Building Ontario's Next-Generation Smart Cities Through Data Governance

Part 4: The Future of Ontario's Data

Fulfilling the potential of smart cities

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ORION

I. ABOUT THE SERIES

Building Ontario's Next-Generation Smart Cities Through Data Governance

There are many definitions of a "smart city," but central to all of them is the implementation of advanced technology for the creation of systems and services to support prosperity and quality of life for people. As cities adopt smart infrastructure, they are beginning to gather useful data. Alone, that data can provide useful insights to help make specific aspects of city life more efficient and more livable. Combined with other data, city data could generate innovative new uses and new value. This emerging opportunity raises important questions on how data might be owned, shared and governed.

It's still early days and cities around the world are still figuring it out, researching and testing new methodologies, and leveraging digital technologies to support them. In such environments, digital research infrastructure is key to the exploration of smart cities data governance.

Rapid advancements in data collection, transfer, and analysis technologies have provided the Government of Ontario with the opportunity to explore new infrastructure systems for economic development. These technologies have enhanced the government's ability to amass volumes of data and interpret them to create data-driven solutions to challenges in infrastructure development and delivery of products and services to the citizens. However, this also raises concerns around privacy, security, individual rights, and privatization of citizen data. In order to balance innovation that leverages this data with individual wellbeing, the Government of Ontario granted Compute Ontario and ORION funding to study smart cities.

To support this deep-dive into smart cities and data governance models, Compute Ontario and ORION convened diverse stakeholders and experts from policy and governance sectors, as well as industry, academia, and research. We brought over 125 stakeholders together at a "Smart Cities Governance Lab" in Kitchener, Waterloo, in March 2019 to discuss and workshop the topic, and assembled a "Smart Cities Advisory Committee" with whom we regularly consulted. The committee brought diverse representation and expertise that informed our areas of exploration, and validated report recommendations. Through three use case studies, we further explored data governance in areas health, personal mobility, and open data architecture to facilitate more equitable access to the data market and enhance economic development within the province.

This series of reports is a culmination of these efforts and focuses on resulting recommendations, existing examples of data governance models, and exploring various data principles, commons, collaboratives, and trusts.

In this concluding report from Compute Ontario and ORION, we provide context about smart cities and data governance, summarize findings from the use cases and present lessons learned as well as recommendations to move Ontario forward.

ACKNOWLEDGEMENTS

Compute Ontario and ORION would like to thank the Province of Ontario for its support of our smart cities work.

We would also like to thank the members of our smart cities advisory committee for their contributions in guiding the formation of this report. The perspectives each provided created a great atmosphere of collaboration, exploration and critique as we explored the topic of data governance in a smart city.

A special thanks to the teams at Institute for Clinical Evaluative Sciences, MaRS and Miovision that led the use case studies explored in this report and to Mary Allen of InsightaaS for her support in drafting early versions of this report.

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Executive Summary

We have an unprecedented ability to collect and interpret vast quantities of data thanks to emerging data-intensive technologies like the Internet of Things (IoT), artificial intelligence (AI) and supercomputing. This ability is creating new opportunities to leverage technology and information to improve the lives of Ontarians. However, the collection and use of data in smart cities raise concerns about privacy, security, individual rights, data governance, and who should benefit from citizens' data. Policymakers are grappling with a rapidly shifting technology landscape, the need to balance innovation that leverages personal and public data, and the challenge of ensuring these activities support the public good. Understanding, developing and adopting adequate frameworks for data governance are essential to fulfilling the potential of smart cities. Data trusts, for example, have emerged as a possible solution for managing the vast amount of data that smart cities will generate, in a way that provides accountability for a wide variety of stakeholders.

This report summarizes findings from Compute Ontario (CO) and ORION's smart cities project. It begins with a definition of a 'smart city,' outlining reasons for the current interest in creating data enabled cities. The report then provides an overview of advanced technologies that are quickly being adopted to drive smart city implementation. An overview of the current state of Ontario smart cities includes specific discussion on smart city initiatives in municipalities, including Stratford, Kingston, Sarnia and Vaughan. These examples highlight the need for actors from various stakeholder groups to align their interests and resources for smart city implementation. The report addresses the challenges associated with smart cities, including the security and privacy risks of implementing advanced technologies, and the often-inadequate attention paid to these challenges.

The principal focus of this report is data governance, which is examined through contemporary models, including data principles, commons, collaboratives and trusts. The report analyzes data trusts – the most promising model – in detail, including how their intermediary role between data providers and users enables confident data sharing and access. We then analyze three specific use case studies which prototype and test our understanding of the roles of various stakeholders in expanded data access scenarios. The first two use cases consider the implications of data governance frameworks for health and personal mobility data. The third use case investigates an open data protocol to support the potential data exchange market that will emerge from smart cities.

The report concludes with lessons learned as well as recommendations for the successful and sustainable implementation of smart cities across Ontario in order to deliver economic development while protecting the privacy of citizens and keeping them at the centre of the design.

Project Overview

The Government of Ontario recognizes the importance of transitioning to a data-driven economy. It is developing a data strategy to maximize government efficiencies and opportunities for economic development, balancing these with requirements to ensure public trust and promote social well-being. To support exploratory work in this area, the government has allocated funds for research into digital structures that can enable these various goals.

The CO and ORION smart cities project brought together a diverse group of stakeholders to provide insights on different data governance models that promote data collection and use, to deliver social and economic benefits while protecting privacy. It focused on emerging data governance models that formalize the roles and functions of diverse stakeholders to support well-managed, strategically used data. Specifically, the goal of the project was to provide policymakers, industry, the general public and government with a vision for advancing smart city initiatives in an evolving data environment.

Over the course of a year, CO and ORION employed a range of activities to deliver the many insights presented in this final report. First, an environmental scan, consisting of a literature review, key informant discussions and jurisdictional analysis of smart cities initiatives from around the world, was employed. Second, the project focused on the exploration of various types of data, data users, data generators and their role in informing data governance. Three important deliverables shaped this latter phase of work. This included:

- Creating an advisory committee of diverse experts to inform and validate analysis and insights continuously;
- Hosting a data governance lab to validate governance models and smart city collaborator profiles of interest and;
- Supporting the prototyping three use cases which explore the application of different data governance models with the potential to benefit Ontario.

The advisory committee included representatives from municipalities, academia, civil society and industry. As such, it brought together experts in law, privacy, security, emerging technologies, economic development, as well as experience in implementing and evaluating smart city initiatives in Canada and internationally. The committee's role was to guide early work, suggest areas for further exploration and to validate concepts as they emerged in project research.

The Smart Cities Governance Lab (SCGL) took place at Catalyst 137 in Kitchener, Ontario, in March 2019. It brought together 125 representatives from the research, industry, government and other not-for-profit and media communities to explore a citizen-centred approaches to smart city data governance. Participants were educated on a range of topics including the role of technology in supporting better data management, Canada's approach to leveraging policy to enable technology for the public good, a legal overview of data trusts, and how to empower digital leadership in local communities. Using design thinking, a range of data governance models and smart city collaborator profiles were analysed.

Through the prototyping of three use cases, three different organizations which represent various smart city collaborators examined the challenges and opportunities that surround various types of data usage and the viability of applying different data governance frameworks in Ontario.

Broad and varied, the CO and ORION project activities have generated a wealth of insights into smart city opportunities, challenges and potential approaches to addressing key data governance issues. These insights are presented in the report, which follows.

Background

What is a Smart City?

A smart city makes informed decisions which benefit all citizens. But what is the source of this intelligence, and what accounts for the current vitality of the smart cities concept in urban development discourse? The construct of a smart city is not new. For several decades now, terms such as information cities, digital cities or intelligent cities have been used to capture the unique qualities of a municipality that can quickly respond to citizens' needs by leveraging advanced ICT.[1] Community priorities are used to interpret and assess citizen needs in order to apply solutions which achieve optimal outcomes.

Perhaps the clearest feature of a smart city is the application of ICT for improved efficiency of government operations and infrastructure management. These efforts include optimizations to the delivery of water, power, transport and other citizen services or to enhance prospects for sustainability – from both business and environmental perspectives. A smart city is also associated with high levels of community engagement. Through the creation of collaborative networks, a culture of ongoing dialogue and iteration between public and private sector actors can lead to better regional economic development outcomes.[2] But central to all definitions of a smart city is the implementation of advanced technology for the creation of systems and services to support prosperity and quality of life.

Today, smart city development is gathering momentum in response to a convergence of trends. These include pressure on public resources, growing awareness of the potential for smart cities to address urban issues, greater digital literacy and the massive new opportunity of increased availability and affordability of advanced technology systems. At a demographic level, an ageing population, income inequalities, in-migration to cities and with it, the increasing densification of the cityscape, are pushing city planners to find new ways to meet the needs of changing populations. In Canada, for example, 81% of the population lived in an urban centre in 2011.[3] However, migration to Canadian urban centres from other countries, combined with specific policies aimed at intensification in urban areas, is placing added strain on municipal resources and structures.[4] Also, cities have a significant collective environmental impact. While they occupy only 2% of the planet's surface and house approximately 50% of the world's population, cities consume 75% of total energy generated and are responsible for 80% of the greenhouse effect – an impact that may be mitigated through the application of smart technologies.[5]

Worldwide, the number and the breadth of smart city initiatives continues to grow, providing additional models that can inform adoption in new locales.[6] In Canada, the federal government's Smart Cities Challenge introduced in November 2017 galvanized 200 applicants from across the country to create and articulate solutions designed to engage and improve the lives of citizens in a variety of urban, rural and far north communities.[7]

Advanced Technologies

Technology is a vital enabler of a smart city. In this section of the report we consider those aspects of ICT which are responsible for collecting, transmitting, storing and analyzing data to derive insights and inform new courses of action. Sensors, wired and wireless networks, cloud computing and storage, as well as data analytics, machine learning and AI, all play critical roles in this process, and all are needed to fulfill the ultimate vision of a smart city. Dramatic improvements in performance and cost of all these components are now making the full promise of smart cities more feasible.

Smart cities are early adopters of solutions aimed at two types of digital innovation – both of which can now be further enhanced with AI. Automation and control can improve the efficiency of city operations while the delivery of intelligence and insights can help humans make better decisions. Traffic management solutions, for example, demonstrate both outcomes. Smart traffic lights and smart parking help drivers and pedestrians more efficiently navigate urban spaces, thereby reducing traffic management issues for city operators. At the same time, data captured through a traffic light and parking sensors also provide invaluable information on traffic patterns that city operators can use in infrastructure planning and optimizing maintenance tasks. Consider building information management systems that collect data on temperature, humidity, or occupancy. Once analyzed, the information can be used to automate environmental control systems, creating huge savings in energy cost and carbon. Or, smart energy that uses advanced meter readings to deliver data that can be used to develop pricing policy, and with it, encourage consumption reduction. Improved public health surveillance is also an emerging application in which data can be combined and analyzed with environmental and population demographic data to predict future incidence and prevalence of disease, allowing for more targeted programming at the municipal level.

