SURFACE TRANSPORTATION-RELATED TECHNOLOGICAL INNOVATION IN CANADA AND ABROAD;

An International Assessment Conducted for the Canadian Transportation Act Review Secretariat

Prepared on Behalf of ITS Canada

by

Brendon Hemily, Ph.D.

27 March 2015

DISCLAIMER

This report reflects the views of the author only and does not reflect the views, policies or programs of the staff or management of ITS Canada, the Canadian Transportation Act Review Secretariat or Transport Canada.

Neither ITS Canada, the Canadian Transportation Act Review Secretariat or Transport Canada, nor its employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy or completeness of any information contained in this report, or process described herein, and assumes no responsibility for anyone's use of the information. None of the above organizations are responsible for errors or omissions in this report and make no representations as to the accuracy or completeness of the information.

Transport Canada does not endorse products or companies. Reference in this report to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not constitute or imply its endorsement, recommendation, or favoring by Transport Canada and shall not be used for advertising or service endorsement purposes. Trade or company names appear in this report only because they are essential to the objectives of the report.

References and hyperlinks to external web sites do not constitute endorsement by Transport Canada of the linked web sites, or the information, products or services contained therein. Transport Canada does not exercise any editorial control over the information that may be found at these locations.

SURFACE TRANSPORTATION-RELATED TECHNOLOGICAL INNOVATION IN CANADA AND ABROAD;
An International Assessment Conducted for the Canadian Transportation Act Review Secretariat

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Given Canada's geography, transportation has always been critical to the Canadian economy and to the wellbeing of its citizens. The transportation companies, whether private or public, tend to be dominated by an operating focus, and the transportation industry is rarely perceived as "high-tech". And yet, transportation, as with all aspects of our society, is increasingly affected by technological developments and public expectations. In fact technology is one of the increasingly important drivers of innovation for the transportation industry, and innovation is the engine for improved efficiency and effectiveness.

However, innovative technology requires extensive Research and Development (R&D), and also adoption / deployment. Unfortunately, the Conference Board of Canada ranks Canada very poorly internationally in terms of R&D in general, and gives it an overall grade of "D", ranking it 13th among 16 peer countries.

The question with respect to the Canadian Transportation Act Review (CTAR) is whether the situation is any different with respect to Canadian involvement in *transportation* technology. Questions to ask might include:

- How is Canada positioned with respect to transportation technology?
- How does it compare to the situation in peer countries?
- What useful observations and lessons learned can one gather from the situation in other countries and the strategies and initiatives they have pursued?

As a result, the CTAR Secretariat has asked ITS Canada to conduct a high-level strategic assessment. ITS Canada is the forum for bringing together Canadians with the application of advanced technology in transportation, and has a wide network of interactions with similar-minded organizations around the world.

The scope of the assessment was the application of advanced technology in surface transportation with a special focus on roads, trucking, buses, and rail to a limited degree. It did not include aviation or shipping.

The methodology included an extremely extensive identification and review of organizations, web sites, resources, and documents in Canada, the U.S., Australia, the Netherlands, and the European Commission. The organizations were classified into various categories based on their role with respect to technology policy, research, development, deployment and adoption. Individual web sites were reviewed to determine the types of activities and projects they were involved in, the degree of involvement, as well as the availability of documents or other resources. The research then compared peer organizations in different countries to enable a comparative international assessment of activities and degree of involvement by organizations.

The analysis of organizations and resources, and international comparative assessment, were supplemented by select interviews with experts.

OBSERVATIONS

Observations from the research can be summarized along five themes:

- Importance of Transportation Technology
- Important Role of Public Sector in Transportation Technology R&D

- Various Approaches that Exist to Encourage and Structure Transportation Technology Research and Development
- Importance of Knowledge Dissemination to Encourage Technology Adoption, and
- Importance of Professional Capacity Building to Encourage Technology Adoption

Importance of Transportation Technology

There appears to be a universal recognition, in countries small and large that technology plays an immense role in addressing various economic and societal challenges, and that the future of developed societies will be driven by continuous technology development, and its adoption by private and public practitioners.

The benefits to be derived from investment and / or facilitation of research, development and deployment of transportation technology relate to:

- Enhanced safety and security,
- Improved mobility for persons;
- Improved mobility of goods,
- Environmental benefits,
- Improved accessibility for disadvantaged persons,
- Improved productivity through innovation, and
- Economic growth through jobs development in an increasingly competitive world.

These are described in some detail in Chapter Two on "Why Transportation Technology?". Many of the identified benefits directly support topics of concern for the Canadian Transportation Act Review.

In addition, many organizations advocate the need for being prepared for the coming of disruptive technologies that will affect transportation in particular, including Big Data and Automated / Autonomous Vehicles.

This recognition appears to have existed in Canada at the early stages of development of Information and Communications Technologies deployment in transportation, but is not as evident in Canada today at the level of the national government. And this lack of recognition of the critical importance of technology exists despite recent calls for action by entities such as the Conference Board of Canada. At the provincial level, there appears to be anecdotal evidence of policy interest and initiatives, but these are difficult to measure because of a lack of documentation and knowledge dissemination, and the degree of interest seems to vary enormously from Province to Province.

Important Role of Public Sector in Transportation Technology R&D

It is evident that the private sector is a prime stakeholder in developing technology, whether through large multinational corporations or small high tech start-ups.

However, at the same time, it is evident that countries small and large perceive that technological development cannot rely uniquely on the market, and that governments must play a critical role in shaping the framework for research, development, and even adoption through the establishment of well thought-out and widely discussed policy frameworks.

The U.S. and the European Commission have devoted enormous resources to developing and implementing transportation research, development and deployment.

However, even individual smaller countries, such as the Netherlands, the UK, Australia, and Singapore, have invested impressive efforts to develop frameworks for transportation technology R&D, as well as interoperability standards that will guide the development and adoption of technology for years to come.

The Canadian government, and most Provincial Governments with some exceptions, such as New Brunswick and Ontario, are showing little leadership that would help:

- Systematically build the public private partnerships,
- Frame the discussions and develop a shared vision among stakeholders,
- Structure activities through strategic plans,
- Develop coherent and continuous technology R&D frameworks,
- Coordinate the development and application of architectures and standards,
- Monitor developments,
- Conduct pilot projects to test potential technologies, and
- Promote the adoption of technology by potential private and public users through widespread knowledge dissemination.

Various Approaches Exist to Encourage and Structure Transportation Technology Research and Development

The research has observed that there are many different approaches to encouraging transportation technology R&D.

The U.S. illustrates the widest variety of approaches to stimulating R&D, many of which involve R&D directly sponsored by the Federal government. Examples include:

- Academic research
- Government and affiliated research facilities
- Federally-sponsored University Transportation Centers
- Federally (and some state) sponsored research projects by independent research centres, consultants, associations, universities, etc.
- Federal competitive requests for consortium proposals for pilot projects or model deployments, involving researchers, industrial partners, universities, and state or local deployment agencies
- Federally-funded national cooperative research programs for highways, rail, transit, freight, administered by the non-profit Transportation Research Board of the Academy of Sciences.
- Pooled research among state DOTs
- Association-managed research centres (i.e. the rail Transportation Technology Center operated by the Association of American Railroads)
- Programs to sponsor private-sector technology development (e.g. Small Business Innovation Research, Defense Advanced Research Projects Agency)

However, other innovative models exist as well:

- Europe's R&D programs (Horizon 2020, FP7, DRIVE) force researchers and developers (university and industrial) to partner with technology adopters (national or local governments, private or public transport companies, etc.) to address the whole chain of research, development, and deployment.

- NICTA in Australia, is a consortium of university laboratories that pool expertise and create international-caliber synergy in cutting edge Information and Communications Technologies applications.
- Innovate UK, is a quasi-autonomous non-governmental organization (quango) that structures and promotes consortiums of expertise (university, consulting, and industrial); three of the networks relate directly to mobility-related technology.

In comparison, Canada seems content to “follow on the coat tails” of our U.S. counterparts, and not invest in similar R&D catalytic activities.

Academic research is important as a continuous stimulus for the development of technology and the analysis of the challenges in its effective utilization. Canadian academics are quite competitive internationally, on an individual basis. They however lack the support one finds in other countries in terms of networks that create synergy (e.g. the University Transportation Centers in the U.S., the Transportation Operations Research Groups and Innovate UK's Knowledge Transfer Network, European Commission R&D programs). They are also less proficient in terms of disseminating the knowledge derived from applied research projects to the greater community.

Importance of Knowledge Dissemination to Encourage Technology Adoption

U.S. institutions (government agencies, universities, associations, etc.) seem to have a natural inclination to promote dissemination of knowledge. Provision of detailed information, descriptions of projects, and free links to the actual reports is the norm across the board, and the number of web sites is almost overwhelming.

U.S. dissemination of R&D results is supplemented by an aggressive program of "Professional Capacity Building" with documentation of benefits, costs, lessons learned, and webinars and training course materials, available in the majority of cases for free.

European Commission institutions have also made recent progress in improving public dissemination of knowledge concerning their R&D initiatives through the centralized Transport Research & Innovation Portal and Eltis urban mobility dissemination portals, as well as through a myriad of web sites devoted to the hundreds of projects they have funded over the last two decades.

European Transport Research & Innovation Portal

Although less effort is devoted to knowledge dissemination in smaller countries, an institution such as Austroads in Australia offers a remarkable repository of information, reports, and guidebooks, all publicly available for free.

Universities in the U.S. place great emphasis on the dissemination of knowledge concerning their applied technological research projects, but one sees more variability in the quality of dissemination by universities in Europe and Australia.

In contrast, most Canadian institutions, and in particular government agencies and universities, appear to have little natural inclination to systematically build dissemination into their practices.

There appears little current interest or effort related to the dissemination of knowledge on Federal web sites today. For example, those web sites related to transportation technology and R&D provide minimal public information, and are universally out-of-date. There are few descriptions of Federally-funded projects, and some significant ones, such as the ACTIVE-AURORA and NSERC-DIVA R&D networks, merit no mention at all. There is not a single report

of pertinent Federally-sponsored studies that can be downloaded from the Transport Canada web site.

In most cases, web sites by Provincial agencies are only marginally better, with some exceptions, such as New Brunswick.

As for universities, dissemination is clearly focused on the traditional approach used to share academic research through peer-reviewed academic journals. These have no impact on potential private company or public agency innovation adopters since they do not read, nor have access to these academic journal articles. As for more applied sponsored research, in many cases projects are only briefly described, if at all, and reports are not provided or even listed. The comparison and differences between Canadian and U.S. University web sites is striking.

Trade associations remain the main mechanism for dissemination in Canada, though it should be noted that much of their information is exclusively available to their members.

In that respect, it should be noted that the ITS World Congress is coming to Canada (in Montreal in 2017) and is being jointly hosted by ITS Canada and ITS America. This is the pre-eminent forum for sharing knowledge concerning the cutting edge of transportation technology and discussing its implications. It is hoped that Canadians will rise to the occasion, contrary to what happened in 2014 in Detroit, where Canadian representation among the world's experts was half of that of peer countries like the UK and Australia, even though the Congress was on our doorstep compared to others coming from around the World.

Importance of Professional Capacity Building to Encourage Technology Adoption

Given the natural human resistance to change, adoption of innovative practices and new technology is difficult under the best of conditions. It is much easier to encourage the adoption of new technology directly by consumers, than it is to persuade private companies requiring a clear return on investment, or risk-adverse and resource-poor public sector organizations. Encouraging technology adoption therefore requires dissemination of knowledge to potential adopters about the technology developments themselves, but also about the potential benefits to be derived from technology adoption.

However, encouraging technology adoption must go beyond mere dissemination, to a more comprehensive approach that in the U.S. is called "Professional Capacity Building (PCB)". This is a major thrust of the U.S. DOT, and includes a wide range of efforts and mechanisms, including sponsoring or organizing professional development courses, webinars, wiki-style knowledge communities, peer-to-peer exchange programs, etc.

Such efforts are aimed at ensuring that potential adopters are not only familiar with, but have the skills necessary to assess and deploy technology, and thereby encourage technology adoption by private and public organizations.

It may be that for a small country such as Canada, which cannot afford the level of technology R&D investment of the U.S. and the European Commission, it is even more important to maximize the effectiveness of its small and targeted investments through extensive and more effective efforts aimed at disseminating knowledge and encouraging the adoption of innovation through professional capacity building.

CONCLUSIONS

With respect to the original question being asked by the CTAR Secretariat, Canada would appear to be a laggard in terms of transportation technology research, development, deployment, and adoption, and even more so with respect to its future prospects in a highly competitive technology world.

At a very high level, one can make the following characterizations:

- The U.S. and the Europe Commission are both pursuing absolutely all steps of the technology development cycle (e.g. R&D policy frameworks and plans, standards, research projects, development, pilot projects, dissemination of knowledge, support for deployment and adoption, etc.), and are doing so in a variety of ways. There are slight variations, with the U.S. having separate processes and initiatives for the different steps of the cycle, while Europe tends to bundle research, development and deployment into multi-country, multi-stakeholder, partnerships. The U.S. also appears to place more emphasis on government-sponsored training and professional capacity building.
- The Netherlands takes full advantage of European projects to enhance its interoperability with European projects and systems, but also pursues a large number of projects on its own, in order to increase safety and mobility at the national, regional, and local levels.
- The UK appears to be investing less in projects to encourage deployment and adoption today, but rather focusing aggressively on building a competitive industrial future based on automated and autonomous vehicle technology. This involves a national review of the regulatory environment and the launch of a large and competitive program, funded by significant public and private funding, to stimulate public / private partnerships of universities, industrial partners, and consultants.
- Australia is somewhere in between, trying to capture near-term benefits through the dissemination of technical reports to encourage adoption, but also through the development of a comprehensive policy framework to encourage interoperability and to stimulate markets in the future.

Canada in contrast, appears to be mostly coasting along, still benefitting from investments made ten to fifteen years ago in transportation technology R&D. These resulted in some successful commercial successes in the private sector (e.g. Weigh in Motion), and the early adoption of a number of advanced technologies by some governmental agencies (e.g. Weigh-in-Motion, Rural Weather Information System, Advanced Traffic Management Systems).

It is also benefitting from its academic institutions that have a solid international quality, and are relatively well funded by the Research Councils. These have been enhanced in the past by ad-hoc publicly sponsored applied R&D projects. There has however only been minimal large investment of this type in recent years (i.e. the ACTIVE-AURORA and NSERC DIVA University-based R&D network projects)

However, Canada is very poorly positioned for a future that will be characterized by disruptive technologies (e.g. Big Data, Internet of Things, Connected Vehicles, Automated and Autonomous Vehicles, Mobility as a Service, etc.), and already sees a very high level of international competition in their development and deployment.

Canada lacks:

1. Solid and collaborative public-private forums for discussion of the many complex policy challenges raised by future transportation technologies,
2. Any discussion of a vision for technology development and adoption,
3. A process to assess the regulatory and standards implications and needs related to future connected and automated / autonomous vehicle technologies,
4. Coordinated efforts to plan and conduct transportation technology research, development, and deployment activities, and
5. Any significant coordinated efforts at dissemination of knowledge, or building the human professional capacity to assess, adopt and effectively use transportation technology. .

This is in stark contrast to both large entities like the U.S.A and the European Commission, but also even to similar or smaller-sized nations such as Australia, the Netherlands, the United Kingdom, or Singapore as is evident from a scan of the Appendix; an enormous number of organizations have been identified as engaged in the development and adoption of transportation technology around the world, which have created considerable resources for the benefit of their national stakeholders.

The risks for Canada to continue along a "Do-Nothing" path are several-fold:

- Private companies and government agencies are adopting technology at slow rates, and are thus not benefitting from the numerous benefits that are being achieved in other countries. There are few efforts in Canada to encourage and support the adoption of transportation technology, and this is in great contrast to comparable countries, large and small, deploying considerable efforts.
- As a result, Canadian society is not benefitting from the safety, security, environmental, efficiency, mobility, and accessibility benefits that could result from greater adoption of technology.
- Private firms are not achieving the productivity to be gained from technology adoption, and this will over time decrease their competitiveness with respect to international competitors.
- The technology being purchased and deployed in Canada is increasingly foreign-made. Canada has few, if any, multinational transportation technology firms creating jobs. Industrial market benefits will only accrue from a continuous stream of creation of small high-tech start-up firms, but there is little, or no, support for sharing the risks and costs for these firms in Canada. Competitor countries are, on the contrary, developing comprehensive frameworks to support the continuous development of technology innovation, in some cases, such as in the UK and Australia, explicitly in an effort to build an internationally competitive industrial market for the future of automated vehicles. Canada is gradually foreclosing on such future markets.
- The lack of transportation technology adoption, policy, and forums for discussion leave it at a great disadvantage, compared to other countries, if the future is truly likely to be one characterized by *disruptive* technologies, as an increasing number of experts are suggesting.

However, Canada has a solid foundation in the field of transportation on which to build if it so desires. Hopefully, an environmental scan at what is happening in most developed countries will encourage a rethinking in Canada that will lay the foundation for a future that seizes opportunities and addresses the challenges of an increasingly technological-driven future in the realm of transportation.

1. INTRODUCTION

1.1. BACKGROUND

On June 25, 2014, the Honourable Lisa Raitt, Minister of Transport launched a statutory Review of the *Canada Transportation Act*. The Act is the umbrella economic legislation for Canada's national transportation system.

The mandate of this Review stems from section 53 of the *Canada Transportation Act* (PDF version) which requires a comprehensive review of the operation of the Act and certain other acts pertaining to the economic regulation of transportation. The Review will be guided by the Terms of Reference which establish the scope for the Review. One of the specific issues to be assessed by the Panel relates to technology:

> *how technological innovation can contribute to improvements in transportation infrastructure and services;*

Given Canada's geography, transportation has always been critical to the Canadian economy and to the wellbeing of its citizens. The transportation companies, whether private or public, tend to be dominated by an operating focus, and the transportation industry is rarely perceived as "high-tech". And yet, transportation, as with all aspects of our society, is increasingly affected by technological developments and public expectations. In fact technology is one of the increasingly important drivers of innovation for the transportation industry, and innovation is the engine for improved efficiency and effectiveness.

However, innovative technology requires extensive research and development (R&D), and also adoption / deployment. Unfortunately, the Conference Board of Canada ranks Canada very poorly internationally in terms of R&D in general, and gives it an overall grade of "D", ranking it 13th among 16 peer countries (see Exhibit 1).

The question with respect to the Canadian Transportation Act Review (CTAR) is whether the situation is any different with respect to Canadian involvement in *transportation* technology. Questions to ask might include:

- How is Canada position with respect to transportation technology?
- How does it compare to the situation in peer countries?
- What useful observations and lessons learned can one gather from the situation in other countries and the strategies and initiatives they have pursued?

As a result, the CTAR Secretariat has asked ITS Canada to conduct a high-level strategic assessment. ITS Canada is the forum bringing together Canadians with the application of advanced technology in transportation, and has a wide network of interactions with similar-minded organizations around the world.

Exhibit 1. Conference Board of Canada: Canada's International Ranking on Innovation

How Canada Performs: International Rankings-Innovations, Conference Board of Canada, 2015
< http://www.conferenceboard.ca/hcp/details/innovation.aspx>

- International Ranking of Canada on Innovation: "D"
- Despite a decade or so of innovation agendas and prosperity reports, Canada remains near the bottom of its peer group on innovation, ranking 13th among the 16 peer countries.
- Countries that are more innovative are passing Canada on measures such as income per capita, productivity, and the quality of social programs.
- So far, there are no conclusive answers—or solutions—to Canada's poor innovation ranking.

The Conference Board defines innovation as a process through which economic or social value is extracted from knowledge—through the creating, diffusing, and transforming of ideas—to produce new or improved products, services, processes, strategies, or capabilities.

Countries with the highest overall scores have successfully developed national strategies around innovation, giving them a substantial lead over their peers in one or more areas. Ireland has seen enormous success as a host for leading innovative companies. The U.S. fosters a combination of top science and engineering faculties, broad and deep capital markets, and an entrepreneurial culture. Japan is committed to efficient manufacturing and new product development. Switzerland, the top-ranked country this year, is a leader in the pharmaceuticals industry.

Canada is well supplied with good universities, engineering schools, teaching hospitals, and technical institutes. It produces science that is well respected around the world. But, with some exceptions, Canada does not take the steps that other countries take to ensure research can be successfully commercialized and used as a source of advantage for innovative companies seeking global market share. Canadian companies are thus rarely at the leading edge of new technology and too often find themselves a generation or more behind the productivity growth achieved by global industry leaders.

Canada is well supplied with good universities, engineering schools, teaching hospitals, and technical institutes. It produces science that is well respected around the world. But, with some exceptions, Canada does not take the steps that other countries take to ensure research can be successfully commercialized and used as a source of advantage for innovative companies seeking global market share. Canadian companies are thus rarely at the leading edge of new technology and too often find

1.2. OBJECTIVES AND SCOPE OF THE INTERNATIONAL ASSESSMENT

The objectives of this research project is to address the following issues:

- Taking into account transportation-related technological innovation trends, is Canada a global leader or laggard, including with respect to implications for safety, efficiency and operation costs?
- Conduct an environmental scan on at least three, and up to five countries, as best practices for Canada to model after. Identify any strategies used in the leading countries on technological innovation that contributed to their successes.

The scope of the assessment was the application of advanced technology in surface transportation with a special focus on roads, trucking, buses, and rail to a limited degree. It did not include aviation or shipping.

In terms of technology, the primary focus involved the intersection of Information and Communications Technologies and transportation, involving such technologies as: wireless communications, real-time location monitoring, data capture technologies, real-time information services and devices, connected vehicles and infrastructure, automated and autonomous vehicles, etc. These are often referred to collectively as Intelligent Transportation Systems (ITS).

The scope did not include mechanical engineering, advanced materials, and propulsion technologies, though "green technologies" were peripherally included since they often interact or require Information and Communications Technologies and ITS. It should be noted that a parallel study being conducted for the CTAR is focusing on the Greening of the Supply Chain.

1.3. METHODOLOGY

The methodology included an extremely extensive identification and review of organizations, web sites, resources, and documents in Canada, the U.S., Australia, the Netherlands, and the European Commission. The organizations were classified into various categories based on their role with respect to technology policy, research, development, deployment and adoption. Individual web sites were reviewed to determine the types of activities and projects they were involved in, the degree of involvement, as well as the availability of documents or other resources. The research then compared peer organizations in different countries to enable a comparative international assessment of activities and degree of involvement by organizations.

The analysis of organizations and resources, and international comparative assessment, were supplemented by select interviews with experts.

Altogether, this provided a basis for assessing Canada's position with respect to the development and adoption of transportation technology in Canada, and to compare it to what was observed in other comparable countries

The Outline of the Report is as follows:

- Why Transportation Technology?
- Stimulating Technology and Innovation Through Research, Development, and Deployment
- Canadian Transportation Technology Assessment
- Comparison with Transportation Technology Abroad
- Summary of Observations
- Conclusions

The Appendix provides a comprehensive catalogue of the extensive resources that were identified and their web location (where possible), and provides some brief descriptions and commentary that were input into the assessment. It should be a valuable resource in its own right for anyone interested in transportation technology.

2. WHY TRANSPORTATION TECHNOLOGY?

The development and adoption of technology requires financial and human resource investments and also causes change, which can be uncomfortable for operations-driven companies and agencies that tend to rely on Standard Operating Procedures that create reliability and predictability for their customers.

So the question should be asked of why invest in transportation technology? This section will explore some of the benefits that can be addressed through technological innovation.

2.1. BENEFITS

2.1.1. Improved Safety and Security

The first area of benefits that may be addressed through technological innovation relates to safety and security. This is a major focus in many countries.

