National Research Council

WORKSHOP REPORT

NRC Cities of the Future Workshop
December 14, 2017, Ottawa

PREPARED BY:

Intersol

Table of Contents

Background

The National Research Council (NRC) is engaging with cities, industry and other stakeholders to support future sustainable urban growth in Canada and around the world through the development of game changing technology solutions solutions that will allow better infrastructure and infrastructure management, efficient transportation, clean technologies, and enhanced resource and waste management while contributing to the growth of Canada's digital economy.

Infrastructure Canada works to deliver new and existing infrastructure programs to ensure that the federal government's investments in public infrastructure will build communities that are livable, sustainable and prosperous for all Canadians. It recently kicked off the Smart Cities Challenge which challenges communities of all sizes to come forward with their best ideas for improving the lives of their residents through innovation, data and connected technology.

With this background as context, key stakeholders from municipalities, the private sector, the federal government, non-governmental organizations, universities and the research community met during a one-day workshop co-hosted by NRC and Infrastructure Canada on 14 December, 2017 in Ottawa to discuss the challenges in building smart, sustainable, and integrated cities in Canada.

The purpose of the workshop was to address to the following questions:

- What key science and technology (S&T) issues must be resolved on the 5- to 10-year horizon to create the smart and sustainable integrated city of the future that we envision?
- For each key S&T issue, what is the desired end state and what must we do now to achieve that end state?

This report summarizes the presentations given and discussions that took place during the workshop and presents the resulting six priority areas identified by the participants: Harmonization and Data Sharing (including standards); Procurement Challenges; Engagement, Education and Awareness; Cybersecurity; Governance and Policy Coherence; and Connectivity. The report will be used by NRC to inform its ongoing Cities of the Future planning process. The official agenda is attached in Appendix A.

Welcome and Introductions

Iain Stewart, President, National Research Council

With more than 80% of Canadians now living in urban areas, cities play an immense role in Canadian GDP, said Iain Stewart in his opening remarks. Like others around the world, our cities face a range of challenges that will only grow larger and more complex. These include generating millions of tons of waste every year; an infrastructure deficit; increasing traffic congestion; sustainable development challenges; and, susceptibility to extreme weather events and climate change.

NRC works in the innovation space related to cities with projects that include digital technologies, construction, traffic optimization, transportation systems, waste treatment and bioenergy systems. NRC is looking to expand its activities in sensors, cybersecurity, data systems, smart and green materials and new approaches to energy and emissions.

Both NRC and Infrastructure Canada are committed to supporting the Government of Canada priorities and to improving the quality of life of Canadians through innovation. This workshop is an opportunity to envision what cities of the future might look like. We need to consider the S&T issues to be resolved and the linkages and the practices needed to collectively support the success of the cities of the future in Canada.

The power of the innovation system is the breadth and diversity of the players involved and the voices of municipalities, university, colleges, and private sector and government organizations. NRC is changing how it operates within this innovation system in order to work in more structured collaborations (Collaborative R&D Programs, Collaboration Centres) in support of Canada's needs. NRC is both a partner with resources and capacity and a platform for collaboration with cities, other research organizations, universities and the private sector, he concluded. As a community, NRC and its stakeholders can bring their resources to bear on the challenges we face.

Kelly Gillis, Deputy Minister, Infrastructure and Communities, Infrastructure Canada

Deputy Minister Gillis called the workshop a timely session. To support rebuilding for the 21st Century, Canada is making important investments in its communities and infrastructure. Sustainable growth and understanding data and technology for Canadian cities is an important part of that. The team at Infrastructure Canada has consulted with communities across the country to understand the kind of outcomes that can make a difference in their localities. Infrastructure Canada has also recently launched the Smart Cities Challenge.

This Challenge seeks to encourage communities and their most creative minds to adopt "smart city" approaches to solving community issues: delivering meaningful outcomes by leveraging data and connected technology. Communities of all sizes are coming forward with ideas that cover a large spectrum of smart city applications, from sustainability and the environment to security and inclusion. Applications submitted will be open so that others can learn from and replicate projects.

The Deputy Minister noted that the diverse audience of subject-matter experts, municipalities, academics and other actors present at the workshop is a testament to the type of collaboration that is desired through the Smart Cities Challenge. There is a need and an opportunity to make a difference for society and to maintain the standard of living of Canadians.

Key Challenges and Experiences: Panel Presentations and Discussion

Moderated by Marc Valois, a panel of representatives from several cities across the country made brief presentations and took questions under the theme: What are the key challenges to achieve smart and sustainable integrated cities in Canada?

Panelist Presentations

Nasir Kenea, Chief Information Officer, City of Markham

Markham has a strong concentration of information and communication technology companies, organizations and institutions and is becoming more urbanized, said Nasir Kenea. The city is expanding broadband internet connectivity over the next several years through cooperation with commercial providers. Markham is now implementing its Digital Markham strategy, which was developed through extensive consultation with the community and local experts. Approved and funded by council in 2017, the strategy provides a technology roadmap for the next three to five years.

