be an area of interest to those concerned with privacy — particularly in how exactly distress and suspicion are trained and defined within these systems.

Additionally, the capacity for nested RPAS across a city raises concerns regarding mass, ubiquitous surveillance, as this innovation has been shown to work in combination with full automation, one-to-many operation, BVLOS operations, cross-platform data integration, and remote command centres. This combination has the potential to greatly expand areas of operation and develop wide area motion imagery-like (WAMI) capabilities.

In Tijuana, Mexico, a single RPAS was deployed to proactively patrol and monitor public spaces in select neighborhoods in 2016. By 2019 this program expanded to two RPAS able to cover 30 neighborhoods at a time.[65] Similar deployments are also in place in Ensenada, Mexico, where police report that the RPAS program, with a single aircraft, has resulted in a 10 per cent drop in overall crime rates through patrol functions and its ability to rapidly arrive on scene.[66] Constant and ubiquitous monitoring using small RPAS was first implemented by the Dubai Police in 2020, with each RPAS being assigned to a 50 km² area

63 Airborne Public Safety Association. 2018. "Unmanned Aerial Systems Award." https://web.archive.org/web/20230925163439/https://publicsafetyaviation.org/2018-award-winners-scholarship-recipients.

64 Saskatoon Police Service Podcast 2024. "Deals, Debts, & Death." https://saskatoonpolice.ca/podcast/ ; Calgary Police Service. 2023. "Cost of Crime." https://m.facebook.com/watch/21374974529/1657073987743540/; TBNewsWatch 2023 "Thunder Bay Police use Drone to Conduct Traffic Blitz." https://www.youtube.com/watch?v=Kjo9aOgNVo0.

65 Voice of San Diego. 2022. "Inspired by Chula Vista, Tijuana Police Are Flying Drones to Police Neighborhoods." https://voiceofsandiego.org/2022/01/24/inspired-by-chula-vista-tijuana-police-are-flying-drones-to-police-neighborhoods/.

66 Wired. 2018. "A Single Drone Helped Mexican Police Drop Crime 10 Percent." https://www.wired.com/story/ensenada-mexico-police-drone/.

of the city. The system is fully automated with drone-in-a-box technology, which has been in place since 2023.[67]

Police services in Ontario were recognized in three of the reviewed awards for innovation. York Regional Police won the Airborne Public Safety Association's Unmanned Aerial Systems Award in 2022 for the arrest of six fleeing suspects through a UAS-coordinated, multi-platform response involving RPAS, a helicopter, and ground personnel.[68] Peel Regional Police also won this same award in 2019 for tactical and command and control applications.[69] The OPP were recognized in 2017 for a range of applications, primarily for their leadership in expanding the use of RPAS in Canada with their establishment of a Transport Canada-accredited RPAS academy training course for law enforcement personnel from across the region.[70]

4.2 WAMI and integrated data collection

The technology used by police services in the U.S. with the most comprehensive potential privacy impact for aerial imaging technologies is the Persistent Surveillance System's Aerial Investigation Research (AIR) Program. Also known as the "spy plane," the Baltimore Police Department used AIR in 2016 and again over a six-month period from April to December 2020. The aerial vehicle employed the Hawkeye Wide Area Imaging System,[71] which limited the camera resolution to one pixel per half metre, and a capacity to capture visual data simultaneously over a 64 km^2 space.[72] Again, using the Toronto example, with its centre the Queen's Park statue, this would constitute constant and complete data capture within a 8 km by 8 km square, with approximate boundaries at the Eglington subway station (Yonge Street and Eglington Avenue) to the north, Riverdale Farm (near Gerard Street East and the Don Valley Parkway) to the east, Harbourfront Centre (Queens Quay West) to the south, and the Museum of Contemporary Art Toronto (near Dundas Street West and Bloor Street West) to the west.

The technology has been described by its founding company as being Google Earth with TiVo, as it allows operators to pause, rewind, rewatch, and fast-forward through images, to track the movement of everyone and everything larger than a half a metre across a 64 km^2 area of a city over an entire day.[73] With this technology, police can obtain the location of a

67 World Police Summit. 2023. "Police Drones Report." https://rotormedia.com/wp-content/uploads/2023/09/WPS-2023-Drones-Report-6.pdf ; UAS Weekly. 2023. "Airobotics and Dubai Police Partner to Deploy Drone-in-a-Box Infrastructure and Aerial Defense Solutions." https://uasweekly.com/2023/03/13/airobotics-dubai-police-aerial-defense-solutions/ ; Inside Unmanned Systems. 2021. "Airobotics UAS to Be Deployed Over Dubai During Expo 2020." https://insideunmannedsystems.com/airobotics-uas-to-be-deployed-over-dubai-during-expo-2020/; Microavia 2024. "Microavia Unveils the Strategic Importance of Drones for Security." https://microavia.com/microavia_unveils_the_strategic_importance_of_drones_for_security

68 Airborne Public Safety Association. 2022. "Unmanned Aerial Systems Award." https://www.youtube.com/watch?v=JGyBERj537c.

69 Airborne Public Safety Association. 2019. "Unmanned Aerial Systems Award." https://web.archive.org/web/20221129011810/https://publicsafetyaviation.org/2019-award-winners-scholarship-recipients.

70 Airborne Public Safety Association. 2017. "Unmanned Aerial Systems Award." https://web.archive.org/web/20221129005947/https://publicsafetyaviation.org/2017-award-winners-scholarship-recipients.

71 Persistence Surveillance Systems (PSS). 2023. Technology https://www.pss-1.com/technology.

72 Persistence Surveillance Systems (PSS). 2023. HawkEye II EO. https://www.pss-1.com/hawkeye-ii.

73 The Guardian. 2016. "Baltimore police confirms aerial surveillance of city residents." https://www.theguardian.com/us-news/2016/aug/24/baltimore-police-aerial-surveillance-cameras.

reported crime and then rewind to see what people and vehicles were present on the scene and their movements after the incident.

