ITS MARKET DATA UPDATE STUDY

Final Report
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FOREWORD

Over the last two decades, ITS market data was used in many ITS Canada activities. This includes technical committee work as well as international business development (IBD) activities such as CanExport subsidy application and trade mission planning. The market data needs to be updated from time to time in order to execute our Strategic Plan, assist our technical committees, conduct our IBD program and serve our members effectively.

For this reason, ITS Canada initiated an ITS Market Update Study (IMDUS) in January 2021. The Study is divided into two phases, with Phase 1 covering the domestic market while Phase 2 is mostly related to the international one. Phase 1 was completed in early April 2021 and the resulting report has been posted on the ITS Canada website. Phase 2 was initiated in May 2021 and completed at the end of February 2022. A Final Report is presented here.

Both Phases 1 and 2 of the ITS Market Data Update Study were subsidized by CanExport of Global Affairs Canada at 75% over two consecutive fiscal years, namely 2020/21 and 2021/22.

A number of papers, presentations, reports and blogs on disruptive technologies and ITS development were collected and will be submitted after organization and classification. These will serve as valuable references for ITS Canada officials, staff and members alike.

ACKNOWLEDGEMENT

The author wishes to thank CanExport for funding a major portion of the ITS Market Data Update Study, and also ITS Canada for its support and guidance throughout the entire project, particularly those provided by the Managing Director, Janneke van der Zee. My thanks also go to Tineke Poelking for her assistance during the summer months of 2021.

The author is also grateful to the large number of domestic and international ITS stakeholders who provided a significant amount of useful information on the state of ITS development and ITS market in their local areas and/or technology disciplines, and freely provided their opinion and perspective on the various ITS issues discussed in this report.

INTRODUCTION

ITS Canada initiated an ITS Market Update Study (IMDUS) in January 2021. The Study is divided into two phases, with Phase 1 covering the domestic market while Phase 2 is mostly related to the international market. Phase 1 was completed in early April 2021 and the resulting report has been posted on the ITS Canada website. Many of the Phase 1 findings were regarded as interim

at the time.

Phase 2 was initiated in May 2021 and completed at the end of February 2022. The Phase 1 report has been considerably modified and expanded based on findings from additional web research and input from stakeholders, particularly the international ones, since May 2021. This results in the Final Report, which is presented here.

STUDY METHODOLOGY

IMDUS was to be carried out by conducting web research and survey and interviews of stakeholders in both the domestic and international ITS industries. To organize and control the study, a framework was established, setting limits on the study scope, and providing targets for the interviews. Research and stakeholder lists were prepared and submitted for review. The lists, covering both Phase 1 and Phase 2, are considered live throughout the Study, and were modified or expanded as required.

Web Research

In both Phase 1 and Phase 2, research on emerging technologies and how it impacts or enables ITS development was conducted. Because of the Covid-19 crisis, almost all the research activities were carried out on the web, with particular attention paid to the following topics:

- Recent ITS papers and presentations by ITS Canada members in various fora.
- Review of websites related to the study context (e.g., Transport 2030).
- Study of various emerging technologies and their impact on business opportunities via numerous web links and YouTube videos.
- Review of ITS research, development and deployments based on the emerging technologies on a variety of ITS public and private sector websites (e.g., ITS America SmartBrief, TRB and ITS International, Intertraffic Newsletter).
- Review of ITS research activities in the academic sector on various websites of universities and related research institutes and those of centres of excellence involved in ITS innovations (e.g., UTRRI, SFC).
- Monitoring of the latest news on ITS innovations, deployments and the related social and political concerns on various newsletters, such as Mass transit, Smart Cities World, and Govtech Today, which are available electronically on a daily basis.
- Monitoring of development activities by ITS vendors and research centres by reviewing their newsletters and magazines continuously throughout the course of the study (e.g., Inrix, Iteris).
- Study of various emerging technologies and improved ITS solutions by reviewing white papers, eBooks and presentation power point decks available from the above websites and from various ITS experts on request.

In addition, numerous webinars and online workshops on the emerging technologies and their corresponding ITS development were attended. These were offered by research agencies, ITS vendors and conference and exhibition organizers. They provide more current information on the subject matters in a more animated fashion while allowing demos, illustrations and online questions and answers. However, they are available on an opportunistic basis and only useful as a supplement to the web research.

In addition, complimentary webinars on pertinent ITS topics presented by academic and industry experts were attended, including the following:

- UTTRI (University of Toronto Transportation Research Institute) webinars
- SFC (Smart Freight Centre) webinars
- Various virtual conferences on mobility and ITS (e.g., MOVE, Gulf Traffic Exhibition)
- Webinars hosted by various vendors, integrators, and consultants.
- Webinars with international partners (e.g., ITS HK, ITS Indonesia)
- Florida Automated Vehicle webinar series

The Outreaching Process

During Phase 1 of the Study, survey questionnaires were sent out to major groups of stakeholders (ITS Canada members), including municipalities, private companies, academics and ITS Canada BOD members.

The response to the questionnaires was about 25%. The questionnaire process was quickly followed by direct telephone calls to members. As a result, the sample size was increased to above 40%. The telephone conversations were obviously more animated and more informative than responses to the questionnaires.

Information from the private sector is very consistent throughout and it can therefore be assumed that the samples collected were sufficient. All of them understood that the emerging technologies were all around us and were ready to take advantage of them. However, many concerns were also expressed, including staff recruitment and training issues.

Most of the municipal members interviewed have ITS strategic plans in place and already possess ITS they can rely on. They all have plans to expand their systems in size and/or functionality. Contractor performance was also discussed but it is beyond the scope of this study.

Discussions with the ITS Canada Board of Directors and other experts offer good insights into the enabling technologies and their impact on ITS development. Opinion was offered and challenging issues were discussed.

All in all, the outreaching process provided very useful information which is utilized throughout the study. Sufficient evidence was collected which enabled the development of a list of ITS requirements for Canada as well as several recommendations.

The focus of the above process was on domestic stakeholders during Phase 1 of IMDUS while discussions with international stakeholders were held on Zoom or similar platforms in Phase 2. Over 50 individuals around the world in various time zones were interviewed. The questions asked varied according to their background, expertise, interest and sensitivity. Typically, discussions of the following issues ensued:

- Local technology trends and the state of ITS development
- Local ITS market and the ITS solutions in demand
- Local ITS strategy, issues, challenges, investment and government assistance
- Potential cooperation areas with Canadian entities such as ITS Canada
- International partnership and Canadian ITS export
- Challenges during the pandemic and build back better opportunities

Each session was about an hour long, with most of the sessions recorded, and audio files are kept by the investigator on a confidential basis. Of all the people contacted, most responded quickly and favourably. For the minority of unavailable ones for various reasons, alternatives were found.

STUDY CONTEXT

The context for IMDUS was based on the investigator's experience and expertise in ITS and his knowledge of the industry. At the same time, a number of documents and other pieces of information were reviewed, and the notable ones are as follows:

- Transport Canada's Transport 2030 Plan
- Canada's Innovation and Skills Plan
- Canada ITS architecture
- ITS Canada Strategic Plan (2020 – 2025)
- ITS Canada International Business Development Strategy for Fiscal 2021/2022
- Various technical committee documents available.
- Recent papers and presentations on ITS development and application

The Canadian ITS Industry

In 1959, Toronto became the first city in the world to experiment with the use of digital computers for traffic signal control. This led to a full-scale deployment of a computerized traffic signal system in early 1964. Since that time, a number of milestones have been established in Canada which enhance the country's reputation in "traffic control". This includes the Highway 401 COMPASS freeway management system and the Highway 407 all-electronic tolling system. The "Intelligent Transportation Systems" brand was adopted by the global traffic control industry in the early 1990s, but it was not until 1996 that ITS Canada was formed, representing the Canadian ITS industry at home and abroad.

The ITS industry in Canada consists of the following types of companies and agencies:

1. A handful of large, integrated firms, some of which are subsidiaries of foreign or multi-national firms, and they may be consultants, integrators, contractors, or suppliers,
2. The majority of ITS companies are Small and Medium Enterprises (SMEs), including hardware manufacturers, software integrators, and engineering and consulting firms, who develop the ITS technologies and solutions, or assist end users in planning and designing ITS,
3. The academic and research organizations that conceptualize the technologies which are subsequently commercialized by private firms,
4. The public sector agencies at various government levels who are regulators and/or policy makers, and
5. The public sector agencies at the provincial and municipal levels who are operators of highway, urban and transit systems

The above does not include organizations directly related to the technologies themselves, such as companies specialized in CAV, AI and Telecommunications. However, the public sector is included as it can be a significant factor influencing the fortunes of the relatively small ITS industry. With their policies, regulations and procurement volume and practice, the various public agencies of Canada can contribute greatly to the successes of the ITS industry.

According to studies carried out by ITS America, the ITS market in North America and the world has been growing in leaps and bounds in terms of end user revenue. However, it is expected to be significantly bigger than estimated to date because of the increased emphasis on connected and automated vehicles and the many emerging (or disruptive) technologies impacting the development and growth of the ITS industry.

The ITS sector is a well-paying industry, employing well over 200K end user employees with over 500K in the entire value chain, and these figures are growing every year. The ITS industry is also a very innovative one, with ITS patents growing 17% a year compared to little or no growth in other sectors.

Intelligent Transportation Systems

ITS Canada defines Intelligent Transportation Systems as “The application of advanced and emerging technologies (computers, sensors, control, communications, and electronic devices) in transportation to save lives, time, money, energy and the environment.”

ITS provide an important key to achieving many of today’s transportation objectives, namely mobility, safety, efficiency, and sustainability. Leading-edge technologies are already embedded in a variety of ITS to improve transportation around the world. As new technologies emerge, integration of these emerging technologies into ITS applications is necessary to enhance the performance and cost-effectiveness of our transportation systems.

Governments around the world are investing hundreds of millions of dollars in ITS solutions to tackle transportation problems. For example, cities and states in the United States spent around

US$14 billion in 2021 in transportation technology and the amount in 2022 promises to be more. An innovative ITS industry in Canada will not only help to solve domestic transportation problems but also be able to take advantage of this huge ITS global market.

Transportation 2030 Plan

Transport Canada's vision for a safe, secure, green, innovative, and integrated transportation system is detailed in The Transportation 2030 Plan. It supports trade and economic growth and a cleaner environment, with the following focus on mobility and technology:

- The traveller, instead of the various transportation modes, by providing greater choice, better service, lower cost, and enhanced rights
- Safer transportation for all operators and travellers across all modes
- Green and innovative transportation by reducing environmental impact and embracing new technologies

It is significant that the Plan places emphasis on the traveller and his/her mobility rather than the various modes of transportation and the hardware, software and systems involved. Mobility enhancement has to be mode neutral.

Canada's Innovation and Skills Plan

The Canadian Government announced in 2017 the Innovation and Skills Plan as an ambitious effort to make Canada a world-leading centre for innovation, to create well-paying jobs and to help strengthen the economy. It will help establish Canada as one of the most innovative countries in the world and foster a culture of innovation from coast to coast to coast.

High-skilled labour has been highlighted as an area of great concern. In particular, the shortage of software skills which are crucial in many ITS development and deployments has been identified as a problem.

As part of the Innovation and Skill Development Plan, there is a long list of grants and subsidies to help Canadians in innovation and an e-book on Building a Nation of Innovators is also available, which contains very useful information on the innovation process.

Canadian ITS Architecture

Technology and therefore innovation are critical for successful ITS development. To assist Canadians to understand ITS and their building blocks, Transport Canada developed the Canadian ITS architecture, which identifies various ITS technologies as "User Services".