Smart city applications such as these are typically powered by an assembly of sensor, data compute and networking capabilities, which is often referred to as the Internet of Things (IoT).

Internet of Things (IoT)

Widely touted as the 'third wave' of the Internet, the IoT communicates information about the physical world, allowing policymakers and city planners, industry and entrepreneurs, researchers and residents to make more productive decisions about work management and social life.[8] Since the early 2000s, the IoT has transformed from simple instrumentation of the physical world to highly sophisticated sensor-based systems that collect data from objects through wireless technologies and transmit this information through global communications networks for analysis and to support control functions, often in real-time.

The number of expected IoT devices is massive and highlights the tremendous opportunity for new applications and opportunities that will further drive smart city development. This growth in connected devices also emphasizes the significant demands that will be placed on hardware (networks, compute and storage) as well as the need for scalable software (big data solutions, analytics and AI) to extract actionable insights. A 2019 IDC report forecasts 42 billion IoT devices worldwide by 2025, generating an astonishing 80 ZB of data.[9] [10]

Communication Networks

Ubiquitous and fast networks are critical to the successful operation of IoT and smart city applications. IoT devices are generally connected to wireless networks but wired, and broadband networks are also engaged through applications that transmit data to the cloud. Once in the cloud, analytical tools process and return derived insights to the consumer or enterprise.

IoT, and therefore, smart cities will likely be revolutionized by 5G – the fifth generation of wireless cellular technology, which is expected to be widely deployed within a few years. As compared to current LTE and 4G networks, 5G promises significant increases in data transfer rates, lower latency (or lag) and reduced power consumption. 5G can also accommodate many more devices per square kilometre. In July 2019, Canada's first pre-commercial 5G wireless testbed – the industry-led ENCQOR 5G project – was announced at five hub locations in Ontario (Ottawa, Toronto, Kitchener-Waterloo) and Quebec (Montreal and Quebec City). The program is designed to support innovation initiated by small and mid-sized organizations in IoT, smart city and other solution areas.

The federal government has declared high-speed broadband an essential service. In 2016, Ottawa committed to an ambitious program aimed at establishing universal coverage with unlimited data by 2031, a tenfold increase to the coverage targets set in 2014.[11] In many regions, such as Ontario, high-speed networks, including ORION, exist to support rapid data transfer. New, purpose-built networks, such as South Western Integrated Fibre Technology (SWIFT), which is designed to establish equitable coverage across regions, are under construction to facilitate IoT development. Also, cellular networks are expanding capacity, reach and reliability, while improving speed and latency to address IoT requirements.

Compute, Storage and Data Analytics

The volume, variety and real-time streaming of data from IoT systems pose significant challenges for data storage, processing and analysis. However, advancements in technology continue to drive down the cost of data storage. The establishment of large public cloud services in Canada has enabled ready access to on-demand, dynamic resource pools of computing power that may be tapped by both large organizations and smaller entrepreneurs without significant capital investment in ICT infrastructure. Data analytics have become increasingly sophisticated over the past decade. AI now provides novel insights into complex datasets over a wider range of applications, as well as machine learning that can deliver new levels of automation and control in areas such as smart cities. Technology advances continue to empower new uses for smart city data.

Cybersecurity

Cybersecurity is especially critical in smart city and IoT solutions. The anticipated rapid adoption and unprecedented scale of sensor deployments present more attack vectors for cybercriminals because security risk varies directly with the number of networked devices. Cybersecurity requirements are non-negotiable in a smart city due to the potential impact of the failure of critical infrastructure systems like traffic systems or power grids, and the potential risks associated with the collection of sensitive or personal data.

In 2018, there were 6,515 publicly disclosed events of compromised data globally, which exposed over five billion sensitive records.[12] The IoT systems powering smart city infrastructure are especially vulnerable to security breaches due to a lack of security standards and multiple integration points which introduce new vulnerabilities. The use of lightweight sensors with limited CPUs that can't accommodate security capabilities and a general lack

of an end-to-end security strategy also put security at risk. At scale, smart systems may be difficult to update, and security may be further compromised by the common practice of running smart systems over the public Internet as opposed to private networks. The growing incidence of data breaches is alarming.[13]

In smart cities, however, the inconvenience or financial loss of a security failure can translate into significant damage, including loss of life. Trust in governments' ability to protect citizens is critical to smart city success, a proposition that becomes ever more difficult with the explosion of data that smart cities are expected to generate.

The Ontario Landscape

Across the province, municipalities have taken up the gauntlet. Sixty-four Ontario communities self-identified as 'smart' in the federal government's recent Smart Cities Challenge, representing 40% of total applicants to the contest and approximately 22% of all of Ontario's large, medium and small population centres. 14 [15]

To learn more about this enthusiasm for smart city building, we questioned several communities of varying size and commercial make-up on their goals, challenges and current state of smart city deployment. Answers to the questions generated a remarkably consistent set of common values and patterns of activity. As is the case with many cities around the world, Ontario municipalities are looking to smart city development to create operational efficiencies and cost savings, while improving quality of life for citizens. Municipalities plan to leverage technology and automation to offset ageing infrastructure and the increasing service-level and operating pressures they are currently experiencing, but wrestle with outmoded processes around technology procurement. They expect the expansion of technology infrastructure to mobilize entrepreneurship, innovation, job creation and economic development but are challenged by gaps in broadband access, data sharing and the ability to recruit highly skilled labour in the area of advanced technologies. As Ontario smart city initiatives take shape, they are being defined by characteristics of accessible and sustainable citizen-centric communities, in which citizen needs are front and centre, which ensure inclusiveness and equality of opportunity, and that demonstrate high levels of citizen engagement. However, closing the gap on current challenges will be paramount.

Below are descriptions of smart city profiles we examined and how they are approaching smart city deployments in their communities.

The City of Stratford

For many Ontario communities, the smart city journey begins with communications infrastructure to support smart applications. Stratford, for example, was an early proponent of city-owned broadband services and has leveraged the resulting infrastructure to win important roles in testing and developing smart city related technologies. Advanced connectivity in Stratford has made the city a 'living lab' for the development and testing of autonomous vehicles (see subsection on the AVIN project).

Stratford views affordable Internet access as a key plank in its commitment to social equity, which in turn powers economic development. By improving citizens' quality of life, the city hopes to attract industry. By supporting small businesses through high-value connectivity, it hopes to encourage further development via a virtuous circle of social good. Today, approximately two-thirds of small businesses in the area are supported by the municipality's fibre backbone.

Stratford installed fibre optic cable via its own data utility company, which was created in the 1990s when Ontario's hydro markets were deregulated. This network infrastructure has since expanded across the entire city. It now delivers high-speed Internet access to public institutions, as well as to Internet Service Providers (ISPs) and co-operative networks that take advantage of leasing options. Stratford's fibre has served as the foundation on which additional networks have been layered, including ubiquitous WiFi delivered by a city-owned ISP. Connectivity is provided to business customers and to residents at highly affordable rates (free WiFi in the downtown core and Internet subscription services at 1$/day) to ensure all residents have access to broadband. By 2021, a $45 million investment by a local provider will deliver one Gigabyte (up and down) fibre connectivity to every home.[16]

At the city management level, Stratford's communications infrastructure has enabled applications such as smart power metering and an artificial-intelligence-based online virtual concierge that can help visitors plan trips to the city. More recently, the city has also deployed a Long Range Wireless Area Network (LoRaWAN). This low-power, IoT-friendly, wide-area network supports the development of a smart parking pilot based on 78 sensors embedded in parking spots. By 2020, the city will have close to 200 sensors installed and a live public map of the deployment. This project serves many masters. Data collected through the parking initiative will inform city planning, providing information on high and low-use locations that will enable reallocation of spots to better suit traffic needs. Data will also contribute to a strategy for building vertical or horizontal parking infrastructures, and it will help administrators plan for mass transit or parking services for the city's influx of visitors in the summer festival season. Parking data has also been used to create a smartphone application that can alert drivers to available spaces.

The City of Kingston

The critical importance of connectivity is apparent in Kingston's smart city initiatives, as well. The city is focused on planning and has developed its Smart Kingston Strategy. This roadmap will guide the implementation of smart city governance, policies, programs, funding, infrastructure and applications. A foundational component of this plan is a broadband strategy designed to identify gaps in internet infrastructure coverage, performance and rates, and to address any shortfalls. Kingston expects to implement this strategy in consultation with academia, businesses, residents and telecom service providers. In early 2018, the city announced a public-private relationship with a large telecommunications provider – a collaboration that will see Kingston build on the provider's smart city platform and advanced fibre and wireless broadband networks to deliver a series of connected IoT applications.[17]

In addition to these efforts, The Mayor's Innovation Challenge, a competition calling on teams of students from Kingston's major post-secondary institutions to develop innovative proposals to address an identified challenge faced by the City of Kingston, has been effective in fostering engagement, advancing innovation and recruiting highly skilled talent for the City.

Sarnia-Lambton

In many smaller, more rural regions of the province, service provider business models result in limited broadband coverage and performance. For communities in these areas, network constraints on smart city deployments are being addressed through networks created to deliver good connectivity to underserviced regions. Funded by the federal and provincial governments, the SWIFT regional broadband project was developed to subsidize the construction of an open-access, high-speed broadband network in Southwestern Ontario, Caledon, and the Niagara Region, a prerequisite for smart city deployment. SWIFT is also supported by

300 municipal member organizations that recognize the importance of networks to future economic development, including Lambton County, which plans to expand its communications infrastructure by contributing to SWIFT construction costs in the county.[18]

Sarnia-Lambton is leveraging its good connectivity in applications such as Clean Air Sarnia and Area (CASA), which uses smart environmental monitoring technology to address pollution challenges. The CASA network continually monitors common air pollutants, select volatile organic compounds, wind speed and wind direction at several industry and community sites. CASA then reports real-time data to alert citizens of poor conditions, and government and industry partners of potential pollution emergencies.[19] Like many other Ontario municipalities, Sarnia-Lambton is focused on planning for a smart city. The Intelligent Sarnia-Lambton Task Force, for example, has a mandate to scope additional opportunities that rely on ICT to create prosperity and enrich the quality of life for all residents.