Although these images alone would not contain sufficient pixels across a face for identification at the DORI standard, and light and visibility limitations restrict data collection to daylight flights in relatively good weather,[74] the technology's benefits to policing and its key privacy impacts are:

- The capacity to track individuals and vehicle movement across a large area of the city.
- Integration with ground-based data collection tools, including red-light cameras, automated licence plate readers (ALPRs), police service computer-aided dispatch, Shot Spotter technology, and private surveillance cameras registered with police as part of the CitiWatch program.[75]

More specifically, these data are not for real-time use, but for later investigations where the AIR program's "when-and-where" location data enhance the identifying capabilities of stationary on-the-ground cameras and other data collection tools.[76]

Over the period of use in 2020, data collected through the AIR program enabled the visualization of 14 per cent of all reported crimes in Baltimore, provided actionable evidence for police officers in 75 per cent of those cases which were investigated, and ultimately increased the rate of clearing or solving cases by two to 16 per cent in the cases where AIR program data were used.[77]

When challenged in court, the program's warrantless operation was ultimately deemed unconstitutional under the Fourth Amendment, which protects against unreasonable search and seizure — even though Privacy by Design practices had limited the resolution of collected images (current WAMI military cameras are reported to be at least 8.1-gigapixel EO with 180-megapixel IR).[78] The U.S. Court of Appeals for the Fourth Circuit found that "the AIR program enable[d] police to deduce from the whole of individuals' movements" and, as a result, accessing the image data from the program was found to legally constitute a search requiring a warrant. This ruling relied on *United States v Jones*, 565 US 400 (2012) and *Carpenter v United States*, 138 S Ct 2206 (2018), which address the shift in

74 Rand Corporation. 2021. Preliminary Findings from the Aerial Investigation Research Pilot Program. Page 2 https://www.pss-1.com/_files/ugd/3489dc_8de8d4ba5fed42b281b9cb33dfc39706.pdf.

75 Rand Corporation. 2021. Preliminary Findings from the Aerial Investigation Research Pilot Program. Page 3 https://www.pss- 1.com/_files/ugd/3489dc_8de8d4ba5fed42b281b9cb33dfc39706.pdf; The Policing Project. 2020. Civil Rights and Civil Liberties Audit of Baltimore's Aerial Investigation Research (AIR) Program. https://www.pss-1.com/_files/ugd/3489dc_369b07464020491e81762edf4aedd855.pdf; City of Baltimore 2024 CityWatch https://cityservices.baltimorecity.gov/citiwatchresident.

76 The Policing Project. 2020. Civil Rights and Civil Liberties Audit of Baltimore's Aerial Investigation Research (AIR) Program. https://www.pss-1.com/_files/ugd/3489dc_369b07464020491e81762edf4aedd855.pdf ; United States Court of Appeals for the Fourth Circuit. 2021. Leaders of a Beautiful Struggle; Erricka Bridgeford; Kevin James V Baltimore Police Department; Michael S. Harrison, In His Official Capacity As Baltimore Police Commissioner. No. 20-1495 (Fourth Cir. 2021). https://cdn.vox-cdn.com/uploads/chorus_asset/file/22680040/fourth_circuit_decision_baltimore_june_24_2021.pdf

77 Rand Corporation 2021 Preliminary Findings from the Aerial Investigation Research Pilot Program. Page 3-4 https://www.pss- 1.com/_files/ugd/3489dc_8de8d4ba5fed42b281b9cb33dfc39706.pdf.

78 United States Court of Appeals for The Fourth Circuit. 2021. Leaders of A Beautiful Struggle; Erricka Bridgeford; Kevin James V Baltimore Police Department; Michael S. Harrison, in his official capacity as Baltimore Police Commissioner. No. 20-1495 (Fourth Cir. 2021). https://cdn.vox-cdn.com/uploads/chorus_asset/file/22680040/fourth_circuit_decision_baltimore_june_24_2021.pdf ; SNC. 2024. "Gorgon Stare Wide-Area Motion Imagery (WAMI)." https://www.sncorp.com/capabilities/wide-area-motion-imagery/

how collected data is interpreted — from single instances of data collection regarding an individual's movement in public, where there is no expectation of privacy, to what was deemed long-term monitoring of an individual's movements in the public sphere.[79]

This second long-term collection was found to infringe upon an individual's reasonable right to privacy, as it captured "the whole of [a person's] physical movements."[80] In doing so, it can reveal "intimate details through habits and patterns," not only of an individual's "particular movements, but through them [their] familial, political, professional, religious, and sexual associations." Importantly, this technology was deemed to be distinctive from the police simply "tail[ing] suspects," which would not be protected, because in using this long-term "retrospective data" or data with a capacity to access the past, police would not need to "know in advance whether they want[ed] to follow a particular individual" and as a result, would be violating the expectation of privacy that people have in the whole of their movements.[81]

5. Capabilities of small to mid-sized RPAS today, in five years, and military trends

Given the trend of military technological innovations later being marketed for civilian law enforcement, it is important to look to these sources to assess potential future directions for RPAS use by police services in Ontario. This section features data drawn from a set of requirements developed by DRDC for the procurement of the Canadian Armed Forces' RPAS under the Remotely Piloted Aircraft System Project (previously the Joint UAS Surveillance and Target Acquisition System under the Air Force), as well as publicly available information on Canada's procurement of RPAS for Ukraine and their applications in the field.[82]

5.1 Payloads and sensors

In its 2018 procurement documents for RPAS, the Remotely Piloted Aircraft System Project identified its full complement of sensors, including EO/IR, electronic support measures (ESM), synthetic aperture radar (SAR), signals intelligence (SIGINT), and automatic identification system (AIS). These documents also specify several capabilities that would need to be achieved by the sensor packages of any UAC under consideration for purchase (see Table 5.1-1).

79 Carpenter, 138 S. Ct. at 2217

80 United States Court of Appeals for the Fourth Circuit. 2021. Leaders of a Beautiful Struggle; Erricka Bridgeford; Kevin James V Baltimore Police Department; Michael S. Harrison, In His Official Capacity As Baltimore Police Commissioner. No. 20-1495 (Fourth Cir. 2021). https://cdn.vox-cdn.com/uploads/chorus_asset/file/22680040/fourth_circuit_decision_baltimore_june_24_2021.pdf.

81 United States Court of Appeals for the Fourth Circuit. 2021. Leaders of a Beautiful Struggle; Erricka Bridgeford; Kevin James V Baltimore Police Department; Michael S. Harrison, In His Official Capacity As Baltimore Police Commissioner. No. 20-1495 (Fourth Cir. 2021). https://cdn.vox-cdn.com/uploads/chorus_asset/file/22680040/fourth_circuit_decision_baltimore_june_24_2021.pdf.

82 Ball, M.G. 2018, "JUSTAS Requirements." https://pubs.drdc-rddc.gc.ca/BASIS/pcandid/www/engpub/DDW?W%3DSYSNUM=806064&r=0.

Table 5.1-1. Sensors packages required in Canadian procurement documents, 2018

EO/IR	Imaging sensors that capture both visible light (EO) to generate of colour images or streaming video, and infrared light (IR) with wavelengths above red visible light. More simply, IR sensors identify heat radiating from a surface or a person.
ESM/electronic support	Refers to a range of electromagnetic sensors that can intercept, identify, analyze, and locate hostile sources of electromagnetic radiation while providing protection against electronic attacks.
SAR	A tool for remote sensing that bounces microwave radar signals off the Earth's surface to identify and map physical surfaces and objects. It is very similar to LiDAR laser technologies but uses microwaves.
SIGINT	Refers to sensors capable of intercepting electronic signals from communications systems, radar, and weapon systems. These intercepted signals are then used to generate intelligence about the source of these data.
AIS	A sensor capable of detecting ship transponder data, allowing for the identification and tracking of ships equipped with transponders over the VHF band.

NB: Data from this table is drawn from Ball, M.G. 2018, "JUSTAS Requirements." https://pubs.drdc-rddc.gc.ca/BASIS/pcandid/www/engpub/DDW?W%3DSYSNUM=806064&r=0.

In reviewing current and projected RPAS military capabilities and applications, there are direct connections to law enforcement trends. First and foremost, technological similarities in the use of cameras for identification and streaming video demonstrate similar applications, though military cameras remain far superior. For example, armed forces RPAS are mounted with at least 8.1-gigapixel EO cameras and 180-megapixel IR cameras, giving them 405 times the image resolution of the SkyRanger 70 EO cameras used by police services in Ontario.[83] Also similar is the development of 3D surface or object maps using SAR sensors, which have been used to plan and know the terrain of a given battlespace with fewer concerns over weather conditions compared to law enforcement RPAS using LiDAR sensors.[84] Additionally, this type of surface mapping can be used to detect hidden structures or infrastructure, measure environmental changes though changes in ice levels or deforestation, identify changes in land surfaces after earthquakes or landslides, and monitor minute changes in critical infrastructure like dams and bridges.[85] The only sensors that do not yet have an equivalent in the law enforcement RPAS identified as part of this report are ESM. These sensors work to detect disruptive attacks or RPAS-to-operator communication interference by analyzing electromagnetic field data.

The armed forces sensors which pose the greatest concern for privacy, in addition to EO/IR cameras, are those related to the collection of SIGINT data. In military applications, these sensors intercept individuals' electronic signals within a target area and then use those data to develop detailed understandings about individual movement, communications, and social connections to predict future actions. In law enforcement, some sensors can already act as Wi-Fi hotspots and gather some electronic communications, though the

83 SNC. 2024. "Gorgon Stare Wide-Area Motion Imagery (WAMI)." https://www.sncorp.com/capabilities/wide-area-motion-imagery/ ; Teledyne FLIR. 2024. "SkyRanger R70 The Future of Multi-Mission Small UAS." https://farrwest.com/wp-content/uploads/2024/05/SkyRangerR70DataSheet.pdf.

84 DragonFly Aerospace. 2024. "7 Applications of SAR." https://dragonflyaerospace.com/seven-applications-of-sar/#:~:text=It%20is%20used%20for%20reconnaissance,infrastructure%2C%20providing%20essential%20intelligence%20information.

85 DragonFly Aerospace. 2024. "7 Applications of SAR." https://dragonflyaerospace.com/seven-applications-of-sar/#:~:text=It%20is%20used%20for%20reconnaissance,infrastructure%2C%20providing%20essential%20intelligence%20information.

centrality of SIGINT sensors within the armed forces RPAS programs may further pressure the development of additional sensors designed to capture, record, and analyze civilian cell phone data and other digital communications through technologies like Wi-Fi hotspots, cell-site simulators, IMSI catchers, and DRT boxes.[86]

5.2 Trends in applications

In addition to payload censor capabilities, Canada's 2018 procurement requirements for RPAS identified three applications that new aircraft must support. The first is constant data collection, or 24/7 coverage over a 90,000 square nautical mile (approximately 166,680 km^2) area. The second is the ability to conduct POLA. The third is to allow for remote split operations (RSO) (see Table 5.2-1).

Table 5.2-1. Required applications in Canadian procurement documents, 2018

POLA*	This application uses all RPAS sensors (EO/IR, SAR, SIGINT) to analyze the daily lives of those who are monitored through visual data on movements and electronic cell phone and online activity captured via SIGINT sensors. It can identify normal patterns within a person's life, or a group of people's lives, and detect anomalies.
RSO	This refers to the separation of piloting aircraft locally, allowing pilots to control aircraft from command centres thousands of kilometres away.[87]
Ground Moving Target Indicator (GMTI)	This is a form of radar application used to identify and single out real, selected targets, and maintain the clarity of signals, filtering out random, unwanted, return information, or "clutter" radar data. Additionally, it analyzes data from radar signals to identify a target's mechanical properties and its movement.
Visual and aural covertness	The ability for the RPAS to collect data and perform its a mission without the capacity to be seen or heard by adversaries.

NB: Data for this table is summarized from Ball, M.G. 2018, "JUSTAS Requirements." https://pubs.drdc-rddc.gc.ca/BASIS/pcandid/www/engpub/DDW?W%3DSYSNUM=806064&r=0 **Requisition documents make reference to "pattern of life assessment," however, the term more prevalent in the literature is "pattern of life analysis" (POLA).*

Of the applications identified in the procurement documents, the one most directly related to privacy is POLA. As noted above, POLA involves the very detailed and personal capture of data to not only identifying individuals and their actions, but also to determine patterns of routines, movements, and personal connections, at a community level. It is used to identify:

- actions that are normal across a given community
- single actions that are anomalies in an individual's routine
- variance in an individual person's pattern of life compared to an expected norm or observed community norm of behaviour

Further, the procurement documents specify that 24-7 coverage is a necessary requirement for any purchased RPAS, with a minimum coverage of at least 30 days.[88] As outlined in section 5.2, the use of WAMI in Baltimore enabled police to pause, rewind, and replay

86 Namuduri, Kamesh. 2017."Flying cell towers to the rescue." IEEE Spectrum 54(9). https://ieeexplore.ieee.org/abstract/document/8012238; Miyano, Kosei, Ryoichi Shinkuma, Narushige Shiode, Shino Shiode, Takehiro Sato, and Eiji Oki. 2020. Multi-RPAS Allocation Framework for Predictive Crime Deterrence and Data Acquisition." Internet of Things 11. https://doi.org/10.1016/j.iot.2020.100205.

87 Martin, Matt. 2015. "Remote-Split Operations and Virtual Presence: Why the Air Force Uses Officer Pilots to Fly RPAS."18th International Symposium on Aviation Psychology, 566-571.

88 Ball, M.G. 2018, "JUSTAS Requirements." https://pubs.drdc-rddc.gc.ca/BASIS/pcandid/www/engpub/DDW?W%3DSYSNUM=806064&r=0.

surveillance footage, essentially combining Google Earth and TiVo capabilities for a visual record of an entire community. POLA would extend this capacity significantly by incorporating digital data collection into this pattern-of-life picture. The Baltimore case serves as an example, as it was a test case but was ultimately terminated due to the program's unconstitutionality. It should be understood that POLA, if used by law enforcement agencies, would be considerably more intrusive than what was tested in Baltimore. Here, Canada's constitutional limitations could make this technological application prohibitive for police services in Ontario. To perform the type of analytics necessary for effective POLA on such a large scale, the U.S. incorporated the use of AI under the Algorithmic Warfare Cross-Functional Team, known as Project Maven, in 2018.[89] As described by Google employees, Project Maven is a "customized AI surveillance engine that uses 'Wide Area Motion Imagery' data captured by US Government drones to detect vehicles and other objects, track their motions, and provide results to the Department of Defense."[90] More specifically, its "initial goal was to provide the military with advanced computer vision, enabling the automated detection and identification of objects in as many as 38 categories captured by a drone's full-motion camera," subsequently "provid[ing] the department with the ability to track individuals as they come and go from different locations."[91]

The potential analytical power of this tool was so alarming that Google staff contracted to work on the project issued an internal petition against it, gathering over 4,000 employee signatories and sparking a "do the right thing" sticker campaign at the company's New York offices.[92] Ultimately, Google opted not to renew its contract for the program, and stated it would develop a set of core AI principles to direct future decision-making regarding contract work. The project's application and functionality, however, remain.[93] In a 2018 statement, Google explained that the "open-source object recognition software" used by the Pentagon as part of Project Maven was "available to any Google Cloud customer."[94] By 2024, Google Vision API advertised its capacity to use AI to effectively identify multiple objects within an image, generate metadata detailing the position of the object and rectangular bounds for the part of the image that makes up that object.[95] Objects are identified through AI training,

89 Gizmodo. 2018. "Google Is Helping the Pentagon Build AI for Drones." https://gizmodo.com/google-is-helping-the-pentagon-build-ai-for-drones-1823464533 ; Allen, Greg and Tanielk Chan. 2017. Artificial Intelligence and National Security: A Study on Behalf of Dr. Jason Matheny, Director of the US Intelligence Advanced Research Projects Activity (IARPA). Harvard Kennedy School Belfer Centre for Science and International Affairs.

90 New York Times. 2018. "Google Employee Petition Full Text." https://static01.nyt.com/files/2018/technology/googleletter.pdf.

91 Gizmodo. 2018. "Google Is Helping the Pentagon Build AI for Drones." https://gizmodo.com/google-is-helping-the-pentagon-build-ai-for-drones-1823464533.

92 The New York Times. 2018. "How a Pentagon Contract Became an Identity Crisis for Google." https://www.nytimes.com/2018/05/30/technology/google-project- maven-pentagon.html ; Fedscoop. 2019. "Google's departure from Project Maven was a 'little bit of a canary in a coal mine.'" https://fedscoop.com/google-project- maven-canary-coal-mine/#:~:text=Google%27s%20take%20on%20Project%20Maven&text=Walker%20explained%20Google%20stepping%20away,internal%20standards%20and%20revi ew%20processes.

93 Fedscoop. 2019. "Google's departure from Project Maven was a 'little bit of a canary in a coal mine.'" https://fedscoop.com/google-project-maven-canary-coal- mine/#:~:text=Google%27s%20take%20on%20Project%20Maven&text=Walker%20explained%20Google%20stepping%20away,internal%20standards%20and%20revi ew%20processes.

94 The New York Times. 2018. "How a Pentagon Contract Became an Identity Crisis for Google." https://www.nytimes.com/2018/05/30/technology/google-project- maven-pentagon.html.

95 Google Cloud. 2024. "Cloud Vision API: Detect Multiple Objects." https://cloud.google.com/vision/docs/object-localizer.

with the technology also applying a machine-generated identifier (MID) label to each object entered within Google's Knowledge Graph database.[96] This technology has also been applied to humans, with face detection using body landmarks for identification, creating a capacity to search not only by face, but also by emotional state (with degrees of confidence of image properties, such as joy, sorrow, anger, surprise, and others) and other things like "headwear."[97]

Moving forward, pressures from military applications suggest a continued push for law enforcement technologies that offer the capabilities that POLA currently provides for military operations. More specifically, trends in military RPAS applications may drive demand for the following technologies:

- further development and application of WAMI
- advancements in tracking and identification AI software, as object recognition software in this area has been available on the open market through Google since at least 2018
- expanded development and adoption of digital data collection, including cell phone and internet data, through sensors working as Wi-Fi or cell-site simulators, IMSI catchers, and DRT boxes[98]

5.3. The Ukraine–Russia conflict and future applications

The war in Ukraine is bringing the future trends of drone warfare into view, with a significant shift from the use of mostly large Class 3 (600 kg+) RPAS for surveillance and missile strikes to a large diversity of small Class 1 (under 150 kg) and medium-sized Class 2 (150 kg to 600 kg) aircraft. This includes the identical DJI and FLIR RPAS models used in law enforcement in Ontario.[99] The main reason for this shift to smaller and even off the shelf consumer RPAS is that Ukraine does not have superiority over the combat airspace. This removes the relative safety that previous, large-sized drone dominated RPAS flights enjoyed during previous conflicts.[100] Although Ukrainian firefight data indicates that most casualties remain the result of human combat rather than drones, the use of small and medium RPAS has significantly changed how these technologies will have to be understood, both as an offensive weapon and posing a tactical risk that needs to be defended against.[101] The

96 Google. 2012. "Introducing the Knowledge Graph: things, not strings." https://blog.google/products/search/introducing-knowledge-graph-things-not/.

97 Google Cloud. 2024. "Cloud Vision API: Detect Faces." https://cloud.google.com/vision/docs/detecting-faces

98 World Police Summit. 2023. "Police Drones Report." https://rotormedia.com/wp-content/uploads/2023/09/WPS-2023-Drones-Report-6.pdf.

99 Kunertova, Dominika. 2023. "The War in Ukraine Shows the Game-Changing Effect of Drones Depends on the Game." Bulletin of the Atomic Scientists 79(2). https://www.research-collection.ethz.ch/bitstream/handle/20.500.11850/606858/6/ThewarinUkraineshowsthegamechangingeffectofdronesdependsonthegame.pdf; Technical Airworthiness Authority Advisories. 2013. "Continuing Airworthiness Requirements for Uncrewed Aircraft Systems."

100 Shaw, Ian. 2013. "Predator Empire: The Geopolitics of US Drone Warfare." Geopolitics 18(3). https://doi.org/10.1080/14650045.2012.749241 ; Hall, Cargill. 2014. "Reconnaissance Drones: Their First Use in the Cold War." Air Power History 61 (3): 20–27. http://www.jstor.org/stable/26276490 ; Hudson, Leila, Colin Owens, and Matt Flannes. 2011. Drone Warfare: Blowback from the new American Way of War. Middle East Policy 18(3). https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1475-4967.2011.00502.x?msockid=399d8e5dc35868393dbf9deac2f26920.

101 Eslami, Mohammad. 2022. "Iran's Drone Supply to Russia and Changing Dynamics of the Ukraine War." Journal for Peace and Nuclear Disarmament 5(2). https://doi.org/10.1080/25751654.2022.2149077; Kunertova, Dominika. 2023. "Drones have boots: Learning from Russia's war in Ukraine." Contemporary Security Policy 44(4). https://doi.org/10.1080/13523260.2023.2262792.

conflict has increased demand on the RPAS industry, with 10,000 drones destroyed and in need of replacement each month just on the Ukrainian side.[102] In terms of new applications, data from Ukraine has shown that RPAS are becoming stealthier, speedier, smaller, more lethal and easily operable, and available to more actors.[103] More specifically, new applications:

- providing real-time battlefield views streaming directly to individual soldiers for situational awareness[104]
- changing the tempo and accuracy of artillery fire through real-time visualization and mapping[105]
- using RPAS as loitering munitions, aircraft with explosives that hover over target locations for extended periods to increase destructive impact[106]
- media messaging and perception management, using RPAS to document incidents that demoralize adversaries and mobilize global attention[107]
- swarming techniques, where a larger group of RPAS fly in formations to confuse detection or where RPAS are interconnected in a group and use AI to autonomously aid each other to reduce the impact of jamming piloting signals[108]
- bomb-dropping or suicide drones, which fly into targets or are placed as aerial minefields for other aircraft[109]

Regarding how this will shift understandings and the applications of Class 1 RPAS in law enforcement, the vast spending on the war effort in multiple countries will push the technology to become faster, more affordable, and offer greater processing power. However, as of 2024, these pressures have been documented more for Class 2 RPAS, which are significantly larger than the craft flown by Canadian law enforcement.[110] The use

102 PBS Newshour. 2023. "How Drone Warfare has Transformed the Battle Between Ukraine and Russia." https://www.pbs.org/newshour/show/how-drone-warfare- has-transformed-the-battle-between-ukraine-and-russia#:~:text=Earlier%20in%20the%20war%2C%20outside,for%20Russia%27s%20superior%20electronic%20warfare.

103 Kunertova, Dominika. 2023. "The War in Ukraine Shows the Game-Changing Effect of Drones Depends on the Game." Bulleting of the Atomic Scientists 79(2). https://www.research-collection.ethz.ch/bitstream/handle/20.500.11850/606858/6/ThewarinUkraineshowsthegamechangingeffectofdronesdependsonthegame.pdf.

104 Page, J. M. 2022. "Drones in Ukraine: Claims, Concerns and Implications." Royal United Services Institute. https://www.rusi.org/explore-our- research/publications/rusi-newsbrief/drones-ukraine-claims-concerns-and-implications.

105 Watling, Jack and Nick Reynolds. 2022. "Ukraine at War Paving the Road from Survival to Victory." Royal United Services Institute. https://www.rusi.org/explore- our-research/publications/special-resources/ukraine-war-paving-road-survival-victory.

106 Kunertova, Dominika. 2023. "The War in Ukraine Shows the Game-Changing Effect of Drones Depends on the Game." Bulletin of the Atomic Scientists 79(2). https://www.research-collection.ethz.ch/bitstream/handle/20.500.11850/606858/6/ThewarinUkraineshowsthegamechangingeffectofdronesdependsonthegame.pdf; Voskuijl, Mark. 2022. "Performance analysis and design of loitering munitions: A comprehensive technical survey of recent developments." Defence Technology 18(3). https://doi.org/10.1016/j.dt.2021.08.010.

107 Kunertova, Dominika. 2023. "The War in Ukraine Shows the Game-Changing Effect of Drones Depends on the Game." Bulletin of the Atomic Scientists 79(2). https://www.research-collection.ethz.ch/bitstream/handle/20.500.11850/606858/6/ThewarinUkraineshowsthegamechangingeffectofdronesdependsonthegame.pdf.

108 Scharre, Paul. 2014. "Robotics on the Battlefield Part II: The Coming Swarm." Center for a New American Security. http://files.cnas.org.s3.amazonaws.com/documents/CNAS_TheComingSwarm_Scharre.pdf.

109 Gettinger, Dan. 2022. "Phoenix Ghosts are Part Drones, Part Missiles. How Does That Change Combat?" Bulletin of the Atomic Scientists. https://thebulletin.org/2022/06/phoenix-ghosts-are-part-drones-part-missiles-how-does-that-change-combat/.

110 Kunertova, Dominika. 2023. "The War in Ukraine Shows the Game-Changing Effect of Drones Depends on the Game." Bulletin of the Atomic Scientists 79(2). https://www.research-collection.ethz.ch/bitstream/handle/20.500.11850/606858/6/ThewarinUkraineshowsthegamechangingeffectofdronesdependsonthegame.pdf.

of small RPAS for situational awareness — real-time visualization of soldiers on-the-ground — as well as their ability to be invisible during flights, are capabilities that have already been introduced in police work in North America. However, their prevalence in this conflict and the subsequent pressure on industry to further develop these capabilities as a part of this conflict could make this a greater trend in law enforcement.