The Canadian ITS Architecture has been updated a few times to align with updates in the US, as it

makes sense that Canada adopts similar design approaches and standards as the States.

ITS Canada Strategic Plan (2020-2025)

The recently developed ITS Strategic Plan stipulates that ITS Canada is the hub for mobility technologies and supports them through:

- Championing the benefits of mobility technologies
- Fostering and promoting innovation
- Integrating the expertise, products and services of our members
- Enabling communication for learning and collaboration

ITS Canada therefore supports ITS innovation and development using the latest technologies. This is a strategic position as there are numerous enabling technologies emerging which can be utilized to improve many of the current ITS solutions to enhance mobility and reduce environmental impact.

Canadian Innovation Network

There are many organizations in the research, development and demonstration network of Canada directly or indirectly involved in advancing transportation solutions with the use of new technologies. These include governmental research agencies, non-profit organizations, centres of excellence and university research institutes. The following is only a small number of examples:

- National Research Council of Canada, with various programs to support SMEs for technology innovation and privatization of research concepts and results. They provide R&D funding as well as support international collaboration.
- Ontario Vehicle Innovation Network (OVIN), formerly Autonomous Vehicle Innovation Network (AVIN), which monitors CAV development and help to enable Ontario's automobile networks to transform to the future. B
- University of Toronto Transportation Research Institute (UTTRI), which consists of a large number of research groups involved in research areas including ITS, integrated mobility, logistics and freight movement, and public transportation operation.
- AURORA Connected Vehicle Test Bed, WATCAR and others who are involved in the research and development of CAV technologies.
- Centres of Excellence for Artificial Intelligence.

In 2017, Canada became the first country in the world to develop a national strategy on Artificial Intelligence (AI) and CIFAR (Canadian Institute for Advanced Research) was asked to manage the strategy, in close collaboration with three national AI centres of excellence across Canada, namely AMII in Alberta, Mila in Quebec, and the Vector Institute in Ontario. This has helped to accelerate the AI applications in various fields including transportation. As an indication, at least three firms specializing in the application of AI in traffic management joined ITS Canada as members in 2021.

Many existing members have also improved their products and services using AI technologies.

TRENDS OF ENABLING TECHNOLOGIES AND THEIR IMPACT

The emergence of disruptive technologies is occurring at a much more rapid pace in the past two decades and these new technologies are impacting our daily lives and business operation more significantly than ever before. They enable the ITS industry to develop improved and more effective solutions for our transportation problems. The following are key emerging ones that will enable enhancement of ITS in the next decade.

5G Communications Network

Compared to 4G, 5G provides 10 times the speed, 1000 times the capacity (allowing for multiple streaming) and 70% less latency. With ultra-low latency, the lag between sending a request and the network responding will theoretically drop to one millisecond, 400 times faster than the blink of an eye. This will allow for a massive increase in the number of connected devices (1 million per square mile vs 6,500 for 4G), which is beneficial to ITS network development.

The above advantages of 5G also provide a significantly more favourable environment for edge computing, which is really an advanced form of distributed computer processing. Using AI or data analytics, 5G allows heavy data manipulation in a large network to be pushed to the edges or the points where the data is collected without sacrificing response and support from the cloud or central server. The edge could be a video camera with AI incident detection algorithms, a signal controller which adapts the signal timing to the real-time traffic flow, or a mobile phone used for route optimization in an e-commerce dispatch centre. Moreover, since a network typically has many nodes or edges doing the same thing, identical, off the shelf and modular hardware and software can be used in all the edges within the network more reliably and cost-effectively. These features are exceptionally beneficial for the control of traffic management and most ITS networks. Canadian telecommunication carriers have been busy implementing 5G networks in the country, and this is going to revolutionize digital communications throughout Canada and enhance the efficiency and effectiveness of countless businesses, including the Canadian ITS industry. In addition to providing Canadians with the latest technology, wireless industry investments in 5G networks are expected to contribute an estimated $40 billion to the country's economy and 250,000 permanent new jobs by 2026.

Internet of Things

With the emergence of technologies like AI and Data Analytics, the number of IoT devices recently exploded from 7 billion in 2018 to almost 27 billion in 2019, with close to 130 new IoT devices

connected to the web every second. It is projected that 75 billion IoT devices will be connected to the web by 2015.

In terms of revenue, the IoT global market was US$761 billion in 2020, growing to US$1.39 trillion in 2026, and experts estimate that by 2026, the IoT device market alone in the world will reach $1.1 trillion.

In simple terms, the Internet of Things (IoT) consists of any device with an on/off switch connected to the Internet. This includes mobile phones, traffic sensors, video cameras and connected vehicles. The IoT can be used to organize such things as traffic sensor networks and "Smart cities" can use it to reduce waste and maximize the efficient use of energy.

Connected and Autonomous Vehicles

The Connected and Autonomous Vehicle (CAV) cluster consists of various types and generations of technologies, which can be classified into 5 levels in an ascending order, ranging from a Level zero of traditional non-automated vehicles through various levels up to Level 5 of fully automated ones.

Depending on the features installed, a connected vehicle may be able to communicate with:

- its occupants through their mobile and similar devices
- with other vehicles and road users
- with the transportation infrastructure including roadways and traffic signals.
- Internet based applications and other entities

An automated vehicle:

- Uses a combination of sensors, controllers, and onboard computers, along with sophisticated software
- Allows the vehicle to control at least some driving functions, instead of a human driver (for example, steering, braking and acceleration, and checking and monitoring the driving environment.)

CAV Testing and Piloting. CAV technologies are rapidly emerging, and a number of public agencies and private companies around the world are involved in testing and assessing these technologies. In Canada, Transport Canada uses a hands-on approach to safely study driver interactions with CAV technologies utilizing an in-house driving simulator with driver assistance systems. Eye tracking software is also used to study driver visual behaviour. Information from these research activities provide evidence for the development of guidelines, standards and regulations.

The Government of Canada owns a world-class Motor Vehicle Test Centre in Blainville, Quebec which is a well-equipped area for testing CAV technologies. A number of tests are being carried out here to assess the effectiveness of driver assistance technologies currently available on the market.

In addition, Transport Canada provides funding to agencies across Canada for various endeavours in CAV testing and development. For example, the City of Calgary was funded to test an automated shuttle for light rail connection. The shuttle moved 4,500 members of the public during the trial. The pilot was seen as a success, and the city found a number of positive outcomes, and lessons learned. The City of Calgary was further funded to create a connected vehicle test bed along 16th Avenue North in the city to test connected vehicle technologies, in supporting shorter travel times for emergency vehicles and reducing the risk of collisions.

As another example, the Ministry of Transportation of Ontario was funded to support planning for connected and automated vehicles in the greater Toronto and Hamilton areas, and the Waterloo corridor. Over 73 municipal transportation stakeholders provided input and key insights on challenges and needs related to connected and automated vehicles. The Ontario Smart Mobility Readiness Forum was subsequently created to support collaboration on and to continue conversations in CAV.

However, Canadians are still apprehensive about CAV as a recent Transport Canada public opinion research indicates. This anxiety about mainstream adoption of AV is understandable. Canadians need clear information on AV, how it works and what the limitations are, to allay fears and help them make the right mobility decisions in the future.

Big data and data analytics

Big Data is defined as data that contains greater Variety arriving in increasing Volumes and with ever-higher Velocity (the 3 Vs). These big data sets are so complex that traditional data processing software just cannot manage them, but these massive volumes of data can be used to address a variety of daily problems hitherto unmanageable by traditional means.

Big data can be defined as data sets whose size or type is beyond the ability of traditional relational databases to capture, manage and process the data with low latency. For example, data originating from traffic sensors and video cameras is generated in real time and in a very large scale.

Data analytics is the use of advanced analytic techniques against very large, diverse big data sets from different sources, and in different sizes from terabytes to zettabytes. It can ultimately fuel better and faster decision-making, modelling and predicting future outcomes, and enhanced intelligence.

With the global big data market having reached US$49 billion in size, experts agree that the amount of generated data will be growing exponentially in the future. By 2025, it is estimated that the global datasphere will grow from 4.4 in 2013 to 175 zettabytes (10 to the power of 21). 2 exabytes (10 to the power of 18) of data are generated each day across all industries. By 2023, the big data industry will be worth an estimated US$77 billion.

It is easy to see that big data analytics is taking over the world. Bringing accurate insights to every industry using big data is vital for users and operators alike. However, while there are many IT

experts who are 'big data capable', there are significantly less people who are 'big data functional'. Expertise and experience in the domain area of traffic and transportation are absolutely necessary to define clearly what domain problems are to be solved and what solutions to be achieved. This way, the data can be turned into useful information beneficial to the domain user and then the information can be converted into appropriate intelligence for decision and action.

Artificial Intelligence

The number of businesses adopting AI grew by 270% in 4 years from 2015 to 2019 and the overall global AI market is expected to reach US$267 billion in 2027.
Artificial intelligence is impacting the future of virtually every industry and every human being, and it will continue to act as a technological innovator or enabler of many systems, including ITS, for the foreseeable future. According to the World Economic Forum, AI will create 56 million new jobs by 2022.

Artificial Intelligence (AI) is all around us in our daily lives, from movie recommendation on the web to electronic payment and censorship of undesirable messages in social media. More sophisticated versions use machine vision and pattern recognition in ITS functions and video detection of traffic incidents and congestion is a good example.

Blockchain

Another emerging technology for data processing is blockchain, which is a system of recording information in a way that makes it difficult or impossible to change, hack, or cheat the system. It is essentially a digital ledger of transactions that is duplicated and distributed across the entire network of computer systems on the blockchain. Each block in the chain contains a number of transactions, and every time a new transaction occurs on the blockchain, a record of that transaction is added to every participant's ledger. This means if one block in one chain was changed, it would be immediately apparent it had been tampered with. If hackers wanted to corrupt a blockchain system, they would have to change every block in the chain, across all of the distributed versions of the chain.

The blockchain technology originates from cryptocurrency applications and is still maturing. Its characteristics make it very suitable for applications involving transactions over numerous sites. Tracking of cargo through the entire supply chain is a good example.

Social Networking

The advent of social media to date and their future are in many ways tied to the proliferation of mobile phones. More and more people are using their smartphones as their main source for accessing social platforms. 4.2 billion people around the world now use social media, with 4.15 billion accessing them via mobile phones, and 490 million new users came online in 2020.

The above statistics are significant for transportation vendors, operators, and managers. As indicated earlier, each mobile phone is a source of big data and social platforms can be used to not only transmit data back and forth the traffic management centre but also as means to engage the mobile users as traffic operators, condition informers and incident reporters.

The Covid-19 pandemic saw a surge of social networking as social media activities have increased dramatically across all demographics during 2020 in place of many forms of face-to-face communication. 54% of social media users, aged 16 to 64 in select countries, are reported to spend more time on social channels for shows and 42% more time for messenger services.

Certain businesses have also benefited from the heightened usage of social media. E-commerce has grown in leaps and bounds as a record number of people resort to online shopping, thus creating a new transportation challenge in our cities. All in all, social media will continue to be a highly effective medium to allow people to come together digitally and play a strong role in the development of ITS and smart city concepts.