The City of Vaughan

The City of Vaughan is providing leadership for communities that are just starting to build smart city strategies. Vaughan is building relationships in the smart city movement and demonstrating leadership in planning for digital technologies, as well as extensive, real-life experience and experimentation with smart city applications.

Vaughan was an early proponent of digital city transformation and by 2016 had articulated a Digital Strategy that encompassed six key themes: use of social media to foster community, 24/7 eServices and mobile apps to support citizens, transparent access to city data, barrier-free public access to the internet, citizen focus, digital transformation of internal staff and process, and municipal transformation – or readiness to grasp what's next.[20]

The city has also articulated a Digital Transformation Journey outlining key steps others may follow to ensure progress towards a smart city. This journey begins with Digital Strategy 1.0, including a vision and IT strategy foundation, and progresses all the way to an Intelligent City Framework that includes continuous improvement, as well as a smart cities task force definition and priorities. To date, Vaughan has worked through many of these stages. In 2018, Vaughn established its cross-departmental Mayor's Smart City Advisory Task Force. This group consisted of 35 U.S. and Canadian leaders tasked with researching the inputs needed to develop a successful smart city strategy, understanding how other cities prioritize their projects, and how they address and implement smart city plans.

Vaughan officials believe establishing mid-to-long-term funding models based on 'business-driven' opportunities require a deep understanding of internal business processes before attempts at digital transformation can be made. In addition, they believe internal data standards, governance and policies must be defined and followed. The city must develop an implementation strategy for incorporating digital devices into new and rehabilitated infrastructure. Vaughan advises cities to partner with educational institutions, libraries and technology companies, leveraging testbeds and proofs of concept to focus on fast results before engaging in a full roll-out of smart technologies. This collaborative approach to smart city implementation can be seen in Vaughan pilots of SAVI (Smart Application Virtual Infrastructure), a research initiative out of the University of Toronto that aims to create the Internet of the future – one capable of supporting emerging, smart applications.

York Region

In areas surrounding Vaughan, several forward-thinking projects are also in place. In York Region, for example, many departments and divisions have launched smart city initiatives, built on YorkNet. YorkNet is a region-owned 200-kilometre high-speed, open-access, dark-fibre network that connects public buildings like libraries, schools, hospitals. Assets such as traffic control systems, roadway temperature sensors that signal anti-icing needs, and a supervisory control and data acquisition (SCADA) based water quality and wastewater monitoring system all send information across the network. Other York Region projects include connecting to the ORION network at the Southlake Regional Health Centre in Newmarket to accelerate healthcare research and collaboration, as well as implementing a York Regional Police Business Intelligence initiative. The region maintains a data cooperative, the YorkInfo Partnership for sharing data, applications and tools among local and regional municipalities, conservation authorities and school boards. It also maintains an open data platform, which has been integrated with services including Yelp, a business directory service and crowd-sourced review forum and Waze, a traffic routing application. Meanwhile, York Trax – an internal online tracking system that monitors the life cycle of city applications – helps streamline application development processes.

Research Collaborations

Several Ontario communities are actively engaged in collaboration with academic researchers and industry partners to implement and test smart city applications. Below we highlight two such initiatives: Ontario's Autonomous Vehicle Innovation Network (AVIN), which combines research and a demonstration zone, and the Smart Applications on Virtual Infrastructure (SAVI) networking research and Connected Vehicles and Smart Transportation (CVST) application.

The AVIN Project

The Autonomous Vehicle Innovation Network (AVIN) is an $85-million initiative by the Government of Ontario, led through Ontario Centres of Excellence.[21] AVIN is a key commitment in the government's 10-year vision for competitiveness and growth in the auto sector, outlined in "Driving Prosperity: The Future of Ontario's Automotive Sector." AVIN complements Ontario's globally competitive AV pilot regulations, updated in January 2019 to ensure the province remains at the forefront of innovation-enabling regulations that maintain safety as a priority. The province made the City of Stratford the project's Demonstration Zone while six other regions serve as Regional Technology Development Sites (RTDS).

Designed to reinforce Ontario's leadership in transformative automotive technologies, transportation systems and supporting infrastructure, the AVIN project also acts as an economic engine for the region. It attracts large commercial businesses interested in testing solutions and components. It has also developed a talent development stream, which provides work opportunities with local autonomous vehicle connected businesses for students and new graduates. Which in turn nurtures a new cohort of technology and engineering specialists.

The entire city of Stratford now serves as a demonstration ground to commercialize Ontario AV research and development. The site is used by Ontario-based companies with approval from the Ministry of Transportation to test, validate and showcase connected autonomous vehicle solutions. It provides a controlled environment that complies with provincial laws and regulations to validate mobile platforms including mass light vehicles (cars, trucks and vans), heavy duty vehicles (commercial vehicles, trucks, buses and recreational vehicles), transportation infrastructure, Intelligent Transportation Systems and transit-supportive systems and vehicles.

Operated by its partner, the Automotive Parts Manufacturer's Association, the Demonstration Zone leverages Stratford's existing connected infrastructure, comprised of WiFi covering the city's entire 12 square kilometres and its high-speed broadband network and LTE. Stratford now boasts connectivity upgrades to 12% of the city's intersections and has plans to complete the remainder by 2020.[22]

Beyond the AVIN Demonstration Zone in Stratford, six Regional Technology Development Sites (RTDS) are tasked with helping small and medium-sized businesses to develop, prototype, test and validate new technologies. They are also tasked with providing access to specialized equipment, technical and business advice. Each of these sites specializes in a unique aspect of mobility innovation, based on local partner capabilities and academic competencies. These include:

- **Durham Region** — focused on human-machine interface and user experience in partnership with the Spark Centre (part of the Ontario Network of Entrepreneurs) and in collaboration with Ontario Tech University's Automotive Centre of Excellence, Durham College and the Region of Durham.
- **Hamilton Region** — multimodal and integrated mobility, in partnership with the Innovation Factory (part of the Ontario Network of Entrepreneurs) and in collaboration with McMaster University, Mohawk College and the City of Hamilton.
- **Ottawa Region** — vehicular networks and communications in partnership with Invest Ottawa (part of the Ontario Network of Entrepreneurs) and in collaboration with Carleton University, University of Ottawa, Algonquin College and the City of Ottawa.
- **Southwestern Ontario Region** (London and Windsor) — vehicle cybersecurity and cross-border technologies in partnership with the Windsor-Essex Economic Development Corporation and London Economic Development Corporation, and in collaboration with University of Windsor, University of Western Ontario, Fanshawe College, St. Clair College, City of Windsor, City of London, as well as WETech Alliance and TechAlliance (both part of the Ontario Network of Entrepreneurs).
- **Toronto Region** — artificial intelligence for connected and autonomous vehicles in partnership with the MaRS Discovery District (part of the Ontario Network of Entrepreneurs), and in collaboration with the University of Toronto, Ryerson University and York University.
- **Waterloo Region** — high-definition mapping and localization in partnership with Communitech (part of the Ontario Network of Entrepreneurs), and in collaboration with the University of Waterloo, Waterloo Region Economic Development Corporation and Canada's Open Data Exchange.

SAVI and CVST – Research for Next Generation Applications

The advanced connectivity and infrastructure required for smart applications, both currently and in the near future, are at the heart of the Smart Applications on Virtual Infrastructure (SAVI) research initiative. The project, led by University of Toronto professor Alberto Leon-Garcia, involves nine Canadian universities plus several industry partners. Together, the multi-institution team of student and faculty researchers focus their expertise in networking, cloud computing, services and applications on innovations that will be critical for deploying advanced smart city applications as well as other emerging consumer and industry applications. An application-platform testbed for the project consists of eight inter-connected "nodes" distributed across the country to support the testing of new technologies. A recent platform upgrade, which is now deployed in pilot mode for three smart systems in Vaughan, manages real-time data streams from thousands of data sources.

SAVI investigates the development of a new ecosystem in which cloud computing, integrated wireless and long-haul optical networks, as well as a "smart network edge," work together to support service platforms that allow

for the rapid deployment and scale-up of new applications. Key technologies employed include virtualization, open computing and software-defined networking. Open computing – specifically OpenStack cloud operating systems and Open Flow networking protocols – improves security because open platforms can be tested for vulnerability by thousands of participating coders/developers. Software-defined networking, or the ability to use software to program multiple network hardware components, allows for prioritization and classification of different data on the network as well as the ability to respond to evolving security, privacy, and regulatory requirements. Unlike today's VPN security tunnels, open technologies provide a common framework that can be accessed via standardized APIs. They are the opposite of proprietary technology, which can restrict access and content sharing. Greater programmability of the underlying infrastructure translates to more flexible control over the network, a growing requirement in increasingly complex network environments characteristic of smart city communications.

Some sense of the powerful capabilities these advanced systems can deliver can be seen in Connected Vehicles and Smart Transportation (CVST), a University of Toronto-industry-government initiative also led by Dr. Leon-Garcia. CVST is a flexible and open application platform that combines sensor information, advanced wireless and mobile communications with cloud-based infrastructure to create smart management applications that can improve the safety and efficiency of public transportation. With sophisticated data-processing middleware, CVST addresses data mining challenges, helping to deliver data for smart applications. An illustration of the innovation that can be built on smart infrastructure such as the CVST can be seen in the streaming Live Traffic beta view below. It filters many different kinds of traffic data, including drone cameras and Twitter traffic reports, in the Greater Toronto region to support smarter routing and driving decisions.