6. New and emergent privacy risks

On the subject of privacy, changes in aircraft design, sensors, data collection, and novel RPAS applications identified in this report each, in their own way, highlight the need to reconceptualize privacy and address the new risks introduced by these innovations. More specifically, these evolving perspectives on how RPAS are used and what they are capable of bringing forward risks related to routine deployment, the difficulty in detecting whether a drone is collecting data about a person, the use of data to create narratives about people, and the ability to draw together AI and the multiplicity of sensor data to develop detailed understandings of the patterns of peoples' lives (see Table 6.0-1).

Table 6.0-1. New and emergent privacy risks in small and medium RPAS

Normalized use/ DFR	The shift of RPAS from specialized, pre-planned, and relatively rare deployments with line-of-sight pilots, to their integration of RPAS into everyday police practices, (in some cases all calls for service – Drone as First Responder (DFR)). Some are, and flown beyond visual line of sight (BVLOS) from remote command centres.
RPAS patrols and hotspots	The use of RPAS to routinely hover or fly over a community identified as having an elevated risk for crime.
Visual and aural covertness	The trend of RPAS cameras improving in resolution and RPAS decreasing in size, making them harder for the public to detect, which risks limiting the public's role in identifying misuse and bringing cases to the attention of the IPC.
Media narratives and perception management	The use of collected personal information to create media packages designed to persuade the general public of a certain narrative or to increase public engagement by presenting people's lives as true crime documentaries.
POLA	The collection and analysis of very large amounts of image and digital data — usually in a military context — about the movements and daily life of a community of people. This enables the identification of an individual's deviation from established patterns in group activity or from the established pattern in an individual of interest's personal life.

6.1 Normalized use/DFR

In Ontario and elsewhere, RPAS use by police services has become largely normalized, shifting from specialized, application-specific, and well-planned deployments to an integral part of everyday police work. This means that previous guidance on privacy protection and best practices no longer reflect the realities of how RPAS are deployed in the field. Previously, police services would know that their RPAS would, for example, be deployed to photograph a crime scene as part of an ongoing investigation, on a given day, at a given time. As a result, they could review privacy concerns as part of pre-flight planning. This is increasingly not the case and previous best practice workflows in relation to privacy may no longer be seen as practical or effective. Additionally, in jurisdictions such as Esley, Clovis, Pearland, Chula Vista, York County, and others in the U.S., police have adopted a DRF policy, vastly accelerating the process of RPAS deployment and the frequency of flights, as

RPAS are now mandated to be deployed to every service call. In the case of Chula Vista, California, RPAS launch from either department headquarters or a secondary launch site and are operated from a central command centre, BVLOS. As a result, these RPAS collect data flying to and from each call for service. This normality, the need to deploy quickly, and integration into regular police responses present new risks to privacy, as the potential for over-collection of personal information is high, while current guidance documents do not account for the realities of these new forms of deployment.

6.2 RPAS patrols and hotspots

RPAS patrol and hotspots refers to the routine deployment of RPAS over areas of a city identified as being at greater risk for criminal behaviour. In Ensenada, Mexico, for example, RPAS patrols have become routine, giving officers almost instant access to areas with calls for service. Added to this quick access is the fact that the RPAS effectively captures the comings and goings of all those within the area under surveillance. With their elevation, capacity for multi-sensor data collection, and the retention of these data, RPAS patrols represent a greater and novel challenge to privacy that is significantly different from patrols in cars or on foot. The reported success of this method in news media and by other police services at conferences, and the very real potential of the expansion of these practices to Ontario, represent an emerging privacy risk. As was noted of Baltimore's AIR program (see section 4.2), constant RPAS patrols can invade privacy by uncovering the movements, social connections, and actions that make up the whole of a person.[111] Additionally, RPAS police patrols in Dubai, UAE, have been designed specifically for this kind of continuous, ubiquitous surveillance, which, in a Canadian context, would certainly pose the risk of over-collection of personal information.

6.3 Visual and aural covertness

Visual and aural covertness refers to the growing inability to know whether a drone is collecting data about you. As RPAS become smaller, the sensor technology gets better, and more piloting is conducted BVLOS, it is becoming harder for the general public to see or recognize in the moment that their private data are being collected. This trend poses an emerging privacy risk, especially since police services in North America are deploying a larger number of small and micro RPAS. The DJI Mini 3 Pro used by the North Bay Police Service, for example, is only 362 mm wide by 72mm high but is capable of observing to the DORI standard from a distance of up to 89.4 m and identifying faces from up to 22.5 m. Meanwhile, the larger SkyRanger, used by eight different law enforcement agencies in Ontario, is only 1.35 m in length and can identify faces up to a maximum of 289 m away. These distances are shorter at night with IR cameras, but a black RPAS flying against the night sky would be difficult to detect.

If the trend of shrinking RPAS designs with cameras with increasingly higher resolutions continues, it will make it incredibly unlikely that a member of the public could hear or

111 United States Court of Appeals for the Fourth Circuit. 2021. Leaders of a Beautiful Struggle; Erricka Bridgeford; Kevin James V Baltimore Police Department; Michael S. Harrison, In His Official Capacity As Baltimore Police Commissioner. No. 20-1495 (Fourth Cir. 2021). https://cdn.vox-cdn.com/uploads/chorus_asset/file/22680040/fourth_circuit_decision_baltimore_june_24_2021.pdf.

see the RPAS even if they were having their data collected. This inability to detect RPAS represents an emerging risk to privacy, since current Ontario legislation relies on the public's role of witnessing and reporting potential breaches of privacy to help maintain the privacy of all Ontarians. In jurisdictions in the European Union and the United States, concerns about undetectable RPAS are being addressed though the requirement for remote identification (RI). Remote ID, or RI regulations, require operators to first register their aircraft, and then have a transponder repeatedly broadcast their registration number, as well as current flight, and flight plan data, while the RPAS is operational.[112]

Additionally, some police services, such as the Chula Vista Police Department in the U.S., proactively choose to post flight maps and flight data publicly upon the completion of an RPAS deployment to maintain positive public relations for their program.[113]