Smart City Concepts

A smart city is a framework designed to harness the capabilities of innovative technology to connect, protect, and enhance the lives of its citizens. By harnessing information and communication technologies and the Internet of Things (IoT), a smart city collects and analyzes data from multiple channels to 'sense' the city's environment, providing real-time information to help governments, enterprises, and citizens to make better and more informed decisions to improve the overall quality of life in the community. With the rapid expansion of cities around the world and the ever-increasing complexity of the problems they face, the use of advanced technologies becomes critical in the development and enhancement of the necessary solutions.

Many experts agree that one of the best parameters to determine if a city is a smart city is to check its transportation and mobility parameters, as the transportation system of a city is a key service provided by the jurisdiction to its citizens. Its development and enhancement need to be consistent with the overall strategy the city uses for smart city development. At the same time, ITS can take advantage of financial provisioning of the smart city undertaking and the improvements provided in its various components, including the communications infrastructure and IT capabilities. As technologies become integrated, ITS should become an integral part of the overall smart city. By creating a network of objects capable of smart interactions through IoT, the door is opened to a wide range of technological innovations that could help improve public transportation, provide accurate traffic reports, or manage real-time traffic control.

ITS MARKET TRENDS IN CANADA

Because of functional similarities among technologies and cross-cutting issues related to legal and operational aspects, boundaries among the various ITS user services as defined in the Canadian

Architecture have become blurred. At the same time, recent technology advancement has resulted in a tighter integration of the various ITS applications and encouraged better collaboration of all parties concerned.

ITS Capability Clusters

Transportation 2030 Plan calls for a focus on the traveller rather than transportation modes, and so ITS should focus on system functions and how they interact with the traveller. It is now therefore more practical and meaningful to consider ITS as mobility technology and capability clusters. The following is a potential list of clusters:

Traffic management systems, including freeway traffic management systems, urban traffic signal control system, and any combinations or parts thereof. In these systems, technologies are used to manage and control traffic in the road network. They could manifest themselves as travel time systems to inform travellers of journey time using variable message signs or through social networks, traffic adaptive control systems which manipulate signal timings based on real-time traffic information, or CCTV systems that help to detect congestion and incidents on expressways.

Multi-modal systems including various forms of public transit, taxis, rental cars, shared rides, micro-mobility modes such as e-scooter, and in the near future, air taxis and drones, combined to serve and meet the needs and choices of travellers. This is consistent with the emphasis that Transport 2030 Plan places on the traveller. The above modes could be shared and/or autonomous.

Smart freight and supply logistics including the use of traditional or autonomous trucks for first mile, middle mile, and last mile deliveries. Supply logistics may include automated warehousing or technologies used in optimizing delivery routes and logistics as well as the management of purchasing and sales activities and the tracking of cargoes. E-commerce is becoming a major consideration in this field and has generated many opportunities in the tracking and optimization of delivery activities in the urban area.

Electronic payments are a major consideration in multi-modal systems whether it is for transit rides or bike shares, using cell phones or credit cards. It is also required for parking and toll roads although the latter is not a major consideration in Canada.

Data management and analytics refer to the management of various aspects of data processing including collecting, organizing, reporting, and archiving, and purpose-specific analytics for applications such as traffic flow and travel time analyses, accident black spot identification, congestion detection and origin and destination surveys. It tends to overlap with traffic management systems above, which however tend to deal with real-time requirements. The use of artificial intelligence will be significant in this area.

Smart city concepts including use of technologies in the smart city context or related to the integration of the transportation system with the overall smart city system.

The emerging technologies discussed earlier are termed disruptive because they change our

business models and impact our daily lives. However, many of the ITS designed and deployed have used concepts or technologies which are the previous generations or traditional equivalents of the emerging ones. Traffic managers do not see these new technologies as disruptive but rather enabling them to enhance their systems smoothly and incrementally.

Traffic management systems

Communication infrastructure is the backbone of any traffic management system (TMC) for a signal or expressway network. It is the costliest component and could cost up to 80% of the total system. Copper circuits were first used which were later replaced by coaxial cables and then fibre optics. The Highway 401 Compass System was the first TMC in the world to use fibre optics in its entirety. Its design was quickly copied by several systems in the States. Toronto chose to lease Bell circuits at the beginning and by the 1980's, the rental cost exceeded $1M a year. Later, the Region of York became the first municipality to lease cell data service (not Wi-Fi) from Bell. As Wi-Fi connections became available, many traffic managers opted for them for many of their sensors and other field devices. However, they still insist on using hard wires to connect to the controller cabinets for safety and security reasons. The provision of 5G with ultra-low latency and reliable edge computing may change all that.

Traffic control networks are multipoint by nature. For example, the Toronto system controls over 2,000 traffic signals and collects data from thousands of sensors of various types. Some of the sensors are already connected to central via Wi-Fi. Conversion to 5G communications and of the entire sensor network to IoT would be a welcome scenario. Subject to budget availability, the conversion may be phased over a few years or down to unit-by-unit level.

For many years, the City of Toronto used algorithms to analyze detector data to estimate parameters such as speed, queue length and various indices for control and performance evaluation purposes. Video cameras with image processing capabilities were later introduced for traffic counting and subsequently for incident detection. Currently, video detectors with AI are offered by some ITS product suppliers.

The above history illustrates that the emerging technologies of 5G, IoT and AI are not foreign to the traffic community, but suppliers are concerned that the uptake has been slower than anticipated. This may be due to budgetary constraints. However, the procurement process often favours the low bid vendor who may not be the one using the desired emerging technology. In general, traffic managers are risk averse and they often insist on testing any new product locally before purchasing it.

Multi-modal systems

The public transit industry is a big one consisting of many modes and new ones are still being added to the fold. For example, with the help of emerging technologies, Bus Rapid Transit (BRT) has become popular in recent years, while the last mile challenge is being tackled by many enterprises

using e-bikes and e-scooters. Demand-responsive transit solutions are also on the rise, using optimization software for timely route adjustments and service modifications to meet real-time requirements. The CAV technology will also satisfy some of the mobility demands, particularly for the first and last mile journeys. Self-driving shuttles connecting to mainstream transit are good examples. The entire transit arena should therefore be viewed as a multi-modal industry.

The transit industry uses an array of traditional and emerging technologies, some of which are similar to those used by TMC operators. The traditional technologies are giving way to new ones but in general, public transport managers are slower to change, particularly in the rail industry. For example, AI is still not allowed in many rail-based solutions.

However, lidar (light detection and ranging) detectors which are used mainly in the CAV area are being introduced to public transit for passenger counting. Universal payment technologies are being used for fare collection. GPS is introduced to traffic signal priority and pre-emption for buses arriving at intersections. A variety of emerging technologies has been introduced to various ITS mobility functions. AI is used in mining ridership data to study passenger trends, social media platforms for bus locations and travel time estimation, and web application for route recommendations. Many transit networks have IoT connections which can be put to good use. The use of self-driving shuttles has been tested successfully in many cities, including Calgary, Las Vegas and Taipei, and autonomous modes will be more common soon.

Public transit will always be fighting for ridership and the modal split will never be improved significantly if the first and last mile transfer problems are not solved. With the current urbanization trend and its ill effects, more collaboration among the different modes is necessary.

Mobility as a Service (MaaS). Electric and hybrid vehicles, e-bikes, e-scooters, and shared mobility services have changed the traditional transportation landscape. The system is changing into a more demand-driven way of travelling from A to B. In this process, the focus has shifted from solely supplying transport itself, to additionally providing this service to the traveller in the most effective and efficient way. This led to the development of the MaaS concept in Europe a few years ago. As a Canadian example, the City of Calgary has just completed a study of shared micro-mobility using e-scooters and will be implementing e-scooter sharing service as a step towards MaaS.

Mobility as a Service or MaaS entails one mobility service platform to provide various modes of transport services to the user on demand. It offers added value facilitating an integration of mobility service providers into one application offering real-time and on demand mobility options to the user, including ticket sales and payment services. MaaS therefore covers all mobility segments, from transit and infrastructure to traffic management and parking, all coming together by putting the user first. The mobile phone is used by the traveller for mobility choice and payment with the help of the various emerging technologies, which collect the appropriate data from the various modes connected to develop recommendation and make reservation for the customer. Based on a personal experience in the City of Helsinki, the city where MaaS was first introduced, a typical trip may start with a taxi ride (which arrives within 5 minutes) from the hotel to the subway and then to a bus terminal where a bus ride is taken to a bus stop 2 blocks

away from the meeting place.

The key premise around MaaS is evolving from a product-focused or mode-focused mentality where customers are sold personal vehicles, or transportation on a particular mode on an exclusive basis such as railroad passes, to an open holistic environment where travellers have seamless and flexible access to all modes based on route, preference, price, special needs or services (e.g., carrying packages or traveling with children). This is consistent with the vision of Transportation 2030 Plan which focuses on the mobility requirement of the traveller. However, data sharing among the different transportation service providers is critical and reorganization of the administrative framework may also be necessary. For example, the necessary data sharing legislation was enacted by the Finnish Government before the introduction of MaaS and the transportation department was reorganized from mode-based to mobility-based with the traveller in mind.

Electronic payment systems

An automated fare collection (AFC) system is vital for transit operation. The smart card-based Octopus System was implemented in Hong Kong in 1997 and Oyster was installed in London, UK in 2003. It was not until 2009 that Presto was introduced in Ontario and Compass was not fully operational in British Columbia until 2015.

The proprietary smart card technology is facing some new challenges. In the last century, a major gap existed between the transportation and banking sectors for various reasons and the latter declined to support transit operators in any AFC payment schemes. For a variety of other reasons, the banking sector has now decided to join the competition. Multiple (or Universal) payment machines with advanced software have been developed and the passenger can use his/her credit card for fare payment very easily. Naturally, social media also became involved, and the mobile phone is rapidly becoming the choice as a tool for fare payment. In many major cities in China, for example, most passengers prefer using credit cards or mobile phones. Considering that the implementation of a smart card system requires major capital upfront and/or the system operator charges a processing fee higher than the everyday household credit card, the attractiveness of the smart card is quickly diminishing, not to mention that the passenger has to invest money to buy a stored value card ahead of the trip. Even with the popularity of the Octopus proprietary smart card, transportation providers in Hong Kong are beginning to adopt universal payment systems based on mobiles and credit cards.

Electronic payment is also important for toll road operators. The Highway 407 ETR in Greater Toronto was the world's first all electronic toll highway when it came into operation in the 90's. A significant investment was made to deploy a credible and accurate payment system using two-way transponders, active infra-red laser detectors and a massive central computer, supplemented by video cameras with licence plate recognition software for vehicles without transponders. The transponder has the potential to be used for parking payment, data collection, travel time measurement and many other purposes. For example, transponder readers are used in Taiwan to measure vehicular speeds on non-toll roads.

For parking, payment by credit cards or using mobiles is already commonplace but this is giving way to direct licence plate reading by AI software residing in the video camera at the parking lot entrance gate. On detection, an appropriate payment is charged via the registered mobile. This technology is now extremely popular in China but is not likely to be popular in this country due to privacy concern.

Smart freight and supply logistics

The logistics, freight, and trucking industries have been experiencing major transformations in the past decade, thanks to technological advances and market dynamics. New technologies and opportunities have been introduced to these industries, altering operations at every stage of goods movement. The following are some major transformations that are reshaping the present and future of logistics, freight, and trucking.

CAV is reshaping the future of cargo transportation in major ways. Autonomous trucks are likely to gain widespread adoption quicker than the other types of vehicles. This is mainly attributed to the fact that driving on highways is much more straightforward than in cities. Also, the benefits and cost advantage of deploying autonomous trucking is much greater than those of personal vehicles. For instance, autonomous trucking has been recognized as an opportunity to solve the shortage in truck drivers faced nowadays in the industry and a means for boosting the operational capacity. However, the route to having fully autonomous trucks on roads is quite long, with truck platooning maturing by 2025 and full automation beyond 2027.

Experts agree that the freight and logistics sector will be the first to adopt CAV technology, along with an array of emerging technologies such as AI and blockchain. With a shortage of manpower and the pressure of competition, any innovation that makes business sense will be quickly assimilated and implemented, whether it is for the first-mile journey from production facilities to warehouses, the middle-mile delivery from the warehouse to the distribution centre or the last-mile dispatching of goods to the customers. The entire supply chain is greatly impacted by the emerging technologies.

Apart from technological advances, e-commerce also plays a major part in the digital transformation of the freight industry. The popularity of online shopping has ben increasing in recent years but rose sharply during the pandemic. Revenues of the array of companies involved in e-commerce are spectacular and provide significant funding for innovation. For example, companies like Walmart are investing heavily into CAV and the related emerging technologies.

When the pandemic is over, the situation is not expected to change significantly as consumers are becoming comfortable with the new normal. E-commerce sales reached US$43 billion in 2018 and are expected to increase to US$55.4 billion in 2023. However, as e-commerce grows, consumers' preferences and expectations for deliveries also rise, calling for a smarter customer service.
The middle mile of the goods movement involves mostly long-haul trips, many of which are straight forward point to point movements in an expressway network. CAV is very suitable for this type of journeys and truck platooning using IoT and AI technologies will be attractive to the industry.

The last-mile or curbside delivery of cargo to the consumer's front door is probably the most transformed part of the supply chain and the keys to success here are connectivity and data-driven decision making. Technologies like AI and IOT will play a significant role; in addition, the amount of tracking and the security involved will also accelerate the use of the blockchain technology. A large variety of CAV's are being developed, tested, or deployed for curbside delivery to satisfy customers' needs. These include both ground and aerial vehicles such as drones, droids, mobile lockers, and two-legged robots.

Warehousing is a vital link in the supply chain and a variety of technologies are used in automated warehouses. Various emerging technologies will be adopted here quickly. Tracking and the visibility of goods will be improved by deploying IoT and sensor technologies. The use of AI and advanced data analytics is essential for forecasting warehousing and predicting maintenance requirements. Augmented and virtual recognition using AI can improve the warehouse management process by aiding staff in goods scanning, object recognition and indoor navigation in real time. A large number of heavy-duty self-driving machines will be used for cargo movement, loading and unloading. The availability of the new technologies will also allow consideration for building warehouses for special purposes (e.g., for frozen food)

Data management and analytics

ITS have traditionally relied on a variety of sensors to collect traffic data, various data sciences to analyze the data and optimization algorithms to improve capacity and minimize congestion. In the past, this activity was hampered by the limited amount of traffic data collected over a slow communications network, lack of effective algorithms and appropriate software, and/or the absence of speedy computers. As a result, the ITS users moved through a phase circa the turn of the century when they were dependent on hardware equipment to provide the solution. The emergence of 5G, AI and data analytics will be a welcome scenario, but technology expertise is not enough. Traffic domain expertise and experience have to be recruited and added to the team to help define traffic problems correctly and craft solutions effectively.

Opportunities for traffic improvement are also offered by the social media and the data technologies available on these platforms. Each mobile phone carried by a traveller is a moving node in a gigantic IoT network and it can be used to provide up to the second information on the surrounding traffic conditions. Several ITS vendors supply Bluetooth sensors which, when installed on a pole near the highway, can monitor the movement of vehicles with mobiles in them. Travel time and speed information can be calculated and broadcast back to the motorists through the social media. The Region of York implemented such a network prior to 2019 and intends to expand it in the near future.

GPS data can also be used for a similar purpose. A Toronto company made use of bus GPS data freely available on the TTC website, estimated travel time on Eglinton Avenue and displayed it on message signs within the Eglinton subway construction area.

There can also be interactions, human or otherwise, with the social network for a better result.

During the 2015 Pam Am Games in Toronto, a mobile software start-up, retained by MTO, provided a social media platform to detect accident and identify congested location, and advise the mobile user game venues and recommend multi-modal routing. The drivers who chose to participate can provide feedback by voice or button clicks to confirm congested locations, thus enriching the database. It was found that during the Games, more people downloaded this application than a competing one offered by Google. Another company built an application in partnership with Waze, a social platform for traffic information, based on information sharing and confirmation between Waze and the municipality in question. The Region of Durham is one of the municipalities with such arrangement.

Google also provides very useful traffic data. A Toronto company recently completed a project in New Taipei where Google data was accessed every 5 minutes and an algorithm was used to detect congestion on an expressway location. The client was satisfied with the result and intends to expand the application to other locations.

Another important and interesting aspect of data management in ITS is the construction of data warehouse to enable jurisdictions to share data. The idea was put forward in early 2000 when the private sector was very active in procuring public data for business purposes, and the application is described in the Canadian ITS architecture. Not too many data warehouses were built at the time, probably due to technology limitations. Instead, agencies shared their data through data links between them. For example, an ITS data link with a common protocol has been established between MTO and the City of Toronto. However, there are at least two countries who have built national data warehouses, namely UK and the Netherlands. For a small fee, any public agency can join the group and access all the data it needs to augment its own. Private companies have to pay a higher fee, but they actually prefer buying data from one national entity rather than negotiating with a multitude of municipalities. The emergence of AI and data analytics will rekindle this interest and new types of data warehouses based on the new technologies can be expected in the near future.

Instead of deploying its own sensor IoT network, an agency can outsource data collection and analysis to one of the several ITS firms who collect and store massive amounts of data via GPS and other technologies. This model is quite a commonplace in the US but not expected to be popular in Canada.

Once the deployment of CAV becomes widespread, the amount of traffic data available will explode. It is interesting to note that CAV can be considered as new modes which will support the mobility requirement of the traveller and the requirement of goods movement. However, as a technology, CAV are moving nodes within the entire transportation IoT, contributing real-time data for traffic management purposes, up to 4 terabytes an hour. In return, each connected vehicle will receive recommendations from the TMC on the best route through the city. A few years ago, the City of Las Vegas experimented successfully with connectivity between connected vehicles and its TMC, which can then download signal data to the vehicles for improved safety and more efficient signal progression. Similar systems are now in place in over 40 cities in the US but not yet deployed in Canada. This is certainly a viable concept and should be explored in Canadian municipalities with pilots and demonstrations.

Transportation Integrated with Smart City

Smart city development provides a great opportunity for enabling ITS. As the city is becoming more digital, the transportation people are naturally elevated and become more credible in front of the city decision makers. The mobility group should be proactive and be part of the team, with a higher degree of collaboration to achieve the smart city goals. Experience has shown that the IT Department will become more involved with ITS and this aspect can be managed for mutual benefit.

A smart city will build new infrastructures and improve the communications network, and the transportation people can share this benefit. The streetlight infrastructure is a good example. Smart streetlights can improve energy efficiency and lighting quality while collecting traffic data. Backed by a versatile 5G network, cities can deploy machine learning algorithms to quickly process this data from IoT sensors and analyze it for traffic performance measurement, speed enforcement and incident detection.

In smart cities, crowdsourced data efforts are starting to materialize in ways that drive forward smart city policy. In these types of systems, the resident is technically the sensor. His or her car, phone, and any other connected device may be serving as a data node contributing to the city's decision-making. While not necessarily a direct replacement for municipal infrastructure, this type of data crowdsourcing can serve as a powerful complement to smart city efforts. Speed and location data from these sources are anonymized, aggregated, and used for mobility assessment. Each traveller is both a node in the sensor network and a user of it. If harnessed effectively, crowdsourcing data can enhance ITS and drive the smart city forward. At the same time, the citizens providing the data become a part of the process and feel more engaged.

With big data and IoT technologies, the local TMC can be programmed to monitor a variety of conditions that may affect traffic, such as flooding, earthquakes and power outages, and control their impact for the benefit of public safety and mobility. As an example, a Toronto company devised a link from the TMC in the City of Keelung, Taiwan to monitor the river level. By analyzing ambient rain data from the meteorological office via the web, the system decides when to warn traffic on the adjacent arterial of flooding.

However, the ultimate step of traffic management within a smart city is to integrate the TMC with smart city operation to form a "strategic command centre". All the technologies discussed so far are pooled together at the TMC to provide the following levels of control:

- Level zero – day to day automated operation (traditional TMC operation)
- Level 1 – automated operation of TMC and other systems based on data from other sources (e.g., for flooding and power outages)
- Level 2 – incident situation with intervention by managers (e.g., major accident)
- Level 3 – major disaster, such as an earthquake or hurricane, when the mayor is invited to provide strategic direction, including road closure and opening as well as directing first line responders

AIDA as an Effective and Integrated Link

The emergence of disruptive technologies and how they will impact ITS development have been discussed. There is a lot of technologies involved and more are coming. These require a wide variety of expertise to understand and utilize, and such expertise is not commonly available in the user community. The situation could be confusing and tend to increase the level of risk aversion of the end ITS customer. A practical and sustainable strategy to foster the use of the emerging technologies to enable the enhancement of ITS solutions should be developed based on a number of critical success factors, as follows:

- A clear and concise message on the priority and importance of such technologies on ITS development
- An action plan to promote the use of such technologies for better user and social acceptance and improvement in ITS performance
- An enabling policy framework with technology-friendly regulations
- Coordination of existing funding programs and consideration for funding additions
- Facilitation of international partnership and joint development with foreign partners
- Selection of technology or technologies to channel and deliver the power of the emerging technologies to facilitate ITS enhancement

The last step is very important as it will help to integrate the impact of the various disruptive technologies for easier understanding and adoption.

5G communication is the backbone of the disruptive technologies and its deployment is strongly dependent on the mobile industry and not on the ITS industry. The introduction of 5G in Canada is ahead of schedule, thanks to the local telecom giants.

With the proliferation of 5G, IoT will be expanding, and the availability of big data will increase with a higher degree of accuracy and resolution. This situation is not under the control of the ITS users and yet crucial for improved ITS solutions. Examples include data for disaster prediction, weather forecast and security improvement.

While all disruptive technologies have roles to play, the key to potential improvement in ITS solutions lies in the availability and manipulation of data and its transformation to useful information and intelligence. The recent advancement of data science is vital in this regard. Artificial intelligence and data analytics, in combination with a variety of data technologies for collection, storage, management, analysis and visualization (collectively termed as AIDA in short) is the most appropriate tool to channelize and integrate the power of the various emerging technologies to provide enhanced solutions for various transportation problems.

With the numerous combinations of emerging technologies and ITS applications, it is very difficult to find the handle on pushing ITS forward. We need a consistent and promotable message on an integrated technology package. AIDA could be the key to the situation. We can leave 5G to Bell and Rogers, which will directly impact the proliferation of IoT. Data will then naturally multiply and become available. What we need then is an effective analytic tool to move ITS development

forward.

AIDA is "culturally" acceptable to the traffic world. Traffic engineers used to spend a lot of time studying and developing algorithms, some actually based on AI or pseudo-AI techniques, for a variety of traffic solutions, including adaptive control, congestion prediction, queue detection, incident detection, signal performance evaluation and so on. Unfortunately, in those days, data was limited, the computer was slow, and the analytics technology was immature. AIDA is making things much better, and the traffic community will welcome the new tool in open arms. It will therefore be a very effective link to connect the ITS industry with the technology mainstream offering the disruptive technologies.

The fact that Canada is the powerhouse of AI bodes well with the AIDA concept. As the first country in the world to come up with a national AI Strategy, Canada has three AI Centres of Excellence across the country. This will add further impetus to the use of AI as the engine in ITS applications. In summary, AIDA can be a very effective integrated link connecting the disruptive technologies with ITS applications in an easily acceptable manner. The use of AIDA can easily be assimilated into the various ITS processes and it should therefore be an integral part of a strategy to deliver the advantages of the disruptive technologies to the transportation community.

ITS can be improved significantly with the incorporation of new technologies, which are really all about the availability and manipulation of massive data for enhanced transportation solutions. Of the emerging technologies to-date, AI and data analytics (AIDA) is deemed to be the most effective connecter to channel the power of disruptive technologies to ITS applications. While promoting the AIDA concept, key consideration has to be given to a variety of data issues including open data and data sharing, and the inclusion of various emerging data sciences.

ITS REQUIREMENTS BASED ON EMERGING TECHNOLOGIES

To predict future scenarios, one must look at a Venn Diagram with three crystal balls, namely need, technology and will (or desire). Where the three circles intersect provides information on what can be expected in the future. There is obviously a need for mobility improvement in various transportation fronts and many new technologies are available and have been proven to work. Whether the change will happen will depend on our will or desire, or a number of institutional factors including business motive, social acceptance, legislative measure, political acceptance, and an array of cultural and societal issues. To enlarge the intersecting area of the three crystal balls or in the Venn Diagram requires the following:

- Clear government vision with socially acceptable policy and legal frameworks
- Funding to demonstrate emerging technologies and accelerate development
- User education and skill development
- Export and external partnership for diversity and revenue growth

- Domain expertise in transportation to define problems and expected solutions clearly
- Collaboration among all parties involved with an emphasis on the traveller

Based on society's needs and with the right technologies, the institutional framework can be massaged (e.g., by legislation or marketing) to enhance the environment for transportation improvement.

Many so-called disruptive technologies are emerging rapidly, and they can be expected to provide an impetus to transportation improvement by enabling ITS development and enhancing their performance. Based on the outreaching process in this study, municipalities continue to rely on ITS and have the necessary funding to expand and improve their current systems. With their ITS revenue not adversely affected by the pandemic, the private sector remains confident in their ITS business and feels that the emerging technologies will provide more opportunities. Furthermore, as explained earlier, the Canadian ITS industry is comfortable with concepts provided by the new technologies and so is culturally and institutionally ready for the shift.

The use and integration of the emerging technologies, together with the large amount of data available, the number of opportunities for ITS improvements will be countless but not all of them are suitable or acceptable in Canada. The following are some examples of what can be expected in the various ITS capability clusters, and some less likely possibilities are also discussed. Many of the proposed ITS applications using disruptive technologies can be combined to form strategic demonstration projects to promote the benefit of the emerging technologies in ITS development and also help our exporting firms by showing off these strategic developments to international clients.

Traffic Management Systems. This is an area where ITS will be continuously developed and improved. However, most provinces and major cities in Canada already have their TMC in place and therefore, they will be seeking improvements along several directions provided by the enabling technologies. The following are some examples:

- Use of hardware with AI and edge computing capability embedded (e.g., video with AI functions)
- Reliance on other data sources (e.g., through crowdsourcing and streetlights) but outsourcing data collection and analysis to data companies will not be likely
- Increase in detailed local performance measurements in real time, such as second-by-second, or in even higher resolution, vehicle departure characteristics at signalized intersections
- Rise in a variety of hardware and software for safety for normal, senior, and disadvantaged pedestrians and for micro-mobility mode users
- Need to improve traffic safety at railway crossings
- Need to alert drivers of a variety of hazardous conditions on the roadway, including slippery pavement, potholes, falling rocks and queue ends around corners.
- Increased use of traffic algorithms for various functions (e.g., incident detection, congestion prediction)
- Increase and expansion of traffic monitoring and information systems, using enhanced

detectors, social networks, and CAV
- Use of IoT concept for controller subnetworks in a hybrid arrangement (as a wholesale change is not necessary)
- Use of CAV for data for a variety of traffic management functions
- Data sharing between controllers and CAV (e.g., signal timing data) and synchronization.
- Adaptive control of signals using CAV data

At least three strategic demonstrations can be proposed based on the above:
- Demonstration of the use of AI to improve traffic safety in a number of situations, including intersection crossings by senior and disadvantaged pedestrians, detection of road hazards, such as unforeseen obstacles and vehicle queue ends, weather problems and damaged pavement, for improved driver safety, safety measures at railway crossings and crowd management in transportation hubs.
- Use of AIDA technologies for congestion prediction, incident detection, and adaptive control
- Data sharing between CAV and traffic signal control systems to improve progression in urban networks, to improve a variety of traffic counting and management functions, and adaptive signal control

Multi-modal Systems. In this cluster, a major collaboration effort among all modes is expected to address the mobility concern of the traveller, giving rise to the following opportunities:
- Wide-spread efforts in testing and piloting micro-mobility connections to mainstream transit, including e-scooters, e-bikes, and demand responsive shuttles (including automated ones) with advanced AI techniques for safety, optimization, and interaction with customers
- Increase use of MaaS or pseudo MaaS concepts, starting with smaller and rural jurisdictions with simpler problems
- Better optimized and more responsive signal priority schemes, equipped with more advanced technologies, for transit and micro-mobility modes
- Embedded integrated payment systems in mobiles for mobility customers for MaaS-related trips

The obvious choice for a strategic project is the demonstration of MaaS concepts in a suburban area, incorporating a variety of modes including taxis, subways and buses, micro-mobility modes, and demand responsive shuttles, with data sharing protocols among them. The mobile phone should be used for routing optimization and advice, enroute performance notification, and ticket sales and payments.

Electronic Payment Systems. No new smartcard AFC systems will be deployed in Canada. The legacy ones will slowly give way to credit cards, debit cards and a proliferation of mobile payment apps. This situation will happen to both transit and parking payments. Although a multitude of emerging payment schemes are becoming mature and available, new tolling infrastructure and road pricing schemes will not be expected in Canada.

As universal payment schemes using credit cards and cell phones become more popular around

the world, their use should be demonstrated in a Canadian transit network. Their demonstration can also be incorporated in the strategic demonstration of MaaS above.

Smart Freight and Supply Logistics. The freight industry is transforming rapidly, and the key is CAV technology. In particular, e-commerce will spark a lot of ITS and CAV development for last mile delivery. Significant investment will be made by not only trucking and courier companies but also chain retail stores such as Walmart, to meet the needs of customers and mitigate manpower problems. The following is only a few examples:

- For the middle mile, CAV platooning will be widely used in long haul trucking operation by 2025.
- Full AV trucking for long hauls will be widespread by 2017.
- For the last mile, a large variety of autonomous delivery vehicles and machines, both ground and air, are being developed and will be tested. This situation will be consolidated within the next few years.
- E-commerce will become entrenched in urban areas and there is a need to use disruptive technologies to reduce or eliminate its adverse impact on traffic flow and the environment.
- The blockchain technology will be used for tracking customer order and goods delivery, and a variety of chained processes in the industry.
- More AI-based algorithms will be used for route optimization and selection, scheduling vehicles and manpower, and managing inventory and warehousing.
- Increase in automated warehousing, employing many of the enabling technologies for storing and locating goods, predicting capacity requirement, and automated machines for moving goods.
- Introduction of specialty warehousing (e.g., for frozen food) using a variety of sensors and AI techniques.
- Development of smart trade corridors (e.g., Montreal to Windsor) to minimize delay and congestion to commercial vehicles along the corridors and crossing the border to the US, with integrated ITS using a variety of enabling technologies.
- Development of a variety of techniques, particularly at intersections (e.g., truck priority), to improve the safety of trucking and its sustainability by reducing the amount of braking, noise and emission.

Effectiveness and efficiency of the supply chain are essential to society and demonstration of how they can be improved by emerging technologies cannot be over-emphasized. The following two strategic projects can be structured based on the above requirements:

- An e-commerce demonstration project to illustrate how new technologies can benefit the merchandize delivery in the urban context, incorporating the use of AI-based algorithms in route and schedule optimization, the use of blockchain for tracking deliveries and a variety of hardware and software to streamline the delivery process and mitigate its adverse effect on the traffic network.
- Another worthwhile project is to develop a smart trade corridor to demonstrate various technologies in the minimization of delay and congestion to commercial vehicles along the trade corridor and crossing the Canada-US border.

Data Management and Analytics. ITS development will benefit the most from the increase in the availability of traffic data and the speed of collecting them. Emerging data technologies and the related analytic software are required to use the data effectively. Traffic domain expertise is also essential to interpret the data correctly and utilize it properly for transportation applications.

- Increased use of social network data for various transportation purposes, from analyzing transit ridership pattern to incident detection
- Use of web data (from other city departments or agencies) for traffic prediction, control, and management (e.g., weather data)
- Rise of social platform-based traffic information systems by engaging travellers to provide feedback and validate traffic network condition
- Use of CAV data for various transportation purposes, including intersection performance measurement, pavement condition assessment and provision of origin and destination data for modelling.
- Trials of applying micro-simulation model for real-time traffic signal optimization with the
- Synchronization of data between CAV and the TMC for various functions (e.g., incident warning and parking availability)

As a strategic project, it is proposed that the benefit of accessing social platforms using mobile phones can provide useful data, information and intelligence for decision making to the passenger (e.g., bus delay and occupancy), operator (e.g., maintenance needs and schedule), and the transit company (e.g., passenger feedback and service demand).

Smart City Concepts. As the city is being transformed digitally, more focus will be placed on technology. The credibility of transportation personnel involved in ITS will be increased and they should take advantage of this. There will be a higher degree of cooperation between the transportation and IT departments to mutual benefits. With increased collaboration across all city departments and proactivity on the part of the transportation personnel, many opportunities for ITS enhancements will become available.

- Increased sharing of infrastructures for traffic purposes (e.g., use of streetlights for data collection and sharing of 5G network).
- Use of parking meters for a variety of transportation applications, such as parking reservation, curbside management for delivery trucks and traffic monitoring.
- Increased data sharing across city departments and crowdsourcing data from citizens.
- Increased use of social media platforms for traffic information and management purposes.
- Management and control of planned events like parades and unplanned events like accidents, as well as non-traffic events such as earthquakes, flooding and fires.
- Increased use of the TMC for a variety of city functions (e.g., trucking management and emergency operation).
- Use of mobile-as-emergency TMC in case of major incidents (e.g., fire chief operating the mobile TMC during a major fire).
- Formation of a strategic command centre by integrating traffic operation with smart city requirements.

It will be extremely worthwhile to demonstrate how various emerging technologies can enhance

the operation of a TMC in a smart city context. This strategic project will include the development of a smart city strategic command centre and demonstrate the following:

- Management of planned and unplanned events
- Distributed TMC concept using mobile phones
- Use of TMC for a variety of city functions such as parking management, streetlight optimization and emergency operation
- Use of the TMC as a smart city strategic command centre with various levels of control

The above ITS requirements and strategic projects are only small lists of samples developed based on the following:

- Anticipated impact of the various emerging technologies discussed above
- Readiness of the enabling technologies
- Needs identified in the transportation industry
- Comments from ITS Canada members interviewed
- Consideration of societal, political, and cultural factors in Canada
- Judgement of the investigator based on his knowledge of the ITS industry

The numerous technologies and ITS functions are inter-twined and mutually inter-dependent. There are significant cross-cutting linkages among them, and endless possibilities can be created. There is absolutely no question that the above emerging technologies will significantly impact ITS with improved transportation and mobility for years to come.

CONCERNS AND CHALLENGES

As a result of the outreaching process, the following issues have been identified as concerns of the Canadian ITS industry. Elimination or mitigation of some of these will further enhance the positive impact of the enabling technologies and improve its export potential:

- Despite the significant cross-cutting capabilities of various new technologies, there is still a lack of integration between systems and between modes. This happens not only technologically but also organizationally.
- In many jurisdictions, there is still a lack of cooperation among agencies, such as in the case of data sharing, causing a tardy acceptance of solutions made possible by the new cross-cutting technologies
- ITS vendors find that customers are risk averse and slow in accepting or adapting to new technologies.
- The speed of implementation is often slower than expected due to procurement and other issues as well as the reason cited above, to the frustration of decision makers as well as the vendors.
- There is often a lack of emphasis of technology requirements in infrastructure funding and undertaking and the technology is often added on at the end with the remaining budget on

an ad hoc basis.
- Staff recruitment and development in the ITS industry is a major challenge as a blend of cross-cutting expertise and experience is often required.
- Formal training programs are inadequate in the industry.
- Lack of combined expertise in the emerging technologies and the transportation domain leads to dissatisfaction in deployments. This is obviously related to the above two problems.
- The standard procurement practice of awarding projects to the lowest bidder may cause a problem as the lowest bid may not necessarily be the right bid with the desired technology.
- Recent procurement changes have placed restrictions on communications between clients and vendors.

The list of challenging issues presented above must be dealt with in any attempt to develop procedures and policies to strength our ITS industry domestically, which in turn will affect our ability to capture a reasonable piece of the international market. The human resource issue is a serious one and deserves a more detailed discussion.

Impact of the Pandemic on Revenue

It was thought that revenues of private ITS firms would have been seriously affected during the pandemic but most, if not all, private stakeholders indicated that their revenues have not been adversely impacted and some of them even saw a revenue increase in 2021. Some companies had to hire more staff last year. Many of the responding companies grew significantly in the last few years and some others started as small entrepreneurs with 2 or 3 people and became sizeable corporations of 40 to 50 today. Most ITS customers quickly became so accustomed and comfortable with online chats with vendors and digital procurement procedures that business continued relatively uninterrupted.

Transit operation is a different story, however. Transit ridership around the world have been severely reduced due the pandemic as many passengers take precaution to avoid crowds and many others work from home or have lost their jobs. Transit authorities have a long road ahead of them as they attempt to build back their operation to a sustainable level.

Procurement Issues

Since the City of Toronto initiated ITS in 1959, the demand for ITS technologies from Canadian provinces and municipalities has been steadily increasing and has helped grow a number of ITS consultants, suppliers, contractors and integrators. For some years, access to the domestic ITS markets were relatively easy and innovative solutions were often welcome.

By the new century, the public sector procurement policy and procedure became more restrictive. The insistence on low bids often led to selection of technology not originally intended and, in many cases, vendors have problems accessing clients to provide product information. For example, to

access the City of Toronto staff, ITS technology suppliers must register themselves as lobbyists before they are allowed to meet with their clients. In this regard, ITS Canada can be an important middle person to bridge the communication gaps. An appropriate group of members can be asked to define the procurement issues in more specific details and identify solutions to the problems. The association can also organize webinars and networking sessions to improve communications between vendors and clients.

Skills and Workforce Requirements

The ITS industry is a highly respectable one, producing a significant number of well-paying professional jobs. ITS utilizes ICT and generally require the following expertise:

- Domain expertise in transportation such as signal optimization, supply chain logistics and transit operation
- Communications engineering with rapidly changing requirements from hardwired to wireless systems through various technology generations
- Hardware engineering requiring qualifications in mechanical and electrical engineering degrees
- Software skills requiring software engineering and computer science degrees with expertise on the latest development such as AIDA

A typical ITS firm will require a work force with the above qualifications, in addition to the usual administrative, financial and marketing skills which are required for a successful operation. On an individual basis, there are plenty of academic courses available for the above ICT skills.

However, for system planning, design and development, ITS requires a high-level work force with highly integrated knowledge and skills, cross cutting a variety of disciplines, either in research, development or deployment. Formal training in ITS in the integrated sense is not easily available. Typically, system expertise and experience are obtained through on the job training, and this may take 5 to 10 years as ITS implementation cycles are relatively long. Some universities provide special ITS courses at the post-graduate level with the help of outside practical experts. Very often, these courses are narrowly focussed on particular aspects of ITS, such as traffic signal optimization and freeway traffic management.

ITS equipment vendors are slightly better off in that they can recruit staff with the appropriate background and subject them through in-house product training which usually consists of proprietary elements.

Interviews of stakeholders have revealed that recruiting and retaining ITS specialist is a major challenge with the following problems:

- ITS specialist candidates with integrated knowledge are of limited supply
- There is strong competition from mainstream IT firms in terms of salary level, company image and career advancement opportunities.

- Retaining such specialists is also very difficult for the same reasons as above

The problem in SME firms is more acute because it provides less career options while being more dependent on such specialists.

There is no question that specially-designed ITS courses will be of great value to the ITS community. Introductory courses can be in the form of webinars while in-depth training can be provided as post-graduate short courses by universities or related centres of excellence. Management training through webinars for management staff is also very important. The role of ITS Canada as a planner and co-organizer is vital in this regard and funding from Transport Canada will add to the success of this arrangement. The provision of diplomas or certificates as proof of qualification should be considered. ITS Canada can help to address this important human resource issue by setting up a special task force to discuss this issue, identify potential solutions, determine the training required and execute the mitigation program.

ITS AS AN EXPORT

With the first traffic computer in the world implemented in Toronto as early as 1964, Canada has a strong heritage in ITS which serves as a good foundation for exporting our ITS technology. For most of the companies in the ITS industry, Canada is too small of an ITS market, with its small population spread over a large area. Engaging in international trade is therefore essential for them, and many of ITS Canada members must market abroad to remain sustainable. Yet, many Canadian ITS SMEs resist venturing out of the domestic market due to fear of risks and lack of funds or knowledge. Some subsidiaries of multinationals also do not export due to lack of mandates from their headquarters.

Also, Canadian organizations would do well in partnering with agencies and companies abroad, which would provide the necessary external stimulus to diversify and innovate.

The Canadian ITS private sector consists of the following types of companies:

- Multinationals whose Canadian operations do not have the mandate to export
- Multinationals who allow their Canadian operations to conduct some or all their international business
- Canadian companies who export to the US only
- Companies who export to selected countries based on their connection, cultural background, and the perceived opportunities
- SMEs (Small and Medium Enterprises) who want or need to export but require guidance and/or funding
- Companies who only work in Canada or in some provinces

While our ITS industry has a large number of niche technologies which are quite in demand around the world, many of the ITS companies are SMEs. Unlike Europe and the US, Canada lacks the large

ITS contractors or systems houses to spearhead our exporting effort. The role of ITS Canada as a facilitator is therefore a very important one. Also, instead of directly marketing to the end users, Canadian firms often have to partner with large firms in a foreign country in order to increase our market share in that country and better still, in a third country.

The International ITS Market

Many private studies have been done on ITS markets around the world with similar results that the ITS business is significant and growing, helping to reduce traffic congestion and improving the environment while creating jobs and growing the economy. The Canadian ITS Sector stands to gain significantly from the ITS expenditures in many economies. In fact, the ITS market is expected to be significantly bigger than what was estimated earlier because of the increased emphasis on the emerging disruptive technologies such as CAV and AI. This was confirmed in discussions with the international stakeholders, in which ITS export/import was an important topic.

The US Market. First of all, the well-to-do ITS market in Canada and the US will improve even further in the next few years due to major funding provided by both federal governments on infrastructure improvements and transit recoveries. For example, cities and states in the United States spent around US$14 billion in 2021 in transportation technology and the expenditure in 2022 is expected to be more. The recently approved US$30.5 billion transit rescue plan and the close to US$1 trillion infrastructure bill, along with local matching funds, will add significant funding to the ITS market in the US as the money filters down the transportation hierarchy.

The demand in ITS solutions in the US is a mix of conventional and emerging technologies for both system upgrades and new systems, including ATMS (advanced traffic management systems), ATIS (advanced traveller information systems) and a variety of ITS hardware and software products. Competitions are very keen, however, south of the border due to the size of the ITS contingent there, but Canadian ITS companies can do well teaming with major ITS integrators there or supplying unique solutions not easily available there. ITS products related to new technologies such as AI and CAV will be an asset in this market. Canada has been very strong in the provision of consulting services in planning, designing and integrating ITS as well as supplying traffic management software and smaller ITS companies can team with Canadian ITS consultants who are active in the US.

A significant number of ITS Canada members are doing well in the US market, which is attractive due to a number of reasons, as follows:

- The US speaks the English language and has a similar culture.
- It is close to Canada without major time differences
- The US currency is stable and offers a premium compared to Canadian dollars.

In spite of this, many ITS SMEs need encouragement and require help and support to trade with US enterprises. The role of ITS Canada is essential in this regard.

Latin America. The ITS market in Latin America is not spectacular. There is a reasonable amount of ITS activities in a minority of better developed countries but interests in others are sporadic and opportunistic in nature. Countries in this region worth investigating include Mexico, Columbia and Chile because they have a stable economy. and also have free trade agreements with Canada.

The European Union. This region consists of some 27 countries and represents a major ITS market for the Canadian ITS industry. However, it can be broken into a number of areas with different characteristics and market requirements. Overall, it is an attractive market for the Canadian ITS industry for the following reasons:

- There is a strong need for state-of-the-art ITS solutions because of the EU's congestion problems due to its population density and inefficient road networks
- Many ITS integrators in the EU are very interested to team with Canadian firms in exchange for North American prospects
- The recent signing of CETA (Canadian – European Union Comprehensive Economic and trade Agreement) eliminates tariffs on goods, provides labour mobility and opens up project procurements for Canadian firms (which is estimated to be C$3.3 trillions annually). Also, Canadian firms can now participate in joint ITS technology research and demonstration projects with their EU partners with Canada and EU subsidizing the efforts of their respective companies.

Canadian ITS firms have recently developed an assortment of mobile technologies for ITS applications, which should be very suitable for the European market, where the current emphasis is on Connected Mobility including MaaS. More recently, a number of ITS firms specializing in the application of AI in traffic management has emerged and along with the rising popularity of CAV technologies, Canadians will do very well in the EU.

The ITS market in Western Europe is very busy due to its congestion problems and aspiration for a cleaner environment. Its demand, however, is for ITS goods and services in the area of smart mobility solutions as the European has opted to focus on the individual traveller regardless of their choice of modes. As a result, MaaS and other mix-modal or multimodal concepts are more popular there.

Northern Europe. ITS are very well accepted in the Scandinavian countries and as in Western Europe, smart mobility is the key demand in this region. Scandinavian ITS stakeholders indicated that they feel very comfortable trading with Canadian companies and in many cases, they find Canadian equipment and services more suitable because Canada has similar winter conditions. In this regard, they look forward to discussing ITS opportunities with Canadians, particularly in ITS applications of disruptive technologies such as CAV and AI.

Eastern Europe. Countries in Eastern Europe, whether in the EU or not, are still busy catching up with building transportation infrastructures, using EU funding in most cases, to keep pace with Western Europe, and conventional systems such as ATMS and ATIS are required as part of the new infrastructure. About 75% to 80% of their ITS business go to Western European firms and there are opportunities for Canadian firms if they find the right partners in the EU.

The United Kingdom deserves a separate mention here as it has seceded from the EU. It has an open and sustaining ITS market and is currently preparing to negotiate a free trade agreement with Canada. It speaks the same language as Canada and ITS Canada has a strong and favourable relationship with ITS UK.

The Asian ITS market is huge, diverse and complicated. Some markets are not too open to foreign firms while others significantly rely on outside sources of supply. For the former, experts indicate that there is still a market for niche products and partnerships with local companies offers the best approach. One particular economy with a relatively closed market has indicated that it is now ready to partner with foreign companies to share the local market while attaining international standards to be able to export their products.

At the same time, there is a number of well-developed economies who are ITS-oriented and have healthy budgets but do not produce much on their own. These are favourable destinations. In addition, many countries in Asia have rapidly emerging economies with increased interests in ITS products and services. With their currency disparity with Canada, however, local manufacturers in conventional products, such as video cameras, may be extremely competitive. Having a local partner with local hardware and acting as an OEM for our niche technologies may be a key to success there.

The following provides more details on some of the important ITS markets in Asia:

- Hong Kong – this is an open and busy market with major ATMS projects involving tunnels and bridges. The projects are too big for Canadian SMEs, so teaming with local contractors is essential. To encourage ITS development, a Smart Traffic Fund (2021 – 2026) was announced in April 2021
- Singapore – it tends to require goods and services for the latest technologies but many local ITS contractors have been grown in the past two decades, and they are very export-oriented. Teaming with them is useful for local projects as well as those in other Asian countries
- China – they tend to use local companies now but there are still opportunities for niche products which require partnerships with local distributors
- Malaysia – many conventional products are supplied locally at competitive price levels and it is therefore useful to partner with these suppliers with Canadian niche technologies
- Asian countries such as Thailand and Indonesia – the ITS markets are emerging and worth investigating.
- Taiwan – it has been procuring a lot of international products and so teaming with effective local distributors is essential

In all the above cases, ITS Canada can help and support the marketing activities contemplated as it has great relationships with the local ITS societies. Local trade commissioners can also be very helpful in providing market intelligence and arranging meetings with potential clients and partners. Canada has a free trade agreement CPTPP with a number of countries on both sides of the Pacific and it may be useful for some of the Asian economies.

The Middle East. Stakeholders knowledgeable in the Middle East area indicate that there are huge ITS opportunities in his region, with major ATMS and ATIS projects involving the latest technologies. Consultants including one person experts will also do well in this area. For the supply of goods and services, teaming with European contractors and integrators will be beneficial as many of them are already entrenched there for historical reasons.

As confirmed by the international stakeholders, the global ITS market is fertile and will continue to improve with the introduction of emerging technologies and the increased recognition that ITS is an effective tool in transportation and environmental management. Meanwhile, ITS development has increased elsewhere and many cost-effective ITS hardware and software products have become available from other countries. These may be beneficial to the Canadian ITS industry, even for domestic projects. A two-way international trade is therefore a feasible proposition.

To take advantage of this market, each exporting firm has to develop its own marketing strategy based on its strength and weakness. However, a national strategy with a clear policy, supported by appropriate and sustainable funding for development and promotion will go a long way to motivate the ITS industry to be more involved internationally. ITS Canada also has a strong role to play in developing an effective strategy for its exporting members and supporting them in their international endeavour.

Generally speaking, Canadian ITS firms have good access to the international market for a number of reasons:

- Canada has a favourable image in the world.
- Canada has an impressive heritage in ITS innovation and development.
- Our multi-ethnic background helps to provide links to and information on many cultural settings.
- Canadian firms are regarded as good alternatives to US firms in cases where the client does not wish to trade with the US.
- Global Affairs Canada has a large network of Trade Commissioners who are extremely helpful in supporting Canadian ITS firms in their export activities.
- ITS Canada provides another channel through its cooperation with many ITS associations around the world.
- CanExport of Global Affairs Canada provides subsidy funding to the ITS industry in accessing the international ITS market and this is particularly useful for many SMEs and ITS start-ups.

Importance of International Partnerships

However, there are challenges. Many parties in the global ITS arena feel that Canadian firms are not aggressive enough in the world market. Since most of our firms are SMEs, we tend to be risk averse in terms of international trade and rely on the US for our international revenue. More significantly, Canada lacks large ITS integrator firms who can source products and services from the SMEs and represent them abroad. To improve our international trade, we must help to provide our SMEs with opportunities to partner with large and preferably multinational integrators and

contractors in large economies such as the US and the European Union. The advantage of teaming up with such entities is that it provides market access not only to the target country but also to many other countries. For example, providing technology to a large ITS firm in Germany helps the Canadian SME involved to gain access not only to the German market but also to other countries in the European Union, Eastern Europe and other parts of the world.

Exporting ITS is important for the Canadian ITS industry to grow and diversify. One effective strategy is to access the international ITS network and find foreign partners to work in countries offering the project opportunities. In this regard, ITS Canada's strong link with her sister organizations worldwide can be an asset and trade commissioners in our embassies abroad can also be helpful.

TOWARDS AN INTERNATIONAL BUSINESS DEVELOPMENT STRATEGY

One of ITS Canada's overarching goals is to promote the use of technology in transportation to grow and diversify the Canadian ITS industry with benefits to the Canadian economy while creating meaningful jobs. Since the international ITS market is fertile and can help the industry achieve similar results, it is important that an international business development (IBD) focus be maintained by ITS Canada.

The International Business Development Committee

Of all the transportation related trade associations in Canada, ITS Canada is one of the few, if not the only one, which provides help and support to their members in the international arena. To achieve this objective, an IBD Committee has been created and its mission is as follows:

Based on the goals and objectives of ITS Canada, its International Business Development (IBD) Committee is responsible for the development and update of the IBD Strategy annually and oversees its execution once it is approved by the ITS Canada Board. The Committee is chaired by Mr. Joe Lam, who has over 40 years of ITS export experience, and is comprised of government and industry members who have a direct stake in our export marketing efforts.

The mission of the IBD Committee is to develop and execute export-related activities to foster and develop partnerships and business linkages between ITS Canada Members and friends (interested non-members) and those of our sister organizations/societies around the world, with priority on ITS-growing/emerging economies. By monitoring ITS trends around the world, the Committee also provides information to our members and non-members on the latest ITS technology trends, markets and opportunities for their consideration.

An IBD Strategy is developed annually, along with a program of activities including incoming and

outgoing trade missions. Input from ITS stakeholders throughout this study provides extremely useful and timely information on the global ITS market to enable the formulation of a strategic framework to guide the IBD strategy development and modification.

As new ITS trends emerge and diversify into areas such as smart mobility, big data analytics, AI, smart logistics, CAV technologies and automated warehousing, and innovations are developed in subsequent years, export opportunities for our members will change and hopefully increase, the IBD Strategy will be modified accordingly. As with any active strategic plan, priorities may shift as new opportunities emerge. The IBD Strategy is updated annually, not only to guide our export program execution each year but also as part of our submission package to CanExport for subsidy application.

A SWOT Summary

With feedbacks from the international ITS stakeholders, there is now an enhanced understanding of the Strengths, Weaknesses, Opportunities and Threats (SWOT) facing ITS Canada members in the international market. This information can be used to develop a strategic framework to guide the development and modification of ITS Canada's IBD Strategy.

The ITS industry in Canada has the following strengths:

- The Canadian ITS industry has a strong heritage and achieved many important technology milestones since ITS was introduced in Toronto in the 1960s
- It has many niche ITS products and services in demand in the world market
- Improving ITS solutions using disruptive technologies, such as CAV and AI, is progressing well in Canada
- The Canadian Innovation Network is sizeable and provides useful support to the ITS industry
- There is an excellent relationship between ITS Canada and ITS societies around the world
- Knowledgeable trade commissioners in Global Affairs Canada offices around the world provide useful market intelligence and effective support to the ITS exporting firms.
- There are free trade agreements, such as CETA, CPTPP and USCMA, between Canada and most of the economies with ITS opportunities

The weaknesses on an aggregate basis are as follows:

- There is a lack of major ITS contractors and integrators in Canada, and partnerships with foreign firms are critical
- The Canadian ITS industry consists of many SMEs lacking the interest on and knowledge of the international market and many lack the resources to pursue it. The IBD strategy should place an emphasis on supporting SMEs

As discussed earlier, the international ITS market offer many opportunities, as follows:

- The international ITS market is huge and growing, except for a few economies

- The ITS market growth is accelerated and further expanded with the emergence of disruptive technologies
- The exporting firms can promote their goods and services in a number of world class conferences around the world. The top choice is the annual ITS World Congress which serves as an effective centrepiece of any ITS export strategy.
- Subsidy funding are potentially available from CanExport of Global Affairs Canada, to ITS Canada as a trade association for trade missions and directly to the exporting firms for various exporting needs

There are also threats to Canada's ITS export and these must be mitigated:

- As the economy of some of the export destinations and their ITS opportunities improve, local suppliers mature and may become competitors. Partnering with them should be considered.
- As technology emerges quickly, ITS solutions may be rendered obsolete or too costly.
- The pandemic hinders our marketing activities and alternatives have to be found. This seems to have been addressed in some way as many webinars and online meetings have been hosted by ITS Canada and out private sector members throughout the pandemic.

A Strategic Framework for International Business Development

Based on the above SWOT analysis, a strategic framework can be developed, with the following considerations:

- The IBD Committee should program activities to assist our exporting members in international trade with focus on the target markets.
- We should focus on areas of sustaining ITS markets, namely the USA, the EU and selected economies of Asia, and to a lessor extent Eastern Europe and the Middle east.
- Economies should be prioritized based on the size of the market, the existence of free trade agreements, and RBC (Responsible Business Conduct Abroad) conformance
- The various international market activities should take advantage of government funding, trade commissioner support and cooperation with the Canada's innovation network.
- The marketing effort should be stepped up incrementally in line with our pace of 4 development of improved solutions using new technologies.
- A priority should be placed on partnerships with international ITS integrators and contractors.
- Special considerations should be given to SME members in terms of trade mission participation, networking with foreign entities and export training.
- Communications with members and stakeholders should be frequent, widespread and transparent and should include the IBD program and activities, market focus and intelligence, international market and technology trends, news on upcoming tenders, networking opportunities and partnership potentials.
- There should be training and education on various aspects of ITS international trade,

including market trends, funding and support available, support from the Canadian innovation network and a variety of export requirements like RBC.
- Amiable working relationships should be maintained with our sister societies around the world.

The IBD strategy is designed to achieve the long-term goals of ITS Canada and specifically the following short- and medium-term objectives (in order of priority):

1. Enhance our international reputation as a centre of excellence for the design and manufacture of advanced ITS systems and technologies.

2. Enable our exporting member companies to obtain more sustaining business abroad.

3. Work more closely with our colleague associations and Global Affairs Canada offices around the world to raise awareness of Canadian expertise to our counterparts in the estination markets, and to collect intelligence on upcoming prospects for our members.

4. Encourage other countries to leverage Canadian ITS technologies and best practices.

5. Enable our budding exporters to have a sustaining and successful IBD strategy.

6. Assist more of our members and SME's who currently are domestically focused to transition into their selected international markets.

7. Monitor ITS technology trends and collect global ITS market data for the benefit of our members and provide them with opportunities for knowledge building and sharing with international partners.

8. Recruit new members for ITS Canada through cooperation with technology associations and local chambers of commerce and involving their members in our export activities.

In addition to the above, there are a number of issues related to the IBD Strategy which are worth elaboration, as follows:

Marketing Partnership. ITS Canada has been successful in identifying and securing partners for our members, but we can do more. Going through our sister societies in many economies to reach their members has been quite effective. Because of increasingly restrictive contract tendering processes, it has become more difficult for our members to access their potential buyers directly. By partnering with the local ITS societies (through the signing of MOUs in many cases), we have been able to present our members to the appropriate governmental agencies with greater success. These useful contacts need to be maintained and this is done through our directors and the IBD Chair in their travel and also through online chats. After any successful mission, follow up efforts are critical to maintain the good will and relationship achieved. In many cases, incremental step-up efforts are required to capitalize on the business development effort expended to-date.

Based on the above, we will improve our IBD process in many aspects. We will continue to look for ITS society partners in economies with promising ITS markets and seek to enhance positions of our members through the signing of MOUs. Through conference attendance and incoming missions, we will render our members "easy to market."

Another concern is that not all technology companies, who may be able to help us in or benefit from our marketing effort, are our members. We should therefore reach out to local technology alliances in the various regions of Canada and make them partners in our IBD activities. Members of various technology alliances may strengthen the technology content of our trade missions. For this reason, we will enlarge our IBD scope to include partners from other Canadian groups who may be interested in our IBD activities. These may include local chambers of commerce, technology associations and business associations between Canada and a number of foreign countries.

At the same time, the Committee can provide valuable information to our members in various ways. With the help of foreign experts and Canadian trade commissioners we can appraise our members of the latest ITS technology trends, markets, activities and potential funding opportunities. By partnering with Canadian agencies such as the EDC and CCC and foreign organizations such as the Hong Kong Trade Development Council, we can assist new entrants into the export market in terms of project funding, risk assessment and foreign tendering regulations.

Involvement of the Public Sector. It should be recognized that it is not enough to work with the private sector alone. We have to seek ways and means to educate the public sector in the various economies where they can provide support and in turn end up with better systems and technologies. The Canadian public sector (our governments) can showcase our strategic projects to our foreign buyers while their foreign counterparts can help us by reducing protectionism and project risk by adopting proven technologies from Canada instead of asking local firms to develop similar ones. For example, a demonstration of an integrated traffic management system from jurisdictions across Canada in our Annual Meeting in Calgary in 2016 and subsequently in Montreal in 2017 impressed a large number of the delegates there, including many of our foreign guests.

In future missions, attempts will be made to invite our major municipality clients to travel with us, although public officials are not eligible for CanExport subsidies. Their presence can help us tremendously in marketing our services and products and providing testimonials of the benefit of our technologies.

Member Communications and Education. Through the IBD Committee, we will continuously seek input from our members and other interested parties. We have improved our communications framework with our members so that we can appraise them of our IBD activities, among other things, in a more detailed and timely fashion.

While communications are being improved, education opportunities should be considered. These may take the form of webinars to promote application of emerging technologies, market trend discussions with trade commissioners, and/or export workshops for SMEs. Providing maximum benefits to our members with a cost-effective approach will be the key in our future IBD activities.

Tactical Actions

To achieve the above IBD strategy and objectives, the following tactical actions will continue to be carried out:

- Market research – ITS Canada will continue to collect market intelligence and technology trends through our contacts with our sister societies and other stakeholders. The IMDUS conducted recently has provided a very useful update on the international marketplace and serves as a springboard from which to move forward.

- Member input – The IBD committee should canvass members regularly through face-to-face meetings or online chats to solicit ideas and comments on marketing plans and activities. The objective is to solicit feedbacks to ensure that maximum benefit is provided in a cost-effective manner.

- Marketing plans and activities - ITS Canada's 5-year IBD Strategy is designed for a 5-year period with an associated marketing program. The strategy is meant to cover all areas of the globe where we believe there are markets for our members, but due to limited resources, the IBDC incrementally diversifies its activities geographically and technically across the world. Typically, about 3 or 4 export trade missions are planned for each year. Also, an incoming mission for potential buyers may be organized every year.

The strategy is reviewed and modified at the end of each year to accommodate changes in the marketplace and the associated marketing program updated.

- International conferences – the key events essential for our marketing effort are the ITS World Congress, the ITS European Congress and selected conferences in Asia related to ITS, Smart City or logistics.

We use the annual ITS World Congress as our centrepiece and plan our export activities around it. The World Congress rotates among the North America, European and Asian regions from year to year and it turns out to be convenient for us. Following the World Congress, we can focus our effort from region to region every year, while incrementally enhancing our activities in each region.

- Piloting conferences – our conference attendance activities in each area are incrementally enhanced in the following manner:

  i. Exploratory missions by our staff, directors and/or members to network with the local ITS community to see if further contacts are beneficial.
  ii. Attendances at local conferences with small walk-the-floor contingents to gather intelligence on market prospects, network with potential partners, and assess strength of competitors.
  iii. Full attendance with in-booth exhibitions with concurrent or subsequent meetings with government officials and for business matching.

- Match making – the ITS Congress programs often contain match-making activities which are useful to our members. In some cases, we plan our own with the help of the local trade commissioner. Match making activities are sometimes included as part of our webinars with our sister societies.

- Networking – the IBDC continues to assist our exporting members in networking with potential partners and clients, whether face to face in conferences or remotely in webinars or by letters of introduction.

- Follow-up meetings with delegates – the ITS Congresses are attended by a large number of delegates from around the world. This provides us with the opportunities to arrange meeting with groups to follow up on trade discussions held in previous webinars and/or conferences. It is a very targeted approach and sometimes more effective than the congress itself.

- Trade commissioner support – the IBDC will continue to reach out to trade commissioners around the world to assist in matchmaking, networking and other marketing activities.

- Collaboration with others – if appropriate, we will cooperate with other organizations, including public sector agencies, NPO, ITS societies and local chambers of commerce.

- Information sharing – pertinent information obtained during our missions will be shared with all members by emails or via the ITS Canada websites. However, certain information collected by the participants themselves may be treated as confidential corporate data and will not be shared.

- The public sector as trade mission participant—consideration is being given to inviting public sector representatives to join some of our trade missions. They can provide testimonials on Canadian ITS solutions, thereby helping to influence the potential international clients. It should be noted that they are not eligible for CanExport subsidy.

Measurement of Results

The end game of IBDC is to help ITS Canada members realize international projects and increase their revenue. This performance will be tracked for lessons learned and evaluation of our IBD Strategy. However, as an association, we do not have control over our members' international business practice and their go- and no-go decisions but we can assist them incrementally in intermediate steps, including networking, partnership building and job prospecting. It is therefore important to evaluate our performance for every incremental step of our IBD activities. The performance measures include but are not limited to the following:

- Number of people networked
- Number of potential clients contacted
- Number of potential partners approached and secured

- Number of distributors sought and contracted
- Amount of job prospects

During each IBD activity, the participating members will be asked to keep track of performance measures such as the above and these data will be merged with those collected by the IBD Committee to enable us to continue to evaluate our performance, benefit from lessons learned, and improve our subsequent activities accordingly. It is understood, however, certain information will be regarded as confidential by the companies involved and will therefore not be disclosed. Aggregate information will be shared with all members through the ITS Canada website.

In addition to standard international marketing measurements discussed above, ITS Canada expects to achieve the following as an association:

1. Increased international membership
2. Increase in the number of ITS Canada members that upgrade from Corporate to Sustaining Corporate memberships
3. Growth in overall membership
4. International initiatives with Transport Canada, Industry Canada, Infrastructure Canada, other federal departments
5. International ventures with provincial agencies and ministries
6. International recognition through attendance by foreign delegations at our annual meetings.

These successes, once achieved, will return additional value to the membership at large, increase the revenue potential for member firms and strengthen ITS Canada's international reputation. Given the significant effort to mount export missions, it is very important for ITS Canada to carefully track the results and benefits of our IBD activities so that we can better judge its effectiveness and assess its value to not only our exporting members but also our membership as a whole.

FINAL RECOMMENDATIONS

In the future, our transportation systems have to be smart and integrated while focusing on the traveller's mobility. This is a very appropriate concept as ITS Canada moves forward as the hub of mobility technologies. It is also consistent with Transport Canada's 2030 Transportation Plan. The following is a list of recommendations for ITS Canada to consider in being a hub of support for our members:

Promotion of technologies:

- Continue to champion mobility technologies and serve as a mobility hub for our members and interested parties.
- As a mobility hub, promote the use of mobility technologies by conducting user education webinars featuring success stories of ITS enhancement using enabling technologies.

- Promote the use of AI, data analytics and the related data sciences (AIDA) as the channel for introducing disruptive technologies to improve ITS solutions by conducting workshops and webinars on AIDA topics.
- Provide a forum for the discussion of data issues, such as data sharing and open data policy.

ITS Requirements and Strategic Projects:

- Review the ITS requirements with appropriate agencies for feasibility of implementation.
- Expand descriptions of the selected strategic projects and discuss with appropriate agencies with respect to their potential of deployment.
- Discuss with Transport Canada and other government agencies on the funding for some of the strategic projects.
- The technical committees discuss the concept of mobility clusters as described in the report and the feasibility of transforming from the ITS architecture to mobility concepts.

ITS Industry Concerns:

Set up panels (or task forces) to discuss various concerns expressed by the ITS industry. The panels should be small and provided with a short time frame to deliberate the issues and develop mitigation measures. Four task forces are required to deal with following issues:

- Ways and means to alleviate or eliminate risk aversity of customers for ITS deployments, particularly with new technologies, and to increase the pace of deployments
- Tackling staff recruitment issues for various types of ITS companies, ranging from multi-nationals to SMEs and start-ups
- Identification of skill development requirements and corresponding training programs, including formal courses, technology workshops and user education webinars
- Review of various procurement issues, including bidding practices, technology selection, and communications between vendors and clients, and development of mitigating measures

ITS Export and IBD Activities:

- Continue to reach out to ITS societies around the world and establish cooperative and productive relationships with them. This may result in the signing of memoranda of understanding with some of them.
- Continue to facilitate webinars and virtual meetings with our sister organizations around the world to seek potential partners.
- Continue to reach out to Global Affairs trade commissioners around the world to obtain ITS market intelligence and keep them appraised of our IBD plans and activities
- Continue to provide support to our exporting members in networking with international partners and clients.
- Develop and execute a program to solicit international partners, such as ITS integrators and contractors, on behalf of the Canadian ITS industry, and support partnerships to pursue ITS work, not only in their home countries but also in other economies.

- Develop a priority program for the IBD strategy to support SMEs in international activities
- Conduct export training workshops and webinars, in cooperation with trade commissioners, foreign partners and Canadian agencies like Transport Canada, CCC (Canadian Commercial Corporation) and EDC (Export Development Canada). It should be carried out at least on a bi-annual basis.

In conclusion, ITS is alive and well around the world and can be improved significantly with the incorporation of new technologies, which are really all about the availability and manipulation of massive data for enhanced transportation solutions. In the future, our transportation systems must be smart and integrated while focusing on the traveller's mobility. ITS Canada has a strong role to play in this regard.

To maximize the benefit of the new technologies, an integrated strategy is required to mitigate challenges facing the Canadian ITS industry, accelerate the infusion of the emerging technologies to improve ITS solutions, and assist and support ITS Canada members in pursuing the international market. With periodic reviews and improvements of the strategy, the industry can be brought to a new height. It will excel in both the domestic and international ITS market, enhancing the performance of transportation systems in the world and improving the global environment while contributing significantly to economic growth and job creation in Canada ■