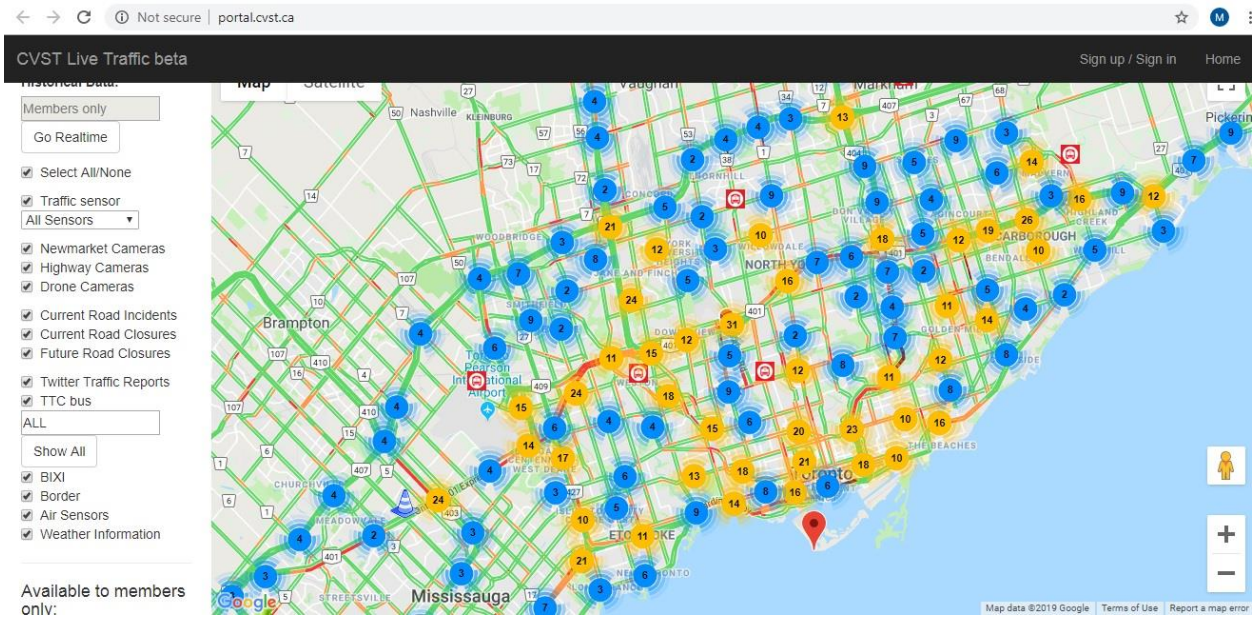

Figure 1. Screenshot of CVST Live Traffic beta

Connecting Smart City Communities

Municipalities and research initiatives, such as those described demonstrate the critical role that partnerships and collaboration play at the local level of smart city planning. However, there is another type of association forming that may also serve to advance smart city rollout across the province and beyond. This relationship is

through not-for-profit collaboration aimed at creating capacity across communities by sharing experiences, connecting experts and developing standards to shape the future of Ontario smart cities.

For example, Ontario communities may benefit from the guidance of home-grown experts such as Evergreen, a national not-for-profit "dedicated to making cities flourish." Founded with an ecology mandate in 1991, Evergreen initially focused on sustainable food production (it opened a farmers' market at the Toronto Brickworks site) but is now also exploring more traditional city-building realms. In 2012, it established CityWorks to address housing and mobility. In 2018, it established Future Cities Canada, a collaborative platform aimed at accelerating the innovation needed to build regenerative, inclusive cities.

Future Cities Canada operates on three program levels. Its Learning Networks generate, curate and share urban research to promote capacity-building for urban innovators and city builders. In Labs, Evergreen offers a place and process for collaborators to problem solve through new approaches to complex urban challenges. These include capital (financing equitable and regenerative urban development), infrastructure (a phased research and scenario-planning project to guide future infrastructure investments), governance (prototyping data governance models) and participation (work with local practitioners and cities to pilot new, local engagement approaches to encourage more people to participate in city-building).

In this work, Evergreen intends to partner with the academic, private and not-for-profit sectors. One example is OpenNorth, the lead technical partner of the Community Solutions Network, a Future Cities Canada program launched in March 2019 to provide information, learning opportunities and advisory services to municipal leaders in key areas of data and technology. With funding from Infrastructure Canada, this new platform looks to connect all kinds of communities – big, mid-sized, Indigenous, small and northern – to build a new national centre of excellence in Open Smart Cities.[23] The Open Smart Cities project is an urban environment "where all sectors and residents collaborate in mobilizing data and technologies to develop their communities through fair, ethical, and transparent governance that balances economic development, social progress, and environmental responsibility." The project_is closely aligned with many of the key components of smart cities identified by Ontario municipalities that responded to CO and ORION's questions about their own smart city activities. To support municipal aspirations to create equitable communities that balance economic development, social progress and environmental sustainability requirements, Open Smart City researchers have built an assessment tool that helps communities deploy large social and technological systems in collaboration with residents, civil society, academics and the private sector. This is operationalized through the Community Solutions Network's event-based programs, portal and one-to-one advisory service, led by OpenNorth and includes basic and advanced courses, webinars, guidelines, templates and one-to-one support from leading professionals and academics from across Canada.

Another good example of smart city expertise is the Open City Network (OCN), a national not-for-profit based in Ontario. It is developing partnerships and plans for new digital public infrastructure to underpin Canadian smart cities, drive government modernization and unlock new data-driven forms of public and economic good. The OCN data exchange platform is designed to allow cities to exchange data with external actors on strict terms, depending on the type of data, the type of actor and proposed use. [24] This includes cities or other orders of government accessing private sector data relevant to their operational or policy goals. Cities will also be able to explore the market value of appropriate data and unlock new revenue to fund further technological modernization. This platform will also enable benchmarking and measurement of provincial and federal policy objectives funded and executed through cities. In addition, the platform's development and deployment will foster necessary data standards and protocols to protect government institutions and further drive public and private innovation. Finally, because many smart cities technologies in Canada exist in a regulatory vacuum, a strong focus will be placed on co-creating public policy and governance solutions.

The Intelligent Community Forum (ICF) is a well-established research body that examines how communities in Canada and around the globe can leverage ICT – and broadband capacity in particular – to build inclusive and prosperous communities, solve social problems and enrich citizens' quality of life[25]. The ICF, which now boasts a Canadian headquarters, has a maturity framework that evaluates a community's progress based on its ability to deliver broadband services, create a knowledge workforce, foster innovation, advocate on its behalf and support digital equality and sustainability. Today, 38 Canadian municipalities, of which 17 are in Ontario, take advantage of the ICF network.[26] These municipalities use the network's research and evaluation approach to develop their strategies, establish communities of practice and benchmark their progress against that of global leaders recognized by the ICF.

Ontario municipalities, along with industry, academic partners and emerging communities of experts, are taking part in cutting-edge connectivity research, testbeds, strategic planning, demonstration projects and pilots, and the creation of advisory bodies. Together, these show strong levels of interest, capability and thoughtful intent concerning smart cities. However, this scan of Ontario initiatives also suggests that with gaps in access to digital infrastructure, data sharing and skilled talent, in addition to challenges with procurement, the digital transformation of city operations is far from complete.

Data, economy and society

Fostering Economic Development

In and of themselves, the efficiencies and social benefits that Ontario municipalities are beginning to garner through technology warrant further exploration of smart city deployments. However, a smart city does more than optimize city operations; it generates vast amounts of data, which, if accessible, enables other stakeholders, including businesses, non-profit and community groups, and individuals, to also participate in and benefit from new economies and intelligence.

The smart city sector is expected to grow substantially. A recent IT market forecast estimated the global market for smart cities products and services at $517.62 billion in 2017 and anticipates spending will reach $2.402 trillion by 2025.[27] That is a compound annual growth rate of 21.28%.[28] But what aspects of smart city development can catalyze economic opportunities? How is economic development defined within the context of Ontario's smart cities? And, who benefits in this new economy?

Through all phases of its life cycle – generation, use, storage and destruction – data is creating new value. When data collected by a smart traffic light is shared in open data formats, businesses and individual entrepreneurs can leverage that information for the development of new services that provide financial rewards back to the business while delivering new citizen services. Consider the mobile application that reports on weather conditions in real time or sends out alerts on pollution levels in specific areas of the city to protect citizen health, or that combines data on bus schedules, current traffic conditions, and the real-time location of a sensor-equipped vehicle to predict actual arrival time for the bus or streetcar. Armed with this kind of information, the citizen can engage in better planning, while the application provider benefits from revenue models designed to support service delivery. Open data, one of the simpler forms of data sharing, creates transparency around the availability of data held by various stakeholders, allows for access to new sources of information creating the

potential for innovation outcomes. When data is available to the private sector to monetize by building new solutions, citizens also benefit through the creation of new job opportunities, products and services.

Cities such as Ottawa, Toronto and Kitchener-Waterloo have already begun to develop the research and innovation clusters that can impact economic development. Featuring research-intensive universities, the highest concentration of technology skilled labour in the province and advanced technologies and infrastructure, these areas can attract international talent and investment. [29] [30] Indeed, they have built accelerator and incubation hubs to transform startups into successful commercial entities[31]. These cities have many of the pre-requisites – access to infrastructure, skills, knowledge and idea sharing and new revenue generation – needed to support successful smart city deployment.

However, social concepts around inclusion and equitable benefit that can be derived from smart city applications that create digital innovation, has also given rise to concerns that communities and individuals who are unable to access the necessary pre-requisites maybe further disparaged without deliberate action.

Within the context of smart cities, the emerging definition of economic development is one that includes efficiency gains, value return, new sources of revenue, the creation of new skills and knowledge, as well as consideration of public good and inclusiveness.

Smart City Governance Lab

Ensuring that adopted technologies are mobilized for social good is a complex challenge for city managers. Smart city ecosystems consist of multiple stakeholders who may have different priorities and resources. Smart city leaders face the challenge of inspire a common vision, in which multiple stakeholders come together in a shared purpose. It is also a vision where appropriate forums and processes are in place for information exchange and consensus-building to support the active collaboration of government, industry, academia and citizens. This vision of a shared city aspires to bring forward the voices of marginalized groups to ensure inclusivity, fairness and equity. It promotes local and national economic development, strengthens democratic governance and institutions, and creates an active community of engagement and empowerment.

How to achieve this future through stakeholder collaboration and governance was examined in detail at the SCGL, held in March 2019 in Kitchener, Ontario, to help inform this report. As one presenter noted, "One does not simply add a sensor and become smart." [32] Rather, decision-makers are tasked with applying proper governance to data and processes to ensure urban development is citizen-centric at a time when the technological change has outpaced relevant policy. Key questions around smart city collaborators and data that must be addressed include:

- What are the roles of stakeholders in the smart city ecosystem and how can they work together to promote public good?
- How and what is privacy in the smart city context?
- How can or should this data be used, and for what purpose?
- Who has the right to the value created by this data?

Figure 2. Smart Cities Governance Lab (SCGL), Catalyst 137. Kitchener, Ontario

User Perspectives

At the SCGL, participants engaged in an exercise devoted to identifying roles and responsibilities in smart city initiatives. The activity offered insight into various user perspectives in smart-city building, and into the communication that is essential to establishing the social licence needed to support the collection and use of citizen data. Participants concluded that all stakeholders must participate and benefit for smart city initiatives to be successful. A win-win-win arrangement is possible only when frameworks are in place to balance the need for access to data with the protection of citizen rights, and to ensure that data generated by the public remains in the public domain. But how do various groups contribute to the data-driven transformation of communities? The perspective of multiple smart city collaborators follows below.