In developed countries there has been a gradual decline in the last decades of the number of accidents, injuries, and fatalities. Part of this results from safer design of vehicles, promotion and stricter enforcement of seatbelt laws, and more recently a slight decline in the number of vehicle kilometers driven. The numbers remain nonetheless of concern. According to Transport Canada, there were 2,209 traffic-related fatalities and 11,451 serious injuries in 2009. In the U.S., the number is approximately 30,000 fatalities.

These statistics have been decreasing slowly but seem to have reached a plateau, and in some categories have been actually increasing. According to 2012 statistics of the U.S. National Highway Traffic Safety Administration:

- Large-truck occupant fatalities increased for the third consecutive year (8.9 percent over 2011).
- Motorcycle rider fatalities increased for the third consecutive year (7.1 percent increase over 2011).
- Fatalities among pedestrians increased for the third consecutive year (6.4 percent increase over 2011).

In addition, distracted driving has become a major challenge, and a recent report indicates that people who aren't paying attention while they drive are now the number one cause of fatal vehicle accidents in Nova Scotia. And the problem applies equally to both commercial and passenger vehicles. Incorporating non-distractive consumer technology into the design of the vehicle itself may be one technological solution for this challenge.

The general international consensus is that the decline of traffic fatalities and injuries has slowed down and that we have reached a plateau that cannot be reduced without a paradigm shift, and that technology may offer such an avenue. According to U.S. DOT, if widely deployed, Vehicle-to-Vehicle (V2V) technologies could provide warnings to drivers in as much as 76 percent of potential multi-vehicle collisions involving at least one light vehicle, such as a passenger car [General Accounting Office, 2013].

Another area where technology has been used to enhance transportation safety concerns the development and deployment of Rural Weather Information Systems. These constitute micro-

scale weather stations that report localized conditions that can save lives in the harsh winter conditions that Canada experiences. Canada was one of the pioneers of this technology 10-15 years ago, and through a partnership of Environment Canada, Transport Canada, and the Provinces, deployed a Rural Weather Information System network across the country. It continues to play an important role, and is very pertinent to future developments in Northern Canada.

Technology is also increasingly being systematic incorporated into Emergency Response Planning. Advanced traffic management technologies were used for example in transforming expressways into uni-direction exit pathways, building thereby a more organized and rapid response for evacuation during Hurricane Katy in Houston.

In addition to safety, technology can also serve to benefit security of transportation services. Video surveillance is increasingly prevalent. On highways, surveillance cameras linked to Transportation Management Centres enable the rapid identification of incidents and accidents, which in turn enables the rapid dispatch of emergency services where reduced response times saves lives as well as reduces time to restore operations. Similarly, surveillance cameras in train and rail transit stations, and on-board buses, often are valuable in determining events and apprehending felons. More advanced automated visual recognition systems are being used in Paris and other world cities to monitor prohibited movement such as tunnel intrusion.

2.1.2. Improved Mobility for Persons

A second focus area that can significantly benefit from technological development and adoption concerns improved mobility for persons.

Congestion continues to grow, and the personal and societal costs in terms of lost time and productivity are staggering:

- A 2008 Metrolinx study estimated the costs of congestion for the Greater Toronto Hamilton Area to be $6 Billion per year [Metrolinx, 2008]
- More recent studies form the C.D. Howe Institute, using a more comprehensive methodology including the cost of urban agglomeration benefits, estimates the economic cost of congestion in the Toronto area to be $7 to 11 Billion per year [C.D. Howe Institute, 2013], and for Metro Vancouver to be between $500 Million and 1.2 Billion [C.D. Howe Institute, 2015]

And congestion affects not only automobile traffic, but also contributes greatly to the unreliability of surface public transportation modes, making alternatives less attractive.

However, the 2012 report of Urban Transportation Technology Task Force Urban Transportation Task Force of the Council of Ministers Responsible for Transportation and Highway Safety commented on the role of technology, and in particular ITS, as one potential method to address congestion:

Intelligent Transportation Systems (ITS)

Intelligent Transportation Systems collect, process, and disseminate information to users across transportation networks in order to improve efficiency and safety. ITS takes into consideration the dynamic interaction of all components of a transportation system: passenger, driver, vehicle, and infrastructure. There are multiple applications for both roads and transit. In the case of transit, it can include transit information systems, such as real time schedule information and integrated ticketing systems. On highways, commonly used examples are traveller information systems, such as traffic cameras and signage to provide information on traffic conditions. ITS can also be used for road pricing schemes such as congestion charges or tolls. The use of ITS to actively manage traffic incidents can also reduce congestion. [UTTF, 2012]

2.1.3. Improved Mobility of Goods

Transportation technology benefits not only the mobility of persons, but the mobility of goods as well. Any reduction in general levels of congestion will of course benefit the movement of goods as well, but there are several areas where transportation technology has been targeted specifically to address productivity challenges related to the movement of goods. Examples include accelerated border crossing through electronic pre-clearance, and Weigh in Motion. Canada was a pioneer in R&D in both areas.

Given the high percentage of Canada's economic activity that is transported by trans-border trucks, and the considerable delays that are often caused by the heightened need for security since 9-11, transportation technologies can play an important role in reducing the impact in terms of unproductive time at border crossings. Technology solutions exist and continue to be discussed by the Joint Canada-U.S. Regulatory Cooperation Council.

Weigh-in-Motion is another technology aimed at reducing unproductive time for trucks. Canada has also been a pioneer in this technology through R&D partnerships between the Federal government and industrial technology suppliers. Deployment of this technology has yielded significant benefits as indicated by the assessment of a single Weigh-in-Motion site in New Brunswick (See Exhibit 2)

Exhibit 2. Benefits of Weigh-in-Motion Technology from New Brunswick Site

http://www2.gnb.ca/content/gnb/en/departments/dti/trucking/content/weigh-in-motion.html

Four Weigh-in-Motion systems on the Trans-Canada Highway (Routes 1 and 2) are increasing efficiency for the trucking industry by reducing the number of weight compliant vehicles required to exit the highway and report to the scales. These systems are jointly funded by the Governments of Canada and New Brunswick.

Trucks approaching these systems are now required to use the right hand driving lane. Loops embedded in the roadway track the movement of each vehicle through the system. The system registers a vehicle's weight and axle configuration, as well as other information, as it travels over the Weigh-in-Motion scale at highway speed.

An evaluation of the Longs Creek site indicates that approximately **$600,000 per year is saved by the commercial trucking industry as the number of trucks required to report to the scales has been reduced by approximately 55 per cent.**

Technology has also served greatly to monitor compliance with hours of service requirements and pre-clearance of hazardous materials transportation. In the longer term, even greater benefits from more advanced concepts such as signal priority for trucks at critical intersections and automated platooning of trucks, possibly in dedicated lanes or highways, which would be used to create "truck trains".

Need to say that this area is stalled now as R&D incentives from government has ceased and Canada risks losing its lead.

2.1.4. Environmental Benefits

Transportation technology can also serve various environmental benefits including reduced energy consumption, increased use of alternative energy (green energy), and improved air quality from reduced congestion.

In fact the environment is the third pillar of the major effort in ITS, after safety and mobility by the U.S. Department of Transportation (U.S. DOT). It is also inherent in Canada's participation in the Regional Cooperation Council, where one of the action items is to *introduce measures for reducing energy consumption and costs per unit of transport service*;

2.1.5. Enhanced Accessibility for Disadvantaged Persons

Enhancing accessibility for persons with physical disadvantages is a major societal concern, and one of the explicit focus areas for the Canadian Transportation Act Review. Technology offers new opportunities to increase accessibility. For example, the U.S. DOT has recently launched a major initiative to explore the potential offered by technology in this regard, called the Accessible Transportation Technology Research Initiative (see Exhibit 3).

Exhibit 3. Accessible Transportation Technology Research Initiative

The Federal Highway Administration (FHWA) and the Federal Transit Administration are co-leaders of the **Accessible Transportation Technologies Research Initiative** (ATTRI), which aims to enable independent mobility of travelers with disabilities through the use of intelligent transportation systems (ITS) and other innovative technologies.

Supported by the ITS Joint Program Office and the National Institute on Disability and Rehabilitation Research, the initiative focuses on the needs of three stakeholder groups: people with disabilities, veterans, and older adults. Targeting four functional disabilities—visual, hearing, cognitive, and mobility—ATTRI is working to develop technological solutions to remove barriers to mobility and independent travel.

To improve mobility and independent travel, ATTRI solutions will leverage advances in vehicle- and infrastructure-based technologies, automation, robotics, and wireless communication. ATTRI will focus on the following five technology areas: wayfinding and navigation; assistive technologies; automation and robotics; data integration; and enhanced human service transportation. In fiscal year 2015, ATTRI will be requesting information about potential applications in these areas for further development.

Examples of Technology Solutions for consideration:

- **Technology that helps people feel more secure about riding transit / Travel Assistance Device**
  - Mobile application that uses GPS technology to prompt riders with real-time audio messages, visual images, and vibration alerts to prompt a rider to take action
  - Alerts can be given for arrival of transit, upcoming stops, time to pull stop request cord, and arrivals at final destinations
- **Crowdsourcing Application**
  - Mobile application that crowdsources routes and associated data to and from transit stops and locations
- **Integrated Transportation Clearinghouse**
  - Smart phone application that uses location services to display all local transportation information. The application would connect the user to a database of all public and private transportation services
- **Crosswalks for those with limited mobility**
  - Crosswalks with accessible information about the length of time to cross, remaining time to cross, and which direction can be crossed at any given time.
  - Pedestrian walk times need to also better accommodate all types of people
- **Shared Rides with Ride Scheduling / Alert System**
  - Use technology to enable riding sharing program that matches disabled people with organizations providing rides

2.1.6. Improved Productivity Through Innovation

Technology stimulates innovation and creates the opportunity to improve productivity through a review of internal business processes. Technology offers private companies and public agencies not only the ability to carry out new tasks, but also to do things differently. Some examples include:

- Private truck companies can use wide-range communication systems and real-time information of traffic and road conditions to adjust management of just-in-time delivery fleets and truck loads.
- Deployment of technology (e.g. road surveillance cameras and sensors, changeable message signs, etc.) enables management of Transportation Management Centres to

review how they design the tasks and procedures of traffic monitoring staff, and how best to deploy standby tow trucks and response units.
- Snow removal can be conducted more scientifically by monitoring road conditions with more sophisticated sensors, dispatching snow ploughs and salt trucks where they are needed in real-time, adjusting salt spreading levels, tracking performance, etc.
- Transit systems can monitor in real time from a central location safety and security incidents, and adjust accordingly how they deploy field supervisors, standby buses, etc.

2.1.7. Economic Growth Through Jobs Development

Technology development stimulates job growth, both through domestic adoption, but also through exports. The stakes are significant.

For example, NRCan in its Electric Vehicle Technology Roadmap for Canada (NRCan, 2009) identifies some of the threats that could result from a lack of investment in technology:

1. *The US automotive industry could move out of Ontario.*
2. *We will be passed by efforts in the US and elsewhere and relegated to consumer status in the automotive world.*
3. *Canadians are lulled by current low prices of fossil fuels and see no urgency to move to EVs.*
4. *Support for other fuels could continue at a relatively high level and preempt support for development of the EVs that are the focus of this Roadmap.*

Advanced technology is one of the core mechanisms for stimulating high-tech start-up firms that create well-paid jobs. This is recognized by the most developed and emerging countries, and is creating high levels of international competition (see Exhibit 4).

Exhibit 4. European Statement on Innovation and competitiveness

http://ec.europa.eu/research/transport/priorities/innovation_and_competitiveness/index_en.htm

With competition from emerging economies intensifying, innovation and high tech knowledge are needed to maintain Europe's competitiveness. In transport, this means using research to ensure sustainable, efficient and affordable transport services and to develop new skills and job opportunities.

Research priorities

- *Develop new generations of transport products that are highly competitive, emit less CO_2 and other pollutants, and are tailored to customers' expectations.*
- *Create new niche markets for high technology added value products and services and take full advantage of eco-innovations.*
- *Improve the quality and competitiveness of surface transport services considering features such as price attractiveness, environmental friendliness, punctuality, frequency, real time information or leisure and work during travel time*
- *Drastically reduce maintenance and inspection costs*
- *Sustain economic development in Europe, create job opportunities and technology skills, with special focus on green technologies.*
- *Promote the start-up and emergence of new high-tech Small and Medium Sized enterprises.*

2.1.8. The Concept of Disruptive Technology

There is a growing discussion around the world that technology is bringing about societal changes that will no longer be evolutionary, but both revolutionary and "disruptive". Examples include:

- The Internet of Things,
- Big Data,
- Mobility as a Service, and
- Automated and Autonomous Vehicles

Although all three of the above trends will impact transportation, Automated / Autonomous Vehicles has been the primary focus in the transportation community around the world.

The Conference Board of Canada has in fact just published in January 2015 a significant report entitled **Automated Vehicles: The Coming of the Next Disruptive Technology**. This report intends to be a call to action (see Exhibit 5).

Exhibit 5. Conference Board of Canada Report on Automated Vehicles

http://www.conferenceboard.ca/e-library/abstract.aspx?did=6744

The arrival of automated vehicles (AVs) is imminent. And, the first generation of AVs is already with us. Google has—as part of its "Chauffeur Project"—rolled out prototype AVs in California and elsewhere. And, there are numerous other developments in the U.K., Singapore, and other countries that are speeding-up the development of AVs. However, Canada needs to keep pace with this rapidly evolving technology. AVs have the potential to bring immense benefits—particularly saving us time and reducing the number of collisions on our roads. But as they roll out, AVs will be disruptive to both the public and private sector in the process. Governments and businesses must begin to plan for the arrival of AVs sooner, rather than later. This report provides an overview of the potential benefits of AVs and the highlights some of the issues that we need to start planning for—now.

2.2. INTEGRATED APPROACHES TO TECHNOLOGY TO ACHIEVE MULTIPLE BENEFITS

Transportation technology development and deployment / adoption can therefore serve multiple benefits. Many of these are synergistic, with the same technologies, such as ITS, addressing different challenges and/or delivering multiple benefits. Exhibits 6 and 7 provide integrated statements on benefits from the U.S. and Australian perspectives.

Exhibit 6. U.S. Perspective: Benefits of Intelligent Transportation Systems (ITS)

http://www.its.dot.gov/factsheets/pdf/JPO_BenefitsITS_v4.pdf
Extracted from Factsheet:

ITS technologies advance transportation safety and mobility and enhance American productivity by integrating advanced communications technologies into transportation infrastructure and into vehicles. ITS encompasses a broad range of wireless and traditional communications-based information and electronic technologies.

A Growing Problem
While America's transportation system remains one of the Nation's greatest achievements and the life blood of the U.S. economy, the system continues to have serious challenges:

- **Safety:** In 2011, there were 5.3 million crashes and 2.22 million injuries. The number of fatalities dropped by 1.9 percent but still accounted for 32,367 deaths, according to the U.S. National Highway Transportation Safety Administration.
- **Mobility:** In 2010, the cost of congestion in urban areas was $101 billion, according to the Texas Transportation Institute. U.S. highway users waste 4.8 billion hours a year stuck in traffic—nearly one full work week (or vacation week) for every urban traveler.
- **Environment:** The total amount of wasted fuel topped 1.9 billion gallons in 2010, according to the Texas Transportation Institute, equivalent to about 2 months of flow in the Alaska Pipeline.

ITS Overview and Benefits
The ITS Joint Program Office (JPO), within the U.S. Department of Transportation's (U.S. DOT's) Research and Innovative Technology Administration, is responsible for conducting research on behalf of the U.S. DOT and all major modes to advance transportation safety, mobility, and environmental sustainability through electronic and information technology applications, known as ITS. ITS applications focus on both the infrastructure and vehicle, as well as integrated applications between the two, to enable the creation of an intelligent transportation system.

The U.S. DOT's ITS Program supports the overall advancement of ITS through investments in major research initiatives, exploratory studies, and a deployment support program. Increasingly, Federal investments target opportunities or major initiatives that have the potential for significant payoff in improving safety, mobility, and productivity. Some of the most prominent ITS technologies already deployed across the country include electronic toll collection, ramp meters, red light cameras, traffic signal coordination, transit signal priority, and traveler information systems. Among these technologies, ITS deployment appears to have the most broad-based benefit in the area of improved mobility (i.e., in the form of travel-time reduction), according to the U.S. DOT's *ITS Technology Adoption and Observed Market Trends from ITS Deployment Tracking* report.

Exhibit 7. Australian Perspective: Benefits of ITS

Extracted from "Policy Framework for Intelligent Transport Systems in Australia", Standing Council on Transport and Infrastructure, 2012

ITS have the potential to contribute to addressing a number of significant challenges for Australia's transport networks that are emerging, and are expected to grow stronger over the medium-term. These include:

- the expected growth in the freight task, with road freight alone projected to increase by 80 per cent by 2030;
- road crashes cost the nation in the order of $27b a year;
- road traffic congestion will cost the nation in the order of $20b a year by 2020. Delays result in lower productivity, cause flow-on delays in supply chains and increase the transaction cost of business;
- managing CO_2 emissions, with road transport accounting for 14 per cent of Australia's total greenhouse emissions;
- driving in stop-start congested traffic increases fuel consumption and greenhouse gas emissions by around 30 per cent compared with normal driving conditions during the day2;
- delivering national approaches and regulatory reforms that facilitate competition, open access and compatible systems;
- pressures created by the growth of our major cities limiting transport efficiency and flow on productivity benefits to the economy including the mobility requirements and social inclusiveness of our cities;
- increasing complexity in the operational environment in delivering ITS services; and
- increasing barriers to the construction of major new infrastructure to address urban transport issues – for financial, space, planning and environmental reasons.

The development of ITS under this framework cannot be divorced from economic, social and environmental development, including advances in land use planning, urban design and sustainability. Future uses of ITS must promote a transport system that enhances the mobility of people and products and delivers the economic, social and environmental outcomes the community wants. In addition, this policy framework supports the Commonwealth Government's National Digital Economy Strategy goal for 'smart management of our environment and infrastructure'.

The response to these major challenges cannot be limited to traditional measures. Innovative solutions are needed if we are to successfully address them. The Australian Government's National Urban Policy highlights the role that new technologies can play in improving and enhancing safety, efficiency, cost effectiveness and environmental performance of existing infrastructure networks, and reduce the need for costly new investment.

3. STIMULATING TECHNOLOGY AND INNOVATION THROUGH RESEARCH, DEVELOPMENT, AND DEPLOYMENT (R, D & D)

3.1. ENCOURAGING INNOVATION: RESEARCH, DEVELOPMENT, & DEPLOYMENT / ADOPTION

Technology is constantly evolving and renewing itself. It requires a comprehensive framework that will: 1) stimulate the R&D needed to create and develop the technologies; 2) enable testing of high-risk technology and innovations in a way that allows risks to be shared; 3) trains the experts required to promote, sell, deploy, and use the technology; 4) encourages, and if need be facilitates, adoption, etc.

The benefits from technology will only accrue if there is adoption of technology by private and public sector organizations, and the adoption must be a continuous process since technology does not stagnate; it becomes obsolete quickly.

In addition, if one is interested in the economic development and growth potential of advanced technology, then one needs to recognize that competition is fierce internationally. It cannot therefore be a one-time investment, but needs to be a permanent and continuous framework for supporting technological innovation

It is worth noting the important role of standards in encouraging development, adoption, and the creation of economic markets for transportation technologies. Technological devices on vehicles must be compatible and able interface with other devices on systems on vehicles. That is why there has been considerable effort over the past 15-20 years to support the development of an ITS architecture and a related series of standards. This enables interoperability across different vehicles, but also jurisdictions. This in turn creates the conditions for stable technology markets, and also encourages adoption by end-user organizations. The need for interoperable standards for high-speed communications protocols and data formats, etc. is likely to become even more significant in the future as surface vehicles start communicating with other vehicles, and communications increase between intelligent vehicles and intelligent infrastructure. This requires significant efforts to create the forums for discussion of the design of these standards between the numerous concerned stakeholder groups.

This chapter will analyze the various components of the Research, Development, and Deployment process that lead to adoption / deployment of transportation technology. These will serve in the next chapters as the basis for conducting the assessment of Canada's performance, and comparison to what is happening in comparable countries.

3.2. FUNDAMENTAL ACADEMIC RESEARCH

Universities are the primary source of technology development and innovation. Academic researchers devote their lives to understanding the current boundaries of knowledge, and then seek to expand the boundaries of knowledge in their respective fields through the development of new methodologies and/or new technologies.

The development of technology therefore requires basic research, but also requires more applied proof of concepts if the technology is ever to result in eventual actual deployment / adoption.

It is worth noting a significant challenge in translating university research into technology applications and their adoption. The university research system focuses primarily on validating and disseminating results to other academic researchers, and the career incentive structure is entirely based on the publishing of peer-reviewed papers in academic journals, and in some areas the development of intellectual property through patents. Some topic areas lend themselves to strategic interest by large multinationals or defense contractors, but it is most often a challenge for universities to develop the mechanisms to move research beyond basic knowledge to the realm of application, especially to small companies with little financial depth.

This is especially true for transportation technology. Therefore, application and adoption of technology will require more than preparing and publishing academic papers for the benefit of other academics, but will require an array of other dissemination tools to reach the potential private and public organizations that might test and adopt technological innovations.

3.3. RESEARCH PARTNERSHIPS

3.3.1. General Discussion

Stimulating technology development and adoption can either be done within large multinational corporations that can afford to have their own private world-class R&D facilities, or through partnerships between research entities, industrial partners, and potential adopter stakeholders. Partnerships are therefore critical because they reduce risks and enable the sharing of costs for technology testing.

Research partnerships also ensure a more comprehensive assessment of challenges, and barriers to adoption of the technology. Encouraging and/or enabling R &D partnerships will therefore require frameworks to bridge the silos of interests between university, private, and public stakeholders. This becomes all the more complex in the case of technology development that requires multidisciplinary research.

3.3.2. Canadian Context

Canada's economy is dominated by an economy of resource extraction and there are very few multinationals that have their international R&D facilities in Canada. As a result, in contrast to the U.S., Canada must focus more effort on the one hand on the stimulation and support of small high-tech start-up firms, and on the other on the adoption of technology. Research partnerships that bring together research centres (academic or government-sponsored), start-up firms, and potential adopters will be very critical in the Canadian context.

3.4. GOVERNMENT-SPONSORED R&D

3.4.1. General Discussion

The Research Councils by and large fund only fundamental research, not applied research. Multinationals sponsor privately-funded research, but this is concentrated in R&D facilities / campuses that are most often:

- near the administrative centres of the multinational corporations
- in geographic locations that have access to research expertise

- in geographic locations where they can attract and retain the internationally highly mobile expertise that is in high competitive demand

As a result, there are extremely few large multinational R&D campuses in Canada, such as those one see in the Silicon Valley, or surrounding Seattle or Boston. Some universities, such as the University of Waterloo and McMaster University, have had some modest success in creating concentrations of small high-tech firms in their vicinity, but these remain vulnerable and volatile. And even when successful, they tend to be acquired by multinational corporations and their research capacity moved abroad, to be integrated with the centralized research facilities. Technology development thus requires a framework that encourages the continuous re-emergence of small high-tech start-up firms.

3.4.2. Canadian Context

Given the lack of the lack of multinational research facilities, the reliance on small high-tech start-ups to create and develop technology, and the lack of financial depth of these small firms, government-sponsored R&D may be viewed as important in order to share the risks.

It will also be very important to encourage university researchers to pursue applied research and the applications of their fundamental research. Normal funding sources for academic research (from the Research Councils) mostly fund basic research. When the Councils do structure programs that can be used for more applied research, there is a tendency to encourage large consortium-based partnerships on "strategic" topic areas, such as aerospace, or Original Equipment Manufacturer-based automotive technologies. The competition for these large strategic projects is extremely competitive across all engineering areas, and is poorly suited to tease out applications from individual or small groups of researchers that might lead to high tech start-ups on transportation technology.

3.5. PILOT PROJECTS

3.5.1. General Discussion

Pilot projects are critical to deploy and test innovative transportation technologies, in real operating contexts. Pilot projects serve to test the scalability and viability of the technology application and related concepts of operations under realistic conditions. They also enable the sharing of costs and risks for innovative technology.

Pilot projects in both Canada and around the world have also been shown to enhance the dissemination of knowledge; realistic pilot projects are often critical in convincing potential adopters to consider the technology for adoption.

Pilot projects have always been a fundamental aspect of Transportation R&D Programs in the U.S. (Model Deployments) and in Europe (Horizon 2020, FP7, or DRIVE) for the last 20 years.

3.5.2. Canadian Context

It is more difficult for smaller countries to carry out large-scale Pilot Projects as in the U.S. or Europe. Nonetheless, the Canadian Federal and Provincial governments have sponsored several smaller scale pilot projects (often referred to as showcases) involving deployment and testing of innovative transportation technology.

Canada also has the advantage of having close organizational and personal ties to the transportation community in the U.S. For example, Transport Canada and some Provincial Ministries of Transportation participate in road technology R&D programs and activities sponsored or organized by the U.S. DOT, or by the American Association of State Highway and Transportation Officials, either as observers, or even in some cases as funding partners (i.e. pooled research fund). In addition, Canadian railroads participate in the Transportation Technology Center in Pueblo Colorado run by the American Railway Association. These contacts sometimes have served to provide insider access to technology pilot projects conducted in the U.S.

In addition, Canadian railroads participate in the Transportation Technology Center in Pueblo CO run by the Association of American Railroads.

3.6. DISSEMINATION

Dissemination of knowledge becomes even more important in a small country such as Canada that can only fund a limited number of test deployments, and where the vast majority of organizations involved in transportation operations, whether private or public, have no capacity to conduct research, or even to monitor innovative developments. They will hire consultants when they are involved in complex capital investment projects.

The potential for technology adoption thus becomes totally dependent on the dissemination of knowledge about the technology developments. This occurs through trade association activities (trade shows, conferences, newsletters, webinars, etc.) or government-sponsored dissemination activities.

University researchers participate in technology-oriented associations (e.g. ITS Canada, Canadian Institute of Transportation Engineers), but more rarely in operations-based trade associations (e.g. the Transportation Association of Canada, the Canadian Transportation Research Forum).

Suppliers provide valuable information about existing technology during trade shows, but there is an important need for independent sources of knowledge for transportation operations management and staff on both current and emerging technology.

Government therefore plays an important role in encouraging dissemination of independent knowledge. This can take different forms: reports on sponsored projects, background assessments of the state of the art, workshops, webinars, peer-to-peer exchange programs, etc. These activities can be conducted directly or in partnership with trade associations or universities.

3.7. PROFESSIONAL CAPACITY BUILDING

In addition to dissemination as a means of acquiring knowledge about innovative practices and technology, transportation operations management and staff can learn about new technologies and their utilization through professional development courses or other means to build professional capacity to assess and utilize the technologies, which facilitates adoption. Organizations such as ITS Canada, CUTA (Candian Urban Transit Association), TAC (Transportation Association of Canada) and IMSA (International Municipal Signal Association)

provide such technical and management training to their members and industry. Transport Canada has been instrumental in supporting such training course development.

4. CANADIAN TRANSPORTATION TECHNOLOGY ASESSMENT

This chapter will conduct an assessment of transportation technology R, D & D in Canada. This assessment will first consider past initiatives, before then turning to the current situation.

4.1. CANADIAN INITIATIVES IN THE PAST

4.1.1. Vision and R&D Framework

The research found that the Canadian government, principally through Transport Canada, had developed an active involvement related to advanced transportation technology, and in particular to ITS. Transport Canada had supported during the 1990s various activities through associations such as the Canadian Intelligent Vehicle Highway System (IVHS) Roundtable (the forerunner of ITS Canada), the Transportation Association of Canada, and the Canadian Urban Transit Association. These included support for R&D studies on advanced technology and its uses.

Transport Canada pursued an even more active role in the 1999-2005 period through the formulation of technology-related policy and R&D framework documents. These included in particular the following efforts.

1999 ITS Plan
Transport Canada published in 1999 a document entitled "An Intelligent Transportation Systems Plan for Canada: En Route to Intelligent Mobility". This document explored the potential benefits to be derived from development and adoption of transportation technology. It laid out objectives, pillars, and milestones (see Exhibit 8). It should be noted that this document is no longer posted on Transport Canada web site.

2003: Intelligent Transportation Systems Research & Development Plan for Canada: Innovation Through Partnership
This document built on the previous plan, and operationalized the ITS R&D Plan. The initiatives under the plan were being funded under the Strategic Highway Infrastructure Program. The plan was composed of two parts: *Fostering ITS Innovation* and *Funding ITS Innovation*.

The section on *Fostering Innovation* outlined the following activities:
- Establishing a *technology database* of new and emerging ITS products and services;
- Organizing a workshop on ITS R&D;
- Maintaining the Canadian ITS Architecture; and
- Encouraging the training of ITS professionals.

The section on *Funding Innovation* outlined the mechanisms to meet Transport Canada's ITS R&D priorities. The three primary funding mechanisms available under this ITS R&D Plan were:
- R&D Contribution Agreements;
- R&D Contracts; and
- Bilateral Federal-Provincial Agreements

ATLANTIC (A Thematic Long-Term Approach to Networking for the Telematics and ITS Community) (2003-2004)
A transportation technology project was conducted jointly by Transport Canada, and the provinces of Ontario and Quebec, in order to develop discussion papers concerning ITS

practice in multiple application areas, and to identify related R&D needs as part of the international ATLANTIC Network being led in partnership with the European Commission.

The ATLANTIC project involved a nationwide partnership of university researchers, government agencies, industrial partners, and consultants. Some projects were initiated as follow-up to this identification of R&D needs.

Exhibit 8. Canadian Transportation Technology Plan, 1999

"An Intelligent Transportation Systems Plan for Canada: En Route to Intelligent Mobility", Transport Canada, 1999
(Sections extracted from 1999 ITS Plan)

Benefits:
The potential benefits of ITS applications are considerable for all concerned including users and providers of services, the public sectors and the public at large. There are benefits, for instance, for users in congested urban areas as well as those in rural communities. The key benefits of ITS technologies are improved safety of the transportation system, reduced congestion and improved mobility, enhanced economic productivity, reduced travel time and government, traveler and operator costs, improved energy efficiency and reduced impacts on the environment.

To capture these opportunities, there is a need to accelerate the deployment and use of these systems in all modes across the country. It is with this intention that Transport Canada has initiated the development of this ITS Plan for Canada to provide the much needed impetus for accelerating deployment and integration of ITS applications. The ITS Plan presented in this paper will help realize the above benefits and ensure that intelligent transportation systems are a key component of Canada's ground transportation system for the 21st century.

Mission: En Route to Intelligent Mobility
The mission of this ITS Plan is to provide leadership and guidance for advancing the application and interoperability of intelligent transportation systems across Canada to make the national multimodal ground transportation system safe, integrated, efficient and sustainable. The implementation of this plan is dependent on extensive cooperation and coordination between various players in the public and private sectors.

Focus Areas:
The plan focuses on three streams of activity:
- *Building awareness of and demonstrating the potential of how wide-spread use and interoperability of intelligent transportation systems across Canada and North America can enhance safety and mobility and support interprovincial and international trade and tourism;*
- *Supporting strategic deployment and integration of intelligent transportation systems across urban and rural areas and on inter-city and international corridors; and*
- *Strengthening Canada's ITS industry to take advantage of growing global market opportunities.*

Pillars of ITS Plan
Canada's ITS plan is built upon the following five interconnected pillars:
- *Partnerships for Knowledge - the essential building block.*
- *Developing Canada's ITS architecture - a solid foundation.*
- *A multimodal ITS Research and Development (R&D) Plan - fostering innovation.*
- *Deployment and Integration of ITS Across Canada - moving forward.*
- *Strengthening Canada's ITS Industry - global leadership.*

Other Examples of Technology Research, Development and Deployment
Several Provinces (e.g. Ontario, British Columbia, Alberta, New Brunswick, etc.) had also developed ITS Strategic Plans around the same time frame. Examples include::

- Alberta Infrastructure (2000): *Intelligent Transportation Systems (ITS) Strategic Plan*
- *British Columbia's Provincial Intelligent Transportation System (ITS) Vision and Strategic Plan* (2002)
- The Transportation Association of Canada also published in1999 *A National Agenda for Technological Research and Development in Road and Intermodal Transportation*.

4.1.2. Past Sponsored Projects

In addition to the above-mentioned transportation R&D strategy documents, Federal and Provincial government agencies sponsored a number of projects, across various areas of endeavor.

Many of these were conducted through the Transportation Development Centre (TDC), which was the research arm of Transport Canada, comparable to the Volpe Transportation Systems Center of the U.S. DOT. Exhibit 9 illustrates a sample of the transportation technology-related reports sponsored by the TDC over the period of 2003 to 2010.

Exhibit 9. Past Research Sponsored by Transport Canada: Sample of Technical Reports

Transport Canada, primarily through its technical arm, the Transportation Development Centre was sponsoring research studies on various transportation technologies for a number of years, but appears to have been inactive in the last five years. Below is a sample of the most recent reports that could be identified*:

- Flywheel Energy Storage for Heavy Hybrid Vehicles (2010)
- Maximizing the Benefit of Hybrid Buses (2010)
- Applicability of Vehicle Infrastructure Cooperation to Low- Density and Rural Rail Grade Crossing Safety (2008)
- Commercial Vehicle Dispatch System (2007)
- Development of a Project Evaluation Methodology Framework for Canadian ITS (2007)
- Assessment of Low-Floor Transit Bus G Forces on Rear-Facing Wheelchair Securement Systems (2007)
- Transit Intelligent Transportation Systems (ITS) in Small Canadian Communities: Opportunities and Challenges (2007)
- In-Vehicle Intelligent Transportation System (ITS) Countermeasures to Improve Older Driver Intersection Performance (2006)
- Development of an OPC Server for NTCIP for ITS Equipment (2005)
- 2005 Update of the Highway-Railway Grade Crossing Research Program (2005)
- Development, Implementation and testing of an Advanced Transit Communication and Location System (2005)
- Regional Advanced Traveller Information System (2005)
- Evaluation of Advanced Pedestrian Detection Devices (APDDs) for School Buses - Phase 1 (2004)
- Development of a Multi-Mode Hybrid Electric Bus (2004)
- Advanced Technology Vehicles Program (2003)

* It is to be noted that none of these reports can be downloaded from the Transport Canada web site; the above list was made feasible by consulting non-Federal document repositories.

In addition to the research sponsored by the TDC, two other Transport Canada programs are worth highlighting:

- The Urban Transportation Showcase Program also sponsored demonstrations of advanced green technology in different communities across Canada
- Transport Canada's Moving On Sustainable Transportation (MOST) Program operated between 1999 and 2008, and provided funding to help support projects that stimulate the development of innovative tools, approaches and practices for increasing the sustainability of Canada's transportation system and the use of sustainable modes of transportation. Some of the funded projects were related to electric or alternative fuel vehicle technology.

Both of these programs resulted in research, development, and multiple deployments.

It should be noted that the reports from these projects can not be downloaded from the Transport Canada web site; some summary descriptions exist.

4.1.3. Support for Dissemination of Knowledge

In the past, Federal initiatives provided support to various mechanisms for disseminating technology R&D. Some examples include the following:

- IEEE World Vehicle Navigation and Information Systems Conference (Ottawa, 1993)
- Support to ITS Canada until 2012
- Sponsorship of various technology-related projects through the Transportation Association of Canada's R&D Council (ongoing)
- Participation in occasional projects of the Canadian Urban Transit Association, mostly in the 1990s.

4.2. ADOPTION OF TECHNOLOGY

The above section outlines several government initiatives to support the development and adoption of advanced transportation technology.

Measuring actual adoption is much more difficult.

As identified in the Discussion Paper for the CTAR (see Exhibit 10), levels of adoption of advanced communications are low across all sectors of the transportation industry, and also appear to be decreasing, which is both surprising and disturbing.

Exhibit 10. Percentage of Transportation Enterprises, by Sector, Using Advanced Communication Technologies

Source**:** Survey of innovation and business strategy, advanced technology use, by North American Industry Classification System (NAICS), Statistics Canada

Transportation	2009	2012
Air transportation	28.2	21.7
Rail transportation	14.5	27.7
Marine transportation	39.3	30.2
Truck transportation	23.4	27.0
Transit and ground passenger transportation	26.7	23.7
Scenic and sightseeing transportation	28.7	28.5
Support activities for transportation	21.4	27.9

Nonetheless, previous efforts to develop and promote technology seem to have led to some level of technology adoption at the provincial and municipal levels. Examples include:

- Rural Weather Information System network
- Weigh-in-Motion monitoring sites
- Advanced Traffic Management Systems
- Changeable message signs on freeways
- Automatic Vehicle Location in public transit and public safety

Some assessment of the level of transportation technology adoption can also be gleamed from Exhibits 11 and 12. Exhibit 11 illustrates for example the deployment of advanced technology by Canadian transit systems. It should be noted that foreign companies, with one exception, supply all of the Transit ITS technologies being deployed at transit systems in Canada.

Exhibit 11. Deployment of ITS Technologies in the Canadian Transit Industry

After many years of lagging behind the U.S. and Europe in adopting advanced technologies, transit systems in Canada starting investing heavily in ITS a decade ago.

The following is a partial list of transit systems where ITS has been, or is being deployed, and of the types of technologies being deployed, in various combinations:

- Brampton Transit
- Edmonton Transit
- GO Transit
- GRT (Waterloo)
- London Transit
- Metrobus (St John's)
- Metro Transit (Halifax)
- OC Transpo (Ottawa)
- RTC (Quebec)
- STL (Laval)
- STM (Montreal)
- TTC (Toronto)
- TransLink (Vancouver)
- Winnipeg Transit
- YRT (York Region)

- Wireless Communications (voice and data)
- Computer-Assisted Dispatch (CAD)
- Automatic Vehicle Location (AVL)
- Security Systems
- Schedule Adherence Monitoring
- Passenger Counting (APC)
- Transit Signal Priority (TSP)
- Real-Time Passenger Information
- Advanced Fare Collection

Exhibit 12 highlights the deployment plans for traffic management and other ITS technologies by several provincial and municipal agencies during a recent webinar organized by ITS Canada

Exhibit 12. Technology Roll-Out Plans for 2015
ITS Canada Webinar, February 26, 2015

British Columbia
- Data Warehouse framework development
- Regional Transportation Management Centre Video Wall Expansion – adding 6 cubes
- Traffic Camera Program – adding 30 cameras
- Developing a traffic management Concept of Operations Document
- Looking at including Ramp Metering control into our Advanced Traffic Management Systems
- ATMS access to City of Richmond, and camera sharing with City of Van, and City of Surrey

Ontario
- Preparation for Pan Am / Para Pan Am Games
- Commissioning of new COMPASS Transportation Management Centre
- Integrated Corridor Management framework development
- Herb Gray Parkway Opening
- Border Advisory System to become operational

Toronto
- Advanced Traffic Management Systems Central Software
- 80 Arterial CCTV Cameras
- 25 RESCU UPS Installations at Critical Locations – Advanced Transit Signal Priority Strategy
- Advanced Traffic Adaptive Control System Pilot – Arterial VMS Pilot
- Advanced Traveler Information System Strategic Plan
- Backup Operations Centre Plan

Montreal
- Camera inventory increase to 320
- Official 24/7 operation 4th quarter
- Center-to-center video exchange with MTQ and other traffic manager partners
- Telecom backbone upgrade to 10Gb/s
- 32 travel time detectors
- Dynamic parking information
- Integrated Corridor Management con-ops definition with partners

Vancouver
- Traffic Count Strategy – Data Management System
- Traffic Cameras Software System Update
- Traffic Signal System Update
- Video Analytics for Traffic Counts & Collision Analysis
- $900k Annual budget for automated traffic counters

Calgary
- DowntownParkingGuidanceSystem
- Text your Ride – Customized Event Notification System
- Traffic controller replacement program in the downtown to facilitate remote communications
- 24/7 TrafficInfoTwitterFeed

Edmonton
- Traffic Signal Central System Conversion
- Traffic Camera Streaming Images - Mobile
- Partnership with Province, CCTV on Ring Road – Emergency Vehicle Signal Priority
- Overheight Vehicle Detection System

Ottawa
- Adaptive Signal Capacity system pilot
- Intelligent Transportation Corridor (Highway 174) – Champlain Bridge Reversible Lane System
- Fire Truck GPS pre-emption expansion

4.3. CURRENT ASSESSMENT OF CANADIAN INVOLVEMENT IN TRANSPORTATION TECHNOLOGY DEVELOPMENT AND DEPLOYMENT

This chapter will assess current transportation technology Research, Development and Deployment in Canada from the following perspectives:

- Vision and R&D Frameworks
- Academic Research
- Research Partnerships
- International partnerships
- Sponsored R&D
- Pilot Projects
- Dissemination
- Professional Capacity Building

4.3.1. Vision and R&D Frameworks

The first level of assessment was to ascertain the current governmental vision concerning transportation technology, and the types of R&D frameworks in place.

Transport Canada

There are minimal references to innovation or technology in any official statements on Transport Canada's web site. These are found in Exhibit 13. However, these high-level statements seem to contradict the availability of other information and identifiable initiatives.

There is no ITS Strategic Plan on Transport Canada's web site, and no reference to the 1999 or 2003 ITS Strategic Plans.

The ITS Architecture is the foundation for ensuring interoperability between different interfacing technologies. The current version was developed 10 years ago. There is minimal reference to the ITS Architecture on a dedicated web site, and no indication of activity since 2013. There is some description of the Ontario-Québec Smart Corridor Concept of Operations and Regional ITS Architecture. However, the Concept of Operations web sites have not been updated since 2013.

There appears to be no visible effort to consider the policy implications of the coming connected and automated vehicle technologies, nor to develop a new generation of interoperable standards for communications protocols and data formats for vehicle to vehicle and vehicle to infrastructure technologies.

According to various experts, the ITS Office at Transport Canada has been disbanded, though a web site on the topic remains with minimal information. ITS technologies are now incorporated into the planning and construction of some major transportation infrastructure projects (e.g. the Champlain and Windsor Bridges), but there is no description or reference to these technologies on Transport Canada web sites

Exhibit 13. Statements from Transport Canada's Web Site Concerning Vision and Intended Activities Related to Transportation Innovation

Innovation
http://www.tc.gc.ca/eng/innovation-menu.htm (last updated May 2014)
The transportation system faces many challenges to growth, such as congestion, environmental impacts, aging infrastructure, changing demographics and the impact of climate change. Innovative solutions, particularly the application of new technologies, are critical to address the need for improvements in transportation productivity, sustainability and safety.

Transport Canada and its partners are committed to strategically targeted technological research and development (R&D) and innovation, not only to provide solutions to current and emerging challenges, but also to provide opportunities to increase stakeholder cooperation, build networks, better use resources and increase cooperation both within and outside the department.

Innovation Policy and Transportation
http://www.tc.gc.ca/eng/innovation/innovation-policy-menu.htm (last updated February 2013)

The Government of Canada sees innovation as a way to improve competitiveness and productivity. Transport Canada is well placed to advance innovative best practices, improve technology applications and increase sector research capacity to improve competitiveness and productivity in all modes of transportation.

We believe that innovation is key to addressing transportation challenges such as: aging infrastructure, traffic congestion, volatile energy prices, environmental concerns, climate change impacts and changing demographics.

Innovation Policy is a branch of Transport Canada's Strategic Policy and Innovation Directorate with a focus on transportation innovation, accessibility, and transportation in the North. We:

- *monitor developments, trends and initiatives;*
- *provide policy advice;*
- *research and analyze issues facing the sector; and*
- *help develop policy frameworks aligned to Transport Canada's strategic objectives and the federal government's priorities for innovation.*

To support transportation innovation, we:

- *establish and encourage research and technology partnerships with industry, academia, other federal departments and other governments;*
- *share research, knowledge and intelligence; and*
- *encourage skills capacity for an increasingly knowledge-based economy.*

To increase accessibility, we:

- *support technologies, strategies and policies that help persons with disabilities, seniors and other citizens with unique needs to access the national transportation network without undue obstacles.*

The program budget for "Transportation Innovation, R&D, and Technology" is one sub-component of the "Transportation Analysis and Innovation" Program, whose primary focus is the preparation of Transport Canada's Annual Report, statistical analyses, and support for the Northern Transportation Adaptation Program (see Exhibit 14).

The total budget for all of the activities is $13 Million in 2015-2016. As posted on this web site, Transport Canada's total budget for all of its activities was programmed for 2015-2016 at $1.336 Billion.

Exhibit 14. Transport Canada's Programming for Transportation Innovation, R&D, and Technology

http://www.tc.gc.ca/eng/corporate-services/planning-rpp-2013-14-1009.htm

"Transportation Innovation, Research, Development & Technology" is a sub-component of Program 1.4 **Transportation Analysis and Innovation**

The total budget planned for Program 1.4 is $13 Million in 2015-2016. This budget is for all of the following activities:

In support of this Program, Transport Canada will:

- *Conduct an economic analysis of the transportation sector and its components more specifically, the rail and air sectors. The analysis will include measuring and analyzing their productivity and efficiency.*
- *Enhance marine data collection to near real time and monitor activities on the transportation sector. This will include conducting analyses and determining statistical trends on all modes of transportation.*
- *Partner with transportation stakeholders, governments and academia to address priority transportation innovation issues in the areas of accessibility, cold climate, safety and security. This will include investigating de-icing technologies for the aviation sector; and evaluating the effects of permafrost and new asphalt cold resistant technologies on roads and runways.*
- *Adopt strategies that promote and foster innovation, research, technology deployment, and continue to advance Northern transportation projects, including Transport Canada's Northern Transportation Adaptation Initiative*
- *Develop the 2012 annual report on the state of transportation in Canada for tabling in Parliament.*

These activities focus on providing information, analysis and advice on national and international transportation trends and issues for the Government of Canada and stakeholders, as well as identifying efficiency gains for the sector that contribute to Canada's economic prosperity.

Other areas of Federal involvement in transportation technology research, development, and deployment were identified.

Natural Resources Canada (NRCan) - Green Energy Technology
NRCan is also a significant player, but primarily in the area of energy conservation or alternative fuel technologies, which were somewhat peripheral to the main focus of this research. NRCan appears to have an active program of R&D related to Advanced Fuels, Hydrogen and Fuel Cells, Hybrid and Electric Vehicles.

Joint Canada-U.S. Regulatory Cooperation Council: ITS Work Plan

This Joint Canada-U.S. Council developed an "ITS Work Plan" that addresses technology areas of joint interest to both the U.S. and Canada (e.g. border crossing technology, harmonization of ITS standards). The ITS Work Plan is described on the web site for the "Canada Economic Action Plan", and dates from 2012, with no indication of progress since then, though this has most likely been happening behind the scenes. There is no reference to this ITS Work Plan on Transport Canada's web site, as far as could be determined

The Regional Cooperation Council
Canada is also participating in the Regional Cooperation Council, which promotes mutual cooperation and European and Euro-Atlantic integration of South East Europe in order to inspire development in the region to benefit its people. Infrastructure and Environment is a part of the Sustainable Growth pillar of the South East Europe (SEE) 2020 Strategy that aims to boost growth and jobs by supporting a strong, diversified and competitive economic base, while becoming better connected, more sustainable, and more resource efficient.

Though much of the focus is on aviation and shipping-based transportation, the Council is also focusing on future transport needs and technology, using modern transport management and telecommunication capabilities (such as GALILEO and ITS).

The following lists actions, some of which pertain to transportation technology.
- Develop and implement measures to remove bottlenecks and unnecessary technical cross border barriers;
- Ensure harmonisation with the EU transport regulatory framework for creating common market conditions and safety standards in the region;
- Develop co-modal solutions by optimization of individual transport modes and focus on energy-efficient and environmentally friendly transport modes;
- Introduce measures for reducing energy consumption and costs per unit of transport service;
- Put forward measures to improve the ratio of railway and waterborne transport, foster liberalisation of railway services and open the rail transport market to competition;
- Enhance aviation transport activities and air traffic cooperation in the region and implement JSPA initiative to facilitate air transport;
- Increase the use of Intelligent Transport System in the transport sector.

Other Non-Federal Efforts at Creating a Vision or Framework
Beyond the above limited efforts at the Federal Government, it was extremely difficult to identify references to ITS or transportation technology on any provincial web sites.

There appears to be a current reluctance to make public strategic planning documents by both federal and provincial governments, even when such documents exist. One expert hypothesized that this might occur because some governments may no longer want to commit to their own strategic plans, and do not want to encourage other stakeholders to approach them for funding of projects involving design and stakeholders other than those selected by the government agencies.

There were some exceptions:

- New Brunswick: *Being A Leader With ITS New Brunswick's Intelligent Transportation Systems (ITS) Strategic Plan 2008-2018*
- Ontario ITS Strategy report (undated): Describes current status of ITS in Ontario, and explores potential developments with respect to reducing congestion, more effective border crossings, enhancing vehicle and passenger safety, etc.
- ITS Canada has developed a strategic plan

4.3.2. Academic Research

Basic funding for fundamental research is provided under the Research Councils (primarily Natural Sciences and Engineering Research Council (NSERC) for transportation), and seems to be generally competitive on an international scale. Canada has several universities with transportation programs or individual faculty that research transportation technology, both development and utilization of technology. Exhibit 15 provides a sample of university research centres involved in transportation technology R&D, including applications of the use of data created by technology systems. Many of these have a strong international reputation.

Exhibit 15. Canadian Academic Research Centres Involved in Transportation Technology R&D

- ACTIVE-AURORA, Canada's Connected Vehicle Test Bed Network
- CIRRELT: Interuniversity Research Centre on Enterprise Networks, Logistics and Transportation
- McGill University - Transportation Research at McGill (TRAM)
- McMaster University - McMaster Institute for Transportation & Logistics (MITL)
- Polytechnique Montreal - Chaire de recherche mobilité
- University of Alberta - Center for Smart Transportation
- University of New Brunswick National Rural ITS Research Programme
- University of Toronto
    - Intelligent Transportation Systems Centre and Testbed
    - Integrated Land Use Transportation Environment (ILUTE) Modeling System
- University of Waterloo
    - Waterloo Centre for Automotive Research (WatCAR)
    - Green Intelligent Transportation Systems
- AUTO21
- Canadian Automated Vehicles Centre of Excellence (CAVCOE)
- NSERC DIVA
- ONE-ITS (University of Toronto and University of Regina)

The Ministry of Transportation of Ontario's Highway Infrastructure Innovation Funding Program for Ontario Universities and Colleges provides funding for academic research on predefined topics. Most of the focus is on pavement performance, but some relate to transportation technology.

Dissemination efforts by Canadian university research centres, beyond the publication of papers in academic journals, are generally poor.

- The web sites provide minimal information on activities.
- In some cases, university researchers will list published academic papers on their individual web sites.

- In many cases the web sites do not describe or even list actual externally-sponsored R&D.
- There are minimal links to other research centres.

4.3.3. Research Partnerships

As mentioned, the Research Councils have created on occasion strategic partnerships programs. The most prominent related to technology, are in the domains of aerospace or Original Equipment Manufacturer-related automotive technology.

The Federal Government has funded either directly, or through Innovation Canada, an arms-length funding agency, specific programs that pertain directly or indirectly to transportation technology. The operation of Innovation Canada, and its coordination with other governmental programs and the Research Councils, is unclear.

In most cases, partnerships are structured to involve one or more universities, with other stakeholder partners, either government agencies, or industrial partners.
In some cases, the objective is to link research to the production of Intellectual Property that can be then used by small high tech industrial partners. The research centres sometimes also offer laboratory facilities to test these emerging technologies.

Below are some prominent examples of research partnerships that are involved in transportation technology R&D.

ACTIVE-AURORA: Canada's Connected Vehicle Test Bed
A prominent example is the creation of the joint ACTIVE-AURORA research centre, which declares itself Canada's Connected Vehicle Test Bed Network (see Exhibit 16). This is a partnership of the Universities of Alberta and British Columbia, the Federal Government, the Province of Alberta, and the City of Edmonton. This research centre, opened in 2014, and represents a $6 Million investment, with $3.66 provided by the Federal Government (including $1.3 million from the Asia-Pacific Gateway and Corridor Transportation Infrastructure Fund.)

This is by far the most significant investment in Canada in advanced transportation technology, outside of investments in research directly related to automotive vehicle technology.

It should be noted that despites its significance, this project is not referenced on the Transport Canada web site.

Exhibit 16. ACTIVE-AURORA Connected Vehicle Test Bed Network

> The ACTIVE-AURORA Test Bed Network helps Canada meet that challenge by providing a platform for investigating and implementing innovative Connected Vehicle (CV) technologies. CV technology enables vehicles to communicate critical, real-time information—location, speed, inclement weather, adverse road conditions and more—with other vehicles and surrounding infrastructure via wired and wireless networks.
>
> This initiative is a unique partnership of the University of Alberta Centre for Smart Transportation, University of British Columbia (UBC), three levels of government (Transport Canada, Alberta Transportation, and the City of Edmonton), and industry.
>
> The Government of Canada's contribution for this $3.66 million project includes $1.3 million from the Asia-Pacific Gateway and Corridor Transportation Infrastructure Fund. Other public and private partners are providing funding and in-kind support totaling $2.36 million

NSERC DIVA
The "Developing Next Generation Intelligent Vehicular Network and Applications" (DIVA) network links nine universities, 21 industrial partners, Industry Canada, Transport Canada, Defense Research and Development Canada, and the City of Edmonton, with funding for seven years. The objective is to develop the next generation intelligent vehicular networks and applications. The research themes being pursued are:

- Heterogeneous Vehicular Networks
- Intelligent Vehicular Ad Hoc and Sensor Networks
- Multimedia Service Oriented Architecture for Vanets
- Vehicular Sensor Network Security
- Infrastructures and Applications for Vehicular Communications

As in the case of the ACTIVE-AURORA project, this project is not referenced on the Transport Canada web site.

Automotive Research
Though somewhat beyond the scope of this research, it should be noted that major investments are made in Canada to develop research expertise related to the automotive industry and support OEMs and their subsidiaries. Examples include:

- AUTO21, which brings together 200 researchers and 48 research and industrial partners from across the country and has an annual budget of $11 Million.
- McMaster University - McMaster Institute for Transportation & Logistics (MITL), that works in collaboration with McMaster Institute for Automotive Research and Technology (MacAUTO), with a pertinent focus on the commercialization of electrified transportation.
- Waterloo Centre for Automotive Research (WatCAR) works with companies from across the automotive spectrum to improve the safety, intelligence, performance, and sustainability of modern vehicle systems.

4.3.4. International Partnerships

In addition to the formal R&D partnerships mentioned in the previous section, there are many informal partnerships related to transportation technology R&D. For example:

- Individuals from Transport Canada and MTO participate in U.S. DOT and other committees.
- Canada participates on an ad-hoc basis in the ISO TC204 discussions related to transportation technology, typically by supporting a single individual to attend the meetings
- ITS Canada has signed Memoranda of Understanding with ITS America, ITS Australia, ITS India, etc.

ITS Canada has also been formally designated the host, in collaboration with ITS America, of the 2017 ITS World Congress, to be held in Montreal. This bears recognition of the fact that Canada still holds some reputation internationally.

However, in an effort to assess Canadian's level of international involvement and recognition, the research analyzed Canadian participation in the latest World Congress in Detroit, and compared it to two comparable countries, Australia and the UK (see Exhibit 17). Despite the fact that this World Congress was on Canada's doorstep in Detroit, the presence of Australia and the UK was twice that of Canadian participants, despite the hugely different travel expenses for the different participants. This does not bode very well for Canada's presence at the 2017 ITS World Congress to be held in Montreal unless efforts are made to amend the situation.

Exhibit 17. Comparative Assessment of Canadian, UK, and Australian Presence at the 2014 ITS World Congress in Detroit

The ITS World Congress was held September 7-11, 2014 in Detroit. It is the pre-eminent international forum for the exchange of information concerning advanced transportation technology, attracting 10,000 attendees from 90 countries. 1025 presenters and panelists participated in 555 sessions.

The following table illustrates the relative presence of Canada in terms of presentations and panel participation compared to Australia and the UK.

	Total Number of Speakers / Panelists	Canadian Speakers / Panelists	UK Speakers / Panelists	Australian Speakers / Panelists
Special Interest Sessions (Invited Speakers / Panelists)	455	5	17	12
Technical Sessions (Call for Papers)	570	6	5	11
TOTAL	1,025	11	22	23

4.3.5. Sponsored R&D

Contrary to the assessment of past years, there is no evidence from the detailed analysis of Canadian government websites of any investment in sponsored technology R&D in the last five years (except for the ACTIVE-AURORA initiative).

4.3.6. Pilot Projects

There is no evidence from the analysis of Canadian government websites of any investment in pilot projects since the Urban Transportation Showcase Program, which ended in 2008. The Canadian government had conducted many pilot projects in the 1990s and up to 2008, but has not sponsored any pilot projects in the last seven years as far as could be determined.

Some provincial governments have sponsored pilot projects in recent years, based on anecdotal evidence from interviews or conference presentations. These are however not well documented or disseminated, so they tend only to benefit the stakeholders directly involved in the technology demonstration.

There appears to be a general trend in Canada to view pilot projects as just another form of capital investment, as opposed to a legitimate step in technology Research, Development and Deployment.

4.3.7. Dissemination

Federal Government

There is currently a clear lack of interest at Transport Canada with respect to the dissemination of information related to transportation technology, as evident from the following observations:

- There are no references to ITS or transportation technology projects actually sponsored by Transport Canada on its web site.
- All references to the dozens of past projects and reports are not referenced on the Transport Canada web site.
- All web pages on the Transport Canada related to technology or R&D have not been updated since 2013.
- There are less than a dozen links to any other pertinent web sites in all of Canada on the Transport Canada web site, and most of the links are no longer valid.

Provincial Governments

- The situation is relatively similar then that at the Provincial level, with no links to the few transportation technology or R&D projects conducted or sponsored by Provincial governments.

Associations and Universities

- ITS Canada provides one of the few forums in Canada for dissemination of knowledge and technology transfer concerning advanced technology R&D. This occurs through its Annual General Meeting and committee activities. Most of this information is however available only to its members.
- Other associations (e.g.Transportation Association of Canada , Canadian Institute of Transportation Engineers, Canadian Transportation Research Forum) represent more-operations focused stakeholders; these associations have occasional conference sessions or workshops related to technology development or policy.
- The Transportation Association of Canada also conducts research sponsored by its members (including Transport Canada) a survey of current projects indicates two of the current 16 projects are indirectly related to technology.
- University researchers naturally focus their efforts on publishing their research in peer-reviewed academic journals. The survey of transportation research centres indicates that only a minority of them even provide a description of sponsored applied research and only three actually provide final project reports.

4.3.8. Professional Capacity Building

- A small development grant was provided by Transport Canada in 2011 to develop an Introductory ITS Professional Development curriculum to be delivered by ITS Canada. These courses are being delivered to members and through affiliated associations (IMSA in Ontario and AQTr in Quebec).
- A very small number of Canadian universities offer some short professional development courses related to technology.

5. COMPARISON WITH TRANSPORTATION TECHNOLOGY ABROAD

The Appendix provides a huge panorama of organizations, web sites and documents related to transportation technology in Canada, the U.S.A., the European Commission, Australia, the U.K. and the Netherlands. The listings provide commentary on the nature of the organizations or programs, and the initiatives they conduct that relate to the development and adoption of transportation technology. It permits a comparison of Canadian transportation technology planning, activities, and resources, compared to those being found in other countries.

The following sections summarize major observations abroad with respect to the Research, Development and Deployment of transportation technology.

5.1. VISION AND R&D FRAMEWORKS

Most national governments that actively engaged in transportation technology believe it is valuable to establish a framework to identify benefits, challenges, and priorities and guide initiatives through the preparation of an ITS Strategic Plan. In the U.S. this is often accompanied by a "Roadmap" that breaks down the initiatives to be pursued according to some typology of high-level categories and sequenced over time.

In Europe, a legal framework (Directive 2010/40/EU) was adopted on 7 July 2010 to accelerate the deployment of these innovative transport technologies across Europe (see Exhibit 18).

Exhibit 18. EC Transportation Technology Directive and Guideline

http://ec.europa.eu/transport/themes/its/road/action_plan/

Intelligent Transport Systems (ITS) can significantly contribute to a cleaner, safer and more efficient transport system. A new legal framework (Directive 2010/40/EU) was adopted on 7 July 2010 to accelerate the deployment of these innovative transport technologies across Europe. This Directive is an important instrument for the coordinated implementation of ITS in Europe. It aims to establish interoperable and seamless ITS services while leaving Member States the freedom to decide which systems to invest in.

Under this Directive the European Commission has to adopt within the next seven years specifications (i.e. functional, technical, organisational or services provisions) to address the compatibility, interoperability and continuity of ITS solutions across the EU. The first priorities will be traffic and travel information, the eCall emergency system and intelligent truck parking.

The Commission already took a major step towards the deployment and use of ITS in road transport (and interfaces to the other transport modes) on 16 December 2008 by adopting an Action Plan. The Action Plan suggested a number of targeted measures and included the proposal for this Directive The goal is to create the momentum necessary to speed up market penetration of rather mature ITS applications and services in Europe.

The initiative is supported by five co-operating Directorates-General: DG Mobility and Transport (lead), DG Communications Networks, Content & Technology, DG Research & Innovation, DG Enterprise and Industry and DG Climate Action.

The Member States have to submit to the Commission a report on their national activities and projects regarding the priority areas. These can be found at: <http://ec.europa.eu/transport/themes/its/road/action_plan/its_national_reports_en.htm>

Individual EC countries publish an ITS Strategic Plan, which identifies strategic directions, priority areas of action, and specific projects. This enables coordination of national-level efforts.

Asian countries are of course at the forefront of technology development, even the smallest ones such as Singapore. Singapore has been actively involved in ITS for two decades and just released their most recent ITS Strategic Plan, entitled *Smart Mobility 2030; ITS Strategic Plan for Singapore*. This plan developed as a collaboration between the Land Transport Authority and the Intelligent Transportation Society Singapore, is intended to develop a holistic plan between authorities and industry to pave the way for a more comprehensive and sustainable ITS ecosystem.

Australia offers another interesting example for Canada. Its statement of need for an ITS policy framework refers not only to being able to take advantage of ITS programs in larger countries, but also to the need for interoperability, and to facilitate access of Australian firms to the growing ITS market (see Exhibit 19).

Exhibit 19. The Need for an ITS Policy Framework: the Australian Perspective

[Extracted from "Policy Framework for Intelligent Transport Systems in Australia", Standing Council on Transport and Infrastructure, 2012]

A number of leading world economies, including Europe, Japan, USA and Korea are developing ITS programs to address issues such as:

developing an open in-vehicle platform to integrate safety, efficiency and commercial applications at low cost to all vehicle models, not just high end vehicles;
implementing common data standards to facilitate cross modal information, to enable door to-door journey planning;
facilitating the development of real time traffic and traveller data including the roles for maintaining critical road attributes required for safety; and
exploring the use of the 5.9GHz spectrum band and other communication alternatives that will enable new generation co-operative ITS applications.

Australia will be able to leverage much of the investment made by these countries, particularly with regard to in-vehicle applications as 85 per cent of our new vehicles are imported. However, national coordination based on clear principles will be required to ensure that ITS benefits are optimised – ensuring interoperable systems and applications while encouraging implementation of innovative and cost effective ITS applications that are tailored to Australian conditions.

Having an effective policy framework in place will also facilitate the involvement of Australian companies and research organisations in the ITS market. In addition to the Australian businesses already active in the ITS area, many Australian companies have expertise in developing IT solutions and embedded technology products and can respond to the opportunity to contribute to the development of ITS.

The implementation of this Australian focus on technology was conducted, among others, by Austroads, which is the association of Australasian road transport and traffic agencies. Its purpose is to improve Australian and New Zealand transport outcomes by:

- Providing expert technical input to national road and transport policy development
- Improving the practices and capability of road agencies
- Promoting operational consistency by road agencies.

Austroads conducts $1 Million a year in "Network" related research, which includes ITS. They have placed a major focus on ITS and connected vehicle ("Cooperative ITS") policy framework, architecture, and standards, and have produced in the last five years a remarkable series of reports to guide policy, development, and deployment, all available for free. The reports are listed in Exhibited 20.

Exhibit 20. Austroads Technology Policy Research and Reports:

- **Cooperative Intelligent Transport Systems (C-ITS) Standards Assessment (2015)**
- **C-ITS Interoperability with Existing ITS Infrastructure (2014)**
- **National ITS Architecture: ITS Business Architecture (2014)**
- **National ITS Architecture: Context and Vision (2014)**
- **Procurement of ITS; International Practice (2014)**
- **Best Practice Guidelines for Procurement of ITS Solutions (2013)**
- **5.9GHz Satellite Interference Study - Field Study (2013)**
- **Vehicle Positioning for C-ITS in Australia; Background Document (2013)**
- **Emerging Digital Mapping Requirements for C-ITS (2013)**
- **Emerging Telecommunication Developments in WAN/LAN for Intelligent Transport Systems (2012)**
- **DSRC Interoperability Study (2011)**
- **Examination of Major Policy Issues Relating to Introduction of Cooperative ITS to Australia (2011)**
- **Defining Applicability of International Standards for Intelligent Transport Systems (ITS) – Final Report (2010)**

These substantial efforts found in the U.S., Europe, Australia, etc. to create transportation technology frameworks and to develop interoperability architectures and standards are in stark contrast to Canada, where no visible effort could be identified to address the policy implications of the coming connected and automated vehicle technologies, or the need for a new generation of interoperable standards for communications protocols and data formats for vehicle to vehicle, vehicle to infrastructure, and automated vehicle technologies.

5.2. GOVERNMENT AND RELATED RESEARCH CENTRES

The U.S. Federal Government continues to operate several transportation research laboratories that conduct research on technology development, deployment, and related policy challenges.

Government-owned or sponsored transportation laboratories have however by and large disappeared in other countries, including Canada. Some have been disbanded (e.g. TDC in Canada), while others have been privatized (TRL in the UK)

5.3. ACADEMIC RESEARCH

Academic research abroad is an important focus for transportation R&D, and resides primarily in the faculties of engineering, as is the case in Canada. However, other countries appear to have more of a tradition of involving multi-disciplinary fields of university research to explore challenges indirectly related to transportation engineering itself (e.g. Human Factors related to human-machine interaction; Computer Science related to Big Data, etc.).

The UK also has a longstanding, more or less formal, network of Transport Operations and Research Groups (TORG), which creates a synergy among transport research academics.

In Australia, NICTA is a national consortium of university laboratories that pool expertise and create international-caliber synergy in cutting edge Information and Communications Technology applications

The U.S. Federal Government structures support for applied research related to transportation through the University Transportation Center (UTC) network. The government holds competitions on a periodic basis for universities to be designated as a UTC and receive the allocated federal funding. The competitions are structured to require the building of consortiums of universities to work in partnership on coherent themes of R&D. In addition, participation requires funding from other internal or external sources to match the Federal funding.

5.4. RESEARCH PARTNERSHIPS

Different models have been identified.

In an effort to link research, development, and deployment in a single process, the European Commission has stimulated, for the last 25 years, its transportation R&D efforts (e.g. Horizon 2020, FP7, and the DRIVE R&D Programs) primarily through massive competitive calls for proposals for consortiums to propose potential projects on pre-defined themes. The consortiums must be multinational, and typically involve consortiums of public, private, and academic partners. They typically involve deployment tests in multiple locations across Europe, and include substantial dissemination efforts. European projects thereby force researchers and developers (university and industrial) to partner with technology adopters (national or local governments, private or public transport companies, etc.) to address the whole chain of research, development, and deployment.

The current FP7 (7th Research Framework) involved 4.16 Billion euros in funding from the Directorate General for Research and Innovation, covering the 2007-2013 period. The survey identified over 100 projects that were being conducted under this program that related in one way or another to transportation technology development and deployment.

Innovate UK is another model. It is structures as a quasi-autonomous non-governmental organization (referred to as a quango in the UK) that structures and promotes consortiums of expertise (university, consulting, and industrial). Three of the networks within Innovate UK relate directly to mobility-related technology.

The UK Driverless Car Project represents another significant investment in a R&D partnership. The UK already benefits from all of the European R&D and partnerships, but has just announced that the National Government is investing an additional 19.2 Million pounds ($37 Million) in R&D partnerships to position the UK at the forefront of the next generation of autonomous vehicles; this $37 Million investment should be compared to the $6 million investment by the Canadian Government in the ACTIVE-AURORA connected vehicle test bed.

Exhibit 21. UK Department for Transport Driverless Car Program

The UK Department for Transport (DfT) has launched in 2014 a major two-pronged program of policy and technical research, development program related to "Driverless Cars"

1) Driverless cars in the UK: a regulatory review
https://www.gov.uk/government/publications/driverless-cars-in-the-uk-a-regulatory-review

- The focus of this review is to ensure the UK is at the forefront of the testing and development of the technologies that will ultimately realise the goal of driverless vehicles.
- Analyses the existing legal and regulatory situation for testing, producing and marketing highly and fully automated vehicles in the UK.

The Pathway to Driverless Cars; Summary Report and Action Plan (February 2015)
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/401562/pathway-driverless-cars-summary.pdf

- This review identifies issues that need to be addressed to enable automated vehicle technology testing on UK roads whilst maintaining high levels of road safety. It covers the best and safest ways to trial vehicles where a qualified individual is present who is capable of taking control of the car. It also looks further ahead, to the implications of potential use of fully autonomous vehicles.
- Findings: Driverless vehicles can legally be tested on public roads in the UK today. The UK is uniquely positioned to become a premium global location for the development of these technologies.
- Next steps and action plan: The Government will publish a Code of Practice in spring 2015 for those wishing to test driverless vehicles on UK roads.
- It therefore makes sense to encourage testing on a national level to gain first-hand experience of these technologies, which can inform our negotiations on international standards.

2) Department for Transport Driverless Car Program

- The Department for Transport has announced that driverless cars will hit the streets in three UK cities starting in January 2015. To facilitate this deployment, the government has launched a competition to spur research and reach the deadline. The competition resulted in the selection of three project consortiums involving four cities: London, Coventry, Bristol and Milton Keynes. The funding provided by Innovate UK will be matched by the 12 consortium members to create a £19.2 million ($37 million) three-year project.
- The projects will examine how different self-driving vehicles could be implemented safely and efficiently across the UK.
- Two different types of self-driving vehicles will be tested: fully autonomous cars with no driver, and self-driving models that can relinquish control to a human pilot.
- In parallel, research is underway to research and formulate new road laws to accommodate such vehicles.

5.5. SPONSORED R&D

The international survey illustrates the huge investment being made by the U.S. Federal Government related to transportation technology.

The U.S. also illustrates the widest variety of approaches being used to sponsor or encourage transportation R&D. Examples include:

- R&D at Government and affiliated research facilities
- Federally-sponsored University Transportation Centers

- Federally (and some state) sponsored research projects by independent research centres, consultants, associations, universities, etc.
- Federal competitive requests for consortium proposals for pilot projects or model deployments, involving researchers, industrial partners, universities, and state or local deployment agencies
- Federal programs to specifically encourage private company-based industrial R&D through the Small Business Innovation Research (SBIR) and the Defense Advanced Research Projects Agency (DARPA)
- Federally-funded national cooperative research programs for highways, rail, transit, freight, administered by the non-profit Transportation Research Board of the Academy of Sciences
- Pooled research among state DOTs
- Association-managed research centres (i.e. TTCI by the ARA)

There are several initiatives of R&D partnerships to develop and test the technologies related to connected vehicles, automated vehicles, or autonomous vehicles.

- Some partnerships are based around academic institutions (e.g. University of Michigan UMTRI, Carnegie-Mellon University T-SET, University of Minneapolis ITS Lab, University of California PATH, etc.).
- The GoMentum test bed represents a different model involving a public authority (The Contra Costa Transportation Authority) creating a test bed and assembling a partnership with private sector entities representing infrastructure owners/operators; vehicle manufacturers; in-vehicle and Roadside Equipment Vendors; technology companies and academia.

It should be noted that all countries surveyed conduct sponsored R&D on technology. Even a small country like the Netherlands is heavily involved in sponsoring transportation technology projects (see Exhibit 22). It should be noted that these national projects are complementary, and coordinated, with EC-sponsored projects. This is all in stark contrast to Canada where no sponsored R&D projects could be identified per se, with the exception of the ACTIVE-AURORA and NSERC DIVA University-based R&D network projects.

Exhibit 22. Sample of Current National ITS Projects (and Budget) in the Netherlands

ACTION AREA 1: OPTIMAL USE OF ROAD, TRAFFIC AND JOURNEY DATA
- NDOV (National Data Project Public Transport) (€ 650.000 annually)
- National Data Warehouse for Traffic Information (NDW) (€ 71 Million
- Open Parking Data (€ 1 Million)
- Electronic Public If Traffic Decisions (€500,000)
- Top 5 Data Improvement: Data About Roadworks, Location Reference, Maximum Speeds, Time Remaining Indication Incidents And Traffic Measures In Control Scenarios (€ 3 Million)
- Database Of Height And Width Restrictions (€ 1 Million)
- Multimodal Travel Information (€ 1.6 Million)

ACTION AREA 2: CONTINUITY SERVICES FOR MANAGEMENT TRAFFIC AND FREIGHT
- Neutral Logistic Information Platform (NLIP): an open Information and Communications Technologies platform on which businesses and government organisations are sharing data. (€ 2.5 Million)
- Paperless Transport (€700,000)

ACTION AREA 3: APPLICATIONS FOR TRAFFIC SAFETY AND SECURITY
- Weigh-in-Motion (€ 4 Million)
- AOS (anti accident systems) (€10 million)
- Secure Lane: camera tracking system in parking areas for heavy goods vehicles, business parks and service stations along motorways (€ 2 Million

Note: These do not include EC-funded projects

5.6. PILOT PROJECTS

Pilot projects serve a valuable role to test advanced technology under realistic application conditions, and thereby validate benefits, and identify challenges and barriers to full deployment. Pilot projects are also used to disseminate knowledge concerning emerging technologies among potential adopters.

Both the U.S. and the EC invest heavily in pilot projects, but take different approaches. The U.S. tends to structure sequential steps, with potentially different partners, for:
- foundation research,
- concept of operations,
- development and proof of concept, and
- pilot projects and/or model deployments.

The EC on the other hand bundles multiyear projects that link all of the above steps with competitively chosen consortia.

Smaller countries conduct pilot projects only in limited and strategically defined areas, such as DAVI - the Dutch Automated Vehicle Initiative (www.davi.connekt.nl).

5.7. DISSEMINATION

There appears to be a fairly universal belief in the value of dissemination of knowledge in the U.S., which extends not only to the government and its affiliated agencies, but also to universities, associations, etc. An enormous number of pertinent web sites were identified through the survey. However, it is not just the number of web sites that is impressive, but also the quality and quantity of detailed information available on these sites, and all this information is available publicly for free. Web sites include:

- Detailed descriptions of policy statements,
- Actual strategic documents and roadmaps,
- Listings and descriptions of sponsored R&D,
- Actual reports from these projects,
- Knowledge about ITS architecture and related standards,
- Databases of deployment surveys
- Summaries of lessons learned, benefits, and costs,
- Webinar recordings,
- Training program modules, etc.

Not only is this large number of programs and projects creating a considerable amount of knowledge, but this is being widely shared through a wide variety of mechanisms.

The European Commission has also clearly seen the value in dissemination, with huge increases in the number of project web sites, improvements in the quality of dissemination, and a great increase in making project reports publicly available for free. Central information portals have also been developed, including the centralized Transport Research & Innovation Portal (TRIP) and the Eltis portal for urban mobility.

Exhibits 23 and 25 illustrate the U.S. DOT and European Transportation R&D Knowledge Resource portals.

Exhibit 23. U.S. DOT Knowledge Resources Portal

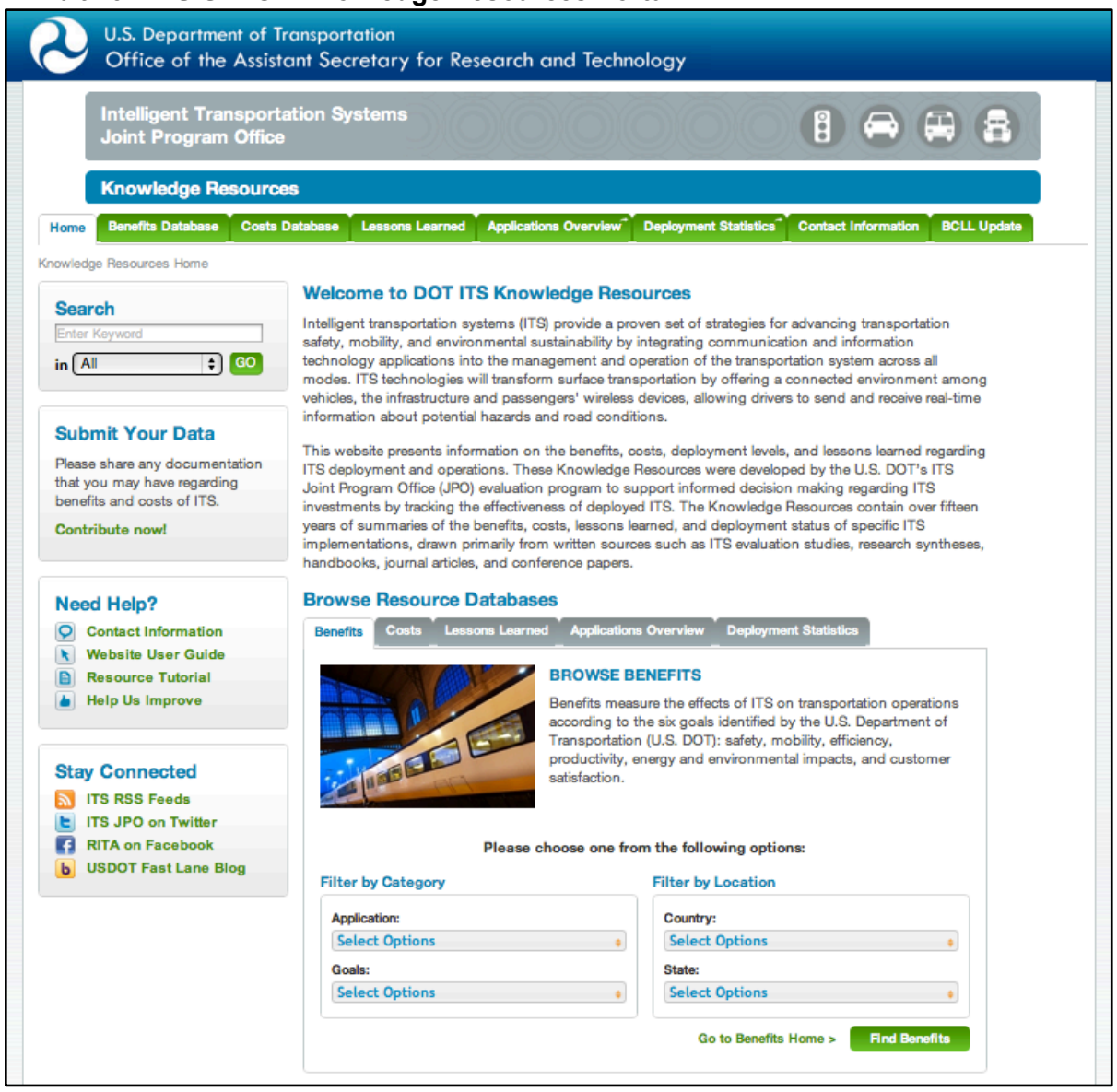
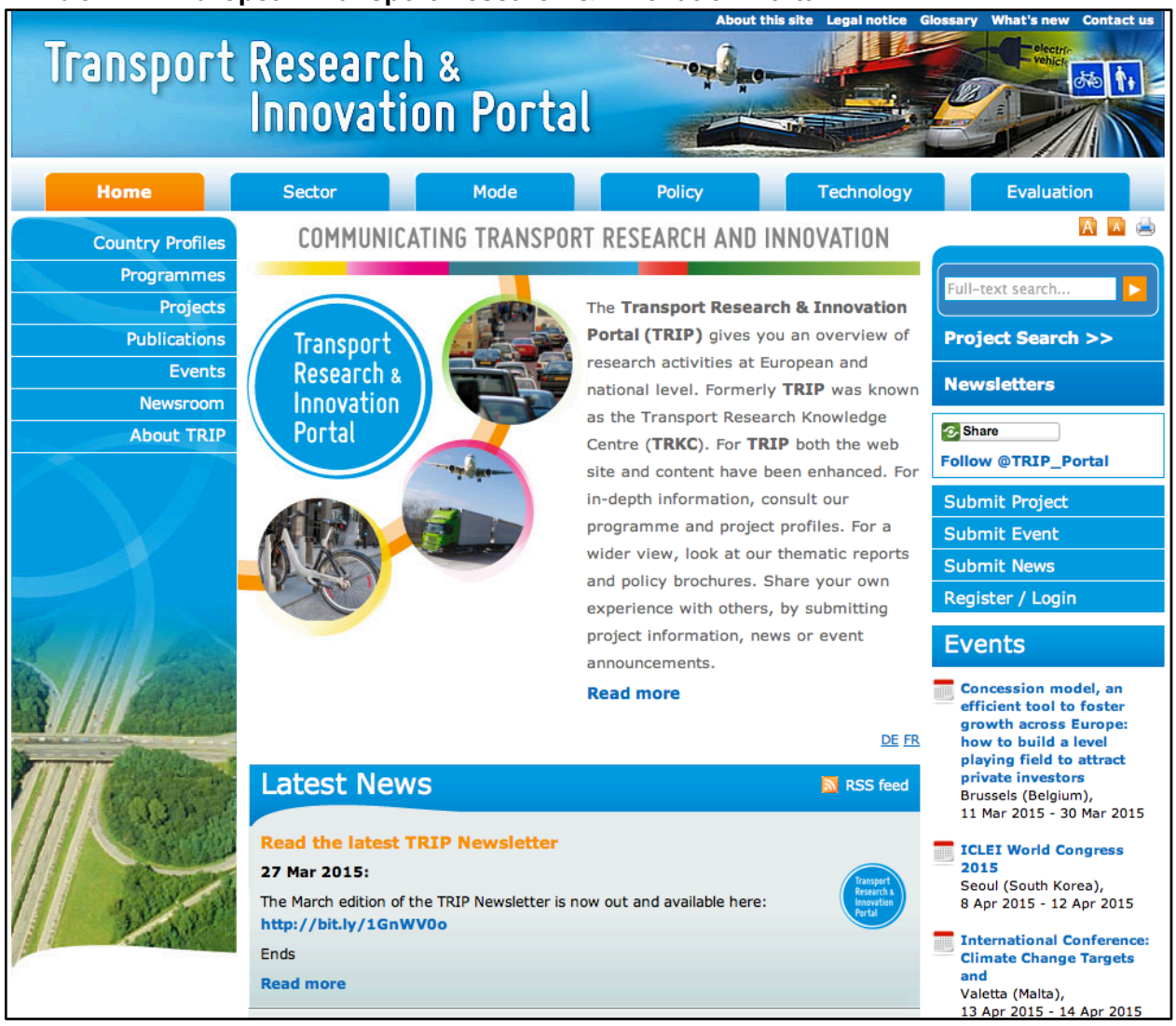


Exhibit 24. European Transport Research & Innovation Portal



Even smaller countries, such as Australia, make publicly available a wide variety of technical guidance and R&D reports through organizations such as Austroads.

This is all in stark contrast to the situation in Canada where government web sites are typified by little, if any, information. Virtually no technical guidance or R&D reports could be found in the course of the survey. The situation is practically the same at provincial government web sites.

Academic web sites abroad generally post actual reports from sponsored projects, in contrast to Canada where one finds just descriptions of projects at best, with some exceptions.

5.8. PROFESSIONAL CAPACITY BUILDING

A logical extension of the extensive efforts in the U.S. towards dissemination of knowledge is the effort to encourage adoption of innovative practices through "Professional Capacity Building". This is a major thrust of the U.S. DOT in general, but in particular with respect to encouraging adoption of advanced technology.

This includes significant efforts along many dimensions:

- Sponsorship of the development and conduct of professional development courses at various institutions,
- Making publicly available professional development modules, such as an ePrimer on ITS,
- Organizing and archiving a large number of free webinars that cover a wide range of topics, from presenting the results from DOT projects themselves to presentations by practitioners of cutting edge applications and best practices related to technology,
- Management of "Knowledge Communities", involving wiki-style forums on various themes,
- Management of the U.S. DOT's "Knowledge Resources Databases", which include information on benefits, costs, lessons learned, summaries of applications, deployment statistics, etc.
- Promotion of the enormous electronic database repository of U.S. DOT-sponsored reports,
- Sponsorship of a peer-to-peer program to reimburse travel expenses of potential adopters to visit and explore specific technology applications on-site, etc.

Neither the EC, nor any other individual country have made such efforts to tackle the problem of adoption of transportation technology in such a systematic approach, involving such a variety of mechanisms.

The vast majority of the knowledge and capacity building resources in the U.S. are publicly available, including to Canadian professionals. Unfortunately, based on interviews, Canadian professionals generally lack knowledge of these resources.

6. SUMMARY OF OBSERVATIONS

This chapter summaries the major observations from the assessment of international trends with respect to transportation technology Research, Development, and Deployment, and Canada's related position or efforts.

Observations can be summarized along five themes:

- Importance of Transportation Technology
- Important Role of Public Sector in Transportation Technology R&D
- Various Approaches that Exist to Encourage and Structure Transportation Technology Research and Development
- Importance of Dissemination to Encourage Technology Adoption
- Importance of Professional Capacity Building to Encourage Technology Adoption

6.1. IMPORTANCE OF TRANSPORTATION TECHNOLOGY

There appears to be a universal recognition, in countries small and large that technology plays an immense role in addressing various economic and societal challenges, and that the future of developed societies will be driven by continuous technology development, and its adoption by private and public practitioners.

The benefits to be derived from investment and / or facilitation of R, D & D of transportation technology relate to:

- Enhanced safety and security,
- Improved mobility for persons;
- Improved mobility of goods,
- Environmental benefits,
- Improved accessibility for disadvantaged persons,
- Improved productivity through innovation, and
- Economic growth through jobs development in an increasingly competitive world.

In addition, many organizations advocate the need for being prepared for the coming of disruptive technologies that will affect transportation in particular, including Big Data and Automated / Autonomous Vehicles.

This recognition appears to have existed in Canada at the early stages of development of Information and Communications Technologies deployment in transportation, but is not as evident in Canada today at the level of the national government. And this lack of recognition of the critical importance of technology exists despite recent calls for action by entities such as the Conference Board of Canada. At the provincial level, there appears to be anecdotal evidence of policy interest and initiatives, but these are difficult to measure because of a lack of documentation and dissemination, and the degree of interest seems to vary enormously from province to province.

6.2. IMPORTANT ROLE OF PUBLIC SECTOR IN TRANSPORTATION TECHNOLOGY R&D

It is evident that the private sector is a prime stakeholder in developing technology, whether through large multinational corporations or small high tech start-ups.

However, at the same time, it is evident that countries small and large perceive that technological development cannot rely uniquely on the market, and that governments must play a critical role in shaping the framework for research, development, and even adoption through the establishment of well thought-out and widely discussed policy frameworks.

The U.S. and the European Commission have devoted enormous resources to developing and implementing transportation research, development and deployment.

However, even individual smaller countries, such as the Netherlands, the UK, and Australia, have invested impressive efforts to develop frameworks for transportation technology R&D, as well as interoperability standards that will guide the development and adoption of technology for years to come.

The Canadian government, and most Provincial Governments with some exceptions such New Brunswick and Ontario, are showing little leadership that would help:

- Systematically build the public private partnerships,
- Frame the discussions and develop a shared vision among stakeholders,
- Structure activities through strategic plans,
- Develop coherent and continuous technology R&D frameworks,
- Coordinate the development and application of architectures and standards,
- Monitor developments,
- Conduct pilot projects to test potential technologies, and
- Promote the adoption of technology by potential private and public users through widespread dissemination of knowledge.

6.3. VARIOUS APPROACHES THAT EXIST TO ENCOURAGE AND STRUCTURE TRANSPORTATION TECHNOLOGY RESEARCH AND DEVELOPMENT

The research has observed that there are many different approaches to encouraging transportation technology R&D.

The U.S. illustrates the widest variety of approaches to stimulating R&D, many of which involve R&D directly sponsored by the Federal government. Examples include:

- Academic research
- Government and affiliated research facilities
- Federally-sponsored University Transportation Centers
- Federally (and some state) sponsored research projects by independent research centres, consultants, associations, universities, etc.
- Federal competitive requests for consortium proposals for pilot projects or model deployments, involving researchers, industrial partners, universities, and state or local deployment agencies

- Federally-funded national cooperative research programs for highways, rail, transit, freight, administered by the non-profit Transportation Research Board of the Academy of Sciences.
- Pooled research among state DOTs
- Association-managed research centres (i.e. the rail Transportation Technology Center operated by the Association of American Railroads)
- Programs to sponsor private-sector technology development (e.g. Small Business Innovation Research, Defense Advanced Research Projects Agency)

However, other innovative models exist as well:

- Europe's R&D programs (Horizon 2020, FP7, DRIVE) force researchers and developers (university and industrial) to partner with technology adopters (national or local governments, private or public transport companies, etc.) to address the whole chain of research, development, and deployment.
- NICTA in Australia is a consortium of university laboratories that pool expertise and create international-caliber synergy in cutting edge Information and Communications Technologies applications.
- Innovate UK, is a quasi-autonomous non-governmental organization (quango) that structures and promotes consortiums of expertise (university, consulting, and industrial); three of the networks relate directly to mobility-related technology.

In comparison, Canada seems content to “follow on the coat tails” of our U.S. counterparts, and not invest in similar R&D catalytic activities.

Academic research is important as a continuous stimulus for the development of technology and the analysis of the challenges in its effective utilization. Canadian academics are quite competitive internationally, on an individual basis. They however lack the support one finds in other countries in terms of networks that create synergy (e.g. the University Transportation Centers in the U.S., the Transportation Operations Research Groups and Innovate UK's Knowledge Transfer Network, European Commission R&D programs). They are also less proficient in terms of disseminating the knowledge derived from applied research projects to the greater community.

6.4. IMPORTANCE OF DISSEMINATION OF KNOWLEDGE TO ENCOURAGE TECHNOLOGY ADOPTION

U.S. institutions (government agencies, universities, associations, etc.) seem to have a natural inclination to promote the dissemination of knowledge. Provision of detailed information, descriptions of projects, and free links to the actual reports is the norm across the board, and the number of web sites is overwhelming.

Dissemination of R&D is supplemented by an aggressive attempt at "Professional Capacity Building" with documentation of benefits, costs, lessons learned, and webinars and training course materials, available in the majority of cases for free.

European Commission institutions have also made recent progress in improving public dissemination of knowledge concerning their R&D initiatives through the centralized Transport Research & Innovation Portal and Eltis urban mobility dissemination portals, as well as through a myriad of web sites devoted to the hundreds of projects they have funded over the last two decades.

Although less effort is devoted to dissemination in smaller countries, an institution such as Austroads in Australia offers a remarkable repository of information, reports, and guidebooks, all publicly available for free.

Universities in the U.S. place great emphasis on the dissemination of knowledge concerning their applied technological research projects, but one sees more variability in the quality of dissemination by universities in Europe and Australia.

In contrast, most Canadian institutions, in particular government agencies and universities, appear to have little natural inclination to systematically build dissemination of knowledge into their practices.

There appears little current interest or effort related to the dissemination of knowledge on Federal web sites today. For example, web sites related to transportation technology and R&D provide minimal public information, and are universally out-of-date. There are few descriptions of Federally-funded projects, and some significant ones, such as the ACTIVE-AURORA and NSERC-DIVA R&D networks, merit no mention at all. There is not a single report of pertinent Federally-sponsored studies that can be downloaded from the Transport Canada web site.

In most cases, web sites by Provincial agencies are only marginally better, with some exceptions, such as New Brunswick.

As for universities, dissemination is clearly focused on the traditional approach used to share academic research through peer-reviewed academic journals. These have no impact on potential private company or public agency innovation adopters since they do not read, nor have access to these academic journal articles. As for more applied sponsored applied research, in many cases projects are only briefly described, if at all, and reports are not provided or even listed. The comparison between Canadian and U.S. university web sites is striking.

Trade associations remain the main mechanism for dissemination of knowledge in Canada, though it should be noted that much of their information is exclusively available to their members.

6.5. PROFESSIONAL CAPACITY BUILDING IS IMPORTANT FOR ADOPTION BUT REMAINS A DIFFICULT CHALLENGE

Given the natural human resistance to change, adoption of innovative practices and new technology is difficult under the best of conditions. It is much easier to encourage the adoption of new technology directly by consumers, than it is to persuade private companies requiring a clear return on investment, or risk-adverse and resource-poor public sector organizations. Encouraging technology adoption therefore requires dissemination of knowledge to potential adopters about the technology developments themselves, but also about the potential benefits to be derived from technology adoption.

However, encouraging technology adoption must go beyond mere dissemination of knowledge, to a more comprehensive approach to encourage innovation and build the capacity to adopt technology among potential adopters, which is called in the U.S. "Professional Capacity Building". This is a major thrust of the U.S. DOT, and includes a wide range of efforts and

mechanisms, including sponsoring or organizing professional development courses, webinars, wiki-style knowledge communities, peer-to-peer exchange programs, etc.

Such efforts are aimed at ensuring that potential adopters are not only familiar with, but have the skills necessary to assess and deploy technology, and thereby encourage technology adoption by private and public organizations.

It may be that for a small country such as Canada, which cannot afford the level of technology R&D investment of the U.S. and the European Commission, it is even more important to maximize the effectiveness of its small and targeted investments through extensive and more effective efforts aimed at disseminating knowledge and encouraging the adoption of innovation through professional capacity building.

7. CONCLUSIONS

With respect to the original question being asked by the CTAR Secretariat, Canada would appear to be a laggard in terms of transportation technology research, development, deployment and adoption, and even more so with respect to its future prospects in a highly competitive technology world.

At a very high level, one can make the following characterizations:

- The U.S. and Europe are both pursuing absolutely all steps of the technology development cycle (e.g. R&D policy frameworks and plans, standards, research projects, development, pilot projects, dissemination of knowledge, support for deployment and adoption, etc.), and are doing so in a variety of ways. There are slight variations, with the U.S. having separate processes and initiatives for the different steps of the cycle, while Europe tends to bundle research, development and deployment into multi-country, multi-stakeholder, partnerships. The U.S. also appears to place more emphasis on government-sponsored training and professional capacity building.
- The Netherlands takes full advantage of European projects to enhance its interoperability with European projects and systems, but also pursues a large number of projects on its own, in order to increase safety and mobility at the national, regional, and local levels.
- The UK appears to be investing less in projects to encourage deployment and adoption today, but rather focusing aggressively on building a competitive industrial future based on automated and autonomous vehicle technology. This involves a national review of the regulatory environment and the launch of a large and competitive program, funded by significant public and private funding, to stimulate public / private partnerships of universities, industrial partners, and consultants.
- Australia is somewhere in between, trying to capture near-term benefits through the dissemination of technical reports to encourage adoption, but also through the development of a comprehensive policy framework to encourage interoperability and to stimulate markets in the future.

Canada, in contrast, appears to be mostly coasting along, still benefitting from investments made ten to fifteen years ago in transportation technology R&D. These resulted in some successful commercial successes in the private sector (e.g. Weigh-in-Motion), and the early adoption of a number of advanced technologies by some governmental agencies (e.g. Weigh-in-Motion , Rural Weather Information System, Advanced Traffic Management Systems).

It is also benefitting from its academic institutions that have a solid international quality, and are relatively well funded by the Research Councils. These have been enhanced in the past by ad-hoc publicly sponsored applied R&D projects. There has however only been minimal large investment of this type in recent years (i.e. the ACTIVE-AURORA and NSERC DIVA University-based R&D network projects).

However, Canada is very poorly positioned for a future that will be characterized by disruptive technologies (e.g. Big Data, Internet of Things, Connected Vehicles, Automated and Autonomous Vehicles, Mobility as a Service, etc.), and already sees a very high level of international competition in their development and deployment.

Canada lacks:

1. Solid and collaborative public-private forums for discussion of the many complex policy challenges raised by future transportation technologies,
2. Any discussion of a vision for technology development and adoption,
3. A process to assess the regulatory and standards implications and needs related to future connected and automated / autonomous vehicle technologies,
4. Coordinated efforts to plan and conduct transportation technology research, development, and deployment activities, and
5. Any significant coordinated efforts at dissemination of knowledge, or building the human professional capacity to assess, adopt and effectively use transportation technology.

This is in stark contrast to both large entities like the U.S.A and the European Commission, but also even to similar or smaller-sized nations such as Australia, the Netherlands, the United Kingdom, or Singapore, as is evident from a scan of the Appendix; an enormous number of organizations have been identified as engaged in the development and adoption of transportation technology around the world, which have created considerable resources for the benefit of their national stakeholders.

The risks for Canada to continue along the current "Do-Nothing" path are several-fold:

- Private companies and government agencies are adopting technology at slow rates, and are thus not benefitting from the numerous benefits that are being achieved in other countries. There are few efforts in Canada to encourage and support the adoption of transportation technology, and this is in great contrast to comparable countries, large and small, where considerable efforts are being deployed.
- As a result, Canadian society is not benefitting from the safety, security, environmental, efficiency, mobility, and accessibility benefits that could result from greater adoption of technology.
- Private firms are not achieving the productivity to be gained from technology adoption, and this will over time decrease their competitiveness with respect to international competitors.
- The technology being purchased and deployed in Canada is increasingly foreign-made. Canada has few, if any, multinational transportation technology firms creating jobs. Industrial market benefits will only accrue from a continuous stream of creation of small high-tech start-up firms, but there is little, or no, support for sharing the risks and costs for these firms in Canada. Competitor countries are, on the contrary, developing comprehensive frameworks to support the continuous development of technology innovation, in some cases, such as in the UK and Australia, explicitly in an effort to build an internationally competitive industrial market for the future of automated vehicles. Canada is gradually foreclosing on such future markets.
- The lack of transportation technology adoption, policy, and forums for discussion leave it at a great disadvantage, compared to other countries, if the future is truly likely to be one characterized by *disruptive* technologies, as an increasing number of experts are suggesting.

However, Canada has a solid foundation in the field of transportation on which to build if it so desires. Hopefully, an environmental scan at what is happening in most developed countries will encourage a rethinking in Canada that will lay the foundation for a future that seizes opportunities and addresses the challenges of an increasingly technological-driven future in the realm of transportation.

QUOTED REFERENCES (other than Resources Identified in Appendix)

C.D. Howe Institute, 2015, "Tackling Traffic: The Economic Cost of Congestion in Metro Vancouver", B. Dachis
http://www.cdhowe.org/pdf/e-brief_206.pdf

C.D. Howe Institute, 2013, "Cars, Congestion and Costs: A New Approach to Evaluating Government Infrastructure Investment", Commentary NO. 385, B. Dachis,
http://www.cdhowe.org/pdf/Commentary_385.pdf

GAO, 2013, "Vehicle-to-Vehicle Technologies Expected to Offer Safety Benefits, but a Variety of Deployment Challenges Exist", U.S. General Accounting Office
http://www.gao.gov/assets/660/658710.pdf

Metrolinx, 2008. "Cost of Road Congestion in the Greater Toronto and Hamilton Area: Impact and Cost-Benefit Analysis of the Metrolinx Draft Regional Transportation Plan." Final Report.
http://www.metrolinx.com/en/regionalplanning/costsofcongestion/ISP_08-015_Cost_of_Congestion_report_1128081.pdf

NRCan, 2009, "Electric Vehicle Technology Roadmap for Canada", Natural Resources Canada
http://www.publications.gc.ca/site/eng/357226/publication.html

UTTF, 2012 "The High Cost of Congestion in Canadian Cities", Urban Transportation Task Force, Council of Ministers Responsible for Transportation and Highway Safety
http://www.comt.ca/english/uttf-congestion-2012.pdf

2015 03 27

APPENDIX - INTERNATIONAL SURVEY OF RESOURCES

CANADIAN TRANSPORTATION ACT REVIEW
TECHNOLOGY REVIEW

ORGANIZATIONS AND RESOURCES RELATED TO
TRANSPORTATION TECHNOLOGY R&D

The following list of organizations, web sites, resources, and documents was assembled as part of the Transportation Technology Review. It was prepared by Brendon Hemily, Ph.D. on behalf of ITS Canada under a project sponsored by the Canadian Transportation Act Review Secretariat.

It is as complete as feasible under the extremely limited time frame for the conduct of this study.

Brief descriptions, derived from the related web pages and documents, are provided for the most pertinent or interesting entries. Commentary notes have been included for some entries in order to assist in the international comparative assessment; all comments reflect the views of the author, and are not those of ITS Canada or the Canadian Transportation Act Review Secretariat.

8. GOVERNMENT WEB RESOUCES

8.1. CANADA

8.1.1. Transport Canada - Transportation Innovation and Technology

Innovation Policy and Transportation
http://www.tc.gc.ca/eng/innovation/innovation-policy-menu.htm
- High-level statement of intent
- Links to some other web pages including the Clean Transportation Initiative on Port-Related Trucking and the Northern Transportation Adaptation Initiative
- Last updated February 2013

Transportation Development Centre (TDC)
http://www.tc.gc.ca/eng/innovation/tdc-menu.htm
- Brief description of TDC R&D
- Web site was last updated in 2013
- Links are provided to only 8 studies sponsored by TDC, a few of which relate to vehicle propulsion technology or accessibility.
- The most recent study listed dates from 2012

ITS Portal
http://www.tc.gc.ca/eng/innovation/its-menu.htm
- One paragraph description of ITS

- No R&D studies identified or available on web site
- No reference to any current or prior R&D projects funded by Transport Canada
- Links to only five related Canadian web sites, of which 4 lead to dead links
- No ITS Strategic Plan
- No links to any academic research centres, though some have benefitted from Federal funding (e.g. ACTIVE-AURORA and NSERC-DIVA R&D Networks)
- Web sites last modified 2013

ITS Architecture
http://www.tc.gc.ca/eng/innovation/its-architecture.htm
- ITS Architecture Release 2.0 (obtainable after registering via submission form)
- The Ontario-Québec Smart Corridor Concept of Operations and Regional ITS Architecture described in some detail http://www.tc.gc.ca/eng/innovation/its-ontario-quebec-1593.html
- The Concept of Operations is not posted, but obtainable upon request
- Web sites were last modified 2013

Urban Transportation Showcase Program
http://www.tc.gc.ca/eng/programs/environment-utsp-showcases-253.htm
- Federal competitive program selected eight Canadian communities to demonstrate innovative greenhouse gas reduction approaches, in most cases involving the deployment of advanced technology
- Brief descriptions are provided for only four of the eight showcase demonstrations
- "Final Results" are no longer available on the web site
- Web site was last updated in 2011

Clean Rail Academic Grant Program
http://www.tc.gc.ca/eng/innovation-571.htm
- Third round of program that provides federal funds ($25,000 each) to academic research programs currently developing technologies and practices that aim to reduce air emissions from the rail sector.
- Past recipients are not listed.

Joint Canada-U.S. Regulatory Cooperation Council: ITS Work Plan
RCC Rail Safety, Dangerous Goods, and Intelligent Transportation Systems (ITS) Working Group: ITS Work Plan
http://actionplan.gc.ca/page/rcc-ccr/intelligent-transportation-systems-its-work-plan
http://actionplan.gc.ca/sites/eap/files/ITS_work_plan.pdf
- Objective: Work together on the development of standards to fully support the integration of intelligent transportation systems.
- Initiatives:
  - Update the Border Information Flow Architecture (BIFA) for ITS.
  - In coordination with industry, identify existing and/or develop new standards to guide the implementation of ITS.
  - Review current US/Canada policies and procedures related to ITS and identify opportunities for better coordination.
  - Identify the opportunity for bi-national ITS initiatives and develop implementation plans
- ITS Work Plan dates from 2012, with no indication of progress since then
- There is no reference to this ITS Work Plan on Transport Canada's web site
- Contact person for Canada has retired two years ago.

8.1.2. Natural Resources Canada - Applied Technology Research for Transportation

http://www.nrcan.gc.ca/energy/efficiency/transportation/research/13613

- Supports the development and commercialization of technologies and fuels that contribute to a more competitive transportation sector and a more sustainable energy mix for vehicles in Canada.
- Focus areas are: Advanced Fuels, Hydrogen and Fuel Cells, Hybrid and Electric Vehicles.
- Provides many links to association and international websites
- No specific descriptions of projects being supported

Electric Vehicle Technology Roadmap for Canada (2009)
http://www.nrcan.gc.ca/energy/efficiency/transportation/7687

- Roadmap provided strategic analysis to promote electric vehicle technology
- Website provides no details of initiatives
- Roadmap has been archived offsite
- Website has not been updated since February 2014

8.1.3. Innovation Canada

http://www.innovation.ca/en

Created by the Government of Canada in 1997, the Canada Foundation for Innovation (CFI) strives to build our nation's capacity to undertake world-class research and technology development to benefit Canadians.

- Has provided funding for Canadian university transportation centres

8.1.4. Ontario - Ministry of Transportation of Ontario (MTO)

ITS on MTO web site
http://www.mto.gov.on.ca/english/its/learnmore.shtml
Four paragraph description of ITS and its importance

- ITS Strategy report (undated): Describes current status of ITS in Ontario, and explores potential developments with respect to reducing congestion, more effective border crossings, enhancing vehicle and passenger safety, etc.
  http://www.mto.gov.on.ca/english/engineering/its/strategy.shtml
- No R&D studies identified on web site
- Links to three ATIS sites in Ontario and BC

Ontario's Transportation Technology Transfer Digest
http://www.mto.gov.on.ca/english/transtek/roadtalk/
Publication content focuses on new transportation technologies or innovations that can be implemented in transportation infrastructure related to design, construction, operations and maintenance, safety and the environment.

8.1.5. New Brunswick

Being A Leader With ITS; New Brunswick's Intelligent Transportation Systems (ITS) Strategic Plan 2008-2018
http://www2.gnb.ca/content/dam/gnb/Departments/trans/pdf/ITS/ITS2008-2018E.pdf

Intelligent Transportation Systems Web Site
http://www2.gnb.ca/content/gnb/en/departments/dti/highways_roads/content/transportation_systems.html

- Provides brief description of ITS and list of developments
- Provides link to ITS Strategic Plan
- Provides link to various pages with useful information or case studies.

8.2. U.S.A.

8.2.1. U.S. Department of Transportation (USDOT) ITS Joint Program Office

http://www.its.dot.gov/

ITS Strategic Plan 2015-2019
http://www.its.dot.gov/strategicplan/

8.2.2. Connected Vehicle R & D

Safety Research
- Vehicle-to-Vehicle (V2V) Communications for Safety
- Truck V2V Research
- Transit V2V Research
- Connected Vehicle Safety Pilot
- Vehicle-to-Infrastructure (V2I) Communications for Safety
- Truck V2I Research/Smart Roadside
- Transit V2I Research
- Connected Vehicle Safety for Rail

Mobility Research
- Data Capture and Management
- Dynamic Mobility Applications

Environment Research
- Applications for the Environment: Real-Time Information Synthesis

Road Weather Research
- Road Weather Connected Vehicle Applications

Policy Research
- Connected Vehicle Policy and Institutional Issues

Connected Vehicle Technology Standards and Deployment Framework
- Standards
- Human Factors Research
- Core Systems
- Certification
- Test Bed
- ITS Standards
- National ITS Architecture
- Evaluation
- International Collaboration on ITS Research
- Vehicle Infrastructure Integration-Proof of Concept

Connected Vehicle Pilot Deployments
- Pilots Deployment Project
- Automated Vehicle Research
- Southeast Michigan Test Bed
- Affiliated Test Bed : Affiliation of 5.9GHz DSRC infrastructure device makers, operators

of vehicle to infrastructure (V-I) installations, and developers of applications
- Connected Vehicle PlugFests : Devices are tested for interoperability with emerging standards

8.2.3. Federal Highway Administration R&D (Other than Connected Vehicle)

Other ITS and intermodal research areas
- Active Transportation and Demand Management
- Integrated Corridor Management
- Clarus : integrated surface transportation weather observing, forecasting and data management system
- Commercial Vehicle Information Systems and Networks Core and Expanded Deployment Program
- Cooperative Intersection Collision Avoidance Systems (CICAS)
- Electronic Freight Management
- Emergency Transportation Operations
- Integrated Vehicle-Based Safety Systems
- Intelligent and Efficient Border Crossings
- Mobility Services for All Americans
- Next-Generation 9-1-1
- Rural Safety Initiative
- Commercial Remote Sensing & Spatial Information (CRS&SI) Technologies

Federal Highway Operations Research

Research areas:
- Arterial Management
- Access Management
- Operations Asset Management
- Traffic Signal Timing
- Corridor Traffic Management
- Congestion Pricing
- Value Pricing Pilot Program
- Emergency Transportation Operations
- Facilitating Integrated ITS Deployment
- Freeway Management
- Freight Analysis
- Freight Infrastructure
- Freight Operations and Technology
- Freight Professional Development
- Manual on Uniform Traffic Control Devices
- National Transportation Operations Coalition (NTOC)
- Planning for Operations (Formerly Regional Transportation Operations Collaboration and Coordination (RTOCC))
- Performance Measurement
- Real Time Traveler Information
- Road Weather Management
- Traffic Analysis Tools
- Travel Demand Management
- Traffic Incident Management
- Planned Special Events Traffic Management
- Vehicle Size and Weight
- Work Zone Management

8.2.4. Federal Railroad Administration R&D

Research areas:

- Railroad Systems Issues
- Train Occupant Protection
- Rolling Stock
- HazMat Transportation
- Human Factors
- Track and Structures
- Track/Train Interaction
- Highway-Rail Grade Crossing
- Testing Facilities & Equipment
- Shared-Use Web-Based Tool
- Train Control
- Intelligent Grade Crossings
- Positive Train Control

8.2.5. Federal Transit Administration Research Programs (Other than ITS)

- National Research and Technology Program
- National Fuel Cell Bus Program
- University Transportation Centers
- International Public Transportation Program
- Transit Cooperative Research Program
- Small Business Innovative Research
- Bus Testing Program

8.2.6. Federally Funded Research and Development Facilities

The John A. Volpe National Transportation Systems Center
http://www.volpe.dot.gov/

The Volpe Center's systems-level understanding of transportation technology, operations and institutions, coupled with a wide range of analytical and engineering capabilities, has been an invaluable resource to DOT and the transportation enterprise.

The Turner-Fairbank Highway Research Center (TFHRC)
http://www.tfhrc.gov/

- Research at the Center focuses on a safer, more reliable, and longer-lasting highway transportation system.
- The center performs three overall roles: (1) Coordinator of the development of the national highway research and technology agenda, working with other offices in the Department of Transportation and the Federal Highway Administration and with our partners in the State and local government, academia, industry, and professional organizations. (2) Investigator of new and existing technologies and methods to improve the safety, efficiency, and operation of our highway system. (3) Disseminator of the results of our research to the highway community where it may be placed into practice.

8.2.7. Other Programs Used to Stimulate Transportation Technology Research

Small Business Innovation Research (SBIR)
http://www.sbir.gov

- The Small Business Innovation Research (SBIR) program is a highly competitive program that encourages domestic small businesses to engage in Federal

Research/Research and Development (R/R&D) that has the potential for commercialization.
- Through a competitive awards-based program, SBIR enables small businesses to explore their technological potential and provides the incentive to profit from its commercialization.
- By including qualified small businesses in the nation's R&D arena, high-tech innovation is stimulated and the United States gains entrepreneurial spirit as it meets its specific research and development needs.

Defense Advanced Research Projects Agency (DARPA)
http://www.darpa.mil/Our_Work/
- The Defense Advanced Research Projects Agency (DARPA) was established in 1958 to prevent strategic surprise from negatively impacting U.S. national security and create strategic surprise for U.S. adversaries by maintaining the technological superiority of the U.S. military
- To fulfill its mission, the Agency relies on diverse performers to apply multi-disciplinary approaches to both advance knowledge through basic research and create innovative technologies that address current practical problems through applied research. DARPA's scientific investigations span the gamut from laboratory efforts to the creation of full-scale technology demonstrations in the fields of biology, medicine, computer science, chemistry, physics, engineering, mathematics, material sciences, social sciences, neurosciences and more. As the DoD's primary innovation engine, DARPA undertakes projects that are finite in duration but that create lasting revolutionary change.

8.2.8. Technology Transfer / Dissemination and Professional Capacity Building

Library of Resources
- National Transportation Library
- ITS Research Fact Sheets : 45 Fact Sheets available
- ITS Strategic Plan
- Recent ITS Research Documents
- ITS Videos : 15 ITS-Related Videos

ITS Professional Capacity Building
- ITS Professional Capacity Building

Free ITS Training Courses
- Web and Blended Courses from CITE
- ITS Standards Training
- ITS Architecture Use & Maintenance Training

ITS ePrimer
(Online training course modules)
- ePrimer

Talking Transportation Technology (T3) Webinars
(Over 60 to date in archive)
- T3 Webinar Archive

ITS Knowledge Resources databases
- ITS Knowledge Resources Databases
  (Benefits, Costs, Lessons Learned, Deployment Statistics)

ITS Benefits, Costs, and Lessons Learned: 2014 Update Report
http://www.itsknowledgeresources.its.dot.gov/its/bcllupdate/

Free ITS Technical Assistance
- ITS Peer-to-Peer Program : connects with experienced peers or technical experts.
- ITS Help Line : provides technical support by e-mail or telephone at 866-367-7487.

8.3. AUSTRALIA

8.3.1. Australian Department of Infrastructure and Regional Development - ITS
http://www.infrastructure.gov.au/transport/its/index.aspx
- Overview descriptions of ITS, benefits and how it is being used.
- Extensive set of links to other organizations involved in ITS
- No information on current or past projects or reports.

8.3.2. National Transport Commission (NTC Australia) - Bus and Coach Technology
http://www.ntc.gov.au/bus-coach/technology/
- The NTC is exploring how to best prepare Australia for the introduction of technologies such as in-vehicle telematics systems and Cooperative Intelligent Transport Systems from a regulatory perspective to ensure we can harness these opportunities.
- Several reports are available on web aite.

8.4. EUROPEAN COMMISSION

8.4.1. Strategic Transport Technology Plan (STTP)
http://ec.europa.eu/transport/themes/research/sttp/index_en.htm
- The European Commission is preparing a strategic framework for transport research, innovation and deployment, based on the White Paper's vision for an integrated, efficient, safe, secure and environmentally friendly European transport system by 2050. The first proposals for this framework are presented in a Communication entitled "Research and innovation for Europe's future mobility" adopted in September 2012.
- One of the initiatives that will support the implementation of the strategy is the establishment of a European Transport Research and Innovation Monitoring System (TRIMIS). TRIMIS will be an online information platform with information and data on the European transport research and innovation system. TRIMIS will publicise the agreed roadmaps and report on the progress of their implementation. TRIMIS will include details on public and private R&D investments in the transport sector and report periodically, updating the Capacity Map.

8.4.2. Intelligent Transport Systems: Action Plan and Directive
http://ec.europa.eu/transport/themes/its/road/action_plan/
- There is a great need for the development and implementation of ITS for efficient, safe and clean mobility. Until today, most of the ITS developments in Europe often resulted in

small-scale and relatively expensive ITS solutions that were not compatible with the solution in which investments were being made elsewhere.

- With the ITS Action Plan , laid down in a collection of various documents, the EC stepped up to an ITS Guideline with an aim to co-ordinate the development and implementation of intelligent transport systems (ITS) in road transport and to subsequently facilitate the European market development of ITS and to make it competitive. The EC wants to achieve this by initiating a process of ITS development and implementation with the Action Plan and the ITS Guideline.

- Intelligent Transport Systems (ITS) can significantly contribute to a cleaner, safer and more efficient transport system. A new legal framework (Directive 2010/40/EU) was adopted on 7 July 2010 to accelerate the deployment of these innovative transport technologies across Europe. This Directive is an important instrument for the coordinated implementation of ITS in Europe. It aims to establish interoperable and seamless ITS services while leaving Member States the freedom to decide which systems to invest in.
- Under this Directive the European Commission has to adopt within the next seven years specifications (i.e. functional, technical, organisational or services provisions) to address the compatibility, interoperability and continuity of ITS solutions across the EU. The first priorities will be traffic and travel information, the eCall emergency system and intelligent truck parking.
- The Commission already took a major step towards the deployment and use of ITS in road transport (and interfaces to the other transport modes) on 16 December 2008 by adopting an Action Plan. The Action Plan suggested a number of targeted measures and included the proposal for this Directive The goal is to create the momentum necessary to speed up market penetration of rather mature ITS applications and services in Europe.
- The initiative is supported by five co-operating Directorates-General: DG Mobility and Transport (lead), DG Communications Networks, Content & Technology, DG Research & Innovation, DG Enterprise and Industry and DG Climate Action.

8.4.3. European Commission 7th Framework Programme (FP7)

http://ec.europa.eu/research/transport/publications/items/project_synopses_sstr_volume_2_en.htm

- EC R&D 4.16 Billion Euro program from the Directorate General for Research and Innovation, covering the 2007-2013 period.
- The projects involve a wide partnership of research institutions, industrial partners, governmental agencies, and other experts, across all European countries.
- Many of the projects involve pilot project deployments to test the research concepts.
- The program funded over 100 surface transportation R&D projects in a wide range of topic areas, many of which relate directly to transportation technology, as seen in the listing below.

The Greening of Surface Transport

- CARGOVIBES Attenuation of ground-borne vibration affecting residents near freight railway lines
- COFRET Carbon footprint of freight transport
- ECOLABEL Development of a novel ECO-LABELing EU-harmonized methodology for cost-effective, safer and greener road products and infrastructures
- GRIP Green Retrofitting through Improved Propulsion
- INFRAVATION ERA-NET Plus on Infrastructure Innovation 58

- MERLIN Sustainable and intelligent management of energy for smarter railway systems in Europe: an integrated optimisation approach
- OSIRIS Optimal Strategy to Innovate and Reduce energy consumption In urban rail Systems
- QUIET-TRACK Quiet Tracks for Sustainable Railway Infrastructures 73
- RIVAS Railway Induced Vibration Abatement Solutions 82

The European Green Cars Initiative

- ALIVE Advanced High Volume Affordable Lightweighting for Future Electric Vehicles
- AMBER-ULV Automotive Mechatronic Baseline for Electric Resilient Ultra Light Vehicle
- ARMEVA Advanced Reluctance Motors for Electric Vehicle Applications
- ASTERICS Ageing and efficiency Simulation & TEsting under Real world conditions for Innovative electric vehicle Components and Systems
- BEHICLE BEst in class veHICLE: Safe urban mobility in a sustainable transport value-chain (BEHICLE)
- CAPIRE Coordination Action on PPP Implementation for Road-Transport Electrification
- CITYMOBIL2 Cities demonstrating cybernetic mobility
- CO3 Collaboration Concepts for Comodality
- CONVENIENT Complete Vehicle Energy-saving Technologies for Heavy-Trucks
- CORE CO2 REduction for long distance transport
- DELIVER Design of Electric LIght Vans for Environment-impact Reduction
- E-GOMOTION Job opportunities in vehicle electrification
- E-LIGHT Advanced Structural Light-Weight Architectures for Electric Vehicles
- ECOHUBS Environmentally Coherent measures and interventions to debottleneck HUBS of the multimodal network favoured by seamless flow of goods
- ECOSHELL Development of new light high-performance environmentally benign composites made of bio-materials and bio-resins for electric car application
- ELECTROMOBILITY+ ERA-NET Plus on Electromobility
- ELVA Advanced Electric Vehicle Architectures
- EM-SAFETY EM safety and Hazards Mitigation by proper EV design
- ENHANCED WISETRIP Enhancing Intermodality of Content, Personalised Information and Functionality of WISETRIP Network of Journey Planning Engines
- EPSILON small Electric Passenger vehicle with maximized Safety and Integrating a Lightweight Oriented Novel body architecture
- EUNICE Eco-design and Validation of In-Wheel Concept for Electric Vehicles
- EVADER eVADER: Electric Vehicle Alert for Detection and Emergency Response
- FABRIC FeAsiBility analysis and development of on-Road chargIng solutions for future electric vehiCles
- FASTINCHARGE innovative FAST INductive CHARGing solution for Electric vehicles
- FUEREX Multi-fuel Range Extender with high efficiency and ultra low emissions
- FURBOT Freight Urban RoBOTic vehicle
- GASTONE New powertrain concept based on the integration of energy recovery, storage and re-use system with engine system and control strategies
- HI-WI Materials and drives for High & Wide efficiency electric powertrains
- ICE MagnetoCaloric Refrigeration for Efficient Electric Air Conditioning
- LIBRALATO Libralato Engine Prototype
- LOGICON Lean Secure and Reliable Logistic Connectivity for SMEs
- LOGINN LOGistics INNovation uptake
- LORRY Development of an innovative low rolling resistance truck tyre concept in combination with a full scale simulation tool box for tyre performance in function of material and road parameters

- MAG-DRIVE New permanent magnets for electric-vehicle drive applications
- MATISSE Modelling And Testing for Improved Safety of key composite StructurEs in alternatively powered vehicles
- MODULUSHCA Modular Logistics Units in Shared Co-modal Networks
- NOWASTE Engine Waste Heat Recovery and Re-Use
- OPERA4FEV OPerating RAck For Full-Electric Vehicle
- OPTIBODY Optimized Structural components and add-ons to improve passive safety in new Electric Light Trucks and Vans (ELTVs)
- OPTIMORE Optimised Modular Range Extender for every day Customer Usage
- OSTLER Optimised storage integration for the electric car
- PLUS-MOBY Premium Low weight Urban Sustainable e-MOBilitY
- SAFEEV Safe Small Electric Vehicles through Advanced Simulation Methodologies
- SMARTBATT Smart and Safe Integration of Batteries in Electric Vehicles
- SMARTFUSION Smart Urban Freight SolutIONs
- SMARTOP Self powered vehicle roof for on-board comfort and energy saving
- STRAIGHTSOL STRAtegies and measures for smarter urban freIGHT SOLutions
- SYRNEMO Synchronous Reluctance Next Generation Efficient Motors for Electric Vehicles
- TELLISYS Intelligent Transport System for Innovative Intermodal Freight Transport
- TRANSFORMERS Configurable and Adaptable Trucks and Trailers for Optimal Transport Efficiency
- UNPLUGGED Wireless charging for Electric Vehicles
- URBAN-EV Super Light Architectures for Safe and Affordable Urban Electric Vehicles
- V-FEATHER InnoVative Flexible Electric Transport
- VENUS Switched/Synchronous Reluctance Magnet-free Motors for Electric Vehicles
- WIDE-MOB Building blocks concepts for efficient and safe multiuse urban electrical vehicles
- WINN European Platform Driving KnoWledge to INNovations in Freight Logistics

Encouraging Modal Shift and Decongesting Transport Corridors

- CAPACITY4RAIL Increasing Capacity 4 Rail networks through enhanced infrastructure and optimised operations
- ECUC Eddy CUrrent Brake Compatibility
- EUREMCO European Railway Electromagnetic Compatibility
- GREEN EFFORTS Green and Effective Operations at Terminals and in Ports
- LIVINGRAIL Living in a sustainable world focused on electrified rail
- MARATHON Make Rail The Hope for protecting Nature
- NEAR2 Network of European Asian Rail Research capacities
- NGTC Next Generation Train Control
- SPIDER PLUS Sustainable Plan for Integrated Development through the European Rail network Projecting Logistics & mobility for Urban Spatial design evolution
- TREND Test of Rolling Stock Electromagnetic Compatibility for cross- Domain interoperability
- VEL-WAGON Versatile, Efficient and Longer Wagon for European Transportation

Ensuring Sustainable Urban Mobility

- 3IBS The Intelligent, Innovative, Integrated Bus Systems
- CITY-HUB City-Hub
- METPEX A MEasurement Tool to determine the quality of the Passenger EXperience
- NODES New tOols for Design and OpEration of Urban Transport InterchangeS
- OPTICITIES Optimise Citizen Mobility and Freight Management in Urban Environments

- SOLUTIONS SOLUTIONS: Sharing Opportunities for Low carbon Urban transporTatION
- TIDE Transport Innovation Deployment for Europe
- VIAJEO PLUS International Coordination for implementation of innovative and efficient urban mobility solutions

Improving Safety and Security

- ARTRAC Advanced Radar Tracking and Classification for Enhanced Road SafetyAdvanced Radar Tracking and Classification for Enhanced Road Safety
- ASPECSS Assessment methodologies for forward looking Integrated Pedestrian and further extension to Cyclists Safety Systems
- D-RAIL Development of the Future Rail Freight System to Reduce the Occurrences and Impact of Derailment
- EURAXLES EURAXLES: Minimizing the risk of fatigue failure of railway axles
- GETAWAY Generating simulations to Enable Testing of Alternative routes to improve WAYinding in evacuation of over-ground and underground terminals
- PIPER Position and Personalize Advanced Human Body Models for Injury Prediction
- PROS Priorities for Road Safety Research in Europe
- RESTRAIL Reduction of Suicides
- SECURESTATION Passenger station and terminal design for safety, security and resilience to terrorist attack
- UDRIVE eUropean naturalistic Driving and Riding for Infrastructure & Vehicle safety and Environment

Strengthening Competitiveness

- ACEM RAIL Automated and cost effective maintenance for railway
- ACOUTRAIN Virtual certification of acoustic performance for freight and passenger trains
- AUTOMAIN Augmented Usage of Track by Optimisation of Maintenance, Allocation and Inspection of railway Networks
- EATS ETCS Advanced Testing and Smart Train Positioning System
- INROADS INtelligent Renewable Optical ADvisory System
- LOWFLIP Low cost flexible integrated composite process
- MAINLINE MAINtenance, renewaL and Improvement of rail transport iNfrastructure to reduce Economic and environmental impacts
- MAXBE Interoperable Monitoring, Diagnosis and Maintenance Strategies for Axle Bearings
- MOSAIC Materials Onboard: Steel Advancements and Integrated Composites
- ON-TIME Optimal Networks for Train Integration Management across Europe
- OPTIRAIL Development of a Smart Framework based on Knowledge to Support Infrastructure Maintenance Decisions in Railway Corridors
- REFRESCO Towards a REgulatory FRamework for the usE of Structural new materials in railway passenger and freight CarbOdyshells
- ROSANNE ROlling resistance, Skid resistance, ANd Noise Emission measurement standards for road surfaces
- SMART RAIL Smart Maintenance and Analysis of Transport Infrastructure
- SPECTRUM Solutions and Processes to Enhance the Competitiveness of Transport by Rail in Unexploited Markets
- SUSTRAIL The sustainable freight railway: Designing the freight vehicle - track system for higher delivered tonnage with improved availability at reduced cost
- TRIMM Tomorrow's Road Infrastructure Monitoring and Management

8.4.4. Transport Research and Innovation in Horizon 2020

http://ec.europa.eu/transport/themes/research/horizon2020_en.htm
http://ec.europa.eu/programmes/horizon2020/en/

- **Horizon 2020** is the European Commission's proposal to generate ideas, growth and jobs through the world's largest collaborative programme for research and innovation (2014-2020). It is the successor program to follow-up FP7.
- In the transport sector, the Commission will strive for a balanced approach in implementing the programme that takes into account the specifics of each mode (rail, road, waterborne and air transport) while remaining holistic; an approach which reconciles competitiveness with sustainability and which invests both in technology and in relevant socio-economic research.
- The four main priorities for transport research under Horizon 2020 are:
  - Making transport more sustainable: resource-efficient transport that respects the environment.
  - Making transport and transport systems seamless: better mobility, less congestion, greater safety and security.
  - Keeping transport competitive: the European transport industry as a global leader.
  - Making transport research responsive: socio-economic research and forward-looking activities for policy-making.

8.4.5. European Institute of Innovation and Technology (EIT)

http://ec.europa.eu/programmes/horizon2020/en/h2020-section/european-institute-innovation-and-technology-eit

- The European Institute of Innovation and Technology (EIT) is a key driver of sustainable European economic growth and competitiveness. It works to reinforce the innovation capacity of the European Union and its Member States in order to address grand challenges facing European society. From 2014 to 2020, the EIT will receive € 2.711 Billion to continue promoting innovation in Europe.
- The EIT has been created to enhance Europe's ability to innovate by integrating, for the first time at EU level, education and entrepreneurship with research and innovation. The main operational arm of the EIT is its Knowledge and Innovation Communities (KICs). Through them the EIT develops and tests a new model of how innovation is approached, managed, financed and delivered in Europe. The KICs offer a genuine opportunity for top innovation players to be part of a highly collaborative community, based on the principles of excellence and commitment, to achieve pan-European impact.
- In record time, the EIT and its existing Knowledge and Innovation Communities, or KICs, have brought about promising results by training more than 1000 students, creating more than 100 start-ups which have launched more than 400 products and services.
- The EIT's three initial KICs were established in 2010 to address:
  - Climate change (Climate KIC)
  - Sustainable energy (KIC InnoEnergy)
  - ICT innovation (EIT ICT Labs)
- A new KIC on Urban Mobility will be launched in 2018

8.4.6. EC Technology Transfer / Dissemination and Professional Capacity Building

Transport Research & Innovation Portal (TRIP)
http://www.transport-research.info/web/index.cfm

- The Transport Research & Innovation Portal (TRIP) provides summary descriptions of research activities and projects at European and national level.

Eltis: The Urban Mobility Observatory
http://www.eltis.org

- Eltis facilitates the exchange of information, knowledge and experiences in the field of sustainable urban mobility in Europe.
- Under three key themes – **DISCOVER, RESOURCES, PARTICIPATE** – Eltis provides the information, good practices, tools and communication channels needed to help you turn your cities into models of sustainable urban mobility.
- Contains much information on green technology.

EC Research and Innovation - Transport Publications
http://ec.europa.eu/research/transport/publications/index_en.htm?Page=1

- Many reports providing various overviews of the Transport research programs of DG Research and Innovation

Intelligent transport systems; EU-funded research for efficient, clean and safe road transport (2011)
http://ec.europa.eu/research/transport/publications/items/intelligent_transport_systems_en.htm

- This brochure reviews the contribution made over 15 years of EU-funded research in the field of ITS by the Sustainable Surface Transport programme. Its main contribution is the support for an integrated systemic approach to transport research. This evolution is described through the presentation of research projects including: road safety, traffic management and intelligent infrastructures, holistic solutions, multimodality, freight logistics and international cooperation.

Keeping Europe's cities on the move; EU-funded research to ensure urban mobility
http://ec.europa.eu/research/transport/publications/items/keeping_europe_s_cities_on_the_move_en.htm

- Urban mobility is a major priority for the EU, and since 1998, the EU has invested over EUR 300 million in urban transport research. This brochure offers a snapshot of European urban transport research, and explains how the results of EU-funded projects are already helping to improve passenger and freight flows in cities. The projects profiled cover all aspects of urban mobility, including urban infrastructure, demand side measures, new forms of organisation of urban mobility (public transport, car-sharing, car-pooling, demand-responsive transport), urban mobility services (with the support of information and communication technologies), urban mobility systems (innovative and clean urban vehicles, accessibility of vulnerable users, quiet cities) and city logistics. In addition, actions to promote and disseminate urban transport research and international cooperation are highlighted.

8.5. U.K.

8.5.1. Department for Transport (DfT)

ITS in the United Kingdom Report (2011)
https://www.gov.uk/government/publications/intelligent-transport-systems-in-the-united-kingdom
- No ITS division was identified
- But 2011 report provides status and strategic plan for ITS.

8.5.2. DfT Driverless cars in the UK: a Regulatory Review

https://www.gov.uk/government/publications/driverless-cars-in-the-uk-a-regulatory-review
- The focus of this review is to ensure the UK is at the forefront of the testing and development of the technologies that will ultimately realise the goal of driverless vehicles.
- Analyses the existing legal and regulatory situation for testing, producing and marketing highly and fully automated vehicles in the UK.

The Pathway to Driverless Cars; Summary Report and Action Plan (February 2015)
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/401562/pathway-driverless-cars-summary.pdf
- This review identifies issues that need to be addressed to enable automated vehicle technology testing on UK roads whilst maintaining high levels of road safety. It covers the best and safest ways to trial vehicles where a qualified individual is present who is capable of taking control of the car. It also looks further ahead, to the implications of potential use of fully autonomous vehicles.
- Findings: Driverless vehicles can legally be tested on public roads in the UK today. The UK is uniquely positioned to become a premium global location for the development of these technologies.
- Next steps and action plan: The Government will publish a Code of Practice in spring 2015 for those wishing to test driverless vehicles on UK roads.
- It therefore makes sense to encourage testing on a national level to gain first-hand experience of these technologies, which can inform our negotiations on international standards.

The Pathway to Driverless Cars: a detailed review of regulations for automated vehicle technologies (February 2015)
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/401565/pathway-driverless-cars-main.pdf

8.5.3. Department for Transport Driverless Car Program

https://www.gov.uk/government/news/uk-to-lead-development-of-driverless-car-technology
- The Department for Transport has announced that driverless cars will hit the streets in three UK cities starting in January 2015. To facilitate this deployment, the government has launched a competition to spur research and reach the deadline. The competition resulted in the selection of three project consortiums involving four cities: London, Coventry, Bristol and Milton Keynes. The funding provided by Innovate UK will be matched by the 12 consortium members to create a £19.2 million ($37 million) three-year project.
- The projects will examine how different self-driving vehicles could be implemented safely and efficiently across the UK.

- Two different types of self-driving vehicles will be tested: fully autonomous cars with no driver, and self-driving models that can relinquish control to a human pilot.
- In parallel, research is underway to research and formulate new road laws to accommodate such vehicles.

8.5.4. Innovate UK - Knowledge Transfer Network (KTN) - Transport

https://connect.innovateuk.org/web/transportktn

- Innovate UK is the new name for the Technology Strategy Board - the UK's innovation agency, accelerating economic growth. It is defined as a quango, a quasi-autonomous non-governmental organisation, and its objective is to fund, support and connect innovative businesses through a unique mix of people and programmes to accelerate sustainable economic growth.
- Transportation is a specific area of strategic focus of Innovate UK.
- The mission of the Transport Community on the Knowledge Transfer Network is to support the development of integrated, efficient and sustainable transport systems, by bringing together independent but interrelated organisations to stimulate innovation through knowledge transfer.

Intelligent Mobility KTN
https://connect.innovateuk.org/web/intelligent-mobility

Transport Systems Catapult
https://connect.innovateuk.org/web/transport-systems1/overview

Sub Group Local Authority Solutions for Integrated Transport
https://connect.innovateuk.org/web/local-authority-solutions-for-integrated-transport

8.6. THE NETHERLANDS

8.6.1. Ministry of Infrastructure and Environment

ITS in the Netherlands (2011)
http://www.connekt.nl/uploads/2011/09/its-in-the-netherlands.pdf

- This report contains the 2011 National Inventory of ITS for roads in the Netherlands in response to the demand formulated in EC Directive 2010/40/EU.
- This report contains an overview of the current status of ITS in the Netherlands (the installed base) and provides a (non-exhaustive) list of past and present actions.
- This report is issued by the Ministry of Infrastructure and the Environment and is written by Connekt ITS Netherlands.

ITS Plan - The Netherlands 2013-2017
http://ec.europa.eu/transport/themes/its/road/action_plan/doc/2012-its-plan-the-netherlands-2013-2017.pdf

- Five-year investment plan with description of projects fore research, devlopment, and deployment in four target priority areas.
- Lists projects at all levels: EC, National, Regional, and local

I & M creates space; The Infrastructure & Environment Ministry's Strategic Knowledge and Innovation Agenda (SKIA) for 2012-2016
http://www.government.nl/files/documents-and-publications/reports/2012/09/01/i-m-creates-space-strategic-knowledge-and-innovation-agenda-2012-2016/im-creates-space-online.pdf

- The Ministry of Infrastructure and Environment's first SKIA outlines seven target themes around research and innovation over the next four years. We will be acting jointly on this agenda with corporates, social organizations and governmentals.

9. MULTINATIONAL GOVERNMENTAL AND NON-GOVERNMENTAL

9.1. APEC - TRANSPORTATION WORKING GROUP (TPT-WG)

http://www.apec-tptwg.org.cn

- The Asia-Pacific Economic Cooperation (APEC) is a multinational forum for discussing and addressing topics of common interest among member countries.
- Focus areas for the TPT-WG are supply chain connectivity, road and rail safety, security, energy consumption, sustainable intermodal transportation, etc.
- ITS is addressed as it relates to the above themes, but little focus on technology R&D per se.
- Working documents (agendas and minues) publicly available.

9.2. GLOBAL TRANSPORT KNOWLEDGE PRACTICE (GTKP)

http://www.gtkp.com/themepage.php&themepgid=8

- On-line library on road infrastructure and transport.
- Contains case studies, research papers, publications, reports, presentations, available for free.
- ITS is one focus area, with emphasis on safe roads and driving, and road sustainability.

9.3. INTERNATIONAL BENEFIT, EVALUATION, AND COST (IBEC) WORKING GROUP

https://sites.google.com/site/ibecits/

- Forum for international experts to discuss and research issues related to economic assessment of ITS technologies.
- Various technical documents available for free.

9.4. INTERNATIONAL ROAD FEDERATION

http://www.irfnet.org

- Mission to encourage and promote development and maintenance of better, safer and more sustainable roads and road networks around the world.
- Limited technical information on transportation technology R&D.
- Webinars, e-training, and conference proceedings available to members only.

9.5. THE WORLD ROAD ASSOCIATION-PIARC

http://www.piarc.org/en/

- The World Road Association-PIARC was established in 1909. It brings together the road administrations of 122 governments and has members--individuals, companies, authorities and organizations--in over 140 countries.
- Comprehensive library of technical reports and professional journal articles on road operations and maintenance, freight transport, etc., including some related to transportation technology.
- Documents available for free.

10. ASSOCIATIONS AND NON-PROFIT

10.1. CANADA

10.1.1. Intelligent Transportation Systems Society of Canada (ITS Canada)

http://www.itscanada.ca

- ITS Canada is the primary forum for ITS technology in Canada.
- The web site provides general descriptions of ITS as well as information for its members.
- The web site provides considerable information and links related to ITS standards.
- Conference presentations are available to Members.
- There are no specific R&D related information or resources

10.1.2. Transportation Association of Canada

http://tac-atc.ca/en

- Focuses primarily on road design, construction, and safety, traffic management, and transportation policy, financing, and planning
- ITS is peripherally addressed with respect to road operations and traffic management
- TAC provides on their web site a wide range of documents for free to the general public including briefing documents, primers, and conference papers. Technical reports are available for purchase.
- No links are provided to other web sites.
- Two recent projects peripherally relate to transportation technology:
    - Moving Smarter - Exploring Solutions for Canadian Cities to Reduce GHG Emissions
    - Traffic Monitoring Practices Guide for Canadian Provinces and Municipalities

10.1.3. Canadian Institute of Transportation Engineers

http://www.cite7.org/

- Extremely limited references to ITS or technology in list of presentations at conference over last three years
- All technical publications processed through ITE Library in the U.S.
- Technical publications and conference presentations only available to ITE Members

10.1.4. Canadian Transportation Research Forum (CTRF)

http://ctrf.ca

- To promote the development of research in transportation and related fields and provide a forum for networking and discussion
- Members include railways, trucking companies, airlines, port and airport authorities, shipping lines, terminal operators, shippers, transit operators, and pipeline companies, government agencies, consultants, and universities

10.2. U.S.A.

10.2.1. American Association of State Highway and Transportation Officials (AASHTO)

http://www.transportation.org

AASHTO Pooled-Fund Technical Service Programs
http://www.transportation.org/Pages/Programs.aspx

- Several programs for pooled-funded technical programs, several of which relate to transportation technology, including:
  - AASHTO Rail Resource Center,
  - Equipment Management Technical Service Program,
  - National Operations Center of Excellence,
  - National Transportation Product Evaluation Program,
  - Sustainable Transportation Energy, Infrastructure and Climate Solutions Technical Assistance Program
- Each of these programs much technical information and links to reports on their web sites.

AASHTO Innovation Imitative (AII)
http://aii.transportation.org/Pages/default.aspx?siteid=73 - more-about
- The *AASHTO Innovation Initiative* advances innovation from the grassroots up: by agencies, for agencies, peer-to-peer. The program actively seeks out proven advancements in transportation technology, investing time and money to accelerate their adoption by agencies nationwide.
- Each year, the program selects highly valuable technologies, processes, software, or other innovations that have been adopted by at least one agency, are proven in use, and will be of significant benefit to other agencies.
- Focus areas are: construction, design, environmental, maintenance, safety, traffic,

10.2.2. ITS America

Technology Scan and Assessment
http://www.itsa.org/knowledgecenter/technologyscan
Studies prepared by ITS America through support from US DOT:
- Computer Vision
- Active Sensing Technology
- 4G Wireless
- Vehicles and Nomadic Wireless
- The Internet of Things
- Big Data and Adaptive Services
- Vehicle Electrification and the Smart Grid
- Cyber-Security and Dependable Transportation
- Driver Assistance and Autonomous Vehicles

10.2.3. Association of American Railroads (AAR)
https://www.aar.org/
- Technology and innovations is a specific focus https://www.aar.org/todays-railroads/safety?t=technologyandinnovation
- Owns and operates the Transportation Technology Center Inc. (TTCI) comprehensive rail test facility in pueblo, CO

10.3. AUSTRALIA

10.3.1. ITS Australia
http://www.its-australia.com.au
- Newsletter publicly available.

- Knowledge Centre available to members only.
- No other technical information (proceedings, papers, links to other organizations) available.

10.3.2. Austroads

http://www.austroads.com.au

- Austroads is the association of Australasian road transport and traffic agencies.
- Austroads' purpose is to improve Australian and New Zealand transport outcomes by:
  - providing expert technical input to national road and transport policy development
  - improving the practices and capability of road agencies
  - promoting operational consistency by road agencies.
- Austroads conducts $1 Million a year in "Network" related topics, which includes ITS.
- They have placed a major focus on ITS and connected vehicle ("Cooperative ITS") policy framework, architecture, and standards
- They have produced a major series of reports to guide policy, development, and deployment https://www.onlinepublications.austroads.com.au
- These reports are all available for free and include:
  - *Cooperative Intelligent Transport Systems (C-ITS) Standards Assessment (2015)*
  - *C-ITS Interoperability with Existing ITS Infrastructure (2014)*
  - *National ITS Architecture: ITS Business Architecture (2014)*
  - *National ITS Architecture: Context and Vision (2014)*
  - *Procurement of ITS; International Practice (2014)*
  - *Best Practice Guidelines for Procurement of ITS Solutions (2013)*
  - *5.9GHz Satellite Interference Study - Field Study (2013)*
  - *Vehicle Positioning for C-ITS in Australia; Background Document (2013)*
  - *Emerging Digital Mapping Requirements for C-ITS (2013)*
  - *Emerging Telecommunication Developments in WAN/LAN for Intelligent Transport Systems (2012)*
  - *DSRC Interoperability Study (2011)*
  - Examination of Major Policy Issues Relating to Introduction of Cooperative ITS to Australia (2011)
  - Defining Applicability of International Standards for Intelligent Transport Systems (ITS) – Final Report (2010)

National ITS Architecture

http://www.austroads.com.au/road-operations/network-operations/national-its-architecture

- Responsible for developing national reference ITS Architecture.
- Documents available concerning Context and Vision, and Business Architecture.

10.3.3. The Australasian Railway Association (ARA)

http://www.ara.net.au

- The Australasian Railway Association (ARA) is the peak body representing all passenger, freight, track operators and the wider rail supply industry in Australia, New Zealand and Indonesia.
- Operates the **Australasian Centre for Rail Innovation (ACRI)**

http://www.acri.net.au

- To undertake or facilitate targeted, applied research and strategic analysis to solve issues raised by rail industry participants or other entities whether with a commercial or public policy interest in the rail sector or transport sector more broadly, to support and ensure continued improvement in productivity and sustainability to underpin the competitive position of the Australasian Rail Industry.

10.4. EUROPE

10.4.1. Ertico (ITS Europe)

http://ertico.com

- Involved in European R&D projects, and developing sustaining frameworks for deployment (see below)
- Provides links to 31 current and completed European projects
- No other technical information (proceedings, papers, links to other organizations) available.

ITS Projects: Advancing Research, Development & Deployment

http://ertico.com/projects-categories/projects/

- ERTICO offers a unique networking platform for international collaborative research and development, where innovative ideas are transformed into tangible results.
- ERTICO is involved in R&D projects, including: generating ideas, project proposal submission, project management, disseminating results, etc.
    - Clean Mobility
    - Smart Mobility
    - Safe Mobility

Platforms

http://ertico.com/projects-categories/platforms/

ERTICO increasingly supports the development, deployment and maintenance of services in the context of self-funded activities, including:

- Traffic and Traveller Information (TISA),
- navigation/digital maps linked to Advanced Driver Assistance Systems (ADASIS),
- eMobility ICT Interoperability Innovation (eMI3), and
- Transport Network ITS Spatial Data (TN-ITS).

10.5. U.K.

10.5.1. ITS United Kingdom

http://www.its-uk.org.uk

- Several practical guides publicly available
- No other technical information (proceedings, papers, links to other organizations) available.

10.6. THE NETHERLANDS

10.6.1. Connekt (ITS Netherlands)

http://www.connekt.nl/en-GB/

- Developed the Netherlands ITS Plan in collaboration with the Netherlands Ministry of Infrastructure and the Environment
- Many technical reports available for free

11. ACADEMIC RESEARCH

11.1. CANADA

11.1.1. ACTIVE-AURORA, Canada's Connected Vehicle Test Bed Network

http://www.transportation.ualberta.ca/News and Events/2013/December/TheCSTandtheFirstConnectedVehicleTestBedinCanada.aspx

- The ACTIVE-AURORA Test Bed Network helps Canada meet that challenge by providing a platform for investigating and implementing innovative Connected Vehicle (CV) technologies. CV technology enables vehicles to communicate critical, real-time information—location, speed, inclement weather, adverse road conditions and more—with other vehicles and surrounding infrastructure via wired and wireless networks.
- This initiative is a unique partnership of the University of Alberta Centre for Smart Transportation, University of British Columbia (UBC), three levels of government (Transport Canada, Alberta Transportation, and the City of Edmonton), and industry.
- The Government of Canada's contribution for this $3.66 million project includes $1.3 million from the Asia-Pacific Gateway and Corridor Transportation Infrastructure Fund.
- Other public and private partners are providing funding and in-kind support totaling $2.36 million

11.1.2. CIRRELT: Interuniversity Research Centre on Enterprise Networks, Logistics and Transportation

https://www.cirrelt.ca/default.aspx

Interdisciplinary research focusing on the design, management, operation and safety of logistics, service, and infrastructure networks.

- R&D covers a wide variety of topics including human factors, economics, etc, with many focusing on operations research and routing topics
- Very few relate per se to transportation technology
- R&D studies are listed and available on the web site
- Academic papers are listed on the web site

11.1.3. McGill University - Transportation Research at McGill (TRAM)

http://tram.mcgill.ca/

- Areas of focus are: Public Transit Planning and Operations, Performance Measures and Accessibility, Cycling and Walking, Travel Behaviour.
- Provides on web site complete inventory of Referred Papers, Projects, and Reports.
- Reports and Papers are not available on web site.
- Several papers/reports relate to use of ITS data or the assessment of impacts of ITS technology.

11.1.4. McMaster University - McMaster Institute for Transportation & Logistics (MITL)

http://mitl.mcmaster.ca/

- Multidisciplinary research to improve the efficiency of transportation systems and the competitiveness of the logistics/manufacturing sector.
- Focus areas include: commercial goods movement, routing, congestion, analysis of emissions, electric mobility.
- Technical reports are available on web site.
- Collaborates with McMaster Institute for Automotive Research and Technology (MacAUTO): http://macauto.mcmaster.ca/index.html

11.1.5. Polytechnique Montreal - Chaire de recherche mobilité

http://www.polymtl.ca/mobilite/index.php

Research centre on sustainable mobility

- Focuses primarily on transportation planning, but indirectly pertinent to analysis of transportation technology (alternative modes, data mining and analysis, etc.)
- Academic theses funded under research centre are posted on web site, as are a few research reports

11.1.6. University of Alberta - Center for Smart Transportation

http://transportation.ualberta.ca

- Research programs to address issues related to traffic operations, planning, and safety.
- The core research themes are:
  - Connected Vehicle technology
  - Multimodal Transportation
  - Traffic Monitoring
  - Traffic Safety
- Project descriptions are listed.
- The web site provides no technical reports or lists of academic papers.

11.1.7. University of New Brunswick National Rural ITS Research Programme

http://www.unb.ca/research/transportation-group/research/rural-its-program.html

- Over the last five years, the University of New Brunswick Transportation Group (UNBTG) has been working with the New Brunswick Department of Transportation and Transport Canada to conduct rural ITS research under a $1 million federal/provincial cost-shared contribution agreement.
- The program's goal was to identify innovative and previously unproven technologies for improving rural transportation systems.
- The program has produced 10 research projects and contributed to the development of highly-qualified-personnel.
- Projects are listed
- Over 20 research papers available for free

11.1.8. University of Toronto

Intelligent Transportation Systems Centre and Testbed

http://www.civil.engineering.utoronto.ca/research/transport/its.htm

The ITS Centre and Testbed, launched in 2001, provides an instrumented, multijurisdictional, multiagency transportation operations environment linked to university laboratories for real-world development, testing, and evaluation of ITS technologies and applications.

- Written description from 2003 and overview powerpoint presentation available
- No R&D studies listed on web site

Integrated Land Use Transportation Environment (ILUTE) Modelling System

http://www.civil.engineering.utoronto.ca/research/transport/modelling.htm

- The ILUTE modelling system is an extended experiment in the development of a large scale microsimulation model of the Greater Toronto Area and other Canadian urban areas.
- No R&D studies listed on web site

11.1.9. University of Waterloo

Waterloo Centre for Automotive Research (WatCAR)
https://uwaterloo.ca/centre-automotive-research/
WatCAR works with companies from across the automotive spectrum to improve the safety, intelligence, performance, and sustainability of modern vehicle systems.

- News reports available. Most deal with internal University news, automotive technology, or human factors, though a few focus on ITS: https://uwaterloo.ca/centre-automotive-research/news
- No R&D studies listed or posted on web site

Green Intelligent Transportation Systems
http://www.greenits.ca

- Seven projects listed with abstracts available
- No R&D studies publicly available on web site
- A few notices dating from 2010-2011

11.1.10. AUTO21

https://www.auto21.ca/en/

- AUTO21 is a national research initiative supported by the Government of Canada through the Networks of Centres of Excellence Secretariat.
- AUTO21 brings together nearly 200 top Canadian researchers at 48 universities and partners them with more than 130 industry and government partners.
- An annual research budget of approximately $11 million in federal and industry support fund projects within six key research themes:
    - Health, Safety and Injury Prevention
    - Societal Issues and the Future Automobile
    - Materials and Manufacturing
    - Powertrains, Fuels and Emissions
    - Design Processes
    - Intelligent Systems and Sensors

11.1.11. NSERC DIVA

http://nsercdiva.com/networkadmin.php

- Network linking 9 universities, 21 industrial partners, Industry Canada, Transport Canada, Defense Research and Development Canada, and the City of Edmonton
- Objective is to develop next generation intelligent vehicular networks and applications.
- Research Themes:
    - Heterogeneous Vehicular Networks
    - Intelligent Vehicular Ad Hoc and Sensor Networks
    - Multimedia Service Oriented Architecture for Vanets
    - Vehicular Sensor Network Security
    - Infrastructures and Applications for Vehicular Communications
- Web site lists academic papers all dated 2010-2012
- Hold annual meetings.

11.1.12. ONE-ITS

http://one-its-webapp1.transport.utoronto.ca/web/one-its

- Developed as a Joint Project of the University of Regina and the University of Toronto. ONE-ITS' intent is to facilitate collaborative research & development among the widely dispersed participants in the Canadian ITS research community.
    - Provides descriptions of projects

- Various reports available

11.2. U.S.A.

11.2.1. University Transportation Centers Supported by US DOT

http://www.rita.dot.gov/utc/about/grant_recipients/html/2013_grant_recipients.html

University Transportation Centers

- Periodic competition to select member universities in UTC Network.
- Five National Centers
- 10 lead Regional Centers (plus affiliated academic institutions)
- 20 Tier 1 Centers
- No central clearinghouse for R&D. Need to look at individual centers, but web sites provided on US DOT site
- Regular UTC Spotlight Newsletter: http://www.rita.dot.gov/utc/publications/spotlight

Cold Region Rural Transportation Centers Supported by US DOT

Cold Region Rural Transportation Research Centers

- North Dakota State University
- Montana State University

11.2.2. California Partners for Advanced Transportation Technology (PATH)

http://www.path.berkeley.edu

Many dozens of R&D studies (and reports) available on web site (with report search engine) organized along the following themes:

- Transportation Safety
- Traffic Operations
- Sustainability
- Modal Applications
- Integrated Corridor management

11.2.3. Carnegie Mellon University - T-SET

http://www.utc.ices.cmu.edu/utc/

Technologies for Safe and Efficient Transportation (T-SET)

Detailed summaries (and many reports) available for over 50 R&D studies

- Human-Vehicle Interactions
- Infrastructure technology
- In-Vehicle Technology
- Mobility and Data Analytics
- Policy

11.2.4. University of Maryland - CATT Lab

http://www.cattlab.umd.edu

Center for Advanced Transportation Technology Laboratory (CATT Lab)

Detailed information available on focus areas:

- Information Visualization
- Data Fusion
- User Interface Design
- Performance Measurement & Analysis
- Serious Game & Online Training

11.2.5. University of Minnesota ITS Institute

http://www.its.umn.edu

Many dozens of R&D studies (and reports) available on web site (with report search engine) organized along the following themes:

- HumanFIRST Program
- Intelligent Vehicles Laboratory
- Minnesota Traffic Observatory (MTO)
- Northland Advanced Transportation Systems Research Laboratories
- TechPlan: Policy & Planning for ITS

11.3. AUSTRALIA

11.3.1. Monash University - Institute of Transport Studies (ITS)

http://www.eng.monash.edu.au/civil/research/centres/its/

- Descriptions of projects provided.

World Transit Research (WTR) Database search engine

http://www.worldtransitresearch.info/

11.3.2. National ICT Australia (NICTA) - ITS Business Area

http://www.nicta.com.au/research/archive/business_areas/intelligent_transport_systems

- Australia's Information Communications Technology (ICT) Research Centre of Excellence.
- Focus Areas are computer vision, machine learning, networks, optimisation, and software systems.
- Descriptions of projects provided.

11.3.3. University of New South Wales - (rCITI)

http://www.rciti.unsw.edu.au

- The Research Centre for Integrated Transport Innovation (rCITI) bases all research activities around five core research pillars: Transport Planning, ITS Communications, Infrastructure, Energy/Fuel, Computational Sustainability.
- Web site contains descriptions of projects, and listings of all published papers.
- Many of the papers are available on the web site.

11.3.4. University of Queensland - ITS Research Laboratory

http://www.civil.uq.edu.au/its-lab

- The ITS Research Laboratory was established through an Australian Research Council Infrastructure Grant and contributions from a consortium of Australian universities, road and transport authorities and the private sector.
- The ITS Lab is aimed at developing, evaluating and modeling the impacts of advanced transport technologies aimed at improving the safety and efficiency of the transport system and reducing environmental impacts.
- No R&D studies listed on web site.

11.3.5. University of South Australia - (NLTNA)

http://www.unisa.edu.au/Research/Barbara-Hardy-Institute/Testing-and-evaluation1/NLTNA/

- National Laboratory for Transport Network Analysis (NLTNA)
- Established as a focus for traffic and transport network modeling in Australia.
- No R&D studies listed on web site

11.3.6. University of Sydney - Institute of Transport and Logistics Studies (ITLS)
http://sydney.edu.au/business/itls
- Focus on transport, infrastructure, logistics and supply chain management.
- List and summaries of projects provided.

11.3.7. University of Wollongong - Smart Infrastructure
http://smart.uow.edu.au/index.html
- Focus is on integrated infrastructure planning and management.
- Some focus areas include rail logistics and data management.
- Provides descriptions of projects and lists of published papers.

11.4. U.K.

There is a long standing network of university Transport Research Groups across the UK. Each has somewhat different focus areas, but many address Transportation Technology research:

11.4.1. Coventry University - Integrated Transport and Logistics
http://www.coventry.ac.uk/research-bank/grand-challenge-initiatives/integrated-transport-and-logistics/?theme=main

11.4.2. Cranfield University - Transport Systems
http://www.cranfield.ac.uk/about/cranfield/themes/transport-systems/

11.4.3. Edinburgh Napier University - Transport Research Institute
http://www.tri.napier.ac.uk

11.4.4. Newcastle University - Transport Operations Research Group
http://www.ncl.ac.uk/ceg/research/transport/index.htm

11.4.5. University College London - Centre for Transport Studies
http://www.cege.ucl.ac.uk/cts/SitePages/Home.aspx

11.4.6. University of Aberdeen - Centre for Transport Reseach
http://www.abdn.ac.uk/ctr/

11.4.7. University of Cambridge - Transport Research Group
http://www-trg.eng.cam.ac.uk

11.4.8. University of Leeds - Institute for Transport Studies
http://www.its.leeds.ac.uk/about/

11.4.9. University of Oxford - Transport Studies Unit
http://www.tsu.ox.ac.uk

11.4.10. University of Southampton - Transportation Research Group

http://www.southampton.ac.uk/engineering/research/groups/transportation_group.page

11.5. THE NETHERLANDS

11.5.1. TU Delft - Transport, Infrastructure and Logistics

http://ocw.tudelft.nl/courses/transport-infrastructure-and-logistics/

- Transportation and Spatial Modelling
- Traffic Flow Theory and Simulation

TU Delft - Transport Institute

http://www.tudelft.nl/en/research/thematic-cooperation/research-institutes-tu-delft-institutes/transport-institute/

- Clusters of Research:
  - Coordinated and cooperative traffic management
  - Transport policy
  - Spatial Planning & Mobility
  - Logistics & Freight transport
  - Railway systems

12. OTHER RESEARCH CENTRES

12.1. CANADA

(None identified)

12.2. U.S.A.

12.2.1. Transportation Research Board

http://www.trb.org/Main/Home.aspx

- Established in 1920, TRB is the preeminent forum for transportation research in the U.S., and probably the World.
- Housed in the National Academy of Sciences, its has several divisions

Technical Activities Division

http://www.trb.org/AboutTRB/TechnicalActivitiesDivision.aspx

- The Technical Activities Division has over 200 standing committees and task forces, involving over 5,000 volunteers.
- The committees conduct the annual peer review of technical papers, which is the foundation for the Annual Meeting
- The TRB Annual Meeting brings together over 12,000 researchers, practitioners, government agency staff, consultants, and other experts to discuss the entire spectrum of transportation research, from methodological to applied, in all modes, and in almost 900 podium and poster sessions

Cooperative Research Programs Division

http://www.trb.org/AboutTRB/AboutCooperativeResearchPrograms.aspx

- The Cooperative Research Programs Division of the TRB, administers a number of major research programs sponsored by other organizations.
- The vast majority of the funding for the cooperative research programs comes from the Federal Government.
- All reports from these applied research programs are publicly available for free in electronic form.
- The programs are:
  - **National Cooperative Highway Research Program**
  - **Transit Cooperative Research Program**
  - **Airport Cooperative Research Program**
  - **National Cooperative Freight Research Program**
  - **Hazardous Materials Cooperative Research Program**
  - **National Cooperative Rail Research Program**

TRID Database

http://trid.trb.org

- TRID provides access to more than one million records of transportation research, including all TRB papers and reports sponsored by US DOT

Transportation Technology Center Inc. (TTCI)
http://www.aar.com/

- TTCI is a wholly owned subsidiary of the Association of American Railroads. TTCI is a world-class transportation research and testing organization, providing emerging technology solutions for the railway industry throughout North America and the world.
- Headquartered in Pueblo, Colorado, 21 miles northeast of Pueblo Airport, TTCI manages extensive track facilities, state-of-the-art laboratory facilities, and a highly talented engineering and support staff to make TTCI the obvious choice for meeting your research and testing needs. We encourage you to explore our web site, learn more about us, and contact us to discuss how we can work together.

12.3. AUSTRALIA

12.3.1. NICTA

http://www.nicta.com.au

- NICTA (National ICT Australia) is Australia's Information Communications Technology (ICT) Research Centre of Excellence and the nation's largest organisation dedicated to ICT research. NICTA's primary goal is to pursue high-impact research excellence and, through application of this research, to create national benefit and wealth for Australia. We aim to be one of the world's top ICT R&D centres.
- NICTA's research addresses the technology challenges facing industry, the community and the whole nation. We seek to improve the international competitiveness of both academic ICT research and industry innovation by tightly linking the two to achieve greater economic and social impact.
    - NICTA is a company limited by guarantee. Its members comprise: the Australian National University (ANU), the UNSW Australia, the NSW Government, the ACT Government, the Victorian Government and the University of Melbourne. It has 19 other university alliance partners.
    - Research at NICTA is undertaken within five large-scale Research Groups:
        - Computer Vision
        - Machine Learning
        - Mobile Systems
        - Optimization
        - Software Systems

12.4. U.K.

12.4.1. Transport Research Laboratory (TRL)

http://trl.co.uk

- Originally established in 1933 as part of the UK government, TRL privatised in 1996 to become a fully independent private company. TRL is wholly owned by the Transport Research Foundation (TRF), an independent non-profit-distributing foundation, limited by guarantee and with no shareholders. TRL Limited has two subsidiaries:
    - Appia Infrastructure Solutions Limited (TRL Appia). TRL Appia provides consultancy and software to support the management of highways infrastructure assets. TRL Appia specialises in the delivery of advanced asset management tools and services and has developed their *Scheme Engineer* asset management

software into a new suite of asset management solutions – *iROADS*.

- Transport & Travel Research Limited (TTR). TTR specialises in transport policy research, working with clients to understand the impact of innovative transport policies and measures on travel behaviour and attitudes, energy consumption, the environment and social issues. TTR and TRL work closely together on a number of areas including freight, smarter choices, air quality and low carbon vehicles, travel information systems and joint working in Europe.

12.4.2. Greenwich Automated Transport Environment (GATEway)

http://www.digitalgreenwich.com/driverless-cars/

- GATEway is an £8 million project funded by industry and Innovate UK and led by TRL. Based in the Royal Borough of Greenwich in London, it comprises a team of leading companies and academic institutions. It is a technology-agnostic programme of automated vehicle research and test criteria development that enables industry, government and society to gain critical knowledge, safely accelerate innovation and deliver smart city integration. The objectives are to:
  - demonstrate the safe and efficient integration of sophisticated automated transport systems into complex real world smart city environments, relevant in the UK and worldwide and delivered by a diverse, sector-leading consortium.
  - understand technical, cultural, societal and legal challenges and barriers to adoption based on direct user experience of cutting edge system operation and use.
  - inspire industry, public bodies and the wider public to engage with existing cutting edge autonomous transport technology which can improve mobility choices, integrate within the smart city environment and generate new economic activity.
  - generate valuable, exploitable knowledge of the systems required for the effective validation, deployment, management and integration of automated transport within the smart city environment.
  - create a multifaceted, validated, long term test bed in the heart of the UK's only globally recognised megacity for the evaluation of the next generation of automated transport systems including the detailed testing protocols and benchmark data to provide robust independent verification of automated system.
  - capitalise on the consortium strengths to position UK PLC at the forefront of the global marketplace encouraging inward investment and job creation. The advanced automated vehicle technology to be used in the trial is to be provided by Greenwich-based company, Phoenix Wings. Commonplace will use innovative network-based tools to collect and interpret the live subjective views of participants. Support for the delivery of remote vehicle operation and automation will be provided by GOBOTiX, a start-up company founded by engineers from University of Oxford.

12.4.3. UK Autodrive

http://www.autodrive.co.uk

- The partners within the 'UK Autodrive' consortium are MIRA, Arup, Milton Keynes Council, Coventry Council, Jaguar Land Rover, Ford Motor Company, Tata Motors European Technical Centre, RDM Group, Thales (UK), Oxