

An Independent Study
Commissioned by



RESIDENTIAL AND
CIVIL
CONSTRUCTION
ALLIANCE OF
ONTARIO

Constructing Ontario's Future



MEGATRENDS: The Impact of Infrastructure on Ontario's and Canada's Future



RCCAO

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The Residential and Civil Construction Alliance of Ontario (RCCAO) is composed of management and labour groups that represent a wide spectrum of the Ontario construction industry.

The RCCAO's goal is to work in cooperation with governments and related stakeholders to offer realistic solutions to a variety of challenges facing the construction industry and which also have wider societal benefits.

RCCAO has independently commissioned 37 reports on planning, procuring, financing and building infrastructure, and we have submitted position papers to politicians and staff to help influence government decisions.

For more information on the RCCAO or to view copies of other studies and submissions, please visit **rccao.com**

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- LiUNA Local 183
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MEGATRENDS: The Impact of Infrastructure on Ontario's and Canada's Future

An independent research study prepared for the Residential
and Civil Construction Alliance of Ontario (RCCAO)

By
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former Ontario Deputy Minister
and founding CEO of Metrolinx

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of the September 2015 report)

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AUTHOR AND ACKNOWLEDGEMENTS

Michael Fenn is a consultant and board director. Over the course of an extensive career in public service, he has been an Ontario Deputy Minister under three Premiers, municipal chief administrator in Hamilton and Burlington, and the founding CEO of both Metrolinx and the Mississauga Halton Local Health Integration Network (a regional health authority serving one million residents from Etobicoke to Georgetown). Mr. Fenn is a board director of the \$78-billion OMERS AC pension fund and with the Toronto Board of Education's realty arm, the Toronto Lands Corporation.

Mr. Fenn wishes to acknowledge the support and advice of the RCCAO, especially Phil Rubinoff, chairman, and Andy Manahan, executive director, in the development of this project and in publishing this abridged report. Many of the issues identified earlier have emerged as important considerations in the ongoing discussions about infrastructure investment by governments at all levels and within the private sector and civil society organizations.

An earlier, more extensive version of this paper, the RCCAO's "Building Our Tomorrow: The Future of Ontario's Infrastructure," reflected important contributions by senior futurist Richard Worzel. In addition to Mr. Worzel, Mr. Fenn also wishes to thank the many useful contributions of a number of opinion leaders in the public and private sectors in the development of this report. These contributions include those of Bern Grush and John Niles of the transportation consultancy Grush Niles Associates (Toronto and Seattle), and Dr. Tom Corr, president and CEO of the Ontario Centres of Excellence Inc.

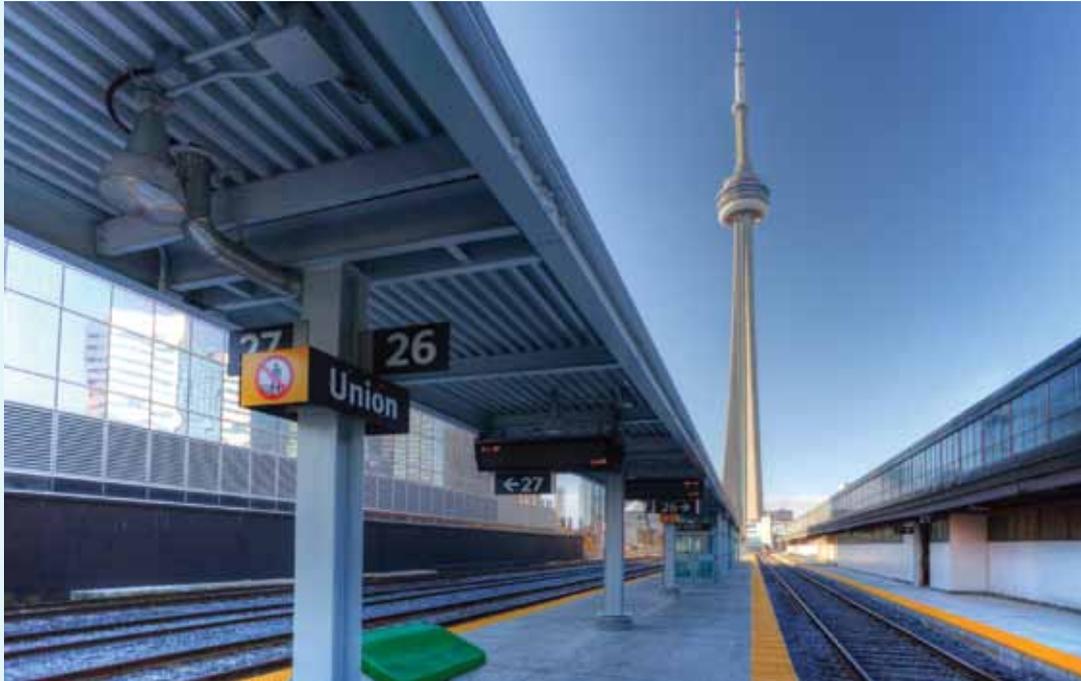
The viewpoints expressed in this report are those of the author and not necessarily the views of the RCCAO, the reviewers and other contributors, nor of the organizations with which Mr. Fenn is associated. Any errors or shortcomings in the report are entirely the responsibility of the author.

“Don't skate to the puck.

Skate to where the puck is going to be.”

— Walter Gretzky, to his son Wayne

EXECUTIVE SUMMARY



The public debate about the need to invest in public infrastructure has reached the point of broad consensus in Canada and across the world. Unfortunately, there is much less understanding of the need to build the right infrastructure for the long term, using the most sustainable and forward-looking financial instruments and tax policies.

Built properly, infrastructure lasts a long time. Good infrastructure decisions can serve us well for decades, economically, socially and environmentally. Poor or short-sighted infrastructure decisions will burden us and those who follow us for generations.

How can Ontario's and Canada's big public decisions about infrastructure ensure that we anticipate the future, in order to promote greater prosperity and a better quality of life? Short-term considerations can result in short-sighted decisions and missed opportunities for dealing with complex but urgent needs.

This report identifies “megatrends” – major trends or movements – and projects their impact on our infrastructure decisions between now and 2030.

SOME KEY FINDINGS

- **Transportation:** Faster and less congested trips, economical long-distance commuting and dependable logistics. Broad-based acceptance of innovations – automated vehicle control, driver-assisted vehicles, road-pricing regimes, in-vehicle technology for distance-separation and collision-avoidance, expressway system-access controls, drone technology, vehicle-and-ride sharing, computer-aided logistics and dispatch, high-speed trains and a renaissance in water transport. They will combine to revolutionize Ontario's transportation system, as well as having huge impacts on patterns urban development and housing costs.

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- **Rapid transit and public transit:** Platform-side doors, automated train control; time-of-day and distance-sensitive, universally accepted, bank-linked, multi-purpose fare-media will increase throughput and reduce congestion, despite increasing passenger volumes. Fare media will also be used for parking and convenience incidentals, like coffee and lottery tickets. But as transportation consultants Bern Grush and John Niles point out¹ driver-assisted and automated vehicles may be a positive or negative development, depending on whether society and the marketplace act pro-actively to plan and manage them. Ride-sharing and vehicle-sharing may displace conventional public-transit vehicles as the predominant feeder system for rapid-transit lines, opening the door to more progressive transit fares and financial sustainability of public transit.
 - **Light, flexible and adaptable infrastructure:** With the convergence of miniaturization, pre-constructed components and new-age design processes, the infrastructure of tomorrow will include rapid construction, more light, flexible infrastructure and new, cost-effective building materials. Some infrastructure will be more resilient to address climate change, but other infrastructure will have shorter life expectancies and amortization periods than traditional structures. Some transportation infrastructure might be relocated or reformatted before its planned end of life. Different delivery models will be necessary due to factors such as evolving economic conditions and changing demographics. Aggregated traffic management data will assist us in better planning for the future, and maximize the through-put of existing transportation systems.
 - In **health care**, the evidence-based test of “right treatment, by the right provider, in the right place, at the right time, for the lowest cost to the taxpayer” will drive integration. Technological and medical measures to maintain the elderly in their own homes and in retirement residences will expand dramatically. But will it also mean less emphasis on “bricks-and-mortar” hospitals and more attention to community health facilities, both public and private? In the future, outside of unserved areas, Ontario might need to build or expand hospitals only for advanced treatments and research.
 - Likewise in **education**, the future will challenge traditional models of bricks-and-mortar campus infrastructure, as technology gives students ready, low-cost access to alternative providers and to the world’s best researchers and instructors, on their tablets, on their ubiquitous smartphones and on their wrists.
 - For **water, wastewater and stormwater**, the impacts of climate change and convergence will demand new designs and greater capacity, integrating delivery and management, while linking financial and environmental sustainability. Regional, commercial utility and watershed will be the organizational frameworks for water, wastewater and stormwater infrastructure.

This report also presents an agenda for action, if Ontario and Canada are to seize the moment and invest in the kind of infrastructure that anticipates the future and prepares us for that future.

BACKGROUND



The Residential and Civil Construction Alliance of Ontario (RCCAO) regularly commissions independent research in fields of interest or concern to its members and to those that they represent. Infrastructure, in all its aspects, is an important part of the RCCAO’s research agenda.

The need for infrastructure investment, both in Ontario and globally, has somewhat belatedly come to be acknowledged across the political spectrum and in all parts of the public and private sectors. That is good news, but it is only a start. That we should act – and that action is long overdue – is now universally accepted. But where to act, what to build and how to finance, manage and sustain it remain important issues.

Ironically, not adequately addressing Ontario’s infrastructure gap in the past may turn out to be a great opportunity. The post-war economic miracles of Germany, Japan, South Korea and now China, show that skipping a generation of infrastructure and technology can enable a society to make a great leap forward in productivity, standards of living and even social equity.

Built properly, infrastructure lasts a long time. Good infrastructure decisions can serve us well for decades, economically, socially and environmentally. Poor or short-sighted infrastructure decisions will burden us and those who follow us for generations.

This report was first proposed by Phil Rubinoff, chairman of the RCCAO. The RCCAO and other thought-leaders have helped to stimulate the current public debate over infrastructure investment across Ontario and Canada. Reflecting on the success of those initiatives, the RCCAO observed that emerging trends and their impacts would have significant implications

for the nature of future infrastructure in Ontario. There is a corollary: new infrastructure will affect the future of work and society in Ontario, particularly for those who design, build, operate, and use civil and economic infrastructure.

This report responds to those twin challenges. It conducts a forward-looking analysis of the infrastructure that we will likely see, and that we may need, in the next generation in Ontario and Canada, particularly in our cities and urban regions.

Among the global thought-leaders in the infrastructure field has been *The Economist*, notably in a series written by researcher Ryan Avent. Avent canvassed academic scholars and other leading thinkers from around the world and in a variety of fields. He interviewed them about global trends and their implications, particularly for the future of work. His thought-provoking “Special Report on the World Economy” appeared in the October 2014 edition of *The Economist*, entitled “The Third Great Wave.”² That special report addressed a wide range of often inter-related emerging economic and societal trends, several of which are important for the focus of this report.

Earlier RCCAO independent research has proved to be a solid foundation for this look into the future, including a longer version of this report issued in September 2015, “Building Our Tomorrow: The Future of Ontario’s Infrastructure,” as well as the RCCAO’s February 2009 study by T. E. El-Diraby, T. Wolters and H. M. Osman, “Benchmarking Infrastructure Funding in Ontario: Towards Sustainable Policies.”³

A meta-analysis of infrastructure

The Economist’s October 2014 analysis gave rise to the proposal that a meta-analysis research project might help to prepare Ontario for the infrastructure challenges that lie ahead. Drawn from medical research, meta-analysis can be thought of as conducting research about previous research. Simply stated, the goal of meta-analysis is to distill an overall conclusion from a wealth of research material, which can often appear confusing or contradictory. Meta-analysis aims to identify evidence-supported, best-practice courses of action or treatments, based on a “balance of probabilities.” It is drawn from the available evidence, produced by recognized researchers and research organizations.

In looking at infrastructure and the trends that affect it, our intention here is not to duplicate work that has been done before, but to profit from it and to try to synthesize it.

This report looks at the many trends and innovations that might influence the nature, pace, financing and construction of the infrastructure of the future. Many experts have commented on the impact of specific trends on infrastructure. Conversely, new types of infrastructure will have an impact on the people, communities and society that they serve. In some cases, the research findings of experts will echo one another; in other instances, they will appear to diverge in their conclusions or their recommendations. Even these differences of opinion, however, can be thought-provoking and lead to new insights.

In keeping with the meta-analysis approach, this report has collected ideas from a cross-section of disparate sources. We have attempted to identify, distill and highlight prevailing views and conclusions. We are also conscious of the risks of “group think” and conventional

wisdom, which can often miss emerging disruptive innovations – and recent decades offer many examples. However, by looking to the work of those who have a track record of accurately foreseeing trends and their impacts, we have tried to mitigate this risk.

In addition, this report endeavours to suggest ways in which governments and their stakeholders can approach the future of infrastructure with flexibility and openness, in a spirit of innovation and overcoming short-term thinking or resistance to unwelcome change. We need to avoid the sins of the past, including the clearly evident neglect of the past several decades, which has left us with a huge infrastructure deficit. This report hopes to remind us of the great potential benefits that foresighted decisions on infrastructure promise for all of us.

The future is a vast and uncharted country. The sheer scope of this investigation has meant that many topics of importance and interest could not be given the profile and analysis that they deserve. This report contains a very extensive Endnotes section, which directs the reader to the research and informed opinions that underpin its observations and conclusions. Serious readers are encouraged to explore these sources for a more fulsome explanation of issues of particular interest, including the September 2015 RCCAO report, “Building Our Tomorrow: The Future of Ontario’s Infrastructure.”

One thing is certain: assuming Canadian society and its various governments can continue into the future by following the paths of the past is the route to unpleasant surprises, with expensive and embarrassing policy failures.

What do we mean by infrastructure?

Infrastructure is made up of the physical plant and distribution systems that make modern society and economic activity possible. It ensures that labour, capital and information can be deployed in ways that are productive and serve society’s needs. Good infrastructure is an essential ingredient in economic growth and prosperity. It is critical to both private sector and public sector productivity. But only if we build the right infrastructure, reflecting evidence and our anticipated future, not political expediency or merely repeating the past. A lack of good infrastructure – and deteriorating infrastructure – can diminish productive capacity and the efficiency of markets for goods and services, resulting in higher costs, poorer price competitiveness, and fewer good jobs.

The term “infrastructure” covers a wide variety of diverse systems and networks. These are governed by differing physical characteristics, uses, ownership patterns and life cycles. This report also makes the case that, in the future, our conventional understanding of infrastructure will change in ways not seen since the advent of steam power, the electricity grid and the automobile.

To add to the complexity of this analysis, various types of infrastructure have different relationships to the society and economy that they serve and support. Some infrastructure is used to transport goods and services to and from centres of production or economic activity. Other infrastructure is used to deliver people and business-support services to centres of employment or education and training. Some infrastructure is used to support a region’s or a community’s quality of life, by underpinning safe, healthy and sustainable living conditions for people and enterprises.

In RCCAO’s earlier publication, “Investing in Ontario’s Infrastructure,” public investment in infrastructure was defined as: “... including roads and highways, rapid transit, water supply and wastewater treatment, rail, aviation, water transportation, as well as electricity and broadband infrastructure ...”⁴ In its subsequent report on the subject, RCCAO expanded the definition to include a wider range of social and technological infrastructure,⁵ to which we could further add infrastructure associated with waste disposal and resource recovery, without even considering important private-sector infrastructure. We will broaden that list to include infrastructure of the future. In our research scope, we have included infrastructure investments that are often overlooked or neglected as politically unpopular. All public infrastructure requires long-term investments that have social and economic effects.

For our purposes, infrastructure focuses on civil infrastructure and public assets, which serve the whole community or broad categories of users. The focus of this report does not generally include infrastructure designed to serve a business enterprise or for commercial marketing, although there may be some overlap (e.g., privately owned natural gas retail distribution networks, or the private bus fleets serving school boards or operated by commercial intercity bus lines).

Trends changing infrastructure needs

As noted above, the importance of infrastructure to Ontario’s future is now widely accepted, across the political spectrum. The need to invest in infrastructure of all kinds – both to make up for past neglect and to build the next generation of infrastructure – has finally reached the top of the public agenda. The calls for immediate action on infrastructure are widespread, echoing those across North America and around the world. For the most part, we have not invested enough to maintain existing infrastructure, much less expand it or build new capacity.^{6,7} Sustained, low-interest rates now make such investments attractive, both to the public sector and to private sector investors and pension plans interested in investing in infrastructure.

History has taught us, however, that widespread consensus and a sense of urgency can lead to inadequate planning and ill-considered choices. The imperative to build infrastructure should not be considered primarily in terms of reasonable or affordable levels of expenditure, or the impact on struggling economic regions or employment. In the infrastructure-building frenzy in China and Japan over the past several decades, there are examples of new towns in the “middle of nowhere,” “roads to nowhere” and grand seaports in tiny harbours. North America is not immune, as former Alaska governor Sarah Palin’s famous bridge-to-nowhere demonstrated.⁸

It is equally important both to sustain public support for an expensive, ambitious infrastructure investment agenda and to respond realistically to political mandates of short horizon.

Looking forward by looking back

One of the best ways to remind us of the importance of anticipating change, and not simply projecting the past into the future, is to consider the pace of change in the last few decades. Few would dispute the accelerating rate of change in Ontario and in Canada. One needs only to reflect on the conditions that prevailed in recent memory to understand the scope and scale of those changes.

A few reminders tell the story:

- Less than two decades ago, only 11 per cent of the residents of the developed world used the Internet; now the figure is 77 per cent, exceeding 85 per cent for Canada, the U.S., Japan and many northern European countries, and a remarkable 46 per cent in China and 250 million people in India. In 1997, the music and movie industries made much of their fortunes selling albums on CDs and renting movies on tapes and DVDs, which had completely displaced modern post-vinyl innovations like eight-track, Beta and VHS.
 - Royalties were a primary source of income for musicians and composers.
 - the iPod, the iPad and music file-sharing did not exist.
 - Blockbuster was a solid investment.
 - but value of a share of Apple common stock had declined to US\$13.
 - in 2000, the majority of television screens were still small, bulky, blurry cathode tubes.
- In the latter part of the 20th century, express passenger trains in North America struggled to achieve speeds of 80 km/hour, and still do. By contrast, in Japan, China and Western Europe, scheduled-service daily passenger trains now routinely quadruple that speed; in 1997, toll roads required toll takers in toll plazas.
- In 1998, Ontario-based investors launched the BlackBerry, which grew to command 43 per cent of the world market for smartphones, including customers like the current president of the United States; at the turn of the Millennium, neither Facebook nor Twitter existed, and Google was a start-up with a 2004 IPO share price of US\$85 (a \$10,000 investment then would have earned you \$139,000 today). Now, Apple is the world's most valuable company, and Google is third, but with far fewer employees than many traditional large commercial, industrial and public sector organizations.
- The famous August 2003 power blackout highlighted the vulnerability of Ontario's electrical power system and the brownout limits on its generating and transmission capacity. Today, Ontario's nuclear energy generation has absorbed the loss of coal-fired plants, while Bruce Power is looking to sell surplus power to the U.S. At the turn of the 21st century, climate-change impacts were a theoretical concern criticized by many skeptics; the Indian Ocean and Japanese tsunamis, Hurricane Katrina and Super Storm Sandy had yet to illustrate the vulnerability of public infrastructure during extreme weather events.
- Buoyed by the coalition triumph of the first Gulf War, future-oriented discussions at the turn of the Millennium revolved around an overblown concern over Y2K, but rarely mentioned the future impact of global terrorism; yet 9/11 was only 21 months away, with the resulting vast public infrastructure expenditures in fields like airport, law-enforcement and security infrastructure.

Similar stories could be told about the unforeseen leap in the Greater Toronto and Hamilton Area's (GTHA) housing prices and the associated high levels of household mortgage debt; the efficiency and success of hybrid cars; the growth of online learning and commerce; the disruptive changes in the business of media and journalism as a result of the Internet, social media and cellphone cameras; the post-SARS awareness of the risks of global contagion; the roles of DNA, CCTV and forensics on the criminal justice system; and so on.

The bottom line is that many of our conventional assumptions and established practices, even those that seem contemporary, can be swept away in a very short period of time. We have many recent examples of the folly of “driving forward but looking backwards.”

We do have some interesting Ontario-based experience in the importance of paying attention to future trends before making major investments in public networks and facilities. While we could cite post-war “urban renewal”, public housing projects, or in-town expressways, a more positive example might be Toronto's Bloor Viaduct, as we study the lessons of the past in planning for our own future-oriented investments in infrastructure:

Bridge building ...

In 1918, Toronto was suffering through Canada's fifth devastating year of the First World War. With an eye to the future, the growing municipality decided to build a monumental bridge to connect the city's great east-west thoroughfare, Bloor Street, with the East York bungalows and Scarborough manufacturing jobs that would welcome returning veterans. Immortalized in Michael Ondaatje's novel *The Skin of the Lion* and named after the dashing young Prince who would one day be king, the Bloor Viaduct was designed with a leap-of-faith addition. Reflecting infrastructure innovations in London, Paris and New York, and at modest additional cost, civic officials and their engineers strung below the bridge's deck the iron superstructure for an east-west transit line – which didn't exist and wasn't planned.

Economic recession followed the war, the dashing Prince abdicated, and the automobile and later the freeway displaced public transit on the public infrastructure agenda. Had that infrastructure investment been misdirected or a waste? A half-century later, the Bloor-Danforth subway opened – a project made much more affordable because subway trains ran along that long-forgotten iron infrastructure below the Viaduct.

This is not only a wonderful example of foresighted planning, but illustrates one of the key difficulties of making clearly thought-out investments in infrastructure:

Today's infrastructure seems horrendously expensive, but yesterday's investments look like incredible bargains.

What questions should we ask?

With infrastructure, the cost and impact of both good decisions and bad decisions are enormously magnified. In addition to the traditional questions about public expenditures on public infrastructure, the ongoing public debate about investing in infrastructure needs to consider some new and fundamental questions.

- What new forms of infrastructure will emerge, and which will be obsolescent?
- Can new technologies render some major infrastructure unnecessary, or open the door to more modest solutions?
- How will major societal and economic trends influence the kind of infrastructure we will need?
- How will these trends change the economy, ecology and society that infrastructure must support?
- What will be the effects on labour and business – especially on those who will design, build, operate and use infrastructure in tomorrow’s changing environment?

This report aims to assist decision-makers – and citizens – with these important decisions, by providing a context within which to weigh their options.

What do the researchers and forecasters say?

Those who think about the future and the impact of megatrends on our future are careful to make the distinction between predicting and offering prospects, possibilities and options. If we are going to use influential trends as our filter, in order to project the future of infrastructure, what are those trends and where do we find them described? To answer these questions, we have identified several, somewhat differing perspectives, from which we will identify the trends to watch and against which we can evaluate the impact on infrastructure.

It is also important to look beyond leading corporate entities and commercial consulting practices, to hear the futurists. A good futurist does not predict the future, but offers prospects and possibilities. Internationally recognized Toronto-based futurist Richard Worzel wrote two bestsellers: *Millennium: Facing Our Future: The Seven Forces Revolutionizing Our Lives* (1994),⁹ and *The Next Twenty Years of Your Life* (1997).¹⁰ Read today, with the benefit of hindsight, both of these works are surprisingly clear-sighted. Since Worzel’s advice proved prescient in the past, the text of this report benefits directly from his observations about today’s challenging effort to anticipate the future of infrastructure and its impact on society and work.

In looking to other sources for insight into the future of infrastructure, our economy and society, we begin with technological change and the pace of technological change. In our generation, the terms “future” and “technology” have almost become interchangeable. While the future of infrastructure involves much more than just technology, it makes sense to begin our analysis there.

Bern Grush and John Niles are transportation specialists with unique insights into human behaviour regarding personal and public transportation, vehicle ownership and vehicle sharing. Their firm, Grush Niles Associates, is known for interfacing with many of the thought leaders in this world of new mobility. In Appendix C of an earlier RCCAO report,¹¹ they offer a number of provocative and intriguing ideas for anticipating and managing the transportation infrastructure and urban designs of the future.

In its landmark report on the impact of technology by 2022, the world's largest professional association for the advancement of technology, the 400,000-member Institute of Electrical and Electronics Engineers (IEEE) identified some 23 technologies to watch and provided a glimpse into the future.¹² Our analysis of the future of infrastructure considered the implications of the IEEE projections for Ontario, as technology will obviously be a key driver of social, economic and infrastructure change in the near future.

Another source of insight into the trends that will affect our future comes from the well-respected global business strategy firm, Boston Consulting Group (BCG). While understandably more focused on the global economic future, including business risk and business opportunities, BCG identified some 50 trends that will change our economy and consumer society.¹³ They group their findings under what might be termed megatrends: demographic trends, consumer trends, economic trends and technology trends.

Another consulting firm with global reach and a reputation for excellence in business strategy is McKinsey & Co. Three of its preeminent researchers produced a book that analyzes how several global forces are shaping, or will shape, the trends in this report. In “No Ordinary Disruption: the Four Global Forces Breaking All the Trends,” they describe four overarching “global forces”:¹⁴

1. Urbanization
2. Pace of technological change
3. Demographics (aging and immigration)
4. Globalization and connectivity

We need to look at ways in which new infrastructure may shape the nature of work, business, education, training and regulation. This report will give a special focus on those who are engaged in the design, financing, construction, operation and use of civil and economic infrastructure, including the housing market.

“The Third Great Wave” uncovered some very interesting but disturbing trends in areas such as the distribution of wealth and gainful employment in the society of the near future, based on skill-level and field of economic activity. (Some of the findings about capital accumulation and income inequality have echoes of popular French economist Thomas Piketty’s recent bestseller *Capital in the Twenty-First Century*.¹⁵)

Each of these trends has a direct link to the nature, demands and effects of infrastructure. “The Third Great Wave” extended its analysis to:

- The impact of these trends on urban settlement patterns and the cost of housing;¹⁶
- Variable patterns of employment and unemployment, by sector, by skill level and by region;
- When (and if) to use labour-substituting technology and its effect on productivity;
- The impact of industry-based and trades-based regulation on expanded employment;
- The globalization of supply chains and markets (and the associated logistics infrastructure) for even the smallest of enterprises; and,
- The prospects of all of these impacts for social unrest, immigration/emigration and decline in social cohesion, and the unpredictable political implications of all of them.

For the 2015 World Economic Forum, a consortium was commissioned to prepare an outline of global risks and major trends. This 10th edition of the global risk assessment was prepared by the Marsh and McLennan Companies and the Zurich Insurance Group, with the academic advisers from the National University of Singapore, Oxford University (Oxford Martin School) and the University of Pennsylvania’s Wharton Risk Management and Decision Processes Center.¹⁷

In addition to identifying some 28 global economic, environmental, geo-political, societal and technological risks, the forwarding-looking assessment cited a baker’s dozen high-level megatrends that would influence the world economy and affect the identified risks.

Another global trends forecasting firm, Frost and Sullivan, prepared an intriguing, alternative list of megatrends.¹⁸ Frost and Sullivan lists 11 megatrends; a number in common with the foregoing, but also with some new or differing insights.

The global industrial and engineering giant Siemens produces a magazine focused on practical applications of new thinking around the world, with particular application to infrastructure in its broadest context. The fall 2013 edition of the magazine was particularly focused on the impact of trends on the future of infrastructure.¹⁹

It is also important to look closer to home, for perspective on the innovations and trends that will influence the future of the Ontario economy and society. The Ontario Centres of Excellence (OCE) is a government-supported, separately incorporated collaboration among business, government, academic research and entrepreneurs. Its stated mission is “accelerating innovation through game-changing research leading to successful commercialization and vibrant collaboration between industry and academia, launching the next generation of products and jobs.”²⁰

From a variety of geographic locations across Ontario, it targets four sectors: (1) advanced health technologies; (2) advanced manufacturing; (3) information, communications and digital media; and, (4) energy and the environment.

While we have referenced the high-level trends that will affect infrastructure and the society and economy, it is useful to seek out practical applications and examples of innovation. The OCE provides an interesting, ground level window onto the potential impact of megatrends on infrastructure, right here in Ontario.

What are the infrastructure implications of these megatrends?

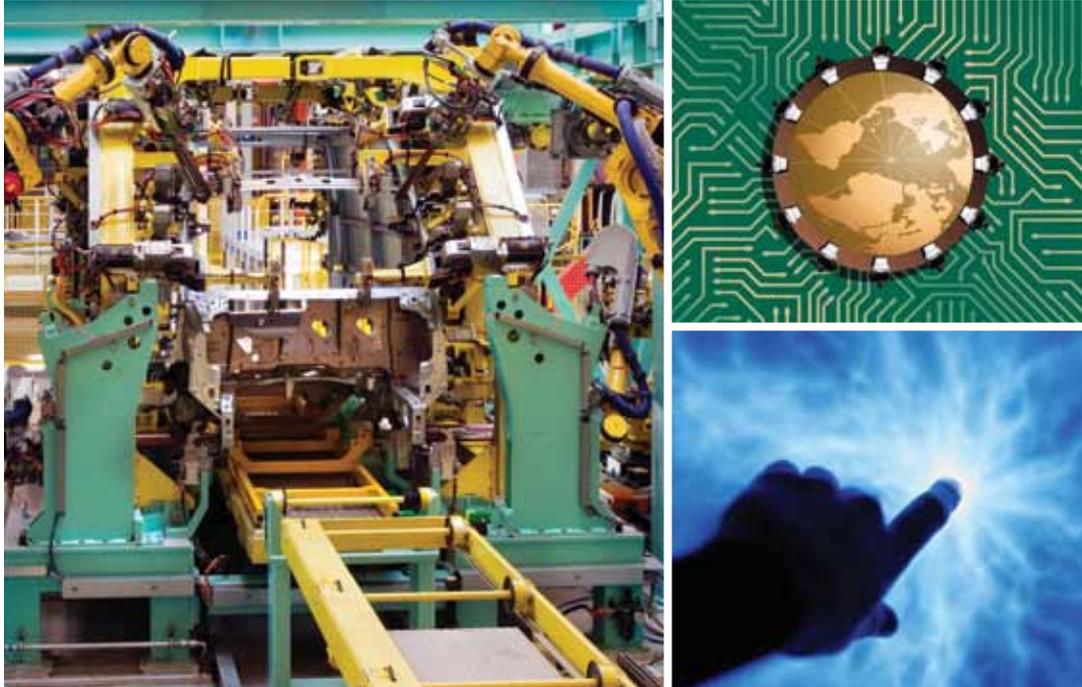
The Economist's “The Third Great Wave” identified several major trends that are likely to significantly affect Ontario in the next 20 years. Some of these trends are global, while others are more indigenous.

It is always necessary to employ restraint and humility in making future projections, reflecting the fact that few would have predicted the course of the last quarter-century. But it is possible to address the medium-term future with more confidence. A frame of reference might be the Ontario of 2030, which for policy-makers, roughly represents four electoral terms at all three levels of government.

We also need to engage in informed, evidence-based projections on the ways in which those broad trends might specifically influence the nature of the infrastructure needed to support the activities of that emerging Ontario society and economy. This would include consideration of policy and fiscal tools and planning processes that might advance good infrastructure decisions.

Societies and economies must be flexible and responsive to change if they are to evolve progressively and prosper. To do so, we must adopt and adapt measures to discourage sub-optimal, inefficient or uneconomic fiscal and policy choices. For infrastructure planning and projects, this includes ways to overcome or mitigate predictable resistance to change or defence of status-quo privileges and entitlements, and even nostalgia and so-called NIMBY/BANANA impulses.²¹ Legendary General Electric CEO Jack Welch best summarizes the risky implications of the knee-jerk, NIMBY response: “If the rate of change on the outside exceeds the rate of change on the inside, the end is near.” Others would cite Darwin: “It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change.”

WHAT ARE THE ‘BIG SIX’ MEGATRENDS THAT WILL AFFECT INFRASTRUCTURE?