The Role of Government

The government arguably has the most critical, challenging and influential role in the smart city ecosystems. Successful coordination amongst all three layers – municipal, provincial/territorial and federal –on priorities and opportunities can help to accelerate adoption.

Municipalities have the closest proximity to citizens. They support the everyday lives of residents and have the ability to understand how derived benefits are conceptualized within communities. Through a digital master plan, cities can guide overarching technology policy and support strategic planning efforts and may address the current absence of defining legislation.[33] These planning initiatives are now underway in many Ontario municipalities.

At the provincial and federal levels, the government has the opportunity to create agile approaches to policy development that can better keep pace with technological change while addressing legislative challenges associated with the broader implementation of technology and expanding digital transformation.

The Digital Charter, introduced by the federal government in May 2019, features ten principles designed to serve as a foundation of trust for Canadians in the digital sphere. In addition to the charter, supportive actions, which

include proposals to modernize the Personal Information Protection and Electronic Documents Act (PIPEDA) and the formation of a Governance Standardization Collaborate designed to help coordinate the development and compatibility of data governance standards, demonstrate Ottawa's intent to balance the need for greater consumer protection and support digitally based commercial innovation. [34]

Beyond efforts to create enabling legislation, governments have a role to play in stimulating innovation and economic development initiatives by investing in research, reducing barriers to market entry for businesses, supporting the creation of innovation hubs and accelerators that catalyze entrepreneurial activity. With direct accountability to citizens, the government also holds responsibility for protecting the rights of citizens and working with other stakeholders to support their understanding and proficiency of the emerging digital society being enabled through smart cities.

The Role of Researchers

Researchers and academic communities are integral to the creation of next-generation solutions that will ultimately be shaped by industry and startups. This role can be seen in SAVI's cutting-edge approach to connectivity, or demonstration projects such as the AVIN in Stratford and the smart city pilots in Vaughan. But research participants at the SCGL also pointed to their role as connectors that align emerging technology opportunities with citizen needs. This function has also been demonstrated in the civic data trust use case, for example, which focused on civic participation as an essential requirement in smart city governance. As they explore new uses for technology and data, researchers were described as a group that looks to create methods and standards that can guide responsible deployment today, and innovation and marketplace adoption in the future.

Researchers and academic communities may also take on a leadership role. Armed with the knowledge and insight needed to identify issues – such as the potential for bias in algorithms and the technical expertise required to address them – researchers can examine challenges that others may prefer to sidestep. Its ability to focus on pure research allows the academic community to push the boundaries of what is possible in a smart city from a technology perspective. The same can be said of researchers focused on legislation, principles, standards and notions of what is socially acceptable in a data-driven society. As they explore different use cases, sharing management or governance requirements with colleagues, and in community forums such as Future Cities Canada, they break down silos in communication, fostering collaboration across sectors essential to successful smart city deployment. Leaders and champions within the government are also vital to sustaining this research momentum, as they support research autonomy and expanded fields of study from which smart cities may grow.

The Role of Industry

In smart city governance discussions, technology vendors are often viewed with some caution as the progenitors of proprietary solutions that are antithetical to the open architectural approach that defines smart cities. While municipalities must remain vigilant about the potential for vendor lock-in, technology companies, including the startup community, play a critical role in commercializing research and in building market-ready solutions. Their ability to deliver market-ready solutions comes from significant investments in technical expertise, in the professional services needed for solution implementation and in broad rollout – often in jurisdictions with diverse requirements and variation in supporting infrastructures and the availability of personnel resources. Technology vendors often claim long-term experience with learning and adapting to specific customer needs.

Vendors at the SCGL identified their value as the ability to leverage experiences and insights to tailor solutions to unique customer requirements. Their value lies in their ability to work quickly, often adapting existing IP to new solutions for smart cities, in areas such as security. They can also apply best practices and lessons learned in other engagements in new smart city deployments. They are willing, often keen, partners that fund innovation in their own companies, which may help with the significant financial investment required to build smart city infrastructure and applications. Industry stakeholder enthusiasm is a function of its market vision, but also a reflection of its understanding of the collaborative nature of smart city implementation. As noted at the SCGL, private sector companies seek guidance and common standards on topics of consent, privacy, ownership and the appropriate use/reuse of data. To test prototypes, they need buy-in from citizens and the adoption of their solutions by public sector administrators.

The Role of Citizens

An engaged citizenry is an informed citizenry, whose concerns may help to set smart city priorities and serve as a counterweight to the influence of private-sector partners. Current limits on citizen engagement were explored at the SCGL. While citizen groups expressed excitement over prospects for addressing challenges in urban life, along with interest in being included in the dialogue, they also admitted to a lack of understanding of technological, legal, privacy and viability issues. Public education programs and engagement campaigns may address this sense of alienation and work best when focused on both human rights and economic development in smart city deployment. Engagement may be specific to a region or municipality; hence, an essential requirement is education that addresses these broader concerns within the context of citizens' unique concerns and interests.

At the SCGL, privacy issues emerged as a primary concern. While citizens recognized the value of attributable data in creating personalized services, they also confirmed their interest in ensuring data users institute the proper safeguards to protect their identity and privacy. This sentiment is consistent with academic researcher that has been conducted on Canadian perceptions on the use of their personal information for smart cities. Canadians are open to their personal information being used to improve their quality of life. However, their willingness depends on what information is being used, by whom and for what purpose. Citizens are concerned about their privacy and would like to have some level of control in how their data is used in smart cities.[35] Ultimately, the citizens groups at the SCGL focused on how smart city initiatives would impact their daily experience of urban life, how smart applications would affect commute time, who would be able to track their movements, and how costs might change.[36]

Citizen Data: Privacy, Trust and Social Awareness

The potential monitoring of citizen behaviour now extends past our personal connected devices and into the physical world, as sensors begin to monitor and transmit data for an increasingly wide range of human activities. Citizens, however, have little insight into what happens with information captured by advanced systems, and transparency issues around ownership and use of data remain a concern. As the population shifts to include millennial-like generations, which may more highly value the personalization services that data collection supports, the protection of data and privacy will take on added importance. The safety risks in smart health-care devices or autonomous vehicles demand attention, and all stakeholders must recognize the importance of ensuring that data security and privacy are fundamental prerequisites. Indeed, they must be held to a common standard.

For the average person, the transformation towards a more connected city goes mostly unnoticed. But the monitoring of citizen location, health, activity, behaviours and consumer preferences can be virtually continuous and occurs in both the private and public spheres. We already have consumer devices such as our phones that track our location, parking spots, health vitals, sleep patterns, entertainment preferences, online search queries and more. In all of these cases, customer convenience allows a significant amount of the data moves from the device to remote cloud facilities for analysis and improved consumer experience. In addition, people voluntarily submit samples for DNA analysis to ancestry sites and their purchasing habits are routinely recorded and analyzed by customer-loyalty applications and credit-card companies.

There are also many cases where citizens have little control over information that is being gathered about them. Indoor-positioning systems already track smartphone locations inside stores and can push targeted advertising to the phones. Private and public WiFi systems know what devices are connected to them when and where. Smart traffic intersections and parking garages may include video-monitoring systems with facial recognition implications. Smart utility meters can track home power consumption with time-resolution good enough to identify what TV program is being watched inside the home. RFID-enabled office access cards are linked to the employee. Over a single day, a typical smart city resident could generate thousands of data points through interactions with instrumented objects and the virtual world, some of which may represent personally identifiable information. Taken individually, much of this information cannot be associated with a specific person. However, when multiple data points are combined, they can create a full profile of the individual, which could expose that person to financial, reputational or even physical risk.

Much of this data collection may not even be legal. Canada's privacy legislation, PIPEDA requires that companies obtain 'meaningful consent' prior to the collection, use and disclosure of personal information[37]. This means individuals must understand the nature, purpose and consequences of what they are consenting to. They must have ready access to critical pieces of information, including what personal information is being collected, who it will be shared with (PIPEDA specifies cross context use constraints), for what purpose the information will be used, and what risks or harm to which the individual could be exposed. According to the act, individuals must have control over how their information is handled and have clear options to share or not share their data. Companies collecting personal data must be prepared to demonstrate compliance. In many smart solutions, however, the technology does not support these requirements as it offers no mechanism to gather consent for the collection, use or secondary uses of the data. Though there is now a thriving secondary market for this kind of data, the organization may not be aware at the time of collection of the data's future use. Consent is not generally sought at each point of interaction and in many scenarios, the individual is not even aware that data is being collected, much less used. In such cases, consent becomes moot.

Misuse of data can have real consequences. In a connected car, for example, information collected on the driver's location may be intended to ensure vehicular or driver safety. That same information may also be used for nefarious purposes, for example by hackers who could use location data to determine that the driver's residence is empty and available for break-in. It could also be used for guerilla marketing in which the individual is bombarded with advertising. In health care, fitness-tracking applications capture data on a range of behaviours and activities such as a person's heartbeat, location and user demographics, which they might prefer not to share. While the user may give an application permission to use their data to improve health outcomes, it is unlikely they would also consent to sharing that information with an insurance company, which could use it to deny claims or adjust fees. Nor would they want to share with an employer who may be monitoring employee behaviours.[38] In another example, data considered low risk, when attributed to neighbourhoods in a smart city, could exacerbate issues with the 'digital divide' created through unequal access to technology and related services. For example, if smart policing data analysis identifies an area as having a higher crime rate, this

designation may reinforce systematic bias and discrimination against marginalized groups – or even cause financial harm through the resulting impact on real estate values or investment potential.

In many ways, smart cities represent a double-edged sword: they offer a huge opportunity to increase operational efficiencies and to improve productivity, but they introduce significant new threats to privacy and trust in the ability of the data-holders to manage new risks. Articulating these concerns, participants in the SCGL, delivered three core messages. Smart cities start with informed citizens who are empowered and engaged in building a city with citizen rights at its core. Secondly, smart cities are open cities in which transparency and communication establish trust and the social licence needed for stakeholders to generate, collect and store data. And finally, a smart city needs trusted data stewards dedicated to data governance, who can sustain the integrity of public interest and ensure governance models stay intact.[39] In working towards these goals, education can drive understanding and social acceptance, transparency can ensure accountability. And, new frameworks can encourage the responsible adoption of new technology to foster public trust.

Data Governance

Data Governance Models

Governance is a complex concept that refers, at the highest level, to how society or groups within it organize to make decisions.[40] At an organizational level, governance is defined as the establishment of policies as well as continuous monitoring to ensure their proper implementation. It includes mechanisms to ensure the accountability of various members of the body and their duty to enhance the prosperity of the organization.[41] Data governance typically involves articulation of a framework that involves defining custodians of the data, processes for storing and protecting the data, standards and procedures that authorize access to the data, and control and audit procedures that ensure ongoing compliance with the organization's internal policies and external regulations.