Mr. Kenea explained how Markham has adopted a "digital first" approach with the goal of creating a "frictionless city" with emphasis in four areas:

- Engaging and serving the community
    - o Increase integrated digital services on the web & mobile
    - o Expand community engagement on digital platforms
    - o Improve digital literacy
    - o Grow Markham's leadership in digital democracy
- Being a digital differentiator for business
    - o Establish a showcase digital community through strategic partnerships
    - o Establish new standards for the smart city
    - o Reduce friction for business
    - o Attract & retain businesses & talent that align with Markham brand
- Supporting the digital workplace
    - o Increase organizational digital maturity
    - o Establish a digital operating model
    - o Enhance data-driven decision making
    - o Increase resiliency of digital infrastructure
- Establishing the city as a platform for innovation and collaboration between citizens, business, and government that contributes to the overall quality of life in the city
    - o Develop a "living lab" in Markham for rapid prototyping new initiatives
    - o Increase awareness of a new, unique #DigitalMarkham brand
    - o Leverage ICT cluster to establish Markham as a showcase digital community
    - o Increase transparency & access to open data

He continued with a description of Markham Centre, a development for residence and business that will include transportation innovation, a city library that will be a hub for learning and technology experience and digitally-enabled buildings with full broadband connectivity and networked services across the development. In presenting Digital Markham's Living Lab for the rapid prototyping of new initiatives, he discussed challenges the city faces related to governance, standards, security and privacy.

Michael Baldwin, Assistant Director, Growth and Community Services, City of Fredericton

Fredericton has a population of 56,000 with projected growth of 20,000 over the next 20 years, said Michael Baldwin. Core infrastructure is critical. In its Vision 2000 plan, the city provided free Wi-Fi through a municipally-owned telco and fibre network. The Vision 2020 plan is focused on digital infrastructure. The visions of the future will emphasize more integration and broadband connectivity. Specific initiatives underway in their integrated approach include Knowledge Park (a technology and research park), Ignite Fredericton (a program to support economic development and entrepreneurial enterprises) and Planet Hatch (New Brunswick's flagship business accelerator and support for start-ups).

The city is serving as a test bed for start-ups in parking, public transport and other areas and provides an open data portal. Challenges have arisen in regards to the integration and coordination of core systems. To make all this work, he emphasized, innovation, e-government and human resources/finance must all work together.

Mr. Baldwin cautioned that innovation is slower in city government. Citizens as consumers expect an app for everything. Community engagement is key. Cities need to be clear on what problem it is that they are trying to solve. This will help define how best to partner to achieve a solution.

Peter Leathley, Sr. Program Manager - Digital Infrastructure and Assets, City of Vancouver

Vancouver has been on a path to create a smart, intelligent, connected, green city. As part of this journey, Vancouver put together a digital strategy five years ago, explained Peter Leathley. They are now in a phase of technology transformation focusing on connectivity and data. By 2019, they expect to enter a three-year optimization phase focused on interoperability.

Projects are focused on four areas of emphasis:

- Engagement and access: Citizens and businesses can easily interact with the City through digital channels (example project: VanConnect app that, among other things, facilitates graffiti removal)
- Infrastructure and assets: A robust digital infrastructure built through strategic investments and partnerships (example project: free Wi-Fi across much of Vancouver)
- Digital economy: Vancouver is a global leader in supporting innovation and growth in the digital economy (example project: the Green & Digital Demonstration Program)
- Organizational digital maturity: Putting the smart in Smart City (example project: a digital dashboard for the city manager).

Collaboration and engagement were key to getting to this point.

He noted that interoperability was a key concern when implementing new technologies and systems. They are creating a "data fluent culture" and are using their mobile workforce to collect data as they carry out their primary roles. In one example, sanitation engineers capture geocoded data that is distributed to social services partners the very next day in order to help them better support the city's homeless population.

John Smit, Director, Economic Development & Long Range Planning, City of Ottawa

Ottawa is integrating planning and economic development so that they work better together, said John Smit. In the future, the city will move to scenario-based planning to identify disruptors, such as Uber, and plan for them rather than looking back at past trends.

Ottawa is acting as coordinator to bring partners together with an emphasis in four key areas: the knowledge-based business sector, rural economic development, tourism and creative industries, and urban services. The city is also working with business improvement areas (BIAs), Invest Ottawa, the Film Office, the Ottawa Hospital and stakeholders in the city's music strategy to attract talent and develop new business lines.

Mr. Smit explained how, through its Smart City 2.0 Strategy, the city is pursuing initiatives in three thematic areas: improving digital connectivity; capitalizing and expanding on Ottawa's smart economy (information technology, health services and knowledge-based industries); and providing innovative, responsive government with three key elements: a robust mobile client experience (interface, apps and content), analytics-driven solutions (transparent and automated, with open data and visualizations to support accessibility and understanding) and intelligent infrastructure (connected, automated and data-rich, with real-time monitoring).

Heather Reed-Fenske, Director/Chief Information Technology Officer, City of Calgary

Heather Reed-Fenske said Calgary has found that a planned approach is the key to success. The city's vision is "making life better every day." Calgary covers a large landmass. To stay on top of it, the city has digitally connected 400 buildings and hundreds of vehicles to constantly provide data input.