Based on research and analysis, several major trends have been identified that will affect infrastructure and infrastructure decisions through to 2030 and beyond. While various analysts (including some cited here) have identified different trends or suggested more or fewer trends, there are six megatrends particularly worth watching, for their impact on infrastructure and correspondingly, for infrastructure’s impact on society and the economy.

① **Technological trends and the pace of technological change**

Infrastructure is, at its heart, technology. As a result, technology trends will most conspicuously affect infrastructure. Recent trends in technology in all fields have taught us a common lesson: many of our conventional assumptions and established practices can be swept away in a very short period of time by the advance of new technology – and the public’s embrace of it. To quote *The Economist*: “Exponential growth ... looks negligible until it suddenly becomes unmanageable.”²²

Our analysis of the future of infrastructure has considered the implications of the IEEE projections for Ontario, as technology will obviously be a key driver of social, economic and infrastructure change in the near future.

As “The Third Great Wave” succinctly concludes:

“Technologies are tools without an agenda of their own, but their influence on society is never neutral. They blindly sweep aside the livelihoods of some people and enrich others. Politics must craft rules and institutions that harness technology to suit society’s values and vision of itself.”²³

Technology can come to the rescue of the mounting problem of deferred maintenance obligations in waterworks, roadways and other public infrastructure, which now also burden the financial balance sheets of municipalities and public agencies. Nano-sensors built into roadways, bridges, parking garages, and under-road water and sewer networks, along with the expanded use of monitoring/inspection technology, will enable a more targeted “no-surprises” approach to maintaining existing infrastructure. When evidence-based findings displace depreciation-based programs of comprehensive maintenance, money and resources can be more effectively prioritized and extend the useful life of physical assets. Technology can also enable a comprehensive, evidence-supported approach to asset management, as cities such as Cambridge, Ont., and Ottawa are demonstrating.²⁴

As noted earlier, technology could also significantly alter the nature of the social infrastructure we use to support a variety of social functions. Despite the rising demand for health care and education, both domestically and globally, will we still need the expensive bricks-and-mortar facilities that we traditionally use to deliver these programs, and the bureaucratic oversight they inevitably entail? Social infrastructure – health, education, custodial facilities, housing for the elderly – may see declines similar to those we have already seen in other fields, when responding to similar trends.

② Urbanization, globalization and connectivity trends

In their new book, *No Ordinary Disruption: the four forces breaking all the trends*, McKinsey analysts include urbanization as one of the four great forces that will affect all of our lives in the future.²⁵

Perhaps the greatest crossover between the broader societal and economic trends and the deployment of the infrastructure of the future comes in relation to transportation and accommodation of workers. The Third Wave summarizes the relationship in these words:

“Having workers in the right places is critically important to generating more and better jobs. In both the rich and the emerging world unmet demand for housing is a significant constraint on growth ... In rich countries restrictions on the supply of housing can be ... pernicious. In economically dynamic places such as New York and London the shortage of housing is a serious constraint on growth in output and highly paid jobs. Inadequate investment in infrastructure exacerbates the problem. As roads and trains become more crowded, residents grow weary of agreeing to new developments, and so it goes on.”²⁶

Advances in “intelligent” transportation technology will change the face and the future of our cities and neighbourhoods, and the transportation and energy infrastructure that serves them.

Consider the infrastructure impacts of emerging technologies:

1. Driverless vehicles²⁷
2. Swedish-inspired road fatality reduction programs²⁸
3. Fully automated transit systems with generic, world-standard designs and equipment
4. Re-engineered road intersections, cycling, pedestrian and parking arrangements
5. More efficient and flexible modes of local public transit, school transportation and inter-urban trains
6. Mobility hubs, like Madrid’s *intercambiadores*²⁹
7. Widespread and more efficient mobility-assisting transportation designs
8. Commercial use of drones and localized logistics for Internet-based goods-delivery fulfillment, including drone-directed dirigibles for remote location bulk goods and machinery deliveries³⁰
9. Very low energy-consumption vehicles and long-charge electric cars
10. Entirely new types of personal vehicles, business vehicles and transit systems, addressing the issues of “the first/last 400 metres,” customization of routing, urban market business-support vehicles, multi-modal connectivity, inter-urban transit, vehicle- and ride-sharing, and so on.

These will combine to alter the look of the street-level infrastructure in our suburbs, our urban cores and across our countryside.

Globalization trends will remind us that neither Ontario nor North America is an island. The growth of the middle-class in the once seemingly far-off lands of China, Indonesia and Brazil and a new round of free-trade agreements, will change our markets, our patterns of commodity production and distribution, and even the demands on our educational and health systems. Correspondingly, commercial, environmental and political developments that were once safely on the other side of the world will increasingly affect our daily lives, much as the revolution in consumer products and durable goods manufacturing has altered North America’s relationships with Asia over the past three decades.

3 Social and demographic trends

As demographers have pointed out since the Baby Boom generation learned to walk, Ontario's patterns of social demands (and related infrastructure demands) can be tracked closely to the annual aging of the post-war demographic cohort. As elementary and secondary schools built decades ago for Boomers (and retained for their "2.5 children") progressively empty, facilities for the frail elderly are in great demand, with someone in North America turning age 65 every seven seconds.

Health-care delivery will need to be integrated across the continuum of care, from primary care, diagnostics and specialists, through hospitals and community care, to nursing homes, hospice and palliative care. Institutional barriers, professional siloes and the unintended barriers to care created by our health privacy rules will be eroded by technology in the hands of both providers and consumers (who will no longer be just patients).

In practical terms, these changes will need to be effected on a regional footprint, involve the full continuum of health-care delivery, and address the compensation incentives and disincentives that can frustrate integration and best practices. The information technology and alternative delivery infrastructures on the near horizon for health care will empower consumer demands for as-needed availability, relative performance data, clinical guidelines, personal case histories and treatment options. Similar trends will affect the continuum of education, from primary school to graduate school.

Suburbs designed for families need to be re-engineered to deal with the changing mobility needs of an aging population and the advent of new transportation technologies.

Mass public entitlement programs, such as Medicare, CPP, and large public service pension funds, depend on a demographic pyramid in which multiples of younger workers at the bottom of the pyramid support the benefits paid to older citizens at the demographic apex. When the pyramid begins to narrow at the bottom, the medium-term fiscal and social consequences can be dramatic, especially if not addressed in a timely and actuarially sustainable fashion.

With falling fertility rates, the need for more immigrants becomes acute, both to attract talent and skilled workers, and to recruit less-skilled workers to support the health care and lifestyles of an aging population. Along with large-scale immigration, however, comes the domestic social and political reaction to the societal changes that other cultures and other values bring.

In our historically low-interest environment, many have forgotten the miracle of compound interest. A modest elevation in the rate of inflation or the interest rates charged on government and consumer debt, including mortgages, could trigger a number of societal shocks. Conversely, a prolonged low-interest-rate environment and a volatile stock market change the retirement calculus upon which millions of seniors plan to depend.

4 Economic and workforce trends

In 2014, writer Ryan Avent canvassed academic scholars and other leading thinkers. He interviewed them about global trends and their implications, particularly for the future of work. *The Economist's* special report addressed a wide range of often inter-related emerging economic and societal trends.

Under the heading “How governments can deal with labour imbalance,”³¹ for example, the special report extrapolates some intriguing and novel collateral ideas about the relationship between the housing market and the cost and distribution of labour. In another analysis, it links the impact of trades regulation and wage policy on business decisions to use labour-displacement technology or outsourcing.

The Economist's special report also raises the encouraging prospect that two large and expenditure-driving elements of government budgets, like Ontario's, may see relief. It projects that technological innovation will reduce the high cost of individualized health-care procedures and therapies, while expanding the availability and lowering the cost of advanced education and training. These developments would have important implications for workers and their families, as well as for employers, governments, hospitals and universities.

Consider our recent experience, where telecommunications and online marketing overtake the in-person retail experience, in areas as diverse as newspapers and magazines, retailing, travel bookings, culture, sports and entertainment. A century ago, every small town had a bustling commercial core, with a theatre or an opera house, and a half-century later, we saw their successors: the strip plaza and the movie theatre, or a nearby drive-in or video rental outlet.

Today, these retail and entertainment functions have largely disappeared from small towns: typically these functions are now commoditized in major urban centres, shopping malls or increasingly, in big-box power centres, with generic retailing, cinema multiplexes and inherently disposable architecture. Major spectator facilities have become mere adjuncts or (often transient) venues for the marketing businesses of professional sport and popular music, or heavily subsidized local venues for one-time events or travelling shows.

In employment, there is an evident loss in the scope for skilled and semi-skilled, blue-collar employment while income levels are not rising for the majority of Ontarians. By contrast, the 20th-century Ontario economy generated well-paying, trade-union jobs for large numbers of Ontarians. Their purchasing power, in turn, sustained demands for Ontario's economic output, including automobiles and housing, and paid the income taxes that financed public services.

While the rate of unemployment is now starting to decline, Ontario's obsolescent jobs are being replaced with large numbers of often more poorly paid and less dependable service-sector jobs. This shift in employment profile means lower capacity to pay taxes for things like infrastructure, and correspondingly, more demands for public services that support lower-income citizens. Those programs benefit the deserving but usually contribute little to improved productivity of the economy and add to government operating deficits.

Emerging technology also makes many service-sector and other lower-skilled jobs vulnerable to labour displacement, with one expert suggesting that 45 per cent of American jobs, and half of retail jobs, are vulnerable to robotic displacement.³²

Some are suggesting that we may see a resurgence of manufacturing in North America, including Ontario. Attenuated Asian supply chains, geo-political instability and a desire to have some percentage of product suppliers ready-to-hand could influence corporate decisions. We will not see a wholesale return of manufacturing from Asia and Latin America, nor would pre-existing wages and benefits be assumed. However, some growth could help to sustain or rebuild domestic manufacturing for a North American or even global market. It would, of course, be contingent on achieving progressively greater levels of productivity and corresponding reductions in marginal costs.³³

5 Environmental and energy trends

Disturbing trends are appearing that affect environmental and energy infrastructure. Sanitary sewers and drainage systems once adequate to face the 100-year storm are increasingly incapable of managing periodic extreme weather events. Water quality and availability are emerging as major issues across North America and around the globe. Environmental impacts are motivating the Gates Foundation to offer rewards for re-inventing sewage systems and household toilets.³⁴

Energy infrastructure will be under increasing demands from burgeoning electronic communications and electricity-powered transportation, with pinch-points in transmission and increasing demands for higher (millisecond) tolerances in electricity stability. A benign combination of favourable public and tax policy, technological progress and rising electricity costs will also give rise to a wave of localized micro-generation, from inexpensive rooftop solar generators to district heating and cooling systems.³⁵ Health and climate-change concerns over fossil fuels have closed coal-fired plants in Ontario, reduced vehicle emissions across North America and Europe, forestalled energy-from-waste and gas-fired electricity-generating initiatives in Ontario, and seen a remarkable growth in public acceptance of nuclear energy (although not yet with a concomitant acceptance of the need for nuclear waste disposal).

Over the long haul, temporary fuel-pump price relief resulting from fracking and low-cost petroleum are likely not sustainable, whether economically (return on capital investment in petroleum sources) or from global public concerns over climate-change impacts. Carbon-pricing and cap-and-trade regimes, along with consumer and corporate interest in green energy, ultimately will alter industrial practices and profitability.

⑥ Political and fiscal trends

At the fulcrum of all of these trends lie government and the public purse. How will these ‘megatrends’ affect those charged with the responsibility for leading change and mitigating its impacts? Leaders in business and labour inevitably need to engage governments in the task of managing the economy in ways that promote prosperity, sustainability, market fairness, a living wage and quality of life. As “The Third Wave” notes, in some situations, this will include a decision by public authorities to exercise restraint. This means to “get out of the way” or not actively respond to demands for government intervention from an apprehensive public or entrenched stakeholders facing unwelcome change.

In its Oct. 4, 2014 editorial, *The Economist* also emphasizes the need to act in a way that is not a historic peacetime strength of governments: to be nimble and rapid in their evaluation and response to demands for the right infrastructure. Of equal importance, governments need to create the right social and economic policy environment to meet the challenges of the new Millennium, including decisions to plan for and correctly select infrastructure by type and priority.³⁶

In the same editorial, two other intriguing ideas were raised.

Although wages have not risen as they did in the early phases of the industrial era in both the developed and underdeveloped worlds, billions of individuals now have Internet access to a vast array of resources and benefits. Communications, information and entertainment are very accessible, but the value of which far exceeds the reach of the masses in previous generations. (Probably with Millennials in mind, it adds: “Few workers would want to go back to a world without the Internet, smartphone or Facebook, even for a pay increase.”)

The other observation was the role that technology was playing to compensate for labour-displacement technologies and the loss of major industrial and service employers. Online services like Etsy and Uber have democratized the local and global marketplace, for everyone from vehicle owners to craftspeople. In June 2015, the BBC profiled how impoverished traditional sari-makers in rural India were using basic CAD and web-based global “fulfilment” to earn much higher salaries than ever before.

Overall, *The Economist* summarized the volatile global situation with this pithy set of observations:

“... the growing wedge between a skilled elite and ordinary workers is worrying. Angry voters whose wages are stagnant will seek scapegoats: witness the rise of xenophobia and protectionism in the rich world. In poor countries dashed expectations and armies of unemployed people are a recipe for extremism and unrest. Governments across the globe therefore have a huge interest in helping remove the obstacles that keep workers from wealth.”³⁷

After that was written, Greece, the Middle East and North Africa were in greater turmoil and hundreds of thousands of refugees and economic migrants were washing up on European shores – in less than a year, those predictions had become stark realities. By contrast, from the economic doldrums, Canada has used “Keynesian” investment in infrastructure and housing to re-employ workers, absorb immigrants and revitalize an economy bruised by the recent Great Recession. One thing is clear: financial success by those at the top of the economic pyramid may correspond to regional prosperity, but it does not translate into broad-based growth in regional household incomes.³⁸

A number of Ontario civil society organizations, including RCCAO, have shown leadership. They have promoted innovative initiatives, by arguing for road pricing, asset recycling and infrastructure banks as ways in which the infrastructure challenge can be met, by beginning with the all-important question of how to finance it. Linking the demand for infrastructure with ways to pay for it is a major political challenge. It can be a tough sell, if proposed in a political environment where the public is skeptical that its taxes, fees and fares are being put to best use. The 2015 defeat of the Vancouver region’s transport sales tax referendum is eloquent testimony to this disconnect. A combination of impartial, arm’s-length, industry-specific regulation and a focus on direct user-pay, user-benefit fiscal policy seems to be the most promising way forward.

This is not to suggest that financing should be the determining factor in deciding to proceed with a project, or indeed, with an overall government program of infrastructure investment. Simply saying that we have an infrastructure deficit and need to invest, or finding a clever or politically opportune way to attract funding, is insufficient grounds to proceed. Too often, shovel-ready projects and time-limited, politically influenced funding, as well as protracted environmental assessment processes, can coalesce to displace better, future-oriented infrastructure ventures. In that respect, the decision of the Trudeau government to adopt a two-phase approach to infrastructure spending, with the bigger, more significant investments to come later, is a very promising change from the usual pattern of Canadian governments.

In a constrained fiscal environment of capital rationing, with a huge overhang (for now) of inexpensively financed debt, governments have another challenge. They must both build the right infrastructure and build it right, using the most sustainable and forward-looking financial instruments and tax policies.

In our increasingly post-industrial society, we are seeing an evolution of economic production “from stuff to fluff” (to use the evocative term of India’s insightful chief economic policy adviser, Dr. Arvind Subramanian). Even in the area of goods production, the “Internet of Things” may diffuse goods production in the same, largely unanticipated way that the mainframe computer came to be rivalled by the personal computer.³⁹

Government tax regimes associated with physical assets, fixed-location retailing, local transactions and corporate head offices will need to adjust to new economic models. This is especially true for municipal governments, which build much of our basic public infrastructure, using property taxes, transfer payments and development charges.

WHAT WILL THESE SIX TRENDS DO TO PLANNING FOR FUTURE INFRASTRUCTURE?



Based on our analysis of the research and the comments of those consulted during this report, we have concluded that the direction of technology, economics, lifestyle and public policy share some common characteristics, as we proceed into the future.

These future directions reflect the changing goals of people in society, whether they call themselves citizens, workers, passengers, consumers, patients, students, taxpayers, investors or shareholders. We probed these trends further, for their implications for infrastructure, and a number of intriguing implications offered themselves.

Our approach has not been to try to use a crystal ball. Realistically, the direction of infrastructure cannot be predicted with great accuracy, nor can we anticipate all the spin-off effects that might be generated by new infrastructure. But we can provide a telescope and a compass. By reflecting on our findings and their experience, those in the infrastructure business can better anticipate, prepare and seize opportunities, early and with more confidence. Of equal importance, they can more easily preempt, deflect or mitigate the avoidable risks. Here are 11 impacts of these trends.

Impact 1: Distances will shrink

The desire to move goods, people and information quickly, efficiently and economically across a region or across the world will continue – and accelerate. Much of this shrinkage in distances will be abetted by new technology, from the Internet of Things⁴⁰ and 3D printing, to high-speed trains and autonomous and driver-assisted vehicles. In addition to the obvious positive aspects, shrinking distances will have a number of disruptive manifestations. It will expand the shadow of urbanization, by allowing long-distance commuting and the development or redevelopment of residential communities and business centres at some distance from major urban centres. It may also risk hollowing out commercial and institutional bases of second-tier cities and less prosperous parts of the province. These developments will have implications for Ontario's Greater Golden Horseshoe Growth Plan and Metrolinx's Big Move Plan, both of which are based on assumptions that may not prevail in the future.

Impact 2: Elapsed times will shrink

From the world of telecommunications and e-business, users of infrastructure will transfer their expectations to public systems, activities and processes. Ontarians will expect infrastructure and the programs it supports to perform instantaneously and simultaneously, not at the pace or in the sequence preferred by the public-agency provider. Demands will grow to deal with cycle-time issues, like reduced waiting times for medical services and more competitive, door-to-door convenience of suburban transit and transportation options. These changes will have dramatic implications for the design, location, operation and, especially, integration – convergence – of infrastructure.

Impact 3: Scale will shrink

Moore's Law predicted that miniaturization would exponentially expand the processing capacity of computer chips. The same pattern will be seen in the next generation of infrastructure. Lightweight, environmentally beneficial materials, energy-efficient systems, functions linked with robotics and radio-frequency identification (RFID) communications, and small-footprint engineering and architectural designs made possible by nano-technology, all will be features of the new infrastructure.

While grand infrastructure projects like those of the past will doubtless be needed, modesty and restraint will be important characteristics of urban infrastructure and infrastructure affecting designated natural areas. With a few exceptions, gone is the era of Robert Moses-style monumental engineering works and transportation and utility corridors that cleared all in their path.

The constraints that "NIMBY" and "BANANA" have imposed on our land-use planning and environmental assessment processes will cause us to rethink the scale, scope and impact of infrastructure (to say nothing of timing). While more defensible, the duty to consult with indigenous peoples, will also have an impact on the timing and scope of infrastructure projects.

Tweaking, refurbishing and technical innovations to improve existing capacity will stand equal with the signature project or the innovative new design.

For the foreseeable future, and until the political discourse and fiscal impacts permit it, the localized impact and the anticipated immediate dysgenesis will often trump the broadly enjoyed benefit of modern infrastructure. To win its social licence and political and legal approvals, the new generation of infrastructure will often need to be unobtrusive, make minimal impact, and confer conspicuous and compensating benefits, ideally at a competitive cost.

Perhaps one of the most significant implications of a “small is beautiful” approach is to ensure that existing systems are maintained in good working order and a state of good repair, extending their useful life where possible. Ideally, we should be able to prioritize our investments, to achieve the greatest rate of return. Unfortunately, some of our biggest infrastructure investments lie below the ground, where they are difficult to monitor, hard to maintain and easy to neglect.

Recent government efforts have aimed to improve the asset-management practices of all municipalities. Municipalities have been required to inventory their infrastructure assets, for both the municipality’s balance sheet and the annual work plan – many of them for the first time. They have also been required to prepare asset management plans, in order to schedule and budget for regular maintenance and rehabilitation. The Association of Municipalities of Ontario has been actively promoting this important work, not only with municipal staff, but also with municipal councillors.⁴¹ More progressive municipalities are using big data to create a fulsome inventory of road, solid waste disposal, water and wastewater assets, targeting system failures, like leakage, waterline breaks and potholes. The result of those latter efforts has been a reduction in the cost of maintenance and repairs, and a much higher level of public satisfaction.⁴²

All of this activity gives us reason to hope that infrastructure repair and refurbishment investment can be more targeted. We should aim to ensure a full lifecycle approach for past public investments and to put off major new infrastructure investments until, and if, they are needed. However, asset-management plans also provide sobering evidence of the degree to which we have neglected infrastructure over the years. They illustrate the need to be wise and evidence-informed in making investment choices, with the limited funds available to the public sector for these purposes.

Impact 4: Functions will converge

Arising from their experiences with smart communications, both society and the marketplace will push mergers and interfaces between previously separate and even previously unrelated providers and organizations. This will have significant implications for the providers of infrastructure and for the ability of infrastructure to provide a suite of functions, rather than a single, closely related set of services or individual functions. The public will care less about the provenance of a service than the quality and flexibility of a service. (More simply, they won’t care whose name is on the truck or the mobile site, as long as the service reflects good value.) This may have implications for a political system based on division of powers, separation of powers, fiscal segregation and political credit. It also has implications for efforts to restrict data for privacy reasons, and conversely to share data for both governmental and commercial reasons.

An enlightening illustration of the way in which convergence will affect public infrastructure is to look at health-care delivery in Ontario, which represents half of the Ontario government's operating budget each year.

As we have seen already in Ontario, there is likely to be resistance to convergence in the health care delivery, unless patients, families, medical practitioners and health-care workers come to see it as beneficial. For a century and a half, we have developed a health-care system that revolves around the family doctor and the hospital – primary care for routine needs, and hospitals for acute care and end-of-life medical and surgical interventions. In the last half-century, we have reinforced this model with the structure of our public health-care insurance system (OHIP) and workers' compensation (WSIB).

With greater longevity and advances in health treatments, however, the traditional model needs to change to reflect those it is serving. Life-threatening health episodes are less likely to be associated with childbirth, workplace trauma incidents, or the acute illnesses that ended the relatively shorter lives of our grandparents. Today's end-of-life illnesses are much more likely to be the chronic or prolonged illnesses of the elderly, like terminal cancer, chronic heart disease, chronic obstructive pulmonary disorder (COPD), hypertension (high blood pressure), renal failure (kidney disease), Type 2 diabetes or Alzheimer's disease. So while our population will increasingly die from episodes arising from chronic illness, that day can be pushed back well into old age. Chronic health conditions are now commonly maintained by prescription pharmaceuticals and the outpatient services of medical specialists, often in family health clinics.

What does this mean for infrastructure? Hospitals were largely developed to deal with acute episodes, from childbirth to heart attacks, as the formal term acute care facility indicates. (A visit to a hospital ER would illustrate the point, as many with chronic disease episodes or non-urgent medical conditions seek care in that traditional setting.) Community-based health care for chronic illness, whether homecare, long-term care, rehabilitation, dialysis, mental illness or hospice care, offer equivalent treatment and efficacy, often with higher satisfaction levels, lower risk of collateral acquired infections and, of course, at a dramatically lower all-in cost to the taxpayer. The same might be said for hospital-based medical testing, diagnostic imaging, dialysis treatments, cardiac rehabilitation and physiotherapy, in relation to privately operated, publicly funded clinics and laboratories.

Does that mean we are building too many multi-million dollar hospitals, at the expense of investments in community-based care and mental health care (and eroding the base for other public charity)? Does it mean that hospitals should increasingly focus on tertiary care, such as complex surgery, trauma incidents and sophisticated cancer treatments? Will the public accept a reduction in the number and convenient location of community hospitals with emergency departments, urgent care facilities and outpatient clinics?

The answer likely lies in ensuring the horizontal integration of health-care services and facilities in individual communities – or convergence. It will involve removing the silos and building infrastructure that promotes integration of service delivery along a continuum. It will also need parallel information technology infrastructure, with seamless, confidential transfer of personal health-care information as part of that continuum of integration.

In the spirit of technological convergence, a patient's health information will need to be available to the full range of medical practitioners, including pharmacists and nursing staff in long-term care homes. In future, up-to-the-minute health-care data will be collected and available from monitoring systems on the patient's wrist or in the patient's home through to various clinical settings, as well as being accessible to the informed patient and/or their trusted caregivers and clinical case-managers.⁴³

All of this obviously represents a revolution in the way in which we build health-care infrastructure and health information systems, to say nothing of the way we educate, deploy and reimburse our health-care professionals and health-care workers.

This convergence story could easily be repeated for other areas of the public sector, again with significant implications for traditional physical and technological infrastructure.

Impact 5: Margins will shrink

As Generation X, Generation Y (aka the Millennials) and new international consumers rapidly become the marketplace, the public's willingness to pay a significant added premium on the price of goods and services as they progress through the value-chain will be resisted – and ways to avoid them sought out by informed consumers and new entrepreneurs. Global competition in other fields has taught these end users and customers that they have options, especially when quality, price or availability of products and services do not meet their expectations.

There will be growing pressure on many traditional protections to value-added services, including our many non-tariff barriers (labour practices, government regulations, market controls, monopolies and concessions, customary business courtesies, etc.). With these pressures on Ontario business will come challenges to their traditional sources of remuneration or profitability, especially if there are emerging, technologically enabled workarounds. Those in the area of suppliers to business – the so-called B2B sector (e.g., subcontractors, material and equipment suppliers, business services suppliers, licensed professionals) – will find their ability to charge for their services squeezed. Their experience will echo the way that, for the past several decades, major North American retailers and vehicle manufacturers have squeezed their domestic, Asian and Latin American suppliers.

In addition to mounting pressure on marginal costs, there will be increasing efforts to link the cost of specific services to specific clienteles. In some respects, government services are society's last frontier in embracing the principles of user pay or beneficiary pay. Beyond charging fees or user charges, in government, there will be efforts to exclude customers or beneficiaries who either do not pay much, if anything, for a public service, who have cost-competitive alternatives or whose economic circumstances do not warrant public subsidy. Finally, as is the case with the rise of electronic banking, retailing and travel planning, the citizen-consumer will increasingly be expected to provide the labour and transaction processing previously offered by providers, through paid staff such as bank tellers, as well as counter staff in offices and retail staff in stores.

Impact 6: Expect individual customization

We will see a rise in customer-focused individualization. In simple terms, we will see less interest in universal, boilerplate and warehouse approaches, from retailing and logistics, to public transit, education and health care. Processes organized for the administrative convenience or cost-efficiency of public-sector suppliers and providers, from health care to governmental programs, will be forced to reorient themselves to the customer's unique preferences.

Fortunately, everything from user-designed smartphone apps to regulatory reforms will make it possible to match consumer needs to infrastructure options. In many cases, a wider array of individual preferences will be met by bundling common needs through wholesale or trunk infrastructure, while also empowering individualization and citizen choice at the retail or "first/last 400 metres" level. While trunk services, like subway lines, hospitals and wastewater treatment facilities, must rely on a collective model of service-delivery, increasingly the retail side of infrastructure – the "first 400 metres" in transit, or in the treatment of chronic disease – will require new, more flexible, consumer-responsive types of infrastructure and service delivery.

Impact 7: Global impacts will become local impacts

The markets for goods and services will reflect changing values and preferences, reflecting the growth of the middle-class in emerging markets. An increase in immigration will also alter domestic consumer preferences, for things ranging from housing choice to education, as they did after the Second World War. Likewise, the ability to source goods, services and information from a global marketplace will devolve to the household level, with implications for things ranging from logistics and order-fulfilment to local production, domestic taxes and regulatory enforcement. With these changes and the connectivity of global commerce, there will be impacts on conventional fiscal arrangements, in much the same way as the private service-sector has had to adjust its business models to survive.

Changing consumer practices and business models will affect: our property and retail sales tax systems and their primary government beneficiaries; zoning and zoning categories; industrial and logistics locations; traffic impacts from changing commercial practices (such FedEx-style in-situ sorting and order fulfilment methodologies, use of drones and declining door-to-door postal delivery).

Beyond consumer impacts, there are other types of global impacts with unforeseen infrastructure implications. The accidental introduction of invasive species, such as zebra mussels in the Great Lakes, the emerald ash borer⁴⁴ and now, beech bark disease⁴⁵ in Ontario's timberlands, or the Asian carp in the Mississippi basin (so far), can significantly affect water treatment, shipping and construction practices, and regulatory costs.⁴⁶

With the recent experience of Ebola and Ontario's tumult with SARS and hospital-acquired infections, the design of Ontario's infrastructure – from health care to rapid transit – needs to anticipate a need to control and manage contagions.

Impact 8: Climate change will be accepted, but will its consequences?

Extreme weather events will become more commonplace. Ontario may not yet feel the full impact being experienced by other jurisdictions, like drought-stricken California or Australia, or the flooding in Calgary and southern Manitoba. But already, the appearance of so-called 100-year storms, now seen every several years in some parts of Ontario, creates the need for more resilience and redundancy in stormwater infrastructure, bridge designs, water and wastewater treatment facilities, and electrical distribution networks.

Will altruistic policy goals on climate change translate into changing consumer habits or political support for infrastructure-related initiatives? It will depend on their relevance, their political marketing and the tolerance of the average citizen. Ontario's move away from coal-fired electricity generation is now recognized as a positive move. Without more practical alternatives, a similar shift in public attitudes in climate change areas like automobile use, localized energy generation and subdivision design will remain problematic.

Impact 9: Demographics will change society's priorities

As the Ontario population moves through the Baby Boom demographic, the political and market influence of the post-war generation will wane, despite its expanding social and health-care needs. We will see less emphasis on bricks-and-mortar infrastructure; more electronic communication, in-situ processing and 3D printers. Within the Baby Boom generation, we may see more demand for services and results, and correspondingly less focus on some durable goods (smaller homes, fully integrated Internet of Things [IoT] technology⁴⁷, live theatre vs. ATVs, etc.).

This change of emphasis may have some positive aspects. Local theatre, the 100-kilometre diet and home renovations have less economic leakage than buying the latest South Korean entertainment technology or importing Chilean vegetables. The 3D printer and the home office connected to the Internet of Things make for less commuting (although arguably, less need for conventional retailing and manufacturing, and more local delivery traffic from fulfilment orders).

The continuing decline in marriage rates may produce more low-income, single-parent families, and over time, a corresponding upswing in the need for certain public services.

Impact 10: New consumer-driven urban designs

Some have predicted that an increase in interest rates will force a correction in the cost of housing and the level of household mortgage debt. However, the U.S. experience after the sub-prime debacle seems to suggest that any declines are short-lived and mortgage indebtedness tends to create resistance to accepting downward price corrections by much of the marketplace. As the cost of home ownership continues to rise for post-Boomer generations, especially the price of low-rise housing (semis, single-family, townhouses), new models of urban residential accommodation will emerge.

The likely prospect is that Ontario will move beyond simple intensification and natural areas policies, which are already generating both community resistance and, ironically, a re-emergence of metropolitan-scale urban sprawl. Our cities and towns will need to be redesigned and to build new models.

The needs are becoming obvious:

- More robust stormwater management.
- Elderly-friendly transport and transport for the physically disabled, especially if fully automated vehicles become widespread.
- Safety and health as criteria for public transportation infrastructure and housing design priorities (personal mobility, health promotion, perceptions of personal safety, school busing and child safety, epidemics and crime).
- Reduction in overhead wiring to accommodate greater use of drones and improved aesthetics, even as rail corridors electrify.
- New types of homes and other living accommodation and new communities, with extensive domestic use of RFID technologies and supported by cheap, longer-distance rail communication, not yet seen in North America.
- A return of the importance of ports as logistics hubs, and greater short-haul water transportation in the Great Lakes Basin.
- The re-engineering of our suburbs to reflect less dependence on the car and easier, less expensive maintenance of public and private amenities, and housing with fewer stairs.

Impact 11: Short-term thinking will threaten progress and sustainability

Political, media and investment horizons have diminished, with the 24-hour news cycle and business performance based on the latest quarter and the closing stock price. These are more often seen as concerns for corporate boards of directors and political candidates.

However, this same “social-media attention span” will make it increasingly difficult to anticipate, manage and motivate decisions focused on medium-term and longer-term trends (aging population, climate change and extreme weather effects, long amortization infrastructure investment, prioritization of significant [vs. insignificant] environmental trends and impacts, shifts in regional prosperity and growth, etc.). Politicians at all levels are driven to think in four-year electoral cycles and increasingly, they are in permanent campaign mode, requiring political donations to sustain the march.

A related issue is the relationship between organizations and those they serve. In the United States, the courts have told the boards and CEOs of distressed companies or companies targeted for mergers and acquisitions that their sole responsibility is to their shareholders. The Canadian Supreme Court has been slightly more Canadian in its outlook, adding responsibilities to a wider array of stakeholders (workers, pensioners, suppliers, creditors, customers and the communities within which the companies operate).

The bottom line, however, is similar throughout the developed world. For business, long-term considerations are increasingly subservient to the here-and-now: share price, return on investment, dividends paid, analysts’ projections, last-quarter earnings, and the demands of the hedge funds and activist investors. This economic and legal environment makes it difficult for either business or labour to consider future opportunities, invest with confidence in the future of companies or preserve economic potential for future generations. In this atmosphere, governments at all levels must play their historic role: setting the rules of the game, promoting productivity and broad-based prosperity, and considering the future as well as the near term.

Are governments up to these tasks?

In a fast-paced world of “short-termism,” can governments discharge this future-oriented role? How might this be done? What changes in our structures, processes and mandates are likely to empower governments to play this forward-looking role? With whom should governments work to ensure that future infrastructure investments sustain our future?

The societal changes and infrastructure challenges that we have highlighted in this report share a common feature: they need to be anticipated by decision-makers – accurately and well in advance. But our 24-hour news cycle, the expectations of market analysts and the rise of social media increasingly drive our political, business, labour and civil society leaders to the short-term time horizon and the here-and-now. Short-termism is not only a threat to business performance and environmental sustainability: it makes effective infrastructure planning very difficult and prone to greater risk of waste and system failures.

Other jurisdictions have addressed this problem with imagination and success. The rigour and evidence-based approaches to collaborative infrastructure planning and implementation in jurisdictions like New South Wales, Singapore and even the U.S. Environmental Protection Agency are models of success. They appear to have made real progress in overcoming short-term thinking and unsustainable practices.⁴⁸

NEW INFRASTRUCTURE AND ITS EFFECTS ON SOCIETY



How will future trends change infrastructure's capacity and form?

How will society's needs for infrastructure change?

What are likely to be the most significant new developments? Which can be managed, changed or mitigated? Which must simply be anticipated and accommodated?

Ideally, seeing accurately (or at least with flexibility) into the future should give us all a head start on new developments and wise investments. If so, that they can favour us, our economy and Ontario society into the future.

As aforementioned, megatrends yield 11 major impacts that will affect both infrastructure and its relationship to society and the economy. In combination, these impacts will have a bearing on the way in which we organize ourselves, both to go to work and at work, as well as the lifestyle and urban environment that we will enjoy when we are not working. Here are five examples of those impacts.

1. New types of infrastructure

One of this report's conclusions is that the next generation of infrastructure may benefit from new technology by altering the nature, weight, lifespan and footprint of traditional infrastructure.

For example, we generally assume that our existing water and wastewater network is universal and standard. In many parts of the U.S., parallel greywater systems are commonplace: piping lightly treated or recycled water for use in landscaping, industrial and construction uses and other non-potable applications. A newer design of domestic toilet technology, quite different than that in use in Western countries, was adopted in post-war Japan. The work of the Gates Foundation, while targeted at innovation in Third World sanitation systems,⁴⁹ could easily produce a next generation of domestic sanitary sewage systems that would revolutionize our vast and capital-intensive wastewater infrastructure.

Heavy infrastructure, like electricity generation and distribution, heavy-rail transit and trolleys, urban street standards, hospitals and college buildings are increasingly paralleled or even displaced by lighter, more flexible, lower-cost options. If so, the pace of infrastructure investment may accelerate and resistance to it decline. The challenge may lie in distinguishing the next generation of new infrastructure from the fads. As we have learned in public transit in Canada, ignoring international transit vehicle standards and idiosyncratic system and station specifications will significantly increase costs and slow delivery times.

2. Long-distance commuting

Next, it seems logical that the next generation of infrastructure users will expect to be able to move considerable distances regionally, rapidly, conveniently, frequently, safely and at low cost. Rising housing prices in major centres will be a factor as well. These people may want to live in one city and work in another, as their spouse/partner travels from home in the opposite direction for his or her work or study. As many more Ontarians will be self-employed and seeking work where they can find it, they will want to be able to serve a much wider market area. These are commuting patterns that are not anticipated in our traditional hub-and-spoke transit and transportation models, in which we have continued to invest so heavily. These new commuting patterns are an example of the individual customization that will be expected.

3. Light and adaptable infrastructure: the impact of convergence

Infrastructure that will accommodate this kind of highly mobile society will need to be inexpensive to build, maintain and operate. It may also have a much shorter lifecycle and amortization period than traditional structures and methodologies. In some cases, infrastructure may need to be moved or reformatted before the end of its planned life. In particular, new transportation infrastructure will need the flexibility to alter its delivery model and scale, when volumes or directions change due to economic conditions, new urban growth patterns or changing demographics. Transit will look to the experience of the Docklands Light Rail and York Region's Bus Rapid Transit (BRT) network for practical, lower-cost and more flexible responses to evolving and changing commuter needs.

On the local level, the design of neighbourhoods and communities will undergo a similar reconsideration. The rationales will range from better health through promoting physical activity (among the young, the old and the sedentary), to a desire to reduce the frequency, severity and cost of injuries caused by automobile accidents, through to a goal of reducing the cost and upkeep of civic infrastructure and the operating cost of municipal services.

Many traditional public and community functions will converge, with the result that traditional segregations will make less sense. Customary distinctions, like those between school systems by physical plant and busing, or the segregation of police, courts, incarceration and release-monitoring facilities for reasons of juridical appearances, may erode. Most conspicuously vulnerable to convergence are the distinctions based on geography, municipal ownership, trade-union jurisdiction and so on.

With the convergence of miniaturization, pre-constructed components, and new building materials, the infrastructure of tomorrow will include more light infrastructure. It will have a shorter life expectancy, new materials and designs, more capacity to be adjusted to meet changing use-patterns, demographics or economics, and with a lower impact and price tag. (Again, the Docklands Light Rail or York Region's Bus Rapid Transit.)

Paralleling light infrastructure is the retrofitting and repurposing of existing infrastructure, to increase its resilience, its through-put, or its life expectancy, as an alternative to the daunting task of securing approval for major new heavy infrastructure projects, networks and utility corridors.

The use of universally accepted, bank-affiliated, smartphone-based fare media will drive convergence in a range of transportation options. These will include: integrated distance-based fare regimes for local and regional transit, on-street and off-street parking location and fee-paying; new formats for taxis and taxi alternatives, including ride- or vehicle-sharing services like Uber, Car2Go, AutoShare and ZipCar; and, RFID-triggering of intelligent transportation networks and GPS guidance, and other in-transit applications, including coffee purchases, dry cleaning and lottery tickets. Another manifestation will be the wider use of Ontario-pioneered transponders for automobile pay-by-distance road-use, high-occupancy toll (HOT) lanes, automobile insurance applications and aggregated traffic management data for use by civic authorities.

4. Think globally, act locally

We can anticipate innovations from elsewhere being adopted here, overcoming the idiosyncratic home-made policies, with these current innovations as a sample:

- The widespread use of heated sidewalks and intersections (Montréal).
- The reconfiguration and sequencing of traffic signals to promote intersection clearance by turning vehicles and safer around-the-corner, right-angle road-crossing by pedestrians and cyclists (Madrid).
- The elimination of raised curbs on streets where the street-function can change with time and season (Montréal, and now, Toronto's Union Station).
- The creation of zero-injury design modifications and programs (Stockholm), like roundabouts (whether new, like in Milton, Ont., or reengineered, as in Naples, Fla.).
- The great increases in urban cycling (in part due to reduced cyclists' and motorists' anxiety over "dooring" and right-of-way conflicts) that come from two-directional, physically segregated bicycle pathways on urban roadways and between suburban subdivisions and transit hubs (Madrid, Copenhagen, Amsterdam, Montréal).
- Public transit models and other public transport options (taxis, Uber, jitneys, informal transit, etc.) that address the "first 400 metres barrier" to broad use of public transit, and to focus public expenditures on efficient rapid transit and inter-urban transit rather than costly feeder systems (Santiago, Chile, and Hong Kong).

5. Demographics and their implications

As the demographic challenges facing the labour market intensify (and the need for young taxpayers and pension contributors grows to support the cost of services to the Baby Boom generation), our population will see increasing diversity. The next wave of immigration will be based not so much on our international treaty obligations for refugee resettlement or our traditional openness to economic migrants. In the future, immigration will reflect our need for the skills and innovative drive of offshore talent and, realistically, the personal care-giving needs of an expanding frail and elderly population. Given the global migration pressures of war and poverty, we may also be affected increasingly by the pattern of "informal" immigration seen in Europe and the U.S.

The prospect of governments building long-term care homes, palliative care wards in hospitals and similar infrastructure for a whole generation appears unsustainable under the present fiscal circumstances. Technological and medical measures to maintain the elderly in their homes and in commercial residences for the elderly will expand dramatically.

LINKING INFRASTRUCTURE AND WORK – IN SOCIETY, IN PRODUCTIVITY, AND IN BUILDING AND MAINTAINING INFRASTRUCTURE

How will the future of employment and the future of infrastructure interact?

Trends and factors that will determine or at least influence the infrastructure of the future have been identified. What will that new infrastructure mean for those who work in the Ontario economy or whose lifestyle is supported by it? In addition, it would be useful to explore the future roles to be played by those who presently design, build, finance, operate and maintain today's infrastructure, and the roles for those who come after them.

As distances shrink, turnaround times are reduced, miniaturization continues and functions converge, infrastructure will change. It is equally intriguing to speculate on the degree to which those same factors will alter the work of those who work in and with infrastructure.

Workers may find that they can (or must) live at considerable distances from their workplace. Availability for work may involve shorter notice and shorter duration – and it may draw from a much wider labour market in terms of both geography and skill requirements. As the nature of infrastructure incorporates more sophisticated materials and technologies, the need for continuous training and education will also increase, including the need for newer forms of safety and materials handling training.

The recognized productivity of the Ontario construction trades is based on a model that produces performance excellence from good initial training, followed by improvement through additional training, practice and repetition. Parts of the construction industry, by the nature of the work involved, have been somewhat insulated from labour-displacement technologies, such as we have seen in other industrial sectors, such as manufacturing or primary industry. But the rapid evolution of robotic technology will have the kind of impact on construction that it has already had on manufacturing and consumer services.

How will labour be affected by the new infrastructure?

On the positive side, a great deal of activity in the infrastructure field means more work for all in the construction trades and in the professions that support it. However, the enhanced technological component will require more training and skill specialization. It will also reduce the demand (and labour-market wage rates) for unskilled and semi-skilled workers. Those who once manually graded roads and spread tar, with the proper training became heavy equipment operators. In much the same way that the job of the automobile mechanic has morphed from engine repair to computer diagnostician, the new infrastructure's impact on skilled workers will not so much displace old skills as require them to be supplemented and reframed.

The demands for reduced marginal costs will put pressure on those engaged in building and operating infrastructure, which will reflect itself in collective bargaining and in increased use of pre-assembled or shrink-wrap approaches to installing and maintaining infrastructure. Plug-and-play, rather than build or repair, may be the preferred format for building and maintaining infrastructure, much as it has become in appliance repair, HVAC maintenance and automobile repair. In a global labour marketplace, the competition for talent will go beyond our experience with importing foreign workers for construction jobs, to a full-fledged competition for talent at

all levels of skill and experience. Pressure will be felt to reform traditional controls on new entrants to the workforce and to reevaluate the criteria for recognizing international qualifications and professional certifications.

Again, on the positive side, the growing interest in creating a Great Lakes marketplace for infrastructure projects will favour Ontario's companies and workers.⁵⁰ To do so, we must anticipate the needs of the next generation of infrastructure and remove our self-imposed restrictions on the awarding of contracts and the movement of labour. In fact, as the appetite for building major infrastructure continues to grow in the developing world, we may see something of a reverse flow, with Ontario workers taking jobs in nearby States, or transferring skills to local workers in overseas projects.

Convergence is a trend that will confront the workplace. As the traditional distinctions between types of work blur, and rigid job descriptions and classifications become less meaningful.

There will be an impact on work from the inevitable shift in the kind of projects being undertaken, both large and small. In areas where major public institutions, big residential developments or large-scale engineering works will be less common, the focus may shift to refurbishment, decommissioning and repurposing. A multiplicity of small-scale projects may fill the order books of firms that used to hire for long-term, single-site projects. In some cases, skills learned in one sector may need to be modified and applied to jobs in a new, related field of infrastructure.

Finally, with the retirement of our current workforce, we will need to find practical ways to introduce a new generation to infrastructure work. We will need to do it in a fashion that meets the next generation's different perspectives of work, while maintaining efficiency and production. It must also be done in a way that balances the need to preserve good wages in an environment of pressure on marginal costs. If our costs are too high, or our productivity cannot match that of others, our ability to afford infrastructure will be jeopardized, or external forces may offer non-traditional solutions to achieve the results that Ontario society and business demands.

The next generation of infrastructure

In examining and responding to impending trends within infrastructure and the trends affecting infrastructure, the role of government has always been central. From ancient times, it has fallen to civic authorities to design, build and operate crucial civil infrastructure. This mantle has included the obligation to anticipate social and economic needs but also, to use infrastructure to create new possibilities. From Roman aqueducts to fibre-optic broadband networks, successful infrastructure often requires new ideas and new approaches to anticipate needs and to serve public policy and economic objectives, often before the markets can catch-up. When done well, major infrastructure development can change a society for the better and assure its continued prosperity, as with the original building of Hwy. 401 or rural electrification of Ontario.

For this reason, it is important for government to have a capacity to look beyond precedent, past practice and near-term horizons in dealing with the needs of the future. As is so often the case with societal innovation and social progress, however, the institutions responsible for meeting emerging societal needs (governments, major corporations and civil society organizations, like universities or the media) – may not always be in the best position to propose reform or to advance radically new ideas. Despite rapid advances in technology and engineering potential, both governments and their private sector and civil society counterparts, are often reluctant or unable to break free of the constraints of convention, risk-aversion, complacency and cost.

What are the various classes of infrastructure – and how will they be affected by these “megatrends”?

With that perspective, let us look at how the six megatrends and their 11 impacts affect each major category of contemporary infrastructure.

TRANSPORTATION INFRASTRUCTURE

Road transportation and transit infrastructure

Road transportation infrastructure embraces arterial roads, expressways, tunnels and bridges. It supports passenger vehicles, transport vehicles, fare-charging scheduled-service commercial passenger buses, school buses and chartered bus transportation. It incorporates toll roads and privileged-use roadways (bus lanes, high-occupancy vehicle lanes, toll lanes on expressways and bridges, etc.) and congestion tolling technology.

Finally, road transportation includes the facilities and services that support truck transport and logistics, including border-clearance infrastructure and intermodal facilities serving some combination of air, water and land transport interface.

Over the next decade, transportation infrastructure will adapt to more intelligent transportation systems (automated vehicle control, driver-assisted vehicles, road-pricing regimes, in-vehicle technology for distance-separation and collision-avoidance, expressway system-access controls, intersection re-design, etc.) and computer-aided logistics and dispatch, from supply-chain and load-sharing, to way-finding, vehicle-sharing and ride-sharing. Some major roadways (and transit systems will be funded directly by road-pricing measures, beginning with technology-enabled, time-sensitive, variable-priced tolling of driver-only cars using dedicated lanes or high-occupancy vehicle lanes, i.e., HOV and tolled (HOT) lanes.

Public transit

Related to road transportation are scheduled public transit services using roadways and rails, as well as commercial bus services and taxi or airport vehicle services, as well as Uber-type services. It includes rail-based municipal transit vehicles (trams or streetcars), surface or sub-surface trains and trams on their own right-of-way. Public transit services include commuter-rail services operated by both public (municipal, GO Transit) and private authorities (VIA Rail Canada).

Over the next decade, public transit will move beyond current access and control systems (stations, switching systems, electronic fare cards, etc.) to platform-side door systems, automated trains, automatic train-control systems, credit-card-based fare regimes, and time-of-day and distance-sensitive fare media, etc.

As part of technology-driven fare-media integration, customer choice and service convergence will be major determinants. Integrated fare media using smartphones, RFID credit cards, and transponders, will allow passengers to decide where they will park, which transit infrastructure or alternatives they will use, other in-transit applications, including coffee purchases and ultimately, where they will travel.

These patterns and these demands will (and should) drive transportation planning. To meet competitive challenges from new technologies and new services, future transit-service infrastructure decisions should not be so influenced by non-consumer factors, such as municipal boundaries, restrictions in collective agreements, protecting fare revenues, or local or regional system ownership (including public vs. private).

Armed with the financial power of integrated fares and smartphone applications, passengers – not providers or politicians – will increasingly determine the transit route map, service levels for mass transit and the popularity of fare options. Simply building infrastructure based on current or past commuting patterns, or because there is an existing right-of-way, or need to respond to time-limited pressures can lock in patterns and infrastructure investments that are sub-optimal. The criteria should increasingly be customer-based: elapsed time, fluctuating work locations, number of vehicle changes, changing consumer preferences, and the price of convenience.

In this environment, flexibility will be important, favouring adjustable, shorter duration, less expensive transit infrastructure. Examples might include: bus rapid transit vs. light rail; awarding proof-of-concept or low-performing intra-regional bus or light-rail route concessions to public or private providers; encouraging informal services to feed rapid transit routes, as an alternative to conventional bus services; and, using or creating Madrid-style regional terminals with inexpensive parking and good connections, to siphon off peak flows from routes like Yonge subway or to mitigate capacity constraints at Union Station.

The observations Grush and Niles make about the impact of automated vehicles, and ride- and vehicle-sharing on both public transit and the personal-use vehicles are especially relevant here.⁵¹

To reduce public education cost pressures, as well as to enhance the viability of municipal transit (especially for poorly performing routes or infrequent services), governments may decide to redeploy “yellow bus” subsidies. This would entail providing incentives for secondary school and college students to shift to municipal transit and away from expensive, no-charge school-bus and college shuttle programs.

Continuing urbanization in Ontario and the growth of its major urban centres will require much broader and more integrated regional transit and transportation planning than has been the case in the past.⁵²

Rail transportation infrastructure

In addition to local public transit and regional commuter rail transport infrastructure, rail transport infrastructure primarily includes the rail beds, tracks, land corridors and switching systems that make possible rail freight transport and inter-city passenger rail transportation, along with the capital rolling stock of locomotives, freight cars and passenger carriages. This category includes “rail interface” infrastructure, such as grade separations and other types of bridges and tunnels, intermodal transport hubs and logistics marshalling yards.

As well, rail has become a major means of transporting bulk commodities, such as petroleum products and dangerous chemicals, needed by society and the economy, but whose transport brings risks, especially in densely populated areas.

Among the most significant pieces of rail transportation infrastructure is real estate, including linear rights-of-way and space-extensive marshalling yards, as well as major terminals (e.g., Toronto’s Union Station) and rapid-transit interchange points (e.g., major Toronto subway stations and Metrolinx’s GO stations).

In the future, transportation infrastructure will be supplemented by the need to support high-speed interurban passenger rail services, where the level of ridership and population can sustain it. If these services are cost-competitive, or subsidized to the user, they may also alter the ex-urban commuting patterns in areas like the GTHA and Ottawa/Gatineau.

Aeronautical infrastructure

The network of major and minor airports and landing strips makes up the majority of this category, including the air-traffic control infrastructure. One of the largest private investments in aeronautical infrastructure – indeed one of the GTHA’s largest single infrastructure projects – was the building of Terminal 1 at Pearson by the “privatized” Greater Toronto Airports Authority in the early 1990s. Also to be included under the heading of aeronautical infrastructure is the health care-related aircraft and heli-pad system for critical patient transport, serving trauma centres and other hospitals.

In future, aeronautical infrastructure will be supplemented to manage consumer and commercial use of drones and localized logistics for Internet-based goods-delivery fulfillment, including drone-directed dirigibles for remote-location delivery of structures, bulk goods and machinery.⁵³

The steady compounding of global air traffic will also necessitate investment in new, more flexible air-traffic control systems, including those needed to handle increased use of regional jets.

Water transport infrastructure

Canals, locks and other inland waterways, ferry services, small craft harbours, port facilities and port-access infrastructure, such as intermodal terminals and customs clearance, would be included in this category. The facilities of ports and harbours variously serve the needs of industry, agriculture, pleasure craft, construction (aggregates, stone, lumber, steel, asphalt, etc.) and municipalities (primarily road salt). There is also mixed-use public infrastructure, such as marinas and waterfront developments. The single largest pieces of Ontario infrastructure in this category are the freight ports, canals and locks that comprise the St. Lawrence Seaway system. Smaller systems, like the Trent-Severn Waterway, serve the tourism industry.

Freshwater transport throughout the Great Lakes has a bright future in inexpensive, environmentally beneficial international and domestic shipping of bulk commodities, agricultural produce and other goods. However, it also faces challenges: the impact of new Panamax and larger salt-water vessels unable to use size-limited freshwater ports, locks and canals; regulatory and taxation impediments to waterborne trade, especially on the U.S. side of the border; the expense of maintaining well-dredged harbours and channels; and the need for better integrated multi-modal transport hubs and incentives to use them.

In common with other transportation and energy infrastructure, ports face competition for their well-positioned real estate. There is risk of losing port lands and utility corridors to competing land use demands, such as residential development and recreational uses, which often represent short-term political or financial gains, but with long-term negative consequences for good infrastructure.

In an export-dependent economy, industrial lands adjacent to transportation hubs like airports and ports are especially important but their broader value to the economy needs to be recognized and valued when they compete with alternative uses, like residential or recreational development.

ENERGY AND TELECOMMUNICATIONS INFRASTRUCTURE

Energy infrastructure

Across North America, energy infrastructure embraces the generation or sourcing, regional transmission and local distribution of energy. Most commonly, “energy” includes natural gas, electricity, petroleum fuels and steam. Electricity’s sources include nuclear energy, renewable-source energy (solar, wind, geo-thermal), burning of fossil fuels (coal, oil, diesel, propane, natural gas, etc.) and hydro-electrical (from turbines fed by dams, tides and waterfalls).

Energy infrastructure will need to be extended in places, in order to improve the electricity grid, to exploit business opportunities for power generation and to overcome traditional transmission capacity bottlenecks such as access to the Toronto region from generators east of the city, linking northwestern Ontario supply with markets east of Lake Superior, and improving connections between Ontario markets and electricity supply from Hydro Québec.

On a macro scale, we will see responses to U.S. global commitments to reduce greenhouse gas emissions. With President Obama’s recent EPA regulations, it is evident that the damaging impacts of coal-fired electricity generation may even come to be accepted by mid-western and northeastern U.S. States, similarly to what acid rain meant for a previous generation. These developments may create business opportunities for Canadian surplus clean energy electricity generators, like OPG and Hydro Québec, and including linking Bruce Power’s off-peak surplus nuclear power supply and storage capacity.

The burgeoning of electronics and wireless technology will add to electricity demand. The widespread use of the electric car and the expansion of electricity-based urban and regional rail transit will also make it necessary to increase electricity supply. It will also cause the private sector to build a network of retail fuel suppliers to parallel gasoline and diesel fuel retailers.

As Richard Worzel⁵⁴ notes in his writing, the patterns of electric power use and production may change significantly in the near future, requiring changes in the infrastructure for power production and distribution. In part, this may be a product of a wave of localized micro-generation, from increasingly inexpensive rooftop solar generators to district heating and cooling systems. The emergence of widespread and increasingly competitive rooftop solar power panels, coupled with local electric power storage systems, such as Elon Musk's Tesla Powerwall and Powerpack, are going to radically and unfavourably change the economics of electric power utilities. Worzel suggests that next-generation solar generation may even radically alter the economic value of conventional power generating capacity. The power transmission grid could become as valuable as large-scale power-generating capacity. If they come to pass, such changes would require a major rethinking of Ontario's power infrastructure. What would this do to the business models of HydroOne and OPG?

Telecommunications and electronic infrastructure

Telecommunications infrastructure includes fibre-optic cable and wired telephony, switching equipment, microwave towers and receivers. Electronic infrastructure similarly includes systems for broadcast and reception of wireless communications, as well as server-farms and data warehouses and air transport communications. An important sub-category in this field is the electronic and diagnostic infrastructure serving the health-care field (diagnostic imaging and related file transfer, robotic evaluation and surgical treatment applications, electronic communications with remote clinics, etc.).⁵⁵

In the future, this infrastructure will likely be supplemented by expanded use of closed-circuit television systems, and security infrastructure related to monitoring and interception of telecommunications and radio-frequency identification (RFID) electronic signals for a wide variety of personal, household, business and public security uses. Mobile communications are exploding, as is the demand for the latest, fastest high-speed Internet.

Much of the infrastructure for this is created by private sector suppliers (Bell, Rogers, Telus, Xplornet in rural areas, etc.), but given the importance of such infrastructure for our economic future, governments and consumers may well ask: "Are we being adequately served by regulated oligopolies?" In places like Singapore and South Korea, the value of public investment in telecommunication and electronic infrastructure is evident. Are we being left behind?

(For example, the \$170-million initiative of the Eastern Ontario Wardens' Caucus to provide broadband connectivity for all of rural and small town eastern Ontario is one of the trendsetting public-private partnerships in the province.)

Telecommunications infrastructure based on distributed cable networks and fibre-optics depends on a reliable consumer base. The growing pattern of households in English-speaking Canada abandoning both cable television and residential land-line telephones has major business implications for private-sector builders of telecommunications infrastructure.

ENVIRONMENTAL INFRASTRUCTURE

Water infrastructure

Water infrastructure includes the treatment and distribution of potable water, the collection and treatment of sanitary sewage or wastewater, and the management of stormwater run-off and drainage. The infrastructure for stormwater management also includes extensive flood-prevention real estate assets held by flood-management agencies (like Ontario's conservation authorities), municipalities and private landowners. In some jurisdictions, like the U.K., responsibility for water utilities and flood management, are often combined in a single authority, typically operating across a watershed. Globally, utilities such as wastewater systems are often organized on a regional basis, and owned or operated under contract or concession by the private sector. In northwestern Alberta, the municipally owned utility Aquatera provides a range of these environmental services to a number of municipal clients. Fiscal, investment and efficiency considerations may generate similar evolution in municipal functions, such as wastewater and/or stormwater management.

The facilities to treat, distribute and collect water also have a close connection to energy infrastructure, as they are substantial consumers of energy.

Extreme weather events and other climate-change impacts will expand the scope of infrastructure related to mitigation and rapid recovery from wind, rain and ice storms, and from power outages, flooding and sewer backups (both sewage and stormwater). Despite our superficially favoured position on the Great Lakes, we could see water shortages already afflicting the western United States could lead to international or even pan-Canadian demands to share our freshwater bounty.

We may see proposals and mounting pressure for drawing-down water on shared waterways, like the Great Lakes, the Red River basin and the Columbia River system, or freshwater swapping with the Hudson Bay lowlands watershed.

Climate change threatens to change precipitation patterns, and may reduce the ready availability of fresh water supplies in various locations around Ontario. Other factors also impinge, such as our society's tendency to chronic under-investment in potable water systems and to waste low-cost, conveniently available water supplies. Fortunately, smart metering infrastructure and variable pricing for water and energy have demonstrated a capacity to alter consumer and industrial behaviour. UN initiatives, supported by the Clinton and Gates Foundations, may also bring Ontario new technologies and new management models to related areas, like the collection and treatment of wastewater and the increased use of greywater.⁵⁶

Shifting weather patterns may also require changing building standards and construction materials. As Richard Worzel observes, a warming climate could bring to Ontario the so-called Tornado Alley of the U.S. Mid-West. Current building standards do not contemplate regular, violent storms and flash floods. But our next-generation infrastructure may need to anticipate it. In some jurisdictions, anticipating new risks, like better seismic or stormwater protections, has increased the previously projected replacement cost of existing infrastructure.

Solid and hazardous waste collection, recycling and disposal

The infrastructure needed to deal with society's waste is complex and often neglected. In most jurisdictions, solid waste management is the responsibility of local government, subject to regulations imposed by provincial governments for waste handling and disposal, and federal regulation of matters such as packaging and importation of foreign materials that will subsequently be disposed of in Canada.

In many municipalities, the responsibility for dealing with solid waste collection and disposal is assumed by the municipality or its contractor for most residential waste and often for the solid waste products of small businesses and small multi-unit residential buildings. The responsibility for industrial and commercial waste, including waste from large, multi-residential buildings, often falls to the owners of those enterprises, notwithstanding the fact that they pay municipal taxes that support the rest of the local waste-management system.

In addition to general waste collection, virtually all urban municipalities and most rural municipalities maintain a program of residential waste recycling (blue box collection, compostable waste and recovery of commercially marketable materials) and parallel programs for the collection and disposal of hazardous waste, the policing of sewer discharges, and the regulation of dumping of construction materials and soil. The government of Ontario also regulates these processes, with particular attention to solid waste disposal facilities and sites, protection of source waters from contamination by waste and so on. The government of Canada regulates wastes associated with the production of nuclear energy.

In the future, when commodity prices for aluminum, steel and precious metals justify it, existing and closed landfill sites may afford opportunities for recovery of metals, as well as established technologies for recovery of methane gases for energy generation. Energy from waste facilities are increasingly using advanced technologies to mitigate real and perceived environmental and health problems with these facilities.

Ontario communities have long faced resistance to the expansion of landfill sites for solid waste disposal and, in particular, energy from waste-incineration plants. Ambitious programs to promote waste recycling and resource recovery have helped to mitigate the impact of this reluctance to accommodate regional waste disposal, but costs are high and markets for most of these products are soft, especially with the decline of the newsprint industry.

In the future, when commodity prices for aluminum, steel and precious metals justify it, existing and closed landfill sites may afford opportunities for recovery of metals, as well as established technologies for recovery of methane gases for energy generation. Energy from waste facilities are increasingly using advanced technologies to mitigate real and perceived environmental and health problems with these facilities.

SOCIAL AND HEALTH INFRASTRUCTURE

Social and health policy

Often not referenced in the definition of infrastructure is the suite of investments made largely by the public sector in health care, education, law-enforcement and critical response (prisons, courts, police facilities, emergency medical response, fire suppression, etc.) and affordable and supportive housing (public and social housing, long-term care homes, among others). A number of cultural, sporting, heritage and recreational facilities would also be included in this category, including legacy facilities from events like the Pan Am games. These infrastructure investments are large, continuing and have a significant claim on the funds available for investment in public and non-profit infrastructure. To this list might also be added the facilities that serve government, including city administration buildings, public works facilities, government office buildings, archives and so on.

Another trend is the ubiquitous use of electronic and wireless monitoring equipment. For health care, care for the elderly, and even custodial care of low-risk offenders, these may be outsourced from expensive, employment-intensive physical plants (hospitals, long-term care homes, prisons) to community-based or home-based settings. At the same time, there will be a dramatic increase in demand for personal care workers of various kinds to cope with the health and acuity issues facing aging Baby Boomers, and to take both the low-skill and higher-skill jobs that slow population growth and other factors leave unfilled.

As America's experiment with high levels of incarceration has demonstrated to all parts of the political spectrum, prisons are neither cost-effective nor socially effective. New solutions will have significant implications for infrastructure-intensive public services, such as prisons, courts and police services, as they are put through an unfamiliar return-on-investment or pay-for-performance tests.

Homelessness and lack of housing affordability impose disproportionate demands on the public purse in policing, health care, shelter costs and income support. The costs and investment potential of public housing realty assets will drive new, more innovative solutions to housing affordability for the disadvantaged, including physical infrastructure ideas like those being proposed by the leadership and membership of RCCAO.

In the fields of social and health infrastructure and policy, the trends will overwhelm our current approaches. The prospect of governments building long-term care homes, palliative care wards in hospitals and similar infrastructure for a whole generation of Baby Boomers appears unsustainable under the present fiscal circumstances. Technological and medical measures to maintain the elderly in their own homes and in retirement residences will expand dramatically.

Despite our investments and progress in areas like diagnostic imaging and laboratory testing, we still do not have easily transferrable electronic medical records and electronic health records. And personal health data is neither intelligible nor conveniently available to the patient and family caregiver. In Ontario, it has been observed, we all have more electronic information about our cars and our cats than we do about our personal health.

Serving a growing and aging clientele in their homes and in community settings often achieves better health results, as well as being far less expensive and more time-responsive than the costly institutional alternatives. Good medicine, it appears, is also good fiscal policy. Integration of health-care delivery is the key. Our infrastructure investments and funding policies should anticipate, facilitate and support those right choices. It will mean less emphasis on hospitals, and more attention to community health facilities of various kinds, both public and private. In the future, outside of unserved areas, Ontario may only need to build or expand hospitals for advanced treatments and research.

The new profile of health-care integration and infrastructure

As noted earlier, the cost of public health care consumes nearly half the annual operating budget of the Ontario government and is arguably a major contributor to the provincial deficit and debt levels over time. With the impact of demographic trends and new medical technology, these costs will continue to rise. Evidence-based best practice, from organizations such as the McMaster Health Forum, tells us that we can achieve better health results and lower costs, if we can ensure that the right care is offered at the right time, in the best venue. Chronic disease rather than acute incidents consume ever more of our health-care dollar. In the 21st century, most of us will decline and die from complications of chronic disease, rather from an acute incident or contagious disease, as would have been the case in the last century.

Unfortunately, most of our health-care system, and the infrastructure that sustains it, reflect past practice and the sector silos within health care. Primary, specialist and surgical care is still largely organized (and paid) to address acute incidents and manifestations of chronic illness, rather than health promotion and case-managing chronic disease. Similarly, hospitals are highly specialized, expensive venues that are better suited to deal with acute illness and injury than the lingering and recurring incidents associated with chronic disease, especially among the elderly and frail. Indeed, frequent and longer hospital visits can add to the problem, through the prevalent risks of hospital-acquired infections and sedentary treatment practices. Finally, long-term care (nursing homes) represents a significant public investment in end-of-life care that will likely be overwhelmed by the numbers as the Baby Boomers age.

Best practice tells us that avoiding ER visits, hospital admissions, long-term stays, frequent re-admissions and delaying premature admission to nursing homes, will achieve better health results for those living with chronic illnesses, as well as reflecting patients' preferences. Serving a growing and aging clientele in their homes and in community settings is also far less expensive and more time-responsive than the costly institutional alternatives. Good medicine is also good fiscal policy.

Yet we continue to expand hospitals and their treatment mandates, and try to stay ahead of the demand for government-subsidized nursing care beds in private and municipal long-term care homes. While Infrastructure Ontario's procurement program has imposed long-overdue constraints on the cost of hospital construction, public and philanthropic funding for hospitals continues to reflect obsolete assumptions. The Ontario government funds most of the capital cost of "bricks and mortar" but leaves much of the increasingly expensive in-house technology to be funded by other means.

From a nominal “good faith” contribution, municipal capital contributions to hospital expansion programs have grown to be sizable “enforced charitable donations” levied on residents and business, and drawn from an overburdened tax base never intended for such commitments. More fundamentally, it is proving difficult to persuade government (and health-care providers) to move funding from the institutional “envelopes” to fund the infrastructure and operating costs of community-based health-service delivery.

Health care is a primary target for “convergence” of infrastructure. In Ontario, the cost of publicly funded health care consumes nearly half the annual operating budget of the province and is arguably a major contributor to Ontario’s deficit and debt levels over time. With the impact of demographic trends and new medical technology, these costs will continue to rise. Ontario needs to meet the evidence-based test of “right treatment, by the right provider, in the right place, at the right time, for the lowest cost to the taxpayer.” Integration of health care delivery, as envisaged by the Local Health Integration Network legislation, is the key to making these evidence-supported choices. Underlying these choices is ensuring that our infrastructure investments and funding policies anticipate, facilitate and support those right choices.

The same convergence principle applies to integration and seamless transfer of patient information through contemporary technological infrastructure. Health care’s institutional and professional silos, and privacy legislation constraints, restrict effective and timely transfer of important medical and pharmaceutical data from provider to provider, and to the patient and family caregiver.

In the health care field for the foreseeable future, the role of the hospital, the urgent care centre, the hospice and palliative care home, and the technology-enabled, elder-friendly residence will need to design both structures and incentive systems that promote integration. But compensation remains a driving factor in human behaviour as much in health care as any other sector:

- As long as in-person visits and approved OHIP codes are the only way some health-care professionals are paid, telecommunications and home-based therapies will not be effectively employed, and waiting rooms, ER backups and fax machines will remain features of our health-care system.
- As long as similar kinds of professional services and personal services are compensated differently among hospitals, private clinics and laboratories, community care access programs and long-term care homes, integration will be difficult and sub-optimal, and potentially risks driving up health-care costs for all of us. The resolution of this dilemma will determine the nature, scale and location of health-care infrastructure, as well as the investment required.
- As long as hospitals are the venue for high-volume, specialized medical practices and the best way to pay for those professional services, other viable options are unlikely to grow. If, however, the compensation regime in health care, in all its many manifestations, can be matched to evidence-based clinical best practices and value-for-money delivery models, the nature of publicly funded health care infrastructure might change quite dramatically.

The new profile of public education and its campuses

Throughout the educational system (as we are already seeing at the post-secondary level and in skills training), considerations of quality, delivery cost, individual pace, child-safety and convenience may accelerate an emerging shift in teaching and learning towards telecommunications-enabled settings. Increasingly, as TED Talks and MOOCs (Massively Open Online Courses) demonstrate, the world's best professors and researchers can be accessed by students at times and in the preferred settings, at a fraction of current costs, with a global scope and with the potential for global interaction. The world of paper textbooks, crowded lecture halls and insular local institutions is already looking obsolescent or even obsolete.

The cost of post-secondary education is high. It combines a time-honoured, tenure-based work environment, the pervasive use of teaching assistants and similar cost-saving instructional practices, and a predisposition by many university faculties to favour research over teaching. It is a model, however, that is very vulnerable to disruptive innovation and more creative delivery formats. Over time, we may see the student market voting with its feet, especially as graduates emerge with heavy student debt loads, and often minimal employment prospects. If post-secondary institutions' exclusivity in credentialing is loosened, physical campuses may give way to alternative, even virtual venues for specialized education and research collaboration. In fact, such virtual campuses are already appearing around the globe, some even affiliated with universities and colleges themselves.

In the field of post-secondary education, the big campus will become less significant for two reasons.

- As an educational venue, universities and colleges will be challenged by the availability of readily accessible, recognized programs featuring the world's best researchers and instructors, in inexpensive and student-determined delivery models.⁵⁷ At the same time, we will see an expansion of Ontario-based services – some offshore or U.S.-based – offering university-style learning in a convenient commercial setting, or even in decommissioned public buildings, like closed public schools.
- As a preferred venue for self-directed primary and applied research conducted under the tutelage of tenured professors, the university will also be challenged by the range of alternative research venues, some of them spawned by the university itself. In fields farther removed from bio-medical, technological and commercial research, the ability of universities and colleges to justify their substantial, continuing commitment to research as an adjunct to instruction or in place of teaching, will be harder to sell to cash-starved governments and competitive philanthropy.⁵⁸

At the primary and secondary school levels, the shrinking and shifting population of school-age children and youth will put pressure on school boards and governments to repurpose and dispose of the valuable land assets occupied by underutilized educational facilities. This pressure may be accentuated by trends that diminish the primacy of public education, in favour of alternative schools, emphasizing religious denomination, program variety or quality of educational achievement.

The retention and refurbishment of public educational facilities implies a continuing societal commitment to the existing model of public education, which is arguably a matter of some disagreement and certainly comes at considerable taxpayer expense. Such an infrastructure reinvestment over time will likely need to be preceded by a societal re-commitment to restore public education as a fundamental vehicle for social integration in an increasing diverse population.

In other provinces, a review of public education and its funding has extended to a reconsideration of constitutionally based linguistic and religious education obligations. Meeting these obligations may no longer need to be equated with separate facilities or separate school administrations. In other words, the future may see combining schools and school boards, for reasons of operational and infrastructure efficiency. For a variety of pedagogical and sociological reasons, it might also result in a reconsideration of the size and scale of school facilities and the volume of school busing, at both the primary and secondary level, resulting in more small schools and the decommissioning of mega-schools.

Above all, such a recommitment to public education would also, realistically, need to address issues of quality, stability and value for money that appear to be undermining public education's traditional, broad-based public support.

How should we manage the portfolio of Ontario elementary and secondary school buildings in the face of: (a) projected declines in student populations; (b) the continuing shift of populations from rural areas to urban areas; and (c) the rapid growth of the suburban and exurban areas of Ontario's major urban centres, especially in the GTHA?

Throughout the educational system considerations of quality, delivery cost, individual pace, child safety and convenience may accelerate an emerging shift in teaching and learning to telecommunications-enabled settings, which may favour smaller format local learning centres in "community hubs." At the post-secondary level, as MOOCs and TED Talks demonstrate, the world's best professors and researchers can be accessed at times and in settings that best suit an individual student, at a fraction of current costs, with a global scope and the potential for global interaction. These developments have significant implications for investments in university and college campuses, research facilities and student residences.

ONTARIO'S AND CANADA'S PORTFOLIO OF PUBLIC ASSETS – TANGIBLE AND INTANGIBLE



There is a long list of public assets in the hands of the governments of Ontario and Canada and their agencies, as well as in the large asset portfolios of local and regional governments and local public authorities. Their combined asset value is also very large, although deteriorating due to lack of timely reinvestment and deferred maintenance. They cut across the main categories of civil infrastructure, and some may be considered a class of infrastructure on their own, like the LCBO chain of stores or the Ontario Lottery and Gaming Corporation casino network.

Many public assets can be found on the balance sheets of governments and other public authorities; others, such as so-called “intangible” assets, like databases, the value of government monopolies or good will, may be understated or largely ignored in financial statements. Finally, financial statements may report the value of many public assets based on depreciated acquisition value (“book value”), rather than their “mark-to-market” value in the hands of others, or in the marketplace, or allowing for their leveraged value given current low borrowing rates.

Government business enterprises (GBEs)

Within each of the foregoing categories, as well as in areas not normally considered infrastructure, are the “businesses” of government, more commonly referred to as “government business enterprises” (GBEs). The way in which infrastructure assets are held may create an additional asset in the form of the corporation or entity that owns, operates and manages a facility or network. Among the GBEs most commonly recognized are the LCBO, Hydro One, Ontario Power Generation (OPG), Ontario Lottery and Gaming Corporation (OLG), Ontario Place and Ontario Northland Transportation.

In any discussion of financing new infrastructure, or refurbishing or expanding existing infrastructure, consideration should be given to the role that could be played by leveraging existing assets, including government business enterprises and their infrastructure. This would include full or partial sale, leasing, concessions, joint ventures, securitization of cash flows, dividends, mortgaging, collateral security for debt and other tools to leverage our significant past investments public infrastructure assets.

Ontario’s public assets portfolio

Traditionally in Ontario (and in Canada generally), public and community assets have largely been acquired, operated and maintained by public authorities and with public finances.

These public assets include, among others:

- Transportation (roads, public transit, Ontario Northland railway, regional and local airports).
- Public utilities (e.g., potable water and wastewater systems; solid waste collection, recycling and disposal; and, Hydro One, OPG and vestiges of local electricity distribution [municipal hydro commissions]).
- Hospitals and public health care facilities.
- Schools and post-secondary educational institutions.
- Parks, recreational, gaming and sports facilities, including stadiums and arenas.
- Stormwater management systems and associated land holdings, including conservation authorities.
- Heritage, library and cultural institutions, including public theatres and museums.
- Emergency medical and firefighting facilities, equipment and services.
- Policing and justice facilities, services and equipment, as well as correctional facilities.
- Social and public housing and long-term care homes.

When preparing an inventory of public assets at the provincial level and on a smaller scale at the local and regional level, one needs to add “government business enterprises” and property holdings. The LCBO, OLG, OPG, Hydro One, the land holdings and buildings managed by Infrastructure Ontario, MNRF, MTO and Waterfront Toronto are a few examples of these valuable public assets held in public hands.

There are a few exceptions to this Ontario and Canadian tradition of funding community, utility and “economic infrastructure” assets through government action. Examples would include Canada’s rail infrastructure, the transmission and retail disposition of natural gas, telecommunications, privately owned cultural enterprises (e.g., Mirvish theatres) and, in recent years, privately operated electricity generation, transmission and retail distribution (e.g., Bruce Power nuclear).

Although these examples demonstrate that not all socially and economically beneficial assets must necessarily be in government hands and financed by government, they remain the exceptions. In Canada, the vast majority of public assets are within the public domain for their (tendered) construction, operation/staffing, maintenance/refurbishment, expansion and, most particularly, for their funding and financing.

Governments record the value of land and buildings on their balance sheets at book value, although often ignoring the value of their redevelopment potential. But they generally do not assign a sufficient asset value to important soft assets of our digital age. These include: information assets, patentable processes and databases; the monopoly position of government business enterprises (GBEs) in specific markets (e.g., liquor and gaming); affinity marketing potential; the government as trusted data source; the tremendous research and procurement potential of a one-payer public health system with 13 million members; the financial leveraging potential of physical and GBE assets; and so on.

As noted, results-oriented regulatory oversight and regulatory restraint will be key ingredients to ensuring that we build and fund the right infrastructure in the future. To some extent, that may entail rethinking rules designed for an industrial age. For example, as an earlier RCCAO study noted, in an increasingly post-industrial society, accounting rules need to evolve, too.⁵⁹

Data management can also have important value and quality dimensions. While the privacy of personal health information is a principle to which most would subscribe, the way in which we ensure it causes significant gaps in information sharing among health care providers and institutions. Technology offers an opportunity to improve health outcomes, prevent incidents of disease and hospital admissions, and to ensure effective follow-up. But only if we let it.

Conversely, the impulse and pressure to give away data through well-intentioned open data and freedom of information initiatives can be overwhelming, if their value or impact are not really appreciated or properly accounted. But innovative data miners, data analytics firms, and “apps” developers will quickly demonstrate its lost opportunity cost to taxpayers. Ironically, opponents of change will be first in line to use freedom of information access rights to thwart threatening policy innovations or infrastructure proposals with unwelcome local or special-interest impacts.

INFRASTRUCTURE AND POLICY OBJECTIVES

Not often considered is the infrastructure to support public policy objectives, such as designing and retrofitting public and private facilities for physical and perceptual accessibility, energy efficiency, systems sustainability (water, building materials, solid waste), emergency evacuation and public safety, and so on.

In the future, building techniques and building materials will be asked to address a range of needs, beyond current LEED standards of sustainable accommodation and energy conservation. Building shells and paved surfaces that respond to environmental considerations, like smog or rainwater preservation, will become more common and may be required by building codes. Conversely, building materials from other jurisdictions will need to meet domestic standards, for things like asbestos content.

There will be pressure (and opportunities) to find new building techniques and to find new applications for existing models of infrastructure and, perhaps more importantly, to try new materials and designs. This will demand new flexibility in government tendering and requests for proposals, focusing on performance-based specifications, and new ways to test the adequacy and compliance of new products, techniques and designs. In our present environment, where concerns over liability, cost-containment and political embarrassment produce much of the volume of public procurement documents, the future will call for new approaches by both government and the construction industry.

Incorporating innovative environmental and energy features into construction projects will not be smooth sailing. We know this from our experience with things like retrofitting green roofs, incorporating stormwater features into surface parking, energy-efficient concrete construction and, recently, securing approval for mid-rise timber-frame construction. The biggest challenges will be to introduce reasonable compliance, testing and liability contract provisions for things that go beyond the scope of traditional construction specifications, like air-quality enhancing building shells or cost-efficient, aesthetically acceptable energy supply for infrastructure projects. If government is to realize the great opportunities created by unleashing the creativity of the construction sector, including architects, engineers and builders, governments must provide realistic incentives and assurances, not just invitations to be innovative.

Infrastructure itself can play a role in achieving public policy objectives, from generating medium-term employment in construction and related fields, through to enhancing the productive capacity of the economy. The 2016 federal budget and recent Ontario government initiatives highlight the fiscal policy role that infrastructure projects can play, from financing new infrastructure by monetizing existing assets (“asset recycling”⁶⁰), through to the use of infrastructure banks, infrastructure trusts and public/private partnerships, to attract long-term third-party investment partners from entities like public-sector pension funds and other patient investors.⁶¹

Indigenous people and communities

There is increasing legal recognition of the rights of indigenous people in Canada, coincident with rapid growth both in urban aboriginal populations and First Nations communities. These developments will have a bearing on the future of Canadian infrastructure. Infrastructure to serve remote communities and to access resources in Northern Ontario will be in demand.

The rapid population growth among indigenous people in Canada will have an impact on the demand for infrastructure investment in First Nations communities and other communities with a significant aboriginal population. The widened scope of aboriginal rights in connection with traditional lands will make public infrastructure subject to new conditions and timing. It will also be reflected in community benefit agreements to compensate for resource exploitation, which frequently include community infrastructure provisions, including training and/or employing indigenous workers or aboriginal-owned companies to work on infrastructure projects.

These investments will often focus initially on communities in remote locations, with better energy, road and telecommunications infrastructure. Over half of Canada's First Nations people now live outside of reserves. With increasing out-migration from First Nations reserves and growing urban aboriginal populations, the future may also see relocating and rebuilding existing remote First Nations communities or incentives to relocated to more environmentally and economically sustainable locations, reminiscent of Newfoundland's Outports Relocation program.

Of equal significance for the shape and timeliness of infrastructure projects will be the enhanced need for consultation, consent and/or community benefit agreements for projects affecting traditional aboriginal lands. The terms and conditions of such infrastructure will require more negotiation than in the past. It is apparent from past history, beginning with the Alaska Highway during the Second World War, that new transportation infrastructure can be a welcome benefit to remote Indigenous communities, but it can also be enormously disruptive. The temporary negative impacts of the Ice Roads in Northern Ontario are an indication of the impacts we can anticipate as access roads are built to serve Northern Ontario's Ring of Fire strategy.

POSITIONING GOVERNMENT AND SOCIETY TO MEET THE FUTURE

What is the role of governments and others?

This report has, as one of its main objectives, the goal of assisting decision-makers in the public sector to think ahead about the selection of infrastructure projects, including the factors that will influence those choices, and the consequences of both action and inaction.

One of the factors that this report identified as having an impact on the future of infrastructure is a tendency that the corporate governance sector has come to describe as short-termism. Despite its origin in the private sector, however, it is arguably every bit as big an issue for the public sector.

Elected representatives at the municipal, provincial and federal levels are typically given four-year mandates, at the end of which their contracts are up for renewal by the voters. In 2014, the turnover of municipal councillors and mayors in Ontario approached an unprecedented 50 per cent and many former members of the Ontario Legislature also retired or lost their

positions in 2014. Similar rates of turnover were evident at the federal level, even in advance of the 2015 election call. In that environment, thinking beyond four-year planning horizons can be difficult. Coupled with this constraint is the burgeoning influence of social media and the more generalized “gotcha” style of journalism that focuses the 24-hour news cycle on mistakes, miscues and missed short-run targets.

Infrastructure, on the other hand, is usually a long-term venture. Its gestation period is long, typically with protracted environmental assessment processes and often acrimonious public debates about both the infrastructure plans and their financing. It is fraught with the attendant risk and political embarrassment of being overdue or over budget, and often both. In our rapidly evolving world, the risks now extend to making costly mistakes about the priority, type and location of the infrastructure to be undertaken, as well as triggering ideological debates about various public-private partnership (P3) delivery models.⁶²

It is an environment that favours the cautious, along with vague plans, deferrals and periodic reconsideration or course correction, all of which can come at the expense of timely delivery and manageable cost.

Given the constraints within which modern governments must operate, it is important to provide them with the tools to do the job that they are elected to do. In many cases, this involves compensating for the recognized shortcomings of the existing decision-making system. The Ontario government’s use of alternative financing and procurement (AFP) is an example of the measures that can be taken to overcome systemic problems, such as the inability to build major infrastructure on time and on budget, without scope-creep and a myriad of in-progress project change orders.

To replicate the policy successes of the past, future infrastructure decisions will require talented people. Policy-makers must go beyond government to recruit leading figures from business, labour, academia and civil society. They must also resource their efforts with public servants and political advisers who have relevant career experience and who enjoy the confidence of political leadership. Whether hired or contracted, staff may need to be compensated in a manner that reflects the market for their skills and experience.

Infrastructure planning and investment also needs a structure/process that is long-lived and self-regenerating, just as our future infrastructure itself must be. RCCAO’s previous independent research has proved to be a solid foundation for this look into the future, including the February 2009 study by T. E. El-Diraby, T. Wolters and H. M. Osman, “Benchmarking Infrastructure Funding in Ontario: Towards Sustainable Policies.”⁶³

Jurisdictions like New South Wales (Australia), Singapore and the United States (Environmental Protection Agency) point the way to evidence-supported decisions about infrastructure and practical performance measurement of needs and outcomes.

Whether it is a designated Ministry, a Committee of Cabinet, a future-focused agenda for ministers, or a reference body of leading Canadians from a variety of sectors, or some combination thereof, the Ontario government and the government of Canada must put infrastructure planning and implementation at the core of public decision-making.

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- 29 Michael Fenn, “Madrid/UK study Tour,” CEO report 08-003, Metrolinx (Toronto: Jan. 25, 2008), pp. 15-18; found at: http://www.metrolinx.com/en/docs/pdf/board_agenda/20080124/CEO_08-003_UK_Madrid_study_Tour_Jan_25-08.pdf
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- 31 Ryan Avent, “The Third Great Wave”; pp. 16-18
- 32 “Do labor-saving robots spell doom for American workers?” PBS Newshour interview with Jerry Kaplan, author of “Humans Need Not Apply”; broadcast on July 30, 2015; found at: <http://www.pbs.org/newshour/bb/labor-saving-robots-spell-doom-american-workers/>
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- “As a result of cheaper labour, more manufacturing jobs that went overseas could return to the United States. At a time of increasing economic inequality, the higher productivity offered by advanced manufacturing often leads to higher wages for workers. (The Brookings report found that workers in advanced industries earned nearly double that of the average worker in other industries.) The innovation and increased productivity of advanced industries also hold the promise of cheaper and more widely available goods and services for the country as a whole, increasing standards of living across the board.
- “Private, public and civic leaders would be wise to embrace the convergence underway and retool economic development – workforce training, community college programs, applied research investments – to this new reality.”

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- 36 “Wealth without workers, workers without wealth,” *The Economist* (London: Oct. 4, 2014)
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- 38 Alan Berube, “Where the rich get richer, the poor often don’t,” Metropolitan Opportunity Series (No. 65), Brookings Institution (Washington DC: March 26, 2015); In a pair surveys of income disparity in 50 U.S. metropolitan areas for periods ending in 2013, Brookings found that the circumstances of low-income households do not proportionally improve, at least as a result of improved results for higher-income families, even in technology-driven economic regions, like Silicon Valley where research previously indicated that “the rising tide was raising all the boats.” In a similar vein, *The Economist* noted that blue-collar men are being “left behind,” creating social and economic problems; found at: <http://www.economist.com/news/leaders/21652323-blue-collar-men-rich-countries-are-trouble-they-must-learn-adapt-weaker-sex>
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- Summary: To explore the growth of the Internet of Things (IoT), researchers created a robot search-engine (“bot”) named Carna and a database (“botnet”). It found that there were already 1.3 billion Internet IP addresses in 2012; but disturbingly, it also discovered that it was not the only global bot collecting all Internet addresses. A bot of unknown provenance, which they called Aidra, was undertaking the same task for undetermined purposes, raising significant potential cyber-security issues. A subsequent article says the Internet addresses will grow to 50 billion by 2020: Philip N. Howard, “Sketching out the Internet of Things trendline,” Brookings Institution (Washington, D.C.: June 9, 2015); found at: <http://www.brookings.edu/blogs/techtank/posts/2015/06/9-future-of-iot-part-2>
- 41 Michael Fenn, John Burke and Donald May, *op. cit.*

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- 42 City of Cambridge, Ont.: Details of program and awards found at: http://www.cambridge.ca/transportation_public_works/asset_management_division (City's explanation of the program, no longer available); <http://smarterplanet.com/blog/2010/09/building-a-smarter-city-in-cambridge-ontario.html> (Program summary for U.S. online magazine); <http://www.cambridge.ca/relatedDocs/AMO%20GTF%20Awards%20News%20Release%20Cambridge%20FINAL.pdf> (AMO 2012 award for public-private partnership); <http://www.cambridge.ca/relatedDocs/2011-05-30%20Computerworld%20Laureate.pdf> (International award for program, with description)
- 43 For a Canadian perspective, see: "Medicine in real time: the future is almost here: e-checkins, medical history updated online – and the first fully digitized hospital," and "Crash course in social media: Most doctors don't use Facebook or Twitter professionally. A university asks: Should they?" *Macleans* magazine (Toronto: March 9, 2015); pp. 44, 46
- 44 http://www.thestar.com/life/homes/outdoor_living/2013/04/04/time_has_nearly_run_out_for_our_ash_trees.html
- 45 <http://www.invadingspecies.com/invaders/pathogens/beechn-bark-disease/>
- 46 Invasive species impacts: <https://www.ontario.ca/page/how-government-combats-invasive-species>
- 47 "Mojix Raises US\$14M Series D Round to Realize Vast Potential of Wireless Sensor Networks & Internet of Things," *Marketwired*, April 6, 2015; Mojix Press Release; Mojix is a private equity 'venture capital' investment of the OMERS pension fund. "With worldwide patents and intellectual property supporting its leading position in the wide area sensor market and burgeoning Internet of Things (IoT) space ... Mojix's STAR (Space Time Array Receiver), first introduced in 2008, ignited a paradigm change for the RFID industry, enabling detection and location tracking of extremely weak signals for passive sensor networks. Key signal processing breakthroughs, now patented, enable the STAR's performance to reach the theoretical limits set by the laws of physics, yielding almost a million-fold improvement over legacy receiver technology."
- 48 Tamer E. El-Diraby *et al.*, *op. cit.*
- 49 "Reinvent the Toilet Challenge Strategy Overview," *op. cit.*
- 50 Sara Ditta, Michael Fenn, Matthew Mendelsohn, and Robert Puentes, "Vital Capital: Using Alternative Procurement and Financing Models to Capitalize on the 'Infrastructure Moment' in the Great Lakes and St. Lawrence Region," Mowat Centre, Research Paper #114, School of Public Policy and Governance, University of Toronto (Toronto: December, 2015) 58 pp.; found at: <http://mowatcentre.ca/vital-capital/>
- 51 Bern Grush and John Niles, *op. cit.*

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- 52 “Building the next generation of Infrastructure. What Leadership is: Kathleen Wynne’s Plan for Ontario,” Premier of Ontario’s website (Toronto: 2015); 10 pp.
- 53 Jane Wells, *op. cit.*
- 54 Richard Worzel, in Michael Fenn, “Building Our Tomorrow ...”; Appendix A, A Futurist’s View of the Seven Megatrends that Will Affect Tomorrow’s Infrastructure, pp. 107-137, notably pg. 120.
- 55 For an illustration of game-changing, Ontario-based technology in this field, consider this innovation: “InteraXon Raises \$10 Million in Series B Led By OMERS Ventures,” OMERS Ventures Website (Toronto: May 7, 2015):
- “Muse, the company’s first product, is a brain fitness tool that measures user’s brain waves using seven finely calibrated electroencephalography (EEG) sensors – two on the forehead, two behind the ears working together with three reference sensors ... The Muse application, which is available for download on Apple and Android mobile Devices, guides you through a focused-attention training exercise that generates real-time feedback. Muse: the brain sensing headband is available from retailers including Best Buy, in both Canada and the United States, Indigo, Amazon, Marbles, Frys and Gaiam.
- “An entire ecosystem is building around Muse. SDKs for Android, iOS, Windows and Mac platforms are currently available for the developer community to build on. “We’re thrilled to note that Muse has been embraced by the medical community, which has found practical applications for the device to alleviate stress and anxiety in patients,” stated Lou Pino, Ph.D., Research Team Lead at InteraXon, adding that Muse is now used in brain research at Mayo Clinic, MIT, Berkeley, UCL and more than 40 other institutions across North America.
- 56 Michael Fenn and Harry Kitchen, “Bringing sustainability to Ontario’s water systems: A quarter-century of progress, with much left to do,” Ontario Sewer and Watermain Construction Association (Mississauga, Ont.: May 2016), 112 pp.; found at: https://www.oswca.org/uploads/oswca_may2016_waterstudyreport_final_001.pdf
- See also: <http://dailycommercialnews.com/Resource/News/2016/5/OSWCA-brings-water-reform-message-to-Queens-Park-1015976W/> and: <https://www.thestar.com/news/queenspark/2016/05/15/water-safety-mismanagement-could-mean-another-walkerton-cohn.html>
- 57 “Dryden teaches class of the future to five universities simultaneously,” Liam Casey, *Hamilton Spectator* (Hamilton, Ont.: March 30, 2015); Ken Dryden addresses university students from Calgary to St. John’s in simultaneous, interactive lecture.

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- 58 Ian D. Clark *et al.*, “Academic Transformation: the Forces Reshaping Higher Education in Ontario,” McGill-Queen’s University Press (Toronto: 2009).
- 59 Michael Fenn, “Unlocking Ontario’s Advantages: Building new infrastructure on the foundation of existing public assets,” Residential and Civil Construction Alliance of Ontario (RCCAO) (Vaughan, Ont.: December 2014); pp. 17ff.; found at: http://rccao.com/news/files/RCCAO_Infrastructure-Investment-Study_Dec2014.pdf
- 60 *Ibid.*
Michael Fenn, “Recycling Ontario’s Assets: A New Framework for Managing Public Finances,” Mowat Centre, Research Paper #85, School of Public Policy and Governance, University of Toronto (Toronto: April 2014)
Found at: <http://mowatcentre.ca/recycling-ontarios-assets/>
- 61 Sara Ditta, Michael Fenn, Matthew Mendelsohn and Robert Puentes, “Vital Capital: Using Alternative Procurement and Financing Models to Capitalize on the ‘Infrastructure Moment’ in the Great Lakes and St. Lawrence Region,” Mowat Centre, Research Paper #114, School of Public Policy and Governance, University of Toronto (Toronto: December, 2015) 58 pp., (Notably pp. 24-40)
Found at: <http://mowatcentre.ca/vital-capital/>
- 62 *Building public infrastructure for the future*, Canadian Union of Public Employees, May 2014; cope491; 2 pages; <http://cupe.ca/building-public-infrastructure-future> ; see also “Asking the Right Questions”;
“While P3s may be tempting to underfunded municipalities, they are expensive and risky – and will not help solve the growing \$123-billion infrastructure deficit. In addition to overall infrastructure needs, investments in social housing and public transit are also pressing priorities, along with funding for wastewater treatment facility upgrades to meet new federal sewage standards ... CUPE, along with University of Winnipeg economist John Loxley have prepared a guide, Asking the Right Questions, to help municipalities considering P3s review all of the evidence before making a choice.”
- 63 Tamer E. El-Diraby *et al.*, *op. cit.*, pp. 25-32.