In smart city environments, where balancing the needs of multiple stakeholders while ensuring social good are both imperative, defining data governance requirements is a complicated exercise. Among the critical challenges to smart city development, Ontario municipalities engaged through the CO and ORION smart cities initiative indicated a need for data governance frameworks, and for the establishment of precedent and policy that can guide implementation, particularly as it relates to protecting personal information. Data governance frameworks encompass many variables and exist in a variety of models. Currently, city administrators have several governance models available to them for addressing data sharing and protection requirements which typically formalized through data sharing agreements. These models, ranging from principles to data trusts can be viewed as a continuum in terms of levels of control, legality, regulation and complexity. This is illustrated in the table below, which was developed by CO and ORION from a review of secondary literature on the experience of exemplary international smart city governance models.

	Principles	Data Commons	Data Collaborative	Data Trust
Features	A decentralized data governance model where stakeholders of the city voluntarily adhere to common principles that outline the rules of participation in the ecosystem and common data sharing and use	A data governance model where data is collectively owned and managed by a community of users. Citizens can view and use the data collected in this model, often through an interactive dashboard on a web portal	A form of collaboration beyond the public-private partnership model, where participants from different sectors, in particular companies, exchange data to create public value	A legal entity that manages data collection and use. It is a centralized mechanism that enables users to access or use data securely and transparently, with pre-existing legal conditions that are defined prior to creating the trust
Pros	Can create a shared vision and mission that looks to balance market growth with social good, while adhering to social, economic and environmental standards for all participating stakeholders	Gives citizens easy access to data collected about them and its use	Industry can find new, innovative and data-driven solutions to combat public problems	Can manage a wide range of data types and uses legal mechanisms to minimize and contain the risks associated with data collection and use. This model allows all stakeholders of the trust to determine the rules and regulations that will govern the data. The trustee then applies the rules.
Cons	There are concerns with this model around the transparency of which data will flow to the wider public and how much citizens will be engaged in its design	There are questions about who is to benefit from the data collected, as well as issues around consent and opting out of data collection	There are concerns around security, as well as standards of quality among a large group of actors. It is also easy to misalign objectives and use this data for private, rather than public gain	Their formal legal structure may result in trusts that are highly specialized in terms of sector/data and for which it is difficult to modify/adapt policies (e.g. in response to new data types or uses)
Examples	**Pittsburgh Principles** A principles-based governance model defining expectations and policies for autonomous vehicle (AV) testing. Principles include transparent communication with annual reports between industry and government, and engaging industry leaders with community stakeholders to work together to facilitate the development and deployment of AV	**DECODE Barcelona** A smart city using IoT technology and a data commons governance model that aims to collect citizen data and keep it in the hands of citizens. Innovators, startups, NGOs, cooperatives and local communities can take advantage of this data to build apps and services to respond to community needs	**Global Fishing Watch** A website that promotes ocean sustainability through greater transparency. It uses technology to visualize, track and share data about global fishing activity in near real-time and for free. This model uses shared data from Google, Oceania and Sky Truth to stop illegal fishing.	**Silicon Valley Regional Data Trust** A data trust that gathers youth data from a variety of health agencies, education institutions and youth services to improve outcomes for at-risk youth. The trust is used to ensure this data is accessed only by partnered organizations and that it is kept safe and secure

Table 1. Governance model continuum

The table describes the key benefits of various governance models as well as challenges that may become critical in a smart city context. The 'principles' approach embraces voluntary adherence to create a shared vision that balances market opportunity with social good. However, the levels of transparency around what data flows to the wider public and citizen engagement are questionable. Similarly, a 'data commons' approach may not address who benefits from the data or questions around consent and opting-out. In a 'data collaborative,' there are concerns around privacy, broad acceptance of data standards across a large group and the potential for data to be used for private rather than public interests. 'Data trusts' have the potential to offer the highest level of control and complexity, entail the least risk and contain legal boundaries that enable the most comprehensive access to data. These trusts bring together government and industry in establishing rules and can evolve with legal frameworks. However, a legal trust can be challenging and time-consuming to set up, as well as difficult to modify should the circumstance arise.

Central to the discussion of data governance is the understanding that the type of data and its intended use drives the degree of complexity embedded in a model. But smart city data is highly diverse and can be used for many purposes by multiple stakeholders – which makes it difficult, and perhaps impossible, to prescribe one single data governance framework. While the principles-based model is not complex, this examination of data governance also suggests that principles play a critical role in establishing a positive data culture and in creating the foundation for more complex governance models. Furthermore, principles can play an essential role in establishing criteria for regulation and the enforceability of law, as demonstrated in the six data processing principles which underpin the EU's General Data Protection Regulation (GDPR)[42]. Mechanisms for building social cohesion in the context of smart cities, based on principles, should not be understated.

In actual smart city deployments, each scenario will likely demand a different governance model, based on the data's level of sensitivity, stakeholder composition and the unique nature of the application. As a result, this project explored three different use cases and the potential of applying a data trust to each of them. This close examination offers further insight into the factors that influence which governance models best support the multi-faceted and increasingly complex adoption of applications in the next stages of smart city development in Ontario.

Defining the Data Trust

So, what is a 'data trust', and why is it garnering so much attention? How does it solve issues with transparency, accountability, the primacy of public interest, data privacy and security, while maximizing the opportunity to share data, share value from data used in a smart city context and promote both public and private sector innovation?

At the SCGL the main components of a legal data trust, as well as the risks and opportunities associated with their use, were outlined. [43] The notion of a 'trust' has a long history, introduced in 1066 when the king of England granted land ownership to feudal lords, trusting that those lords would provide military support in times of need. It evolved to encompass community land trusts, and subsequently to include other classes of assets, including financial. In a legal trust, a grantor puts an asset into a trust, which gives control of the asset to a trustee for a defined purpose, on behalf of a beneficiary. Accepting the view that data is property, this concept provides the legal foundation on which it may be possible to build new approaches to manage data better. A trust promises many advantages. It is based on the asset as opposed to organizational governance; it creates legally enforceable fiduciary duties; it provides oversight for managing various governance requirements; and may be global in reach. As a legal construct, the data trust supersedes the collective holding of assets, and hence may be used to regulate data sharing.

Emerging models of data trust approximate to a legal trust, incorporating attributes of the trustee beneficiary relationships while avoiding some of its restrictive features. The Open Data Institute in the United Kingdom, a recognized leader in the area of open data governance, defines this sort of data trust as "an intermediary between data providers, data users, and other stakeholders in the sharing and use of data. Its central task is to enable data providers and users to share, access, and use data, consistent and confidently while maintaining robust systems to identify and mitigate risk."[44]

To better understand the potential for practical application of a legal data trust, CO and ORION supported the design of three use cases that explore how to protect, yet share, specific kinds of data within the context of a particular governance model.

Testing the Models – Data Governance Use Cases

As noted above, trust models have historically addressed issues associated with property rights, and their use in the world of data is still evolving. Today, its application to data varies by scenario (data sensitivity and uses) and jurisdiction. Limits in current regulatory frameworks constrain their alignment with existing information and protection legislation. This variability makes the sampling of use case pilots in different scenarios, targeting specific needs and opportunities most instructive.

In identifying potential use cases, CO and ORION made several assumptions:

1. Different smart city stakeholders play a unique role in delivering social and economic benefits. Each group will present different opportunities and challenges regarding expanded data uses and overall data governance. The selected use cases should profile the role of various segments of society.
2. Different degrees of sensitivity exist around different types of data, and this informs the expected level of protection. While open or more free-flowing data is generally more useful, the collection and use of public data must return social and economic benefits to the public and managed in a way that balances individual rights.
3. As described earlier in this report, economic development is defined in terms of efficiency, value return, the development of new skills and knowledge, as well as new sources of revenue. The use cases should explore opportunities to derive different types of economic benefits.

It is important that the use cases provide useful insights to Ontario's policymakers, industry and city managers as they look to develop data governance mechanisms. As such, CO and ORION chose to focus on scenarios representing the stakeholders below, which encompass various types of data, economic development and social observations.

The Institute of Clinical and Evaluative Sciences (ICES)

Established in 1992, ICES maintains a repository of population-level health data on Ontarians. Its mandate is to provide the province and other health-care system stakeholders access to quality health data and analytics, so they can make evidence-based policy decisions. As a 'prescribed entity' (PE)* under Personal Health Information

* Prescribed entities under PHIPA must have their practices and procedures approved by the Information and Privacy Commissioner of Ontario (IPC), with renewal of IPC approval required every three years. Ontario has a total of four

Protection Act (PHIPA), ICES occupies a unique position in the management of provincial healthcare data. It is empowered to collect and use personal health information from health information custodians without patient consent to support health system evaluation, planning and monitoring, and can disclose personal health information for research purposes as set out in legislation and regulations.

Given its unique accountabilities, the institute's data stewardship entails many processes and procedures designed to provide maximum data protection. This includes the desensitization of data to ensure confidentiality and rigorous enforcement of access rights by trusted data handlers. In addition, information requests are rigorously assessed in order to identify and mitigate privacy risks, and to ensure compliance with privacy legislation and contractual requirements. These data protection practices underpin and inform the institute's ability to contribute to building a positive data culture. Its data access model is guided by seven principles that could be instructive in other contexts. Briefly, these principles are about data privacy, data security, data education, data empowerment, data justice, data sovereignty and oversight. These principles all underpinned by an oversight mechanism fostered in transparency, trust, integrity and accountability to ensure social acceptance.

This makes ICES an ideal organization for exploring the social acceptance for supporting access and new uses of health data in smart cities.

MaRS Discovery District

The world's largest innovation hub, the MaRS Discovery District, exists to support Canada's most promising startups – helping them grow, create jobs and solve society's greatest challenges. MaRS has made significant inroads into Canada's innovation ecosystem by working with community entrepreneurs, investors, corporations, academics and government partners.

MaRS applies its expertise in design thinking to urban innovation and to supporting early work around data governance for Waterfront Toronto. These qualities uniquely position MaRS to examine one of the most pressing issues in a smart city – the movement and flow of people, vehicles and mobility data. The development of a civic data trust presents a vital opportunity to improve movement and with it, social, environmental, and economic conditions in urban spaces while providing a means for governments to engage with smart city collaborators in a meaningful way.

Miovision

Miovision Technologies is a rapid growth company based in Kitchener, Ontario that creates intelligent solutions for the collection of traffic data in both in-house and outsourced models, and advanced traffic signal operations.[45] It is a contributor to smart city initiatives in Ontario, such as the King Street Pilot, as well as to projects in the United States and Germany. As an active SME in the smart cities space, Miovision understands how industry can collaborate with smart city managers to enable economic development while remaining accountable to citizens. Miovision's focus on an open platform that can support the data exchange market that will emerge from smart cities provides an approach that can broaden and ease access to data by all sizes and kinds of organizations. Through blockchain technology, data protection rules put in place by individual members of the marketplace can be enabled.

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prescribed entities: Cancer Care Ontario (CCO), the Canadian Institute for Health Information (CIHI), the Institute for Clinical Evaluative Sciences (ICES) and the Pediatric Oncology Group of Ontario (POGO).

Representing the perspectives of key stakeholders involved in smart city deployments – researchers, governments, citizens and industry, including small businesses – the use cases that follow explore the impact and opportunity available to many different groups data governance. They reflect the increasing importance of different types of data to broad social and economic development in the province.[46] Key decision factors, governance structures, enablement and learning outcomes are outlined in the executive summaries presented below.

Findings on Health Data Governance

In Ontario, the development of a health data trust is especially pertinent. Healthcare data exists in abundance and is increasingly critical to successful research into cures and the management of diseases that exact substantial personal and public cost. Improved access to health data is the foundation of patient care innovation. However, this data often includes personally identifiable information that is highly regulated and subject to strict rules around collection, use and disclosure. Furthermore, because public health is a municipal responsibility and the management of the health system a provincial responsibility, opportunities for greater alignment on policy, planning and data sharing become even more apparent in the smart cities' context.

By exploring the potential to expand its ability to disclose depersonalized health information for non-research purposes, the health data governance use case is designed to evaluate ICES' services as a data trust for secondary use of data in smart health applications. ICES concludes that the main disadvantage of establishing a data trust is, a separate legal entity, would not have any standing under Ontario's current public sector and health sector privacy laws as they relate to the collection and use of data. As a result, organizations and entities such as local public health units would be unable, under the current legal framework, to receive depersonalized data from ICES without research ethics board approval. Furthermore, the PHIPA restricts how PEs can use or disclose personal health information. Though PE status allows ICES to receive PHI, other government entities looking to access and share this data would need to engage in their due diligence to assess privacy law compliance. However, for ICES to act as a data trust or data hub, regulatory amendments would be required, as outlined in the recommendations table below (Table 2).

Regulatory Amendments – Options	
1	ICES to be named as a health data institute in PHIPA regulations for onward disclosures to third parties to facilitate broader access and economic development, including innovation
2	PHIPA and FIPPA (and possibly MFIPPA) to be amended to clearly permit ICES to de-identify PHI for the purposes of onward disclosure to third parties as part of evidence based-policy making or other broader purposes set out by the government
3	FIPPA to be amended to clearly permit ICES to collect and use PI (non-health data) for wider system planning and evaluation (evidence-based policymaking)
4	MFIPPA to be reviewed to assess whether ICES can collect and use PI (non-health) data for municipal system planning and evaluation (evidence-based policymaking) and if not, to amend accordingly
5	PHIPA and FIPPA to be amended to enable a ministry disclosing PI to allow ICES to collect and link the PI with PHI, and disclose the linked dataset to third parties, whether they be academics, policy-makers, HICs, MOHLTC or other ministries

Table 2. Recommendations for regulatory amendment

Considering all these factors, ICES recommends a new data governance and ethical-use framework that would enable the organization to continue to build on its principles of transparency, data protection and ethics to ensure public trust. These proposed regulatory amendments would allow ICES to operate as a data safe haven – a legal structure just short of a data trust, which carries less liability and risk. This data governance framework would allow ICES to provide broader access to PHI or depersonalized data, and with it, support for the innovation that is expected to emerge through smart city applications. With less complexity and liability than a data trust, the ICES data safe haven offers a possible path for expanding access to health data in Ontario, allowing policymakers and health system stakeholders to use data more effectively.

Findings on Mobility Data Governance

Mobility data offers valuable insight into the flow of vehicles, mass transit and people in an urban environment. These insights could help planners develop new strategies to manage traffic congestion and associated productivity losses that plague many Ontario municipalities. MaRS conducted several research initiatives to test the potential for a mobility data trust to support the responsible use of multi-sector mobility data in a smart city. It designed a discovery workshop at the SCGL to explore data governance use cases and to outline the roles and responsibilities of different participant groups clustered around a particular data type. MaRS staff interviewed various stakeholders in the mobility sector, including public transit operators, government agencies, large private corporations, local start-ups, citizens and academics. Finally, they prototyped a workshop by hosting 15 cross-sectoral stakeholders who played an interactive data-trust game, a tool designed by MaRS to help break down communication barriers and encourage the sharing of insights on the responsible use of data in a smart city.

According to MaRS' research, traditional governance falters in smart cities due to conflicting access and ownership rights in public and private sectors, lack of standardization in technical architectures and inconsistent levels of control and transparency. To address these challenges, MaRS focuses on new governance models to ensure security, privacy, social equity and the economic competitiveness of organizations within the city, while focusing on citizens. MaRS identifies four foundational building blocks of digital governance: legal agreement, business model, civic participation and technical architecture. Together, these components form the pillars needed to harmoniously create a legitimate and sustainable governance model for a smart city initiative.

Figure 3. Recommended pillars for a mobility data trust

As a result of their research, MaRS recommends incorporating a not-for-profit organization to govern mobility data. A not-for-profit corporation would maintain independence from the government while upholding impartiality and avoiding the potential for conflict of interest that can accompany for-profit businesses. A not-for-profit legal structure can deliver the benefits of a legal trust, including fiduciary responsibility, while also limiting personal liability and providing additional flexibility to adapt the trust's purpose over time.

MaRS pays particular attention to civic engagement, a significant aspect of smart city initiatives and assessed civic functions in the governance design for their ability to promote deliberation, inclusivity, accountability, accessibility and convenience. While MaRS' recommendations for civic participation differ according to the stage of implementation – design, build, maintenance of the data trust – they outline a guiding philosophy. Notably, two principles must be consistently applied to meet success criteria for the data trust. First, formal civic participation must be explicitly integrated into the data governance framework. Second, sponsorship of the chosen approaches must be neutral to guarantee that there are sufficient resources to support participation over time. Given fiscal constraints and the current economic climate, strategies must also be cost-effective.

Lastly, MaRS explores several technical architecture options for data sharing, ranging from highly centralized, to a data marketplace, ultimately recommending a decentralized technical architecture, connected through a data trust platform, as the best option for responsible data sharing.

MaRS' examination into mobility data governance concludes with valuable guidance on critical legal, financial, internal processes and design elements for establishing a data trust that engages citizens.

Findings on Open Architecture

The Miovision open architecture use case focuses on the management of data generated in a smart city, but from a more technology-centred perspective. It examines the potential for data sharing in an open data mart. In this data mart, blockchain software creates an interface between various data stewards, generators and users to improve data sharing. Based on the Open City Protocol (OCP), the software's open architecture facilitates improved and direct access to data to all members, enabling municipalities to avoid proprietary relationships with technology platform vendors that might limit data access.

The open architecture use case is made up of four parts. The first involves the development of a governance framework that encompasses data assets as well as the corresponding source code that regulates access to data. The second is a test-bed pilot based on the management of public and private-sector transportation data, designed to assess the feasibility and opportunity to leverage data generated from legacy investments in transportation. The third entails the development of prototype software based on distributed ledger technology. The technology was a blockchain that enables and secures data registration, third party discovery of data, dynamic pricing for data based on supply and demand economics and the sale and purchase of data from the network. The development of a licence agreement is the final component of the use case, which would be made available to third parties who wish to join the federated network. The licence would cover selling data that members own, buying data they have permission to access, or providing network functions associated with network operation. Uses and interactions permitted on the network were encapsulated in the licencing agreement and monitored, managed and enforced through permissions in the distributed ledger.

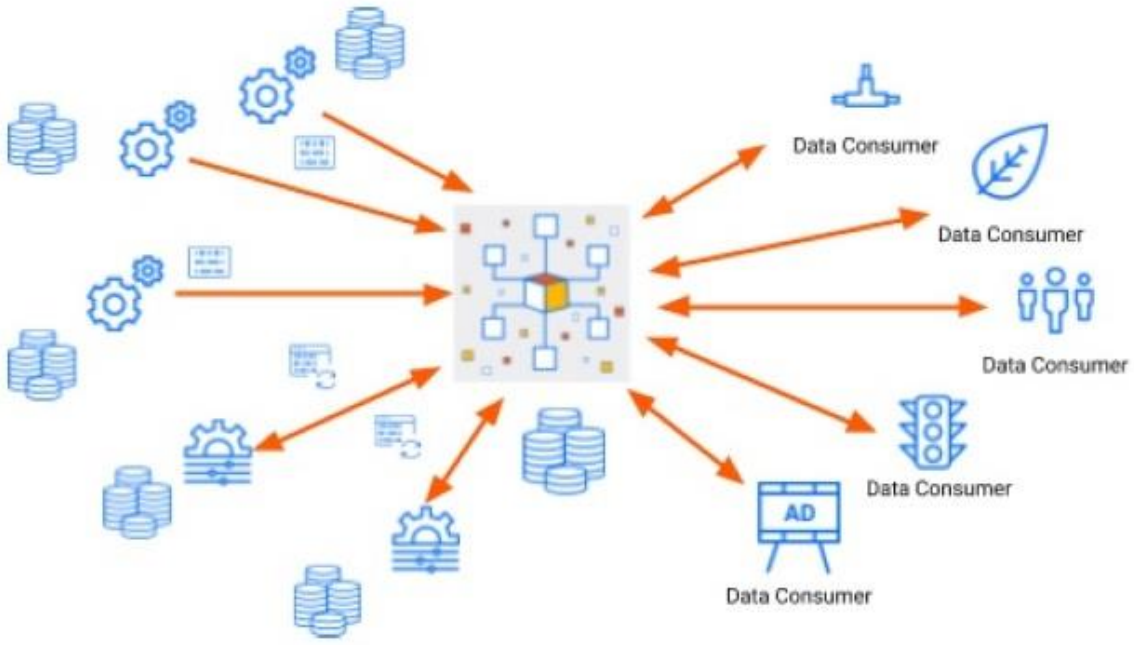

Figure 4. Mobility data exchange in distributed ledger, from Miovision open architecture use case

In this use case pilot, Miovision considers several different data governance structures, including trusts. Given the focus on software and its ongoing development by multiple operating entities, Miovision concludes that a limited partnership would be a more suitable legal structure to support open architecture. A limited partnership allows multiple public and private sector actors to contribute source code, capital and other assets to the initiative. It also allows them to operate a data collective in the same way a corporation would, meaning partners can treat income or losses associated with the undertaking according to their unique circumstances. The limited partnership structure also provides maximum flexibility for participants to enter and exit the relationship as they see fit, as it separates governance of the partnership (i.e. general partner) from contribution to the partnership (i.e. limited partner).