In addition, Calgary has also created a variety of networks: a multiprotocol label switching transport network for high-performance data transfer; radio towers that provide broader network coverage throughout the region; a broadband fixed wireless network; machine-to-machine (M2M) Wi-Fi; and an internet-of-things (IoT) low-power, long-range network across the geographic area. She noted that IoT interoperability was a key issue. They have found that the best way to ensure their IoT interoperability is through the use of open source software, open application program interfaces (APIs) and open standards

The city leases out its dark fibre network which has enabled a number of innovative research projects on topics such as quantum encryption, the use of fibre as a sensor and an acoustic sensor map to support intelligent transportation systems. It has also resulted in innovations to city business operations such as networked water flow sensors for optimizing the management of tree watering.

Questions and Discussion

Following the Panelists' presentations, the moderator asked some probing questions and attendees were invited to ask questions and contribute to the discussion. A summary of some of the key points raised during the discussion is presented below.

What do we need to do to get us to the city of the future?

Panelists agreed that solid network infrastructure is fundamental to cities of the future, equivalent to the importance of roads in the 20th century. Municipal ownership was seen as an important consideration to keeping costs down and maintaining flexibility. Partnering can allow progress in the face of budget constraints, but the business model must be clearly defined and ensure equity for all partners.

Social acceptance and regulatory preparedness were also identified as important for the digital city. Municipalities can govern the areas they control, but provincial and federal law will both positively impact and impede new technology for cities. Privacy, literacy, security and access to all are issues that need to be addressed.

Cities don't have access to the same type or amount of resources. Though there are similarities, municipalities across Canada may differ in their resources and regional context. Telcos, for example, may not want to invest in smaller cities. What can cities do to address their needs?

Fredericton and other municipalities in New Brunswick face this same difficulty in attracting investment. Looking at and drawing inspiration from solutions already in place in other cities is an option. While new systems may improve efficiency, it was also noted that a real or perceived negative impact on jobs may slow down implementation.

Could a common modular platform be developed through which all cities could build and share applications?

There was agreement that it makes sense for cities to replicate existing approaches. Rural areas also have their challenges because they tend to have lower digital connectivity than urban areas.

Hurdles to a common platform were identified. One is the need to be able to accept vertical data sets in order to capitalize on the information that can be gathered. Another is that cities have different procurement systems with varying regulations and timelines, making leveraging new systems difficult. Additionally, some procurement systems preclude companies that participate in the design of technology solutions from bidding on calls for proposals seeking to implement these solutions..

New technology must improve people's lives and not just be tech for tech sake. What is your knowledge management strategy?

Panelists felt systems that improve service delivery lead to positive impacts with real outcomes for citizens. Good governance is necessary to make systems seamless and improve the user and citizen experience. Examples included providing a constant feedback loop through user information channels (such as "3-1-1" apps) and the transparent sharing of data with citizens.

Data has value. Do cities have policies in place in order to capitalize on the data they own?

There is not a uniform policy. Calgary does sell some data, but the shift to open data has made it more difficult. Fredericton lets partners use city data to produce win-win results, i.e. a needed solution by the city and a commercial application for the partner.

Identification of Key issues,

Challenges and Opportunities for Smart City Adoption
Alan Swain, VP, Technology and Operations, Wavefront

To help set the stage for the group discussions on key S&T issues that must be resolved on the next 5 to 10 year horizon, Alan Swain presented on "Challenges and Opportunities for Smart City Adoption". The findings he presented, which are based on Wavefront's primary and secondary research, were mirrored in the participant discussions throughout the day.

He defined a smart city as one that operates a series of internal applications (e.g., waste management, risk management, operations centres, energy and water management) and citizen applications (e.g., smart parking, open data portal, government services, public transit). These applications function on top of an integrated data infrastructure that supports analysis (storage, interpretation and access), communication (various hard-wired and wireless network structures) and collection (via sensors and user input). The security of the entire architecture is ensured through access control, user privacy measures and data integrity approaches such as blockchain technology.

Challenges to smart city adoption:

- Lack of internal budgets to finance initiatives;

- Citizen-funded projects tend to get traction;

- Inter-department coordination and mis-aligned priorities;

- Lack of high tech talent on city staff (difficult to attract and retain);

- Often a lack of community engagement that results in project failure;

- Scaling from pilot to implementation;

- Procurement processes often not designed for innovation; and,

- Rapidly changing technology.

Opportunities to smart city adoptions:

- Leveraging start-ups and small and medium enterprises (SMEs) can reduce costs. The city of Singapore has a devoted group to certify small and medium businesses for procurement;

- Shared knowledge about what does and, maybe more importantly, doesn't work;

- Shared resource models and testbeds can help smaller cities make progress; and

- City master planning focused on citizen-centric design and solutions.

Strategies, Capabilities and Initiatives

To help set the stage for the afternoon's discussion on identifying potential solutions, Patricia McCarney, (WCCD) and Kristina Verner (Waterfront Toronto) were invited to share their perspectives on urban innovation and the related challenges.

