National Research Council Canada

Cities of the Future Executive Summit

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PREPARED BY:

Intersol

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Executive Summary

In 2014, the National Research Council (NRC) began working with internal and external stakeholders to identify areas critical to Canada's future in which technology game changers have the potential for revolutionary impacts on Canadian prosperity and the lives of Canadians over the next 20 to 30 years. Through this process, the NRC identified seven opportunities critical to Canada's future, which were submitted for comments to a diverse range of stakeholders from different backgrounds across Canada in early 2015. The *Cities of the Future* opportunity was then selected as the first area for in-depth exploration with stakeholders and potential partners.

The introduction of new technologies will help shape the cities of the future. NRC has a mandate to help meet Canada's current and future industrial and societal needs through innovation support, strategic research, and scientific and technical services.

A 2015 stakeholder dialogue in the NRC Game-Changing Technologies Initiative identified five challenge areas for *Cities of the Future*, and a number of game-changing technologies that could support future sustainable urban growth in Canada and the world. These areas included:

- Better Infrastructure and Infrastructure Management
- Efficient Transportation
- Localized Manufacturing and Production
- Renewable Energy
- Better Resource and Waste Management

On March 31st, 2016, NRC hosted a one day Executive Summit on the Cities of the Future in Toronto, ON. In advance of the Summit, NRC sent invitations to participate in an online dialogue to more than 1,000 stakeholders, some of whom participated in the dialogue and may also have been in attendance at the Summit.

Participants in the online dialogue were presented with the five challenge areas above and were asked to narrow the focus further by identifying those challenge areas among the five that they felt presented the greatest opportunities for technologies development in Canada. Participants identified *Better Infrastructure and Infrastructure Management*, *Efficient Transportation and Renewable Energy* as the challenges that Canada is best positioned to pursue.

At the Summit, a panel of three senior executives representing urban strategies, green buildings and urban transit shared their perspectives on the issues and trends that will shape the future landscape of cities.

Summit participants were then presented with a summary of the online survey inputs received and identified the following eight topics which were the focus of discussions at the Summit:

1. The decision making support system – how does integration occur?
2. Collection and use of data
3. Renewable energy sources
4. The food, energy, water nexus
5. Autonomous vehicles and transportation systems
6. How to pull the right minds together to define and invent the smart city of the future
7. Buildings and the build environment – demand reduction technologies
8. Re-imagining the city of the future in Canada – something that doesn't exist today

The context for discussion was further set by the presentations of four executives who shared their views and/or work on next-stage cities technologies and perspectives.

Discussion on each of the eight distinct discussion topics identified by Summit participants contributed to a better understanding of the needs and opportunities of all of the five overarching challenge areas. The following **key messages** emerged from the discussions:

- For the Infrastructure and Infrastructure Management challenge, there was a focus on collection, use and integration of data and data systems to assist with decision-making;
- The Infrastructure and Infrastructure Management challenge also surfaced a need for fit-for-purpose, adaptable cities and buildings that are adaptable to shifting needs;
- Autonomous vehicles and transportation systems were presented as an integral part of an efficient transportation system and, while many of the technologies are available today or will be in the near future, for the most part these technologies have not been included in municipal planning exercises; and
- Widespread development and adoption of renewable energy and smart grid technologies were positioned as integral to the success of the cities of the future.

To achieve the envisioned futures, appropriate policy and regulatory frameworks in support of the development and adoption of new technologies was often mentioned as the key enabler.

Background

In 2014, the National Research Council (NRC) began working with internal and external stakeholders to identify areas critical to Canada's future in which technology game changers have the potential for revolutionary impacts on Canadian prosperity and the lives of Canadians over the next 20 to 30 years. Through this process, the NRC identified seven opportunities critical to Canada's future, which were submitted for comments to a diverse range of stakeholders from different backgrounds across Canada in early 2015. The *Cities of the Future* opportunity was then selected as the first area for in-depth exploration with stakeholders and potential partners.

In 2014, more than half (54%) of the world's population lived in cities, and this number is forecast to grow to 66% by 2050.[1] Over 81% of the Canadian population already lives in an urban area, and this number has risen steadily over the last century.[2]

Cities are engines of economic growth, with just 600 global cities generating 60% of the world's GDP.[3] However, rapid urbanization can also lead to social unrest, food, energy and water insecurity, congestion, pollution, failure of infrastructure, and the spread of disease. Cities of the future will need to manage growth in a way that is smart and sustainable.

In early 2015, NRC employees and a large and diverse group of stakeholders from across Canada were invited to participate in a web-based dialogue on potential game-changing technologies to address the challenges faced by Canadian cities. A review of recent secondary literature completed this *Cities of the Future* opportunity assessment.

Participants to date in the game changing technologies initiative highlighted pressing Canadian needs such as: infrastructure monitoring and maintenance; use of smart/functional materials for infrastructure to increase durability, performance while reducing costs; ICT infrastructure; efficient transportation; renewable energy solutions; waste management; ensuring access to water; local production of food.

On March 31st, 2016, NRC hosted a one day Executive Summit on the Cities of the Future in Toronto, ON. In advance of the Summit, NRC sent invitations to participate in an online dialogue to more than 1,000 stakeholders. This report summarizes the online inputs received as well as the discussions that took place during the Summit. It is intended as a record of the meeting, to be used by NRC as it moves to the next phase in identifying national R&D opportunities and potential partners to accelerate the development of game-changing technologies that could help transform our cities.

Panel Discussion

Cities Panel: What are the key challenges facing cities over the next 20 to 30 years?

Led by the Marc Valois, the Summit moderator, three senior executives representing urban strategies, green buildings and urban transit shared their perspectives on the issues and trends that will shape the future landscape of cities. A summary of some of the key points raised by the panelists is presented below.

Rollin Stanley, General Manager, Urban Strategy, City of Calgary

Calgary's demographic picture is looking like a population dome (Figure 1) with a very large senior population moving to the top as the city is experiencing unprecedented growth in its senior population. The ratio of working aged adults to seniors in Calgary in 2039 is predicted to be 2.7 to 1 representing a 58% drop in 30 years. To address the anticipated short to medium term needs of this cohort, investments have been made in the development of infrastructure for seniors that won't be needed in 30 years. By 2050 it is predicted that the U.S. will need 35 million more workers, Japan will need 17 million, Europe 80 million, and Canada which just passed a law to restrict entry of foreign workers, will need 1 million more workers than it is producing domestically. Women, youth and minorities are the means for winning the global cities competition. India has more honours graduates than America has children. They need four million engineers – they have 500,000 – and by 2020 they will have 12% of the world's 25 to 34 year olds.