6.4 Media narratives and perception management

Media narratives and perception management may not be the first things that come to mind when thinking about privacy and RPAS. The capability for these aircraft to collect data about individuals and their lives, combined with police efforts to shape narratives about events, groups, and individuals, however, represents an emerging privacy risk in Ontario. Public perception of police services and their actions is a continuing concern in law enforcement, and one police services consciously work to manage.[114] In 2018, the Airborne Public Safety Association recognized the Cass County Sheriff's Department with their Unmanned Aerial Systems Award, in part for their RPAS program's capacity to record video that framed protesters of the Dakota Access Pipeline as violent and in need of control. These video packages were then shared with news media and picked up at the national level.[115] Similarly, RPAS footage has been used to attract attention and influence international audiences, a tactic specifically identified as an effective application of this technology in the Ukraine-Russia conflict.[116]

Although police services conducting public relations is not something new, the types of data now available through RPAS — including video, cell phone, internet use — coupled with the trend of police services creating their own media in house, presents an emerging privacy risk. Examples of this practice in Ontario include video data recorded with an RPAS being released and used by news media in Thunder Bay, Ontario, where drone footage

112 European Union Aviation Safety Agency. 2023. Remote identification will become mandatory for drones across Europe. https://www.easa.europa.eu/en/document-library/general-publications/remote-identification-will-become-mandatory-drones-across ; European Union Aviation Safety Agency. 2022. Annex to Delegated Regulation (EU) 2019/945. PART 2 — Requirements for a Class C1 Unmanned aircraft system. Section (12) https://www.easa.europa.eu/en/document-library/easy-access-rules/online-publications/easy-access-rules-unmanned-aircraft-systems?page=19 ; Federal Aviation Administration. 2024. "Remote Identification of Drones." https://www.faa.gov/uas/getting_started/remote_id

113 Chula Vista Police Department. 2024. "Drone Program Historical Flight Data." https://app.airdata.com/u/cvpd.

114 Duncan, Jamie, and Kevin Walby. 2021. "Police Union Political Communications in Canada." The British Journal of Criminology,62(1). https://doi.org/10.1093/bjc/azab043 ; O'Connor, Christopher. 2015. "The police on Twitter: image management, community building, and implications for policing in Canada." Policing and Society 8. https://doi.org/10.1080/10439463.2015.1120731.

115 Airborne Public Safety Association. 2018. "Unmanned Aerial Systems Award." https://web.archive.org/web/20221129010805/https://publicsafetyaviation.org/2018-award-winners-scholarship-recipients.

116 Kunertova, Dominika. 2023. "The War in Ukraine Shows the Game-Changing Effect of Drones Depends on the Game." Bulletin of the Atomic Scientists 79(2). https://www.research-collection.ethz.ch/bitstream/handle/20.500.11850/606858/6/ThewarinUkraineshowsthegamechangingeffectofdronesdependsonthegame.pdf.

clearly shows private individuals who had both allegedly violated the law, as well as other surrounding motorists.[117] More invasively, in Saskatoon, Saskatchewan, police data regarding the very intimate details of Kandice Singbeil's life were disclosed as part of a true crime podcast created by the Saskatoon Police Service and made available on Apple Podcasts, Spotify, and Audible.[118]

6.5 Pattern of life analysis

POLA is a term used in military applications and refers to the use of all available sensor data to develop an understanding of the patterns of movement, data use, social connections, and general everyday life – both at the level of the individual, and at the level of a larger community of people. It begins with capturing video for an extended period over of a large portion of a selected city through Wide Area Motion Imagery (WAMI). This, in turn, allows for analysts to pause, rewind, and playback, everyone's movements across the entire community, and track everyone's comings and goings. In practice, it has been described as working like Google Earth with TiVo capabilities.[119] AI is also applied to identify people and objects and to mathematically establish patterns of what would be considered to be normal or anomalous behaviours, either for a single event in an individual's life, or in measuring one individual's movements, communications, or internet activity, against the pattern of an established group norm (see section 5.2 for more detail).

POLA should be considered an emerging privacy risk, since law enforcement agencies in North America have already taken several steps toward this application.

First, the Persistent Surveillance System's AIR program, tested in Baltimore, demonstrates how WAMI can be deployed with technologies available on the civilian market. The project deliberately limited image resolution with Privacy by Design, using the technology available in 2018. This case also shows the degree to which WAMI imaging can expose people's lives. A U.S. court ruling found that WAMI captured the whole of individuals' movements.[120] It also demonstrates how other data sources, including CCTV cameras, red-light cameras, ALPRs, police service computer-aided dispatch, ShotSpotter technology, and private security cameras from across the city, can be integrated into a larger assemblage to achieve identification and tracking goals.

Second, programs in Dubai and Mexico show that small RPAS — like the ones deployed in Ontario — can be tethered and used to collect the data type, and in the format necessary for WAMI-like collection, over a community on a 24-hour basis.

Third, AI capabilities needed for the identification of people and objects is readily available through Google Cloud services. Meanwhile, FLIR's SkyRanger, used by at least eight

117 TBNewsWatch 2023 "Thunder Bay Police use Drone to Conduct Traffic Blitz." https://www.youtube.com/watch?v=KJo9aOgNVo0.

118 Saskatoon Police Service. 2023. "Deals, Debts, & Death: The Disappearance of Kandice Singbeil." https://saskatoonpolice.ca/podcast/.

119 The Guardian. 2016. "Baltimore police confirms aerial surveillance of city residents." https://www.theguardian.com/us-news/2016/aug/24/baltimore-police- aerial-surveillance-cameras.

120 United States Court of Appeals for the Fourth Circuit. 2021. Leaders of a Beautiful Struggle; Erricka Bridgeford; Kevin James V Baltimore Police Department; Michael S. Harrison, In His Official Capacity As Baltimore Police Commissioner. No. 20-1495 (4th Cir. 2021). https://cdn.vox-cdn.com/uploads/chorus_asset/file/22680040/fourth_circuit_decision_baltimore_june_24_2021.pdf.

different police services in Ontario in 2024, advertises offering onboard AI identification technology that can be fully trained to identifying people and objects to the specifications of the local user, at an additional cost of under $600 USD (approximately $812 CAD).[121] DJI Enterprises, which supplies RPAS to an additional 11 police services in Ontario, also advertises a trainable AI package for its products.[122]

Finally, additional sensor packages have been added to capture digital and cell phone data, with equipment similar to SIGNET sensors, such as cell-site simulators, IMSI catchers, and DRT boxes.

POLA is already in use in the military theatre and that police services in North America are assembling the pieces to develop this capability — with each component independently representing a privacy risk — and this Google Earth-plus-TiVo-like surveillance has already been identified as a privacy violation in other jurisdictions. This should continue to be an area to carefully monitor and assess.

7. Conclusion

This report was organized to provide an overview of the capabilities of remotely piloted aircraft systems (RPAS) in law enforcement, new developments expected in this industry over the next five years, and the top five new or emerging privacy risks that are a result of changing unmanned aerial vehicle (UAV) technology and applications. This section provides a summary of the key findings of this report, as well as the limitations of those findings.

7.1 Summary of literature review results

In summary, the use of RPAS for law enforcement in Ontario is growing, with 31 (60.4 per cent) police services already having active RPAS programs. In Ontario, the FLIR SkyRanger is the most commonly used RPAS, followed by the DJI Matrice 30T, though DJI technologies are much more prevalent in the wider North American RPAS law enforcement market. These small RPAS generally carry visual light cameras capable of identifying individuals up to 457 m away, though in testing, accounting for weather and atmosphere, they achieve about 66 per cent of this distance on a clear day, as well as IR cameras, capable of identifying individuals in darkness at a much shorter distance.

Maximum flight times range between 24 and 59 minutes, though this can be extended with the use of a tether to a maximum of 24 hours. If flown at full speed for the maximum advertised flight duration, RPAS used by police services in Ontario would allow for an estimated range of 14 to 56 km. However, this is limited by the communications distance from the piloting device to the RPAS, which has a reported maximum range of three to 12 km.

121 Teledyne FLIR 2019 “How to Build a Deep Learning Classification System for Less than $600 USD” https://www.flir.ca/discover/iis/machine-vision/how-to-build-a-deep-learning-classification-system-for-less-than-$1000/.

122 DJI Enterprise. 2024. “AI Module.” https://www.dji.com/ca/ai-module/faq#:~:text=Yes.,run%20AI%20recognition%20algorithms%20offline.

Outside of Ontario, innovations by other law enforcement agencies in the use of RPAS have two major overall trends. The first is a shift in how RPAS data are used. Previously, the focus was on the collection of images — mainly for traffic accident reconstruction or as part of other active investigations. New trends in innovation are pushing RPAS use into centralized command and control structures, with live data being made available to commanding officers in positions capable of directing officers on the ground. The second major trend is a shift in how RPAS are deployed, moving from specific, specialized responses to DFR-style programs, and reaching the point where RPAS technology is fully integrated into all police responses to calls for service.

The specific case of the Baltimore Police Department's use of wide area motion imagery (WAMI) to develop a Google Earth plus TiVo-like ability to pause, rewind, and replay daily life across a 64 km^2 area in the larger city of Baltimore was included in this report as well. This case demonstrates both a capability and conceptualization of a police application of camera images that is of particular concern for privacy, with this mass, ubiquitous surveillance model being adopted by law enforcement RPAS in Mexico and Dubai.

Trends in armed forces applications identified a focus on pairing electro-optical and infrared (EO/IR) cameras and signals intelligence (SIGNIT) sensor data to provide intimate details of the physical movements and digital actions of those under surveillance. Added to this is the use of AI to render these data searchable while also establishing norms and enabling the identification of anomalies in the patterns of people's day-to-day lives — the practice known as pattern of life analysis (POLA). With regard to small Class 1 RPAS, the Ukraine-Russia conflict is expected to pressure industry to develop new technologies that are smaller, faster, cheaper, and have greater processing power. Applications coming out of the conflict which may influence law enforcement include live-streaming, situational awareness data to soldiers on-the-ground and using RPAS video for public relations and pre-packaged content for news media. Additionally, the technological capabilities and sensor packages currently in use by the armed forces are likely to place further pressure on police services' RPAS programs to adopt or expand: WAMI or this Google Earth+TiVo-style of video data capture, tracking and identification AI software (object and facial/human recognition) and its application for pattern identification in daily routines, and digital data capture capabilities through the adoption of sensors simulating Wi-Fi hotspots or acting as cell-site simulators (also known as IMSI catchers or DRT boxes).

Based on the evidence reviewed for this report, there are five new and emerging concerns regarding privacy.

Normalized use/DFR

In Ontario, as elsewhere, RPAS use has shifted from primarily being used to conduct specified, pre-planned flights to becoming an everyday component of policing for many police services in North America. Current governance around RPAS and the protection of privacy do align with these new realities, as the high volume of deployments and the largely unpredictable nature of responding to calls complicates best practices, such as non-invasive flight plans and informing the public before deployment. Additionally, new police policies like DFR send RPAS to every service call, flying directly from a police station or another nesting site, collecting video data while in transit.

RPAS patrols and hotspots

Police services in several jurisdictions outside Ontario have adopted RPAS to patrol areas within cities considered as hot spots — areas with elevated rates of reported crime. Unlike patrol cars, the elevated position and range of sensors pose new risks of ubiquitous mass surveillance and the over-collection of personal information.

Media narratives and perception management

Police are using of RPAS data to develop media packages that present a particular view of an individual or their community, as well as for fully produced, in-house police media products, such as videos and podcasts about people's lives.

Visual and aural covertness

The important role of the public in identifying instances of inappropriate data collection and privacy violations, which is a central part of Ontario's privacy legislation, is at risk given the trend of RPAS getting smaller while their capabilities to collect data at greater distances are expanding.

POLA

This is a technique used for investigations or for the development of intelligence, by developing an understanding of habits and behaviours of individuals using AI. The power of this technology is in its capacity to test a person of interest's life patterns against either a norm established through large quantities of observed data, or against new actions taken by that individual. Law enforcement agencies outside Ontario already have programs with one or more of each of the key components of this application.

7.2 Limitations

In performing this literature review, the most difficult and time-consuming aspect was identifying the RPAS currently in use by police services in Ontario. With considerable effort, the type of craft used could only be definitively ascertained in 20 of the 31 cases, while the actual number of RPAS owned and operated by each service could not be found with any consistency. Industry documents and award presentations were much more detailed in identifying the craft type, capabilities, number of trained pilots, and total number of aircraft owned than the vast majority of public-facing police service web pages.

The Existing and Emergent State of UAV/RPAS/Drones Surveillance Capacities and Law Enforcement