Patricia McCarney, President and CEO, World Council on City Data, Director, Global Cities Institute

The Global Cities Institute led the development of the first ISO standard for cities, ISO 37120. Starting with nine pilot cities, the effort looked at what indicators they were using. The World Council on City Data (WCCD) was created to certify cities against the new standard. Sixty cities are now certified cities, including eight in Canada. Twenty countries are voting on the standards.

Based on demand, WCCD has developed new standards for smart cities and resilient cities. Having comparable, high quality data allows for cross-city comparisons and standard measures. The data resides on an open portal, and they are working to generate useful information from the data.

They have found that access to linked data creates a culture of communication between cities to share best practices. Toronto's data supported the development of their Amazon HQ2 proposal. Good quality data helps cities compete internationally and supports meeting the UN Sustainable Development Goals.

Kristina Verner, VP Innovation, Sustainability and Prosperity, Waterfront Toronto

Waterfront Toronto is the revitalization agency for Toronto's 2,000 acres of waterfront. The Quayside Project is the result of a long procurement process awarded to Sidewalk Labs, which is the urban revitalization arm of Alphabet, Google's parent company. Quayside embodies several priorities: sustainability, climate positive, public realm, enhanced mobility, built environment, community, digital platform. As part of the plan, Google will move its Canadian headquarters to the eastern waterfront.

The city is now in the initial planning stages with Sidewalk Labs and will start stakeholder and community consultation shortly. The hope is that outcomes will include reducing the cost of living, saving commuting time, increasing green space and promoting civic engagement.

Key Issues and Recommendations

In the morning, participants broke into small groups to identify key science and technology issues that must be resolved on the five to 10 year horizon to create the envisioned smart and sustainable integrated city of the future. Each table was asked to identify up to four issues. The details of these discussions are presented in Appendix C.

In plenary, the resulting issues were grouped into common themes and concepts. The eleven common themes identified were then ranked by participants in terms of importance and urgency:

Common Themes (in order of total votes)	Rank by Importance	Rank by Urgency
Cybersecurity	4	2
Connectivity	1	6
Procurement Challenges (including IP ownership, scaling, etc.)	5	1
Governance and Policy Coherence	2	3
Harmonization and Data Sharing (including standards)	3	5
Engagement, Education and Awareness	6	4
Big Data and Analytics	7	7
R&D Fragmentation	10	10
New Business Models (IP, Data, ROI (return on investment)	8	9
Resilience	9	11
Standards Development	11	8

This ranking exercise produced a final list of six research priorities that were the focus of the afternoon discussions. On balance (considering total votes, ranking by importance and ranking by urgency), there was a strong clustering of the top six items for overall priority. Six groups, one for each priority, further defined the

issue and formulated a desired end state, and made recommendations for achieving it. The final synthesis is presented below.

Cybersecurity

➢ **Clarification and description of the issue and associated challenge(s)**

Protection of IT hardware and data against both deliberate and accidental corruption of infrastructure and data integrity. For Smart Cities, citizen buy-in and public trust are reliant on security being built-in.

➢ **Vision: Description of a realistic desired end state**

There is no end state because technology is in a continuous state of change and we need to stay one step ahead of the threats. Comprehensive plans will need to be put in place, including risk analysis and management, protection level planning (not all data is equally valuable or sensitive), but they must be resilient. It is analogous to the flu vaccine—the overall strategy remains consistent, but the content of the vaccine must be continually updated. Artificial intelligence will come into play here.

➢ **Key enablers that contribute to achieving this desired end state**

- Education
- Policy
- Subject matter experts
- Funding

➢ **What we need to achieve the desired end state**

There is no end state: the beacons are moved all the time

➢ **Significant barriers or risks, that would hamper our ability to achieve the desired end state**

- Blissful ignorance
- Unwillingness to learn or share knowledge and experiences

➢ **Strengths: What is going well? …What should we continue doing "as is"?**

- Research is doing well
- International collaboration

➢ **Build: What should we start doing that we are not doing now or is there something we should be doing more of?**

- Better education
- Mitigation strategies (back-up plans)
- Resilience
- Sharing information

➢ **Trim: What should we stop doing or is there something we are doing that we should be doing less of?**

- Thinking of security as an afterthought

- Protecting *everything*
- Blissfully ignoring the problems

➤ **Recommendations: what recommendations for action would really move the yardsticks towards the desired end state described? Who will lead each recommendation and who should support each recommendation?**

- Promote increased awareness and information exchange among players and look at other jurisdictions such as California and the EU (European Union).
- Make adhesion to a set of pre-determined guidelines a requirement for federal funding.
- Establish a policy of built-in cybersecurity by design.
- Have a mitigation strategy to fall back on, e.g., ransomware can be addressed with appropriate backups.

Connectivity

➤ **Clarification and description of the issue and associated challenge(s)**

The issue of network connectivity and data fluidity applies to all systems: IT, data, water, electricity, etc.

How do we ensure that data is available for use at any given moment to enable real-time services, decision making and provide added value?

➤ **Vision: Description of a realistic desired end state**

We achieve 100% connectivity managed by public infrastructure with a set of federal standards that has clearly articulated roles and responsibilities, is flexible and is based on solid collaboration.