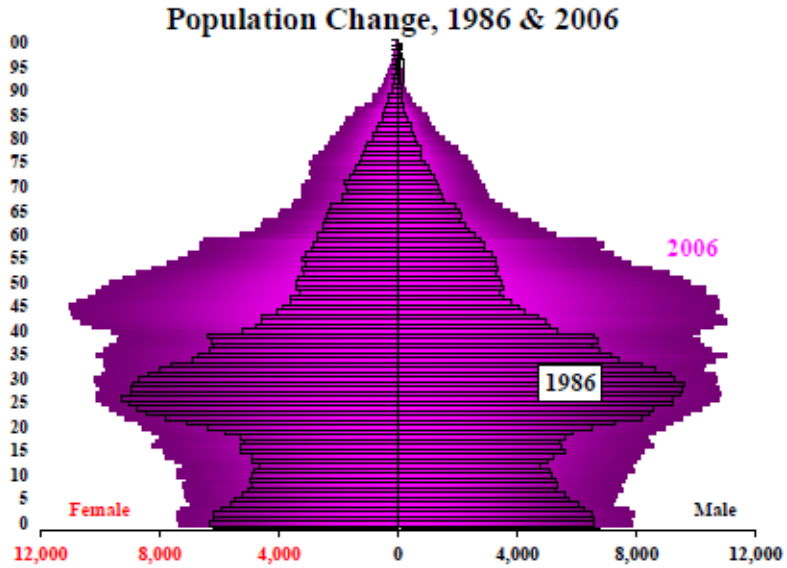

Figure 1 Population Dome

By 2050, there will be more MBAs than people who have no degree and there will be more kids living at home. The top ten jobs in demand in 2010 did not exist in 2004. Today's children will have 10 to 14 jobs in their lifetime – 5 years ago that was 8 to 10 jobs. Half of what college students learn is out of date by the time they are 30 years old.

The smart phones in our pockets have as much processing power as computers of the 80s. In Cambodia, 1200 factories employ approximately 700,000 people, mostly women and they account for approximately 80% of their exports. Twenty years ago these factories did not exist. While the decision making process will stay here, production can go almost anywhere therefore the impact of our decision-making affects the lives of others living in poor countries. With this background as context, there will be four types of cities in the future: the brain hub like Silicon Valley, low tech like Buffalo, undecided like Phoenix and energy based like Calgary.

Thomas Mueller, President and CEO, Canada Green Building Council

New LEED (Leadership in Energy and Environmental Design - a rating system recognized as an international mark of excellence for green building in 150 countries) certified floor space has increased more than tenfold from 2009 to 2014 which constitutes tremendous growth in an area that is not regulated. The benefits of LEED buildings include energy and water savings as well as additional ones associated with recycling. Canada's green building industry contributed $23.45B in GDP and almost 300 thousand direct jobs.

Trends in the marketplace include increased benchmarking, reporting and energy labelling, an increased focus on existing buildings and retro-commissioning, a shift towards community focused design for health and social

wellbeing and a movement towards net zero buildings. At the same time, there is a focus on lowering construction costs and improving the affordability of housing.

On a city scale, Vancouver has adopted a green city framework that promotes local food production, clean air and water, access to nature, zero waste, climate leadership, green transportation and green buildings. Buildings account for 55% of greenhouse gases (GHGs) in Vancouver. The 2020 target is for all new construction to be carbon neutral and to improve the efficiency of existing buildings by 20%. To reinforce this point, an example was provided of a low carbon district energy utility where a neighbourhood was converting waste to heat to meet 75% of its demand.

Industry growth may be accelerated by:

- Increased investment in research and innovation
- Improved asset planning
- Bridging the gap between design and performance
- Adoption of green technologies
- Supportive government policies and incentives

Wendy Reuter, Vice-President, Canadian Urban Transit Association

Integrated urban mobility is a people-focused goal that starts with public transport services connected to all modes of transport including walking, cycling, auto and alternatives to transportation. It enables door-to-door and seamless mobility throughout an urban area, and is designed for all segments of population.

Traffic congestion is up 17% in North America and people are spending 59% more time in their vehicles. City infrastructure and transit oriented street designs are reshaping how people move through a region and link with various modes of transportation. This in turn is having a positive impact on real estate values.

Commercially available by 2020, autonomous vehicles will impact infrastructure and the transportation of goods and people. There will be a decrease in the need for parking space in the urban core and the movement of people will evolve based on whether they work from home or the office, how they shop and how they seek entertainment. Bern (Switzerland) has made dynamic parking available to citizens to decrease the travel time associated with looking for parking. Transit systems will have to adapt to the changing lives and preferences of people as they move through different stages of life. The integrated service will have to offer a range of choices including mass transit, car sharing and bike sharing where mobility is seen as a necessary accessible service.

* * *

Following the Panelists' presentations, attendees were invited to ask questions and contribute to the discussion (summarized below).

The broader context for cities is anticipating the transformation that's coming. People will continue to want to live in cities. Millennials are moving into 275 square foot apartments so they can live downtown (close to work/school/social or cultural activities). More people are working in cafes instead of cubicles. They will be using 3D printers to produce at home what they now buy on Amazon. This raises new questions about the movement of goods and raw materials for 3D printers. Younger people aren't buying cars like they used to and have less interest in driving. They want to live downtown and walk, bike or take transit.

There are big gaps in our knowledge of what cities will look like. Who will design, who will curate and who will facilitate the development of the cities of the future?

How to scale and transform cities will be a challenge. The greenest building or the greenest car is the one that is already built. The carbon cost associated with demolishing and building new far outweighs the cost of maintaining and greening old buildings. They are significant investments but worth it.

There is a significant governance challenge to be overcome as cities need to be able to move faster in a more integrated way. In Ontario, the government forced the amalgamation of municipalities across the province into large cities such as the GTA. This will help increase collaboration and reduce what has traditionally been significant competition between multi-municipality regions.

Pre-Summit Survey Inputs

Top Challenges for the Cities of the Future

The 2015 stakeholder dialogue in the NRC Game-Changing Technologies Initiative identified five challenge areas for *Cities of the Future*, and a number of game-changing technologies that could support future sustainable urban growth in Canada and the world. These areas included:

- Better Infrastructure and Infrastructure Management
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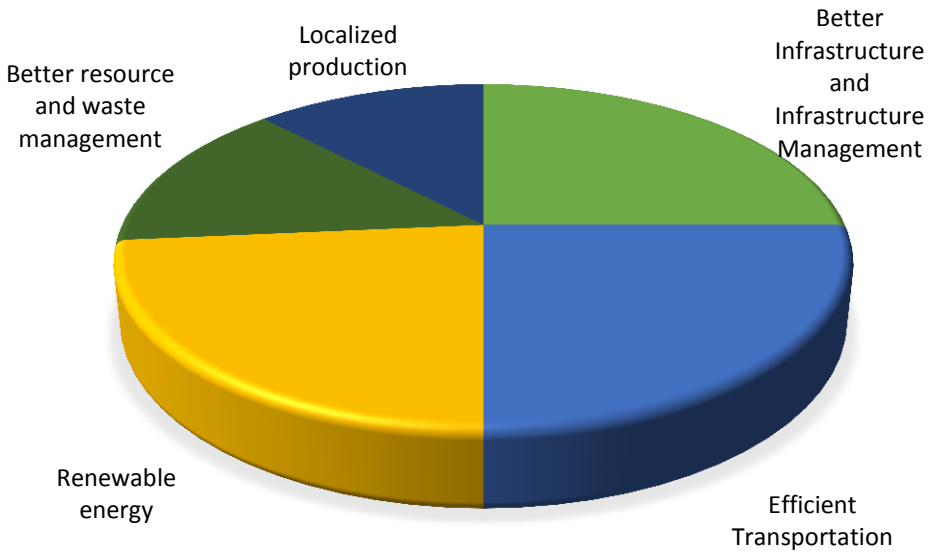