Though Miovision settles on a limited partnership, it should be noted that OCP is essentially an underlying protocol for data exchange. With built-in concepts such as identity management, use and transfer of value that is agnostic to the data governance framework adopted by various data generators and users. In principle, OCP could be used to support the open data sharing policies of a municipality or province, as well as the governance policies underlying a legal data trust or other sophisticated governance model.

Use Case Summaries

A central component of a data trust is its legal structure. Interestingly, the three use cases adopted governance models that approximate, but do not equate to, a legal data trust. Even with the suggested legal and regulatory amendments, ICES focused on a data safe haven – a legal structure just short of a data trust which carries less liability and risk. The urban data trust model proposed by MaRS also approaches but does not realize a legal data trust structure. Similarly, Miovision chose a limited partnership rather than a data trust, as this model for governing relationships in a software environment offered greater flexibility.

All use cases, however, did opt for publicly operated governance models, reinforcing a common perception that public institutions are better suited to manage data for smart cities than private ones[47]. While the selected use cases fall short of advocating a legal data trust, they do outline prototypes that warrant further exploration. A summary of key elements underlying all three use cases is provided below (Table 3.).

	ICES Health Data Governance	MaRS –Mobility Data Governance	Miovision – Open Architecture Prototype
Goal	To provide groups outside of the research community with access to quality health data and analytics	To use multi-sector mobility data in a smart city to better understand, manage, model and regulate traffic flow and associated infrastructure, all under a citizen-centric approach	To promote more equitable access to data (for generators, processors and users), and opportunities for monetization, while maintaining citizen-centricity with security and privacy
Potential Users	Ontario researchers from academia and not-for-profit organizations and other health system stakeholders	Public transit operators, government and public entities, private organizations, startups, academia and civil society	Data generators, processors, aggregators and consumers from both the public and private sector
Data Type	Population level, longitudinal health data	Multi-sector mobility data	Transportation data
Organizational Structure	Independent publicly funded research and data organization, a 'prescribed entity' under PHIPA (Personal Health Information Protection Act)	Not-for-profit innovation hub and registered charity that helps innovators create a better world	Private company that aims to transform the way traffic is managed through AI. The goal is to improve the transportation experience for drivers, cyclists and pedestrians
Governance Model*	Data Safe Haven	Non-Legal Data Trust	Data Mart
Citizen Engagement	Public advisory council to provide guidance to ICES on what matters most to Ontarians in relation to their research and analysis	Citizen deliberation is an element of the not-for-profit entity designed to operate the trust, including a citizen assembly or jury to approve and co-design the trust. Civic participation may also take place in a dynamic consent platform, where citizens decide how they share data and what it can be used for	Citizens act as generators of data
Legal Structure	A legal data safe haven developed as a charitable trust based on promoting or advancing health and health care	A not-for-profit legal structure can provide the benefits of a legal trust, while limiting liability and offering increased flexibly to adapt the purpose over time	A limited partnership which allows multiple public and private sector actors to contribute source code, capital and other assets and to operate the data collective like a corporation.

Table 3. Summary table of the three use cases
*Note – It is anticipated that a distributed system with the appropriate underlying network security would be required to facilitate data exchange in all of these scenarios.

The hesitation to adopt a legal data trust model in these use cases may be a function of the need for the further evolution of Ontario's data sharing landscape and the data trust model itself. In his presentation at the SCGL, Digital Public cofounder Sean McDonald argued that a legal data trust is still an immature form that requires further definition before it can be usefully applied. In his view, an enabling environment, based on a theory of

legal rights, will be needed to elucidate many issues. Legal principles of accountability, ownership and usage rights and mechanisms for redress require greater clarification. Ultimately, said McDonald, a key question is whether data trusts can make money. If the answer is 'no,' it could hamper the use of this legal structure to protect data in smart city applications.

Trust, shared goals, clear accountability and known risks amongst stakeholders is integral to any data governance model. Failure to effectively demonstrate confidence, particularly to the satisfaction of citizens, can have negative consequences. In the case of the Sidewalk Labs proposal for smart city development of the Quayside property on Toronto's eastern waterfront, scrutiny over transparency around data uses, procurement and plans to usurp certain municipal functions has resulted in public unease. It also used an Urban Data trust model, which defines how data will be collected and controlled, and which relies on an independent third party to oversee the proper distribution of data value and to ensure security and privacy rights.[48] This oversight is intended to reinforce public confidence in the Quayside project. But as the Toronto example shows, the social contract between citizens and government – in which citizens give up their data in return for initiatives that will benefit the public – translates less easily to the private sector, where accountability is less certain.[49] Social acceptance – and public trust – it appears, rests in transparency around contractual agreements that detail roles, rights to protect and value data, and which specify responsibilities concerning data stewardship.

III. RECOMMENDATIONS

Smart city development is gaining momentum in Ontario, growing amongst a broad ecosystem of collaborators. Municipalities are already experimenting with smart deployment in the form of autonomous vehicle testing, air pollution monitoring, traffic congestion analysis and more. Despite nearly endless opportunities for smart cities to improve citizens' quality of life, there are many challenges. At the forefront of these are concerns around the use, privacy and security of citizens' data. Smart city projects involve a wide range of stakeholders, including civil society, government, academia and industry, which makes keeping goals aligned critical. Keeping smart cities citizen-centric and creating economic development opportunities for municipalities must be priorities.

Data governance is a vital piece of the smart cities puzzle. A robust framework, policies and regulations can ensure data is securely stored and used for its intended purpose. The question of which data governance model is ideal for a smart city still must be answered. Data trusts are emerging as a promising model for confidently enabling data sharing and access, but must be analyzed soon in a real-world pilot. The health, personal mobility, and open architecture use cases will help answer this complex challenge. If all stakeholders play their role, and data trusts can deliver their designed outcomes, smart cities are poised to impact Ontarians' everyday life positively.

Lessons Learned

The emergence of the smart city raises many questions about data governance, accountability and opportunities to facilitate improved social and economic benefit for the good of the public. The following are lessons learned from the Compute Ontario and ORION smart cities project:

- **Governance is not monolithic** – A clear takeaway from this examination of data governance models is that there is no one-size-fits-all approach. More sophisticated models, such as a data trust, may be needed in use cases involving personal information, stakeholder composition or where the intended uses are explicit. Multiple entities with different governance frameworks will likely exist at once within a smart city; one governance mechanism will not manage all data from all sectors with varying levels of sensitivity. When developing data-driven innovation policies, policymakers have to consider the ability to transition to new governance models as users' data needs evolve. Learning more about increasingly complex data governance models is worth further exploration.

- **All stakeholders have a unique role** – The delivery of social benefit will require leveraging the unique advantages that each stakeholder group brings to the smart cities' ecosystem. While some roles are more apparent than others, the value of researchers in investigating, testing and evaluating new technologies and ideas before they are deployed at scale, should not be diminished.

- **Education and consultation are integral** – While significant emphasis has rightly been placed on informing and educating the public, it is equally important to consult with other stakeholders such as researchers and industry to ensure they understand emerging concepts and their implications. Forums for bringing together diverse groups are important as they foster the development of a common language,

helping each stakeholder group understand the other's concerns, motivations and provide feedback as governance concepts evolve.

- **Think near-term and long-term action** – There are actionable steps that can be taken in the near-term while investments can be made and pilots created to test concepts to understand long-term objectives around data governance and smart cities better. Awareness-building and education can promote a positive data culture helping to coalesce shared interests, agreed upon accountabilities and risks needed to explore new models while working to solve longer complex issues like regulatory requirements.

- **Modernize policy and law** – As observed in the use case studies and illustrated by initiatives such as the development of a digital charter for Canada, a more agile approach to data regulation is required to keep pace with technology change and citizens' service expectations. Modernization of information protection legislation is also needed to ensure data from people, and things deliver the value promised by our emerging data-intensive future.

- **Ontario's smart city ecosystem is fragmented –** Smart cities is an emerging sector in Ontario, driven by dynamic, rapidly changing technologies. Stakeholder groups within smart cities have different motivations and concerns, leading to fragmented perspectives on issues such as smart cities' goals, who should enjoy the benefits, and who should participate. With no single voice or organization leading smart cities implementation in Ontario, with critical questions surrounding privacy, with trust and data management still unresolved, the region's smart city ecosystem lacks alignment. A framework that includes technology standards and governance guidelines is needed to accelerate deployment.

Recommendations to Fulfil the Potential of Smart Cities

Opportunities for economic development via smart city deployment are impressive, and there is strong momentum in smart city development in Ontario. The province continues to lead in research and testing in priority areas such as connected and autonomous vehicles, and there are several municipal pilots underway to validate smart applications in city operations, such as transport, energy and water.

Ontario's smart city initiatives to date are mainly ad-hoc and concerned with pilots and testbeds. Integrating and scaling these efforts to fully realize their potential will require addressing the many data governance issues identified above. For Ontario's smart city potential to be sustainable, it must be based on the creation and deployment of citizen-centric applications that offer stakeholder engagement and realize economic value. This report makes the following recommendations for provincial smart city decision-makers:

1. Consider regulatory amendments to the Municipal Freedom of Information and Protection of Privacy Act (MFIPPA) in order to allow the use of provincial health data for municipal system planning and evaluation;

2. Implement and evaluate at least one of the prototypes supported through the CO and ORION's smart cities pilot as a first step towards understanding the real-world benefits of complex data governance models;
3. Improve awareness of initiatives such as Evergreen and it's Future Cities Canada partnership, the Open Cities Network and Intelligent Communities Forum, which are focused on smart city related issues such as: community building, knowledge sharing, digital public infrastructure and solutions to municipal challenges;
4. Designate a not-for-profit organization to take a lead role in addressing challenges around data governance for smart cities. This includes evaluating pilots to identify policy and regulatory changes, analyzing economic development opportunities, coordinating the growth and scale of projects, and aligning goals and outcomes for stakeholders (e.g. skills training and expertise in data analytics, cybersecurity and advanced technologies).

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