Costs are brought down to a point where services become affordable for all and properly serve the tax payer (both private and corporate citizens).

➤ **Key enablers that contribute to achieving this desired end state**

- Inter-operable connectivity standards that can be easily benchmarked
- Fibre systems linked through wireless; choose a network topography that can be changed on demand

➤ **What we need to achieve the desired end state**

- Recognition that connectivity is an essential component for quality of life, and that a proper P3 collaboration (across all levels of government) is essential.
- A national strategy that starts with federally and migrates down to the municipality.

➤ **Significant barriers or risks, that would hamper our ability to achieve the desired end state**

- Funding
- Political risk aversion
- Misunderstanding of the value of failure

➢ **Recommendations: what recommendations for action would really move the yardsticks towards the desired end state described? Who will lead each recommendation and who should support each recommendation?**

- To address differentiation across cities, work with the Federation of Canadian Municipalities to facilitate the development of a national strategy, led by Infrastructure Canada/Innovation, Science and Economic Development Canada, that filters down to provinces and cities.

- Start developing a model for connectivity that is seen and treated as key infrastructure.

Procurement Challenges (including IP ownership, scaling, etc.)

➢ **Clarification and description of the issue and associated challenge(s)**

Traditional prescriptive procurement does not support innovation. It imposes onerous requirements on SMEs, requires that the city knows the solution in advance (which may not be best) and precludes proof of concept demos to reduce risk.

➢ **Vision: Description of a realistic desired end state**

An outcome driven process that promotes innovation and flexibility, enables demos and proofs of concept, eliminates barriers to SMEs and remains impartial and transparent. The approach should be for the city to define a problem in an RFP (request for proposal) and ask bidders for solutions.

➢ **Key enablers that contribute to achieving this desired end state**

- Defining the problem and not defining the solution in the RFP

- Innovative evaluation criteria: Pilots are used to demonstrate the solution and the winner is selected based on performance criteria

- More flexible but robust risk assessment criteria

- IP management: Needs flexible processes

- P3 (public-private) and other innovative partnerships

➢ **What we need to achieve the desired end state**

- Culture change and a willingness to approach things differently

- Change management

- Civic or corporate champion for change

- Legal and risk management support

➢ **Strengths: What is going well? …What should we continue doing "as is"?**

The current system is fair, respects trade agreements and is an open process that manages risks well—but at the expense of innovation.

➢ **Build: What should we start doing that we are not doing now or is there something we should be doing more of?**

- Build specialised teams with technical knowledge to write the specs and RFP, and conduct bid adjudication

- Hire procurement consultants or specialists for buying

➢ **Recommendations: what recommendations for action would really move the yardsticks towards the desired end state described? Who will lead each recommendation and who should support each recommendation?**

- Pilot innovation in procurement for the public sector.
- Cities should develop dedicated technical teams to support the procurement process.

Governance and Policy Coherence

➢ **Clarification and description of the issue and associated challenge(s)**

There are several levels of government with different drivers. For coherent policy and data, these need to be integrated, addressing gaps and minimizing overlaps.

➢ **Vision: Description of a realistic desired end state**

Everyone at each level knows their role and has the ability to advance outcomes with identified funding. A productive relationship exists between the public and private sectors.

➢ **Key enablers that contribute to achieving this desired end state**

- Federation of Municipalities
- Task force of key stakeholders
- Departments with accountabilities in this sector (Infrastructure Canada, Industry Canada)
- Industry driven
- Provincial government
- ADIT (data interface tool) tables
- Predictable partnership framework

➢ **What we need to achieve the desired end state**

- Funding
- Strong partnerships
- An advisory/governance board with accountability

➢ **Significant barriers or risks, that would hamper our ability to achieve the desired end state**

- Absence of collaboration
- Scope creep
- Waiting for others to do it
- Misalignment of resources
- No digital strategy (no one in charge)

➢ **Strengths: What is going well? …What should we continue doing "as is"?**

- World Council on City Data (WCCD)
- Smart City Challenge (innovation)

➢ **Build: What should we start doing that we are not doing now or is there something we should be doing more of?**

- More engagement, more R&D, more living labs, more partnerships for innovative solutions
- Enhanced partnerships with SMEs
- Open data
- New procurement approach
- Education

➢ **Trim: What should we stop doing or is there something we are doing that we should be doing less of?**

- Politicking
- Bad, repetitive pilots
- Lack of transparency

➢ **Recommendations: what recommendations for action would really move the yardsticks towards the desired end state described? Who will lead each recommendation and who should support each recommendation?**

- Develop a federal task force responsible to the Minister of Infrastructure that provides a dashboard on progress and reports on key indicators.
- Create a functional policy framework.

Harmonization and Data Sharing (including standards)

➢ **Clarification and description of the issue and associated challenge(s)**

Each municipality currently has its own plan for dealing with data. We need to have harmonized plans to produce comparable, standardized data.

- Harmonisation could be required through the procurement process.
- We need benchmarks so that reported data can be put in context.
- Other countries do it. We should be able to do it as well.

➢ **Vision: Description of a realistic desired end state**

There is a permanent, widely adopted requirement for data harmonisation. Data is securely held by a dedicated agency that makes it available and accessible, and analyzes it in a timely manner. Stats Canada 2.0 could potentially play that role.

➢ **Key enablers that contribute to achieving this desired end state**

- Cross-sectional consensus is required

- Requirements and specifications for data formats should be designed

- Education about data usage is required

- Public and private benefits need to be articulated

➢ **What we need to achieve the desired end state**

- Government needs to make harmonisation an essential requirement.

- There is a need for partnerships including academia, the public realm and the private realm. Institutions such as hospitals and nursing homes need to be included in the partnerships.

- Data-based benchmarks are required to encourage development in areas where municipalities lag.

- Funding and expertise to manage data need to exist in participating organisations.

➢ **Significant barriers or risks, that would hamper our ability to achieve the desired end state**

- Funding is required without interruptions so that continuous data sets are available.

- Harmonisation needs to be permanent, not project specific.

➢ **Strengths: What is going well? …What should we continue doing "as is"?**

- We are already moving towards open data.

- Technology exists for data visualisation.

- There is recognition that more data will bring benefits but less clarity on how exactly it will happen.

➢ **Build: What should we start doing that we are not doing now or is there something we should be doing more of?**

- Create purpose-driven, intentional connections between participants in the data ecosystem.

➢ **Trim: What should we stop doing or is there something we are doing that we should be doing less of?**

- Stop reinventing the wheel. Currently, each new program develops its own methodology.

- Stop creating parallel, competing standards.

➢ **Is there anything else that we have not discussed that will help inform our recommendations?**

- Create a culture where the political risks of revealing unfavourable data are outweighed by the benefits of having the data in the first place.

➢ **Recommendations: what recommendations for action would really move the yardsticks towards the desired end state described? Who will lead each recommendation and who should support each recommendation?**

- Create an Urban Observatory at Statistics Canada that is trusted by municipalities and fosters a culture for data sharing to support change and progress.

- Support and fund the capacity for harmonized data management across the public sector.

Engagement, Education and Awareness

➤ **Clarification and description of the issue and associated challenge(s)**

This is a critical issue that affects all other issues. Cities need to know the issues that people care about. Processes and solutions must be transparent and driven by end users so that people will participate and care about the outcomes. Quality of life and the quality of the experience are central concerns.

➤ **Vision: Description of a realistic desired end state**

The holy grail is to reach people who don't usually participate. Create a situation in which the people themselves come up with solutions and Canada is recognized as having the highest quality cities in the world.

➤ **Key enablers that contribute to achieving this desired end state**

- Openly available and accessible data

- Safe, comfortable and fun

- Citizen data collection

- Shared and verified best practices

➤ **Recommendations: what recommendations for action would really move the yardsticks towards the desired end state described? Who will lead each recommendation and who should support each recommendation?**

- Create an interactive best practices repository and a community of practice to promote success stories.

- Engage citizens to gather data by going to them and encourage all Canadian cities to gather data in a similar manner.

- Promote high quality urban design to make our cities enjoyable, wonderful and delightful.

- This effort should probably be led by the Federation of Canadian Municipalities with support from other not-for-profits, our communities and all levels of government.

Closing Remarks and Next Steps

Geneviève Tanguay, Vice-President Emerging Technologies at NRC, closed the workshop by stressing that collaborative and innovative systems will be needed to build the cities of the future envisioned by participants. The stakeholders represented by workshop participants, in partnership with NRC, can help make this happen by creating a community of practice. Such a community, through a variety of means, would help connect cities, researchers, industry, app developers and other stakeholders and assist them in building on each other's experience.

She noted that several living labs are under development across Canada. This presents the opportunity to connect these initiatives and to look at technology solutions and opportunities through an integrated systems perspective, for example sensors and various "smart" technologies will require reliable and sustainable energy systems. "To continue building this community of practice, we need to learn from past experiences, look at best practices and be inspired by successes". A workshop with regulators and policy makers may also be part of these next steps.

NRC will continue to develop the ideas discussed at this workshop to achieve smart and sustainable integrated cities in Canada, explore opportunities to facilitate connections between its researchers, cities and other stakeholders and support access to NRC expertise. The accomplishments of this workshop will inform that ongoing process, with future meetings to come.

Appendix A – Meeting Agenda

National Research Council (NRC) Workshop on the Cities of the Future
Date: 14 December, 2017
Time: 8:00 – 16:00 (Lunch and refreshments will be provided)
Location: Ottawa Conference and Event Centre, 200 Coventry Road, Ottawa, Ontario, K1K 4S3

"What do we need to do to create the cities of the future that we envision?"
Agenda

8:00 – 8:30   Arrival and Sign-In

8:30 – 8:45   **Welcome and Introductions** – Iain Stewart, President, NRC and Kelly Gillis, Deputy Minister, Infrastructure and Communities, Infrastructure Canada

8:45 –10:15   **Panel Discussion: what are the key challenges to achieve smart and sustainable integrated cities in Canada?**

Heather Reed-Fenske, Director/Chief Information Technology Officer, City of Calgary

Nasir Kenea, Chief Information Officer, City of Markham

Michael Baldwin, Assistant Director, Growth and Community Services, City of Fredericton

Peter Leathley, Sr. Program Manager - Digital Infrastructure and Assets, City of Vancouver

John Smit, Director, Economic Development & Long Range Planning, City of Ottawa

10:15 – 10:45   Break

10:45 – 12:00   **Identifying top issues to address**
Alan Swain, VP Technology and Operations, Wavefront – Challenges and Opportunities for Smart City Adoption

Discussion in groups: What key S&T issues must be resolved on the 5 to 10 year horizon to create the smart and sustainable integrated city of the future that we envision?