Figure 2 Prioritization Results

In preparation for the Summit, various stakeholders were invited to join an online discussion on the *Cities of the Future*. Participants in this online discussion were asked to narrow the focus further by identifying, among the five, those challenge areas that presented the greatest opportunities for technology development in Canada. Ninety eight online participants identified *Better Infrastructure and Infrastructure Management*, *Efficient Transportation*, and *Renewable Energy* as those challenges areas that present the greatest opportunities for Canada. Participants provided the rationale that public infrastructure provides essential services to the public and is the backbone of Canada's economy. Infrastructure shapes consumer and citizen habits, social interactions, etc. – the way people live. There is a lot of aged infrastructure in Canada and massive investments are long overdue. There is a unique opportunity to take advantage of the current wave of investments to introduce new technologies in our public infrastructure. With respect to

Efficient Transportation, participants in the online exercise suggested that modern society cannot function without physical mobility. The transformation of urban transportation systems to a fully autonomous vehicle system (if done in a thoughtful and proactive manner) will be one of the largest changes to cities, providing significant environmental, economic and quality of life benefits, including the reduction in pollution and hydrocarbon use while decreasing wasted time and increasing livability. And, building on the theme of pollution reduction, there is a critical need to reduce our carbon footprint globally. Canada is already a leader in renewable energy. Renewable energy sources such as the bio-refining sector as well as hydro, geothermal, tidal, solar and other renewable energy sources offer tremendous opportunities for Canada. Online participants also highlighted the importance of energy storage technologies due to the cyclical nature of energy usage patterns. Participants noted that the fragmented nature of energy policy in Canada is a major obstacle to the development of a national strategy.

Aspects for Which Canada has a Competitive Advantage

As part of the online exercise, participants were asked to prioritize the challenges – the highest priorities being those for which Canada has a competitive advantage – and to provide a rationale for their choices. In order of priority, the following challenges were chosen:

Better Infrastructure and Infrastructure Management

Canada's knowledgeable workforce with expertise in the areas of architecture, civil engineering, high technology, energy and water were highlighted by participants. From a technology perspective, online participants noted Canada's leadership position in renewable sources of energy technologies such as solar, geothermal, wind and tidal energy as well as energy storage. Other areas mentioned included sensor and monitoring technologies as well as water and waste water technologies. It was also strongly suggested that there is a need for policy leadership to support innovation and more sustainable technologies as well as a shift to a service delivery and user pay paradigm. Finally, greater use of data was proposed as critical to improvements in construction design, operations and maintenance as well as to the development of autonomous transportation systems.

Efficient Transportation

With regard to efficient transportation, Canadian expertise in autonomous systems and transportation, long distance travel efficiencies, harsh climate science and public-private partnership procurement were emphasized by online participants as well as technologies such as autonomous and electric vehicles, metal fuels, sensors and monitoring. They also proposed greater use of data for traffic optimization and cited the need for public data to be open for research and development purposes. Policy leadership will also be required in order to change behaviours and to increase use of public transit.

Renewable Energy

Building on the energy related infrastructure knowledge and expertise highlighted above, participants in the online exercise also noted Canada's expertise in nuclear energy, bio-refining and other renewable energy industries. They also underscored Canada's expertise with systems based approaches to the integration of renewable energies. Renewable energy related technologies were highlighted in addition to those noted above included hydro, nuclear, micro-grids and waste conversion. Once again, policy leadership will be required in order to stimulate the necessary shift to smart cities strategies, clean technologies and greater use of renewable energy models.

The outcomes of this online exercise were presented to participants and helped to shape the discussion at the March 31st, 2016 Summit.

Technology, Strategy and Capabilities Showcase

The NRC then invited three companies and organizations to share their views and/or work on next-stage cities technologies and perspectives.

Amir Rashid, Chief Strategy Officer, Pacific Controls Canada

Pacific Controls has developed Galaxy, an enterprise platform that delivers city centric services for the management of the critical components of its ecosystem. Smart software agents and unobtrusive automated tools for customer support have been integrated into the Galaxy service delivery platform. The platform has been used in a whole range of applications. Examples provided included aviation, where everything is automated (e.g. lighting, baggage control, security infrastructure) maximizing passenger and baggage flows, and command centres that monitor roads and bridges with sensors to capture and analyze data with 2 way communication enabling diagnosis and repair.

Ritch Dusome, CEO, Centre of Excellence in Next Generation Networks (CENGN)

Canada's CENGN is a consortium of industry, academic and research leaders dedicated to accelerating the commercialization of next generation communications solutions. CENGN's internationally recognized testing centre employs interoperability between multiple software and hardware products. Their state of the art physical and virtual multi-vendor, test, certification and validation platform provides a unique environment to commercialize advanced products, applications and services. They bring students together with small innovation companies and create an open source environment to accelerate innovation and commercialization.

Jean-Francois Barsoum, Senior Managing Consultant, Smarter Cities, Water & Transportation, IBM Canada

City resiliency is at the centre of improving sustainability, technology itself is not the biggest obstacle. There is a need for city resiliency in today's context and the use of technology for a purpose. The development and use of smart city technologies should be mission critical components that contribute to the ability of a city to recover from disaster.

Potential Solutions

To help set the stage for the development of potential solutions, Ysni Semsedini, the CEO of Festival Hydro spoke about the city of Stratford's driverless car pilot project. Mr. Semsedini stressed that the key to the initiative's success was Stratford's decision to maintain control of their municipal hydro infrastructure. Profits

generated by the utility are reinvested in new smart city infrastructure technologies. These technologies have enabled Stratford to become a test bed for new emerging smart city innovations such as autonomous vehicles. Companies wishing to ground proof their emerging smart city technologies are invited to submit proposals to city council. Mr. Semsedini pointed out that the smaller scale of his municipality makes it more manageable and enables the technology companies to achieve the required proof of concept before attempting to move to the larger scale cities. None of this would have been possible without the control and the investments made in their smart grid.

Participants were asked to identify top *Cities of the Future* challenges that would be the focus for the Summit. They agreed on the following eight topics for further discussion

1. The decision making support system – how does integration occur?
2. Collection and use of data
3. Renewable energy sources
4. The food, energy, water nexus
5. Autonomous vehicles and transportation systems
6. How to pull the right minds together to define and invent the smart city of the future
7. Buildings and the build environment – demand reduction technologies
8. Re-imagining the city of the future in Canada – something that doesn't exist today

For each of the eight topic areas, participants were then asked to respond to the following:

a) Problem definition – clarify, define and document the problem.

b) Describe the desired end state in the year 2036

c) Describe the current state of technology as it relates to this challenge or need.

d) Describe what is required to achieve the desired end state.

e) What do we need to do together to achieve the desired end state?

f) What are two suggested immediate next steps to move forward?

Inputs from the discussions helped to shape the following five key challenge areas with a primary focus on **Better Infrastructure and Infrastructure Management**, **Renewable Energy** and **Efficient Transportation.** Input on **Localized Production** and **Better Resource Management** was received as well. The details of each of the table discussions can be found in Appendix C.

Better Infrastructure and Infrastructure Management

For purposes of discussion, Better Infrastructure and Infrastructure Management was described as a greater ability to monitor and maintain infrastructure (buildings, roads, bridges, and waterways) more cost effectively and efficiently. This includes the use of smart, functional materials to increase durability of infrastructure or to sense environmental changes; using basic structural features (e.g. windows, walls, floors and doors) as energy exchange/storage devices, communication interfaces, and/or as filtering systems for air and water.

- **Summit Inputs: Aspects for Canada – Big Data Focus**

By 2036 participants envisaged a centralized command and control system with an integrated dashboard that has "smart" decision making abilities to manage infrastructure need by integrating multiple issues and inputs from multiple sources and big data.

An affordable, secure, smart shared infrastructure will be required to achieve the end state. To attain this goal, standardized nomenclature of the components across jurisdictions will be required as well as open data systems. Additional requirements will include the compatibility and interoperability of systems and the broad deployment of the internet of things.

To get there, we will need to resolve the issue of data ownership and learn from other jurisdictions to focus on the outcome vs. what we can't do.

Finally, we need smart systems that can learn in order to provide support for decisions and we will need proactive policy vehicles to enable the necessary change to occur.

Social, Technological, Environmental, Economic and Political (STEEP) Issues: Canada requires a new social contract recognizing the value of open data, with more education and outreach about the value of data and a new public-private agreement on access and use of data, including access to data from private companies by cities and vice versa.

There is a need to develop security at the device level to ensure privacy and integrated systems security as well as to ensure the resilience of the integrated systems.

Cities also need to have Chief Data Officers in place.

- **Summit Inputs: Aspects for Canada – Infrastructure Assets, Energy, Adaptability**

By 2036 Canadian cities will be fit for purpose, relevant to the time and needs, developed based on global collaboration using ongoing processes and tools and reconfigurable with a certain level of agility.

Canada needs demand reduction technologies and approaches to incentivize GHG reduction on a national level. We need to develop systems that reduce demand on infrastructure services (water, sewage, energy, etc.) as reducing demand for energy is cheaper than generating more energy to service increased demand. To enable this, Canada will need a mandatory energy labelling system for homes and private sector buildings, and mandatory reporting of energy use intensity. This includes rules for building energy management, grid technologies for a distributed and bidirectional energy system to achieve a net-zero community and energy storage capacity. As well, there will be a need to develop data analytics to assess how the grid will react to an increased load from Electric Vehicles (and other technologies).

In the future, infrastructure components that can change and adapt to multi-uses, and to changes in technology will be the norm. The home of the future will be a component of the connected system – IoT (e.g. environment, energy, water, air quality, health of occupants). Building anticipated performance into the design and taking into account the changes to materials over time will make structures more efficient and adaptable.

STEEP Issues: Canada needs a cross-generational and cross-country collaborative instrument that enables us to tap into the best talents from across the world to develop sustainable cities. This will need to be done as a collaborative effort with municipalities, utilities and developers. As well, in order to incent the change necessary to increase the resiliency of buildings, a climate change risk factor should be incorporated into insurance premiums.

In addition to community education and engagement to change societal behaviours, a mandatory performance labelling program as well as energy and carbon pricing strategies must be implemented to force homeowners to care about energy demand reduction.

Efficient Transportation

Efficient Transportation was described as the efficient movement of people and goods using autonomous systems and intelligent controls with detection avoidance systems; use of mass transit corridors to reduce the need for personal transportation. Use of artificial intelligence to monitor and control transportation systems.

- **Summit Inputs: Aspects for Canada**

By 2036 participants proposed that Canada will have a predominantly electric transportation system comprised of autonomous and electric (ACE) cars, buses, trucks and robotic delivery which contributes to significant emissions reductions. The autonomous transportation system of the future will result in the emergence of new companies and the creation of jobs. Safety improvements to vehicles will contribute to a reduction of accidents and insurance claims.

With the exception of the required security protocols, many of the technologies, including vehicle design, lower cost sensors and monitors, artificial intelligence (AI), and machine learning analytics are available today.

Participants identified a number of outstanding technical issues to be addressed including, vehicle to individual (V2I) and vehicle to vehicle (V2V) interactions which need to be better refined – this also includes vehicle recognition of human signals (e.g. traffic cop).

There is a need for more refined AI decision making for collision avoidance, with an ability to connect vehicles to traffic flow patterns as well as a way to deal with Canadian winter climate by integrating next generation highly accurate GPS.

STEEP Issues: Autonomous and non-autonomous interactions will be a challenge as we move to implementation (social engineering). If Canada is to take a lead in the development and deployment of cyber security technologies, we will also need to lead in information privacy as well as the in the development and implementation of the required regulatory frameworks.

A key to success will be education of municipal leaders in order to win political support, as the vast majority of municipal master plans in Canada have yet to mention autonomous vehicles as a future component of their plan.

Renewable Energy

For purposes of discussion at the Summit, Renewable Energy included renewable energy generation, storage, distribution and efficient use in residential and commercial buildings; energy conversion / thermodynamic efficiency and the ability to convert readily available point-source energy into useful forms.

- **Summit Inputs: Aspects for Canada**

Participants' vision for Canada by 2036 was that there will be no energy security issues, that we will be "Prosumers" (selling as much as we consume) and energy networks will be totally interconnected. In this preferred future, energy usage in cities will be 100% renewable, and the marketplace for energy supply and demand will exist and operate very efficiently. Integrated management and smart control of all renewable

energy sources will exist and will work effectively with real-time matching of energy supply and demand, and will be protected against attacks.

At present, many technologies are still at the proof of concept stage and have not yet progressed to a commercial scale sufficient to meet the needs of a municipality.

To achieve the envisioned future for Canada there is a need for multi-modal renewable energy sources and storage systems as well as buildings that interact efficiently with the smart grid and the smart city and a shift to green energy use by all homes. Scaling renewable technologies to match the population demand of a province or city will also need to be addressed.

Canada needs to be a leader in smart grid technologies and should play the role of technology integrator as opposed to developing the individual components.

STEEP Issues: A change in societal behaviours through community education and engagement is required. At present there is low customer demand for renewables due to the availability of lower cost alternatives. As a result, renewables will likely require subsidies until such time as the technology is technically viable and economically cost effective to be fully competitive with non-renewable energy sources.

Better Resource and Waste Management and, Localized Manufacturing and Production

The two remaining challenge areas, Better Resource and Waste Management and Localized Manufacturing and Production, received inputs from the discussions related to the the Food, Energy, Water Nexus.

The focus of these two challenge areas included improving water and waste management to deal with increasing urban population; adopting closed loop systems for product design to ensure end of life product disassembly and waste reduction; developing adaptive infrastructure; and mining municipal waste products. There were also discussions on communities within urban centres, with food, water, energy, education, and virtual jobs available close by. This included localized production of food to reduce transport of goods and encourage sourcing locally or within cities. The ability to produce locally with 3D technologies was also part of the discussion.

- **Summit Inputs: Aspects for Canada**

By 2036 participants felt there would be a cultural shift and people would understand the need to conserve and be stewards of resources. Canada's mid-sized cities would have extensive localized water and food production capabilities, along with a balance of agriculture and fishing in local environments and agri-food businesses. In this preferred future water loss would be reduced to 5% of total use, by employing more efficient systems and infrastructure. As well, there would be decreases in energy consumption while at the same time recovering energy from moving water.

A circular economy will have emerged through the implementation of integrated production systems that produce food, re-use water and bio-digest compost to produce energy and use residues as fertilizers.

Many of the technologies such as moisture extractors, bio-digesters and aquaponics systems already exist but will need to become much more efficient. In-situ trenchless repair technologies to address water losses exist today but there is no available capital to deploy these and the cost-benefit ratio is not convincing at this time. New waste water treatment technologies are also available when upgrades are needed, including localized distributed treatment technologies.

Self-repairing materials should be available within 20 years.

STEEP Issues: The issue is equitable access and supply of food, energy and water. At present, the availability of these resources is sufficient to meet current needs however these are finite resources and it is not clear when one or more of the resources will no longer be adequate to meet the need. There is significant wastage and improper use of potable water as well as a social perception that this is an unlimited resource. In this case governance and cost are the issues, not technology.

Key Messages

Discussion on each of the eight distinct topics identified by Summit participants contributed to a better understanding of the needs and opportunities of all of the five overarching challenge areas. The following key messages emerged from these discussions:

- For the Infrastructure and Infrastructure Management challenge, there was a focus on collection, use and integration of data and data systems to assist with decision-making;
- The Infrastructure and Infrastructure Management challenge also surfaced a need for fit–for-purpose, adaptable cities and buildings that are relevant to the time and shifting needs;
- Autonomous vehicles and transportation systems were presented as an integral part of an efficient transportation system. While many of the technologies are available today or will be in the near future, for the most part these technologies have not been included in municipal planning; and
- Widespread development and adoption of renewable energy and smart grid technologies were positioned as integral to the success of the cities of the future.

To achieve the envisioned futures, appropriate policy and regulatory frameworks in support of the development and adoption of new technologies was often mentioned as the key enabler.

Appendix A – Detailed Table Discussions

Topic #1 – The decision making support system – how does integration occur?

a) Problem definition: Clarify, define and document the problem

Systems (ICT or otherwise) need to support decision-making (e.g. through data analysis, AI). We currently live in a stove-piped system with public and private infrastructure systems operating often in isolation and where decisions are made separately. Private data is treated as proprietary and is not shared. There needs to be a shift to integrating data to support better project management and more proactive vs. reactive systems development to optimize assets.

b) Describe the desired end state – it is the year 2036, the challenge or need has been addressed, describe what is happening now and how a new or breakthrough technology has helps us to overcome the challenge or address the need.

A centralized command and control system with an integrated dashboard. The system has decision making ability to manage needs and is anticipatory – it is able to suggest that a decision be made and makes regular routine "smart" decisions by integrating multiple issues, inputs from multiple sources and big data. The system is a trusted source of data and information. It knows where the issues are, when an issue is occurring and how to manage it. It is an affordable (possibly P3), secure data system where current and historical data are maintained with checks and balances in place that determine what information can be shared.

c) Describe the current state of technology as it relates to this challenge or need.

We have a series of proprietary systems in place that don't communicate – the systems themselves are advanced but not integrated. The legacy systems in place are difficult to replace. The governance model is not integrated nor do we have a policy framework in place that encourages open systems and protocols. There are very few smart buildings capable of adapting new technologies. We don't have a system in place to capture what the population is thinking – a smart system that is participatory in real time – and, there is limited deployment of the Internet of Things (IoT).

d) Describe what is required to achieve the desired end state

A change to the silo mind set; protocols and agreements to work together; a longer term business model and; the regulations, standards and codes to make it work. As well, there will be a need for shared infrastructure, the availability of open data, standardization of understanding and nomenclature across jurisdictions and, the spectrum necessary to operate the system. Compatibility and interoperability of systems and significant deployment of IoT will also be required to achieve the end state. The deployment must be safe and secure, it must address a real challenge and, it must provide a return on investment. Finally, we need smart systems that can learn in order to provide support for decisions and we will need proactive policy vehicles to enable the necessary change to occur.

e) What do we need to do together to achieve the desired end state?

Create a national agenda and vision inclusive of all levels of government with a commitment that we want the system to be integrated for all. Use the urban agenda to create the national agenda. Resolve the issue of data ownership and learn from other jurisdictions to focus on the outcome vs. what we can't do. Use a competitive process and build best practices awareness and on our expertise with P3.

f) Suggested immediate next steps

- Identify quick wins and deployments
    - Hold a national competition
    - Create an open space where good ideas can be quickly adopted by jurisdictions that are ready and committed to uptake
    - Develop use cases for small, medium and large scale settings
    - Develop the education and skills needed for the task ahead.
- Learn from others' live, tangible examples
    - Learn from smaller jurisdictions that are doing now as they may be better incubators.

Topic #2 – Collection and use of data

a) Problem definition: Clarify, define and document the problem

Need to figure out how to ensure access to the data required to enable the appropriate actors to improve the quality of cities? Several additional issues provide more texture to this challenge including, the reliability of data and data security, privacy issues (although they are changing with demographics), data ownership and, how to plan infrastructure for which private companies own the data. There is also a need when speaking of data to distinguish between sensor data and data collected by other means.

b) Describe the desired end state – it is the year 2036, the challenge or need has been addressed, describe what is happening now and how a new or breakthrough technology has helps us to overcome the challenge or address the need.

There is trusted access to data. With the exception of sensitive information, data is open to all. Cities collect and make data available, preferably in real time, and oversight is in place to govern access and to ensure privacy protection. Inventions are emerging as a result of access to the data from the networks of sensors in place. Something has improved because we had better information (e.g. revenue, traffic flow, infrastructure)

c) Describe the current state of technology

With the exception of security, many of the technologies are available today. Analytics is fairly mature and a new wave of cognitive, machine learning capacity is coming. The format of legacy data is an issue that will need to be dealt with.

d) What will it take to get us to the desired end state?

A new social contract recognizing the value of open data, more education and outreach about the value of data as well as a new public-private agreement on access and use of data including access to data from private companies by cities and vice versa. From a technology perspective, there is a need to i) develop security at the device level to ensure privacy, ii) develop integrated systems security as well as iii) ensure the resilience of the integrated systems. Cities need to have Chief Data Officers in place. Other issues associated with data include:

- Data quality (calibration and measurement);

- Reliability of data and potential liability (how much data will you share if you are liable for the quality of the data?);
- Identification of the categories of data to be collected and for what use;
- A need to know the provenance of the data;
- Redundancy of data (broader data and sensor management issue for different uses); and
- Interoperability of data.

e) What do we need to do together to achieve the desired end state?

- Adopt smart cities strategies and manage data resources in a way that fosters collaboration;
- Launch a grand challenge on the use of data to improve a problem faced by cities; and
- Develop policies and standards for the collection, access and use of data – depersonalized data will be required to protect privacy.

f) Suggested immediate next steps

- Create a seed fund;
- There is an opportunity for cities to aggregate data, to provide open access to that data and to launch an open competition for the development of applications to improve cities efficiency and quality; and
- Develop a library of existing use cases, defining data at the front end.

Topic #3 – Renewable Energy Sources

a) Problem definition: Clarify, define and document the problem

"Renewables" really means low-emission energy sources. What is preventing renewable energy from being adopted widely across cities and how can adoption happen faster?

- Government policies and regulations;
- Insufficient financial incentives;
- Insufficient products that consume less energy;
- Lack of cost parity relative to non-renewable energy sources including lack of recognition of full life cycle costs (e.g. $C0_2$ costs are not accounted for);
- High up-front cost of renewables;
- Technology (lack of storage capability); and
- Challenge of looking at things at the "community scale" vs. the individual, household scale.

Utilities need to re-think their business model, to shift from pushing energy out to holistically managing energy and buying/selling energy into the grid.

b) Describe the desired end state – it is the year 2036, the challenge or need has been addressed, describe what is happening now and how a new or breakthrough technology has helps us to overcome the challenge or address the need.

In 2036 there are no energy security issues, people are prosumers (sell as much as they consume) and energy networks are totally interconnected.

Energy usage in cities is 100% renewable. All levels of government are working together toward a common strategy. The marketplace for energy supply and demand exists and operates very efficiently. Society is aware of energy usage and the importance of renewable energy; understands the importance of de-carbonization and has a favourable image of clean energy (and perhaps a margin/financial advantage to adoption of clean energy). Consumers have multiple options available to them (e.g. individual household vs. community vs. industrial applications – each has their own energy option). Integrated management and control of all renewable energy sources exists and is working effectively with real-time matching of energy supply and demand. The entire system and all devices operate at peak optimization and there is transparency in reporting on energy usage.

c) Describe the current state of technology as it relates to this challenge or need.

Technologies exist today but for the most part are still at the proof of concept stage and have not yet progressed to a commercial scale sufficient to meet the needs of a municipality. Scaling renewable technologies to match the population demand of a province or city is still an issue. There is low customer demand for renewables due to the availability of lower cost alternatives. Renewables therefore will likely require subsidies until such time as the technology is technically viable and economically cost effective enough to be fully competitive with non-renewable energy sources. Technology form/design is also an issue (e.g. not everyone will want an ugly solar panel on their rooftop)

d) What will it take to get us to the desired end state?

- Fully engaged utilities and widespread adoption of micro-grid/smart –grids.
- Changes to government policies and regulations and greater interconnections across provinces.
- Incentives to encourage consumer adoption and the introduction of intelligent consumer products (e.g. fridges that don't all draw power at the same time from the grid).
- Increased awareness of the energy costs associated with older vs. newer homes and mandatory, standardized labelling.

e) What do we need to do together to achieve the desired end state?

- Harmonization of policies and approaches, creation of incentive programs to encourage people to change behaviours coupled with communications and education programs to increase awareness and understanding of the importance of energy efficiency (what's in it for me, including the cost to the individual).
- Increased collaboration on common agendas and the creation of an integrated investment board to identify which promising technologies to invest in to achieve success.
- Partner with small business to increase ease of deployment.

f) What are 2 suggested immediate next steps to move forward?

- Canada can play a role as the integrator of technology as opposed to developing the individual components.
- Canada should also develop smart grid technologies (high export potential) and manufacture high quality windows for residential/commercial use (currently we are importing high quality windows).

Topic #4 – Food, energy, water nexus

a) Problem definition: Clarify, define and document the problem

The issue is equitable access and supply of food, energy and water. The availability of food energy and water is sufficient to meet current needs however these are finite resources and it is not clear when one or more of the resources will no longer be adequate to meet the needs.

There is significant wastage and improper use of potable water as well as a social perception that this is an unlimited resource. Utilities and cities however clearly understand the water scarcity issue. Capital costs drive decision making and municipalities don't have the resources to finance the implementation of new technologies. At the same time, there is a need for an infrastructure overhaul to reduce loss (30% or more of loss occurs through infrastructure) as well as to invest in efforts to reduce consumption. More appropriate uses of potable water need to be adopted while incorporating the waste water and grey water strategies used by many other jurisdictions.

Carbon pricing is also affecting accessibility of food and has become a driver for local production.

b) Describe the desired end state – it is the year 2036, the challenge or need has been addressed, describe what is happening now and how a new or breakthrough technology has helps us to overcome the challenge or address the need.

By 2036, there has been a cultural shift and people understand the need to conserve and be stewards of resources. In mid-sized cities there is localized water and food production, a balance of agriculture and fishing in local environments and agri-food businesses. More efficient systems and infrastructure have resulted in reducing water loss to less than 5% and decreasing energy consumption while at the same time recovering energy from moving water. A circular economy has emerged through the implementation of integrated production systems that produce food, re-use water and bio-digest compost to produce energy and use residues as fertilizers. Waste water within the house is re-used for toilets and watering.

c) Describe the current state of technology as it relates to this challenge or need.

Most technologies already exist – moisture extraction, bio-digesters and aquaponics systems exist today. In-situ trenchless repair technologies to address water losses exist but there is no available capital to deploy and the cost-benefit ratio is not convincing. New waste water treatment technologies are also available when upgrades are needed, including localized distributed treatment technologies. Self-repairing materials should be available within 20 years.

Governance and cost are the key issues, not technology.

d) What will it take to get us to the desired end state?

- Governance, policy and regulations, and capitalization
- Behavioural and cultural changes – people accept regulation when they understand there is an issue to be fixed
- Ongoing conservation efforts
- Self-repairing pipes
- Re-use of sewage waters
- Capacity to test water at home

e) What do we need to do together to achieve the desired end state?

- Development of supporting policies and incentives
- Education and awareness raising
- Pilot projects to demonstrate the effect to other potential adopters
- Performance management showing the benefits of prevention describing the investments made and the benefits accrued

f) What are 2 suggested immediate next steps to move forward?

- Convert to smart systems – smart grids, smart sewers with real time monitoring as a proactive way to save energy
- Federal leadership to align the governance and innovation system and to tie funding to integrated planning with strings attached
- Fix water loss problems and set loss reduction targets

Topic #5 – Autonomous vehicles and transportation systems

a) Problem definition: Clarify, define and document the problem

How can we best deploy autonomous vehicles by leveraging the existing car industry to deploy intelligence in autonomous vehicles while developing supportive industrial policy which enables our cities to benefit and our industry to grow? How to shift to an integrated transit system with a "transportation as a service" mind set which includes autonomous cabs?

b) Describe the desired end state – it is the year 2036, the challenge or need has been addressed, describe what is happening now and how a new or breakthrough technology has helps us to overcome the challenge or address the need.

By 2036 we have a predominantly electric transportation system comprised of autonomous and electric (ACE) cars, buses, trucks and robotic delivery which contributes to significant CO emissions reductions. Safety improvements have contributed to a reduction of accidents. The implementation of the autonomous transportation system has also resulted in the emergence of new companies and the creation of jobs.

c) Describe the current state of technology as it relates to this challenge or need

Many of the technologies, with the exception of the required security, are available today. First generation special purpose autonomous vehicles, i.e. shuttle buses, are a reality. Many manufacturers are incorporating advanced drive features such as steering and adaptive cruise control into their vehicles. The required sensors are available and costs for these are decreasing. A shift to Light Detection and Ranging (LIDAR) technologies is underway, the required analytics for autonomous vehicles is fairly mature and, although there is some AI available today, a new wave of cognitive, machine learning capacity is coming. Autonomous and non-autonomous interactions will be a challenge as we move to implementation (social engineering).

d) Describe what it will take to get us to the desired end state

Cyber security technologies and information privacy as well as the required regulatory framework. Outstanding technical issues include vehicle to individual (V2I) and vehicle to vehicle (V2V) interactions (other vehicles are not ready yet), vehicle recognition of human signals (e.g. traffic cop), a need for more

refined AI decision making for collision avoidance, an ability to connect vehicles to traffic flow patterns as well as a way to deal with Canadian winter climate by integrating next generation highly accurate GPS. It will also be important to educate and to win the support of politicians (90% of municipal master plans don't mention autonomous vehicles)

e) What do we need to do together to achieve the desired end state?

There is a need

- For seed funding
- For test sites
- For standards in order to enable V2V (all vehicles can speak to all brands)
- To create an affordable solution
- To deal with existing old car inventory
- For more work on user experience and ease of use inside the vehicles.

f) What are 2 suggested immediate next steps to move forward?

- Establish a partnership with a key manufacturer
- Establish a seed fund
- Build test beds – a large scale, complete facility that replicates real life
- Focus on the developing the underlying technologies not the vehicle – LIDAR, data processing, cloud

Topic #6 – How to pull the right minds together to define and invent the smart city of the future?

a) Problem definition: Clarify, define and document the problem

This generation is defining the future of the next – the challenge is how to involve the citizens of the future (anyone who could contribute - not only the millennium generation) in the cities process and developing the skill sets of these people to participate effectively.

b) Describe the desired end state – it is the year 2036, the challenge or need has been addressed, describe what is happening now and how a new or breakthrough technology has helps us to overcome the challenge or address the need.

In 2036 we have smart cities that fit the needs of the time and optimized the use of the resources that contribute to the functioning of the city. The city is fit for purpose, relevant to the time and needs, developed based on global collaboration using ongoing processes and tools as well as reconfigurable with a certain level of agility. We have developed a cross-generational and cross-country collaborative instrument that enables us to tap into the best talents from across the world to develop sustainable cities. Each group of stakeholders has the skills and capacity to contribute their knowledge and expertise and the instrument enables stakeholders to contribute effectively. The collaborative instrument allows us to take advantage of big data, social media and crowdsourcing in order to tap into more knowledge and temporal processes that enable us to better predict the future.

c) Describe the current state of technology as it relates to this challenge or need

Current state is very disjointed. There is no big picture of what this process and technology could look like – the question is not even on the radar. Government is not focussed on this challenge and investment is reactive and falls short of pulling all the required resources together – patchwork is the operative word.

d) Describe what it will take to get us to the desired end state

A collaborative framework that ensures inclusion of all demographics, generations and resources. Staging the investment over time so that the input of young generations can be considered while continuously evolving the focus and purpose. It will require the incorporation of principles, tools and processes into the education curriculum that align with the adoption of smart city objectives. We will need to learn from other jurisdictions and international models.

e) What do we need to do together to achieve the desired end state?

Open up lines of communication in a real time sense by implementing a national communication strategy. The strategy will require coordination of engagement horizontally and vertically and should be used to develop knowledge of the innovation spectrum, an understanding of each other's role and to create a sense of responsibility at the citizen level to contribute to the creation of smart cities. Consider the method used in Germany.

f) What are 2 suggested immediate next steps to move forward?

Identify a smart cities initiative lead. Consider the model used in France – watershed approach that cuts across the various levels of government and considers the whole picture (water, food, hydro) – force people to look at this from a big picture view.

Establish a federal government sponsored competition for cities across Canada (suggested $100M budget). Winning submission by cities that demonstrate a reduction of X would receive funding of Y. The criteria for submission of bids would include elements of collaboration, inclusion of younger generations, utilization of new technologies, etc.

Topic #7 – Buildings and the built environment – demand reduction technologies

a) Problem definition: Clarify, define and document the problem

How to reduce demand on infrastructure services (water, sewage, energy, etc.). Reducing demand for energy is cheaper than generating more energy to service increased demand.

Half of the housing stock in Canada was built before 1985 and uses more energy than those built after 1985. There is no mandatory energy labelling system for homes and private sector buildings nor is there mandatory reporting of energy use intensity. Builders try to build homes for the lowest cost possible. This may be short sighted as energy costs may render inefficient homes unaffordable in the future. Homes are still built to be part of a centralized system (water, utility, etc.) and with the perception that people work outside the home.

In commercial buildings it is not the age of the stock that matters; it is the management of the building that is the issue. Buildings are an important component of cities but often do not factor into the conversation.

There needs to be a case for demand reduction technologies and approaches as the federal government cannot possibly incentivize GHG reduction on a national level.

b) Describe the desired end state – it is the year 2036, the challenge or need has been addressed, describe what is happening now and how a new or breakthrough technology has helps us to overcome the challenge or address the need.

In a preferred future there will be intelligent energy systems (protected against attacks). Homes with solar power generation would provide excess energy to the grid. New commercial buildings would generate net zero emissions. Multi-modal renewable energy sources and storage would be distributed. Buildings interact efficiently with the smart grid and the smart city and energy used by all homes is green. Thermal energy and electrical energy would be managed and optimized. Home energy management is optimized (smart thermostats, etc.). The business model for the grid and utilities will have changed to support bidirectional energy transportation – your account is no longer your house account, it is you.

All is affordable to the homeowner and home buyer. There is enough confidence in the benefits of the net zero result that the state lends the homeowner the money to build the net zero standard as the savings will pay the loan back. There is a credit system in place for energy and the solar electrical system. Advanced, healthier industrial materials have been developed that improve thermal properties of buildings.

Adaptable infrastructure has been built to accommodate aging populations and pressures on middle-aged generations/families. Infrastructure can change and adapt to multi-uses and for changes in technology. The house is part of the connected system – IoT (environment, energy, water, air quality, health of occupants).

c) Describe the current state of technology as it relates to this challenge or need.

There are off the shelf technologies available for net-zero homes available now. The price of renewable energy and the cost of the technology is a barrier to adoption. The grid is not ready for distributed and bidirectional energy required to achieve a net-zero community and energy storage, while currently being piloted, is not 100% ready, nor has anyone figured out a way to monetize energy storage. We do not have the data right now to assess how the grid will react to an increased load from EVs (and other technologies). There is no political will or appetite to force the change required to build the necessary infrastructure.

d) Describe what it will take to get us to the desired end state

- Political will and a need for collaborative effort with municipalities, utilities and developers.
- Build a climate change risk factor into insurance premiums to incent an increase in the resiliency of buildings.
- Build anticipated performance into design taking into account the changes to materials over time.
- Change societal behaviours through community education and engagement.
- Get data on actual building performance by leveraging sensor technologies and analytics.
- Implement a mandatory performance labelling program as well as energy pricing and carbon pricing to force homeowners to care about home labelling.
- Integrate the fragmented government R&D implementation support programs.

e) What do we need to do together to achieve the desired end state?

Double the investment in renewable energy by 2030 (IRENA report) to decrease the $4.2T annual expenditure in air pollution and climate change. Government must set good policy in collaboration with industry who must take the lead to define how to get there.

f) What are 2 suggested immediate next steps to move forward?

- Implement a carbon pricing scheme
- Undertake major retrofits of existing building

Topic #8 – Reimagining the city of the future – something that doesn't exist today

a) Problem definition: Clarify, define and document the problem

The criteria for the location, design, amenities, etc. for cities are changing. Historically, cities were built near water for a host of good reasons. The rationale may not hold today.

b) Describe the desired end state – it is the year 2036, the challenge or need has been addressed, describe what is happening now and how a new or breakthrough technology has helps us to overcome the challenge or address the need.

There is an opportunity to reimagine a city that is built to address the needs of a changing population and is economically, socially and environmentally resilient. Where the importance of proximity to work, social interaction, access to services, etc. are both flexible and factored into the design based on the importance to those living there. The city is a pattern of complete streets – a modular design. Each complete street is a microcosm of the complete city with robust transit systems.

Helsinki vision was to make mobility so convenient that no one wants to own a car. This involves providing a range of modes of transportation from walking to public transit. This has resulted in an 80% reduction in traffic accidents and fatalities, a greener city with less pollution and a decrease in the requirement for parking spaces. There is potential to export this expertise to build new cities in new, non-traditional locations.

c) Describe the current state of technology as it relates to this challenge or need.

No inputs were provided.

d) Describe what it will take to get us to the desired end state

- Get clarity on the need and determine if there is internet capacity for the IoT.
- We need policy alignment on access to data and water as well as clarity on the role of all actors – not just government.
- Understanding how changing demographics will also change needs as people live longer.

e) What do we need to do together to achieve the desired end state?

We need to understand the problem and develop technologies with multiple users and capabilities in mind. Design and build with flexibility in mind so that buildings can be reconfigured. Neighbourhoods may be multi-generational but the services can be geared to meet the real needs of those who live there by providing for basic needs and personalizing other experiences and services (e.g. a hologram or avatar for the doctor, the gym comes to you, etc.)

f) What are 2 suggested immediate next steps to move forward?

- Investigate the portability/modularity for a neighbourhood or small community and build a pilot to test the concept.
- Provide seed funding and consider emulating the US Department of Transportation smart city competition.

Appendix B – Meeting Agenda

NRC Executive Summit on the Cities of the Future
Date: March 31, 2016
Time: 8:00 – 16:00
Location: Toronto Airport Marriott Hotel, Junior Ballroom, 901 Dixon Road, Toronto, ON

Agenda

8:00 – 8:30	Arrival and Sign-In
8:30 – 8:40	**Welcome and Introductions –** Danial Wayner, NRC VP Emerging Technologies
8:40 –10:15	**1. Cities Panel**: **What are the key challenges facing cities over the next 20-30 years?** Moderator: Marc Valois, Intersol *Rollin Stanley, General Manager, Urban Strategy, City of Calgary* *Thomas Mueller, President and CEO, Canada Green Building Council* *Wendy Reuter, Vice-President, Canadian Urban Transit Association*
10:15 – 10:45	Break
10:45 – 12:00	**2. Identifying top opportunities for Canada to pursue** Moderator: Marc Valois, Intersol • Results of the NRC Cities of the Future on-line survey – M. Valois • Discussion
12:00 – 13:00	**Networking Lunch** Fast pitches to showcase technology, strategy, and capabilities
13:00 – 14:30	**3. What are potential solutions?** *Ysni Semsedini, CEO, Festival Hydro – Stratford's driverless car pilot initiative* Discussion in Groups
14:30 – 14:50	Break
14:50 – 15:35	Plenary to share results
15:35 – 16:00	Wrap-up and next steps

Appendix C – Participant List

Name	Organization
Mohamed Abousalem	TECTERRA Inc.
Mouwafak (Mo) Ayoub	Pacific Controls (Canada) Inc.
Jean-Francois Barsoum	IBM Canada
Andrew Bowerbank	EllisDon Corporation
Sam Boyajian	Siemens Canada
Carl Caron	National Research Council Canada
Mona Chaaban	Hydro-Québec - IREQ
George Charitou	EllisDon Corporation
John Cigana	National Research Council Canada
Brian Colton	National Research Council Canada
Bernadette Conant	Canadian Water Network
Suzanne Connell	Innovation, Science, and Economic Development Canada
Francois Cordeau	National Research Council Canada
David Crenna	Canadian Home Builders' Association (CHBA)
Thérèse De Groote	Social Sciences and Humanities Research Council of Canada
Brad DeFoe	Ontario Ministry of Research and Innovation
Tija Dirks	Ministry of Transportation of Ontario
Ranjith Divigalpitiya	3M Canada Company
Tom Duever	Ryerson University
Michel Dumoulin	National Research Council Canada
Ritch Dusome	CENGN
Hugh Dysart	Communications Research Canada
Matt Eason	City of Ottawa
Alan Fung	Ryerson University
Martin Gillis	National Research Council Canada
Robert Haller	Canadian Water and Wastewater Association
Andrew Hartgers	3M Canada Company
Jean-Francois Houle	National Research Council Canada
Gilles Jean	Natural Resources Canada
Kris Khanna	National Research Council Canada
Barrie Kirk	Canadian Automated Vehicles Centre of Excellence
Robert Lane	CABA
Andréanne Léger	Agriculture and Agri-Food Canada
George Mallay	Sarnia-Lambton Economic Partnership
Shaun Marshall	General Motors of Canada
Magali Merkx-Jacques	National Research Council Canada

Thomas Mueller	Canada Green Building Council
Jonathan Neufeld	TECTERRA Inc.
Trevor Nightingale	National Research Council Canada
Peter Padbury	Policy Horizons Canada
Brian Purcell	IBM Canada
Amir Rashid	Pacific Controls (Canada) Inc.
Wendy Reuter	Canadian Urban Transit Association
Pratap Revuru	Schneider Electric Canada Inc.
Ysni Semsedini	Festival Hydro
Jiri Skopek	JLL
Paul Smith	Xerox Research Centre of Canada
Rollin Stanley	City of Calgary
Alan Steele	National Research Council Canada
Duncan Stewart	National Research Council Canada
Dwayne Torrey	CSA Group
Marc Valois	Intersol
Danial Wayner	National Research Council Canada
Sonja Winkelmann	Canadian Home Builders' Association (CHBA)
Randy Zadra	National Research Council Canada