12:00 – 12:30   Plenary to share results

12:30 – 13:30   **Networking Lunch**

13:30 – 14:00   **Strategies, capabilities, and initiatives**
Patricia McCarney, President and CEO, World Council on City Data, Director, Global Cities Institute

Kristina Verner, VP Innovation, Sustainability & Prosperity, Waterfront Toronto

14:00 – 15:15   **What are potential solutions (medium and longer term)?**
Discussion in groups: for each key S&T issue, what is the desired end state and what must we do now to achieve that end state?

15:15 – 15:45   Plenary to share results

15:45 – 16:00   **Wrap-up, Next Steps and Closing Remarks** – Geneviève Tanguay, Vice-President Emerging Technologies, NRC

Appendix B – Participant List

First Name	Last Name	Organization
Robert	Arnold	National Research Council Canada (NRC)
Michael	Baldwin	City of Fredericton
Antoine	Belaieff	Metrolinx
Scott	Bucking	Carleton University
Frank	Cairo	Caivan Communities
Trinela	Cane	City of Markham
Carl	Caron	National Research Council Canada (NRC)
John	Chiappetta	Open Data Exchange
Béatrice	Couture	InnoCité MTL
David	Crenna	Canadian Home Builders' Association (CHBA)
Berry	De Bruijn	National Research Council Canada (NRC)
Therese	De Groote	Social Sciences and Humanities Research Council of Canada (SSHRC)
Ashley	De Souza	Ryerson Institute for Infrastructure Innovation
Brad	Defoe	Invest Ottawa
Serge	Delisle	National Research Council Canada (NRC)
Christiane	Deslauriers	Agriculture and Agri-Food Canada (AAFC)
Tanya	Doran	Stantec
Hugh	Dysart	Communications Research Canada
Peter	Fedechko	International Road Dynamics
David	Fell	Eastern Ontario Regional Network (EORN)
Soumya	Ghosh	City of Edmonton
Kelly	Gillis	Infrastructure Canada
Ron	Gordon	Cisco Canada
Rafik	Goubran	Carleton University
Allison	Hamlin	City of Ottawa
Patty	Hargreaves	s2e Technologies Inc.
Ian	Hodkinson	Bombardier Transport
Mohamed	Ibnkahla	Carleton University
Gilles	Jean	Concordia University, Montreal
Nasir	Kenea	City of Markham
Khelil	Khelil	Purolator
Bowdin	King	Federation of Canadian Municipalities
Catherine	Lavoie	Centre d'expertise et de recherche en infrastructures urbaine
Catherine	Lavoie	Communauté métropolitaine de Montréal
Peter	Leathley	City of Vancouver
Patrick	Leclerc	Canadian Urban Transit Association
Eric	Lefebvre	Partenariat du Quartier des Spectacles
Renaud	Levesque	Defence Research and Development Canada (DRDC)
Kaili	Levesque	Natural Resources Canada (NRCan)

First Name	Last Name	Organization
Rowena	Luk	
Georgette	Macdonald	National Research Council Canada (NRC)
Jeff	Mackey	CUTA – Canadian Urban Transit Association
Douglas	Macleod	Athabasca University
Joel David	Martin	National Research Council Canada (NRC)
Mark	Masongsong	UrbanLogiq
Patricia	McCarney	University of Toronto/World Council on City Data
Andrew	McCreight	City of Ottawa
Magali	Merkx-Jacques	National Research Council Canada (NRC)
Bill	Munson	University of Waterloo/Institute for Quantum Computing (IQC)
Trevor	Nightingale	National Research Council Canada (NRC)
Anneke	Olvera	Standards Council Canada
Shane	Ottens	Mattamy Homes Limited
James	Patava	World Council on City Data
Aleksander	Patrzykat	National Research Council Canada (NRC)
Gerard	Peets	Infrastructure Canada
Stéphane	Pipon	MDI Conseils et Technologies Inc
Daniel	Potechin	Mattamy Homes Limited
Christophe	Py	National Research Council Canada (NRC)
Sean	Rathwell	Dillon Consulting
Heather	Reed-Fenske	City of Calgary
Bruce	Ringrose	FarmersEdge
Marie-Chantal	Ross	National Research Council Canada (NRC)
Jonathan	Rybicki	Infrastructure Canada
Shawn	Slack	City of Mississauga
John	Smit	City of Ottawa
David	Smith	Sustainable Development Technology Canada (SDTC)
Marjolaine	St-Arnaud	Ville de Montréal
Andrea	Steenbakker	Barrhaven BIA
Iain	Stewart	National Research Council Canada (NRC)
Alan	Swain	WaveFront
Helen	Tang	Defence Research and Development Canada (DRDC)
Geneviève	Tanguay	National Research Council Canada (NRC)
Bala	Venkatesh	Ryerson University
Kristina	Verner	Waterfront Toronto
John	Weigelt	Microsoft
Susan	Weston	Infrastructure Canada

Appendix C – Identifying Top Issues to Address (Group Discussions)

What key science and technology issues must be resolved on the 5 to 10 year horizon to create the smart and sustainable integrated city of the future that we envision?

In the morning, each table was asked to answer this question by identifying up to four issues.

Table 1

- Testbeds to lower the risk of new technologies
    - Cities used to make decisions for 20 years down the road. Now technology evolves incredibly fast. Design should be forward looking and use modular, adaptive approaches to stay current.
    - There is a trade-off between standardization and innovation.
    - To modernize, small cities need to reduce operating expenses by thinking digitally.
- Cybersecurity and privacy strategy: Security should be integrated right from the design stage.
- Tangible benefits for citizens to achieve better buy-in: for example, tax reductions for sharing data.
- Resilience and agility in the face of disasters and emergencies.

Table 2

- Reliance on technology: What happens when the internet goes down?
- Artificial intelligence: Human intervention around important decisions
    - Who develops the algorithms and who ensures they are accurate?
- Virtual/community-based work spaces for corporations
- Electric vehicles and the grid: The capacity and intelligent systems are not yet in place to meet changing demands.
- Digital inclusivity and social acceptance of technology.
- Privacy and security: Facial recognition; identity and access; sensitive data (personal and infrastructure).

Table 3

- Development of horizontal platforms for data collection, aggregation and analytics
    - Data quality is an issue
    - Develop national standards
- Connectivity infrastructure (electoral, waste, water, etc.) must be resilient, sufficient and agile

- Address roadblocks to S&T innovation and adoption for civic engagement, inclusiveness and client experience:
    - Roadblocks include procurement, business models, policy, regulation, uncertainty in legal framework
    - Need to be supportive rather than inhibiting
    - Technology and business models are changing; cities need to be agile
- Education and awareness among users
    - Engagement of constituents
    - Sensitivity, understanding, awareness, social networking issues around cyber security

Table 4

- Governance issues: As opposed to the current siloed approach, cities need to harmonize municipal data collection to make it more useful.
    - Give businesses the opportunity to serve multiple cities with the same product.
- Role of analytics: From the raw data to aggregated, interpreted patterns
- Political will to support open data
    - Politics is not always compatible with data-driven decision making
    - Open data vs. monetized data (both data generated by public entities (cities) as well as that generated by private entities)
- Make long-term plans more specific

Table 5

- Connected technology solutions must bridge new and old infrastructure
    - Must address the financial and environmental sustainability of current infrastructure and its interface with new, smart and resilient infrastructure.
- Policy coherence: Consider integration across all levels of government
    - Across the municipal, provincial, and federal spectrum, broad technical requirements, IP and data policies, technology sharing/financing requirements, and inter-operability requirements need to be identified for municipal infrastructure so that (a) municipalities know how to deploy infrastructure that is adaptable, flexible, upgradable, and easily re-purposed, and (b) technology developers know what they can plug into.
- Academic/private/public (APP) partnership and procurement can support policy coherence
    - S&T advances must be conceived with the involvement not just of academia but also citizens, companies and other stakeholders who are participants in the urban ecosystem.
    - There is a need for a credible, neutral testing space for technologies to reduce risk and build citizen confidence prior to adoption.
- Co-develop technology to benefit small cities

- o Reliable solutions developed through such partnerships (above) could be deployed beyond the original partnership to smaller municipalities that would not normally be co-developers.

Table 6

- Education and training of officials, city staff and citizens will enable cities to better implement new technologies.
- We need a cultural shift in city government to break down silos and support integrated technology development.
- Data: Who owns the data? Is it tax payers, the city or the commercial partners that developed the systems?
  - o Systems should be designed in a way that is transferable to other cities
  - o Cities should be encouraged to share their data (rather than being forced to). In the long term, this will ensure better data quality and make cities the stewards of their data.
- IP Standards: Should there be a return on the investment, should cities be in the business of IP?
  - o Is managing IP a reasonable risk for a municipality to take on?

Table 7

- Procurement: Needs to be more flexible to generate innovation
  - o Enable procurement to include the introduction of state-of-the-art solutions that can be trialed concurrently working with proven systems.
  - o A list of problems communicated to a community of solution providers.
  - o Need APIs (application programming interface) to be compatible with IT infrastructure.
- Develop standards: Every city does technology differently
- Governance: What is the federal role in establishing and promulgating standards?
  - o There are many activities that need regulator involvement to stimulate new collaborative business models.
  - o Carve out a new oversight body to coordinate cyber security, open data and connectivity.
  - o Many private industry solution providers do not have community interest in mind with regards to data. Data is not viewed as a community resource; it is viewed as a revenue generator.
- Sustainability: We don't need to reinvent the wheel in every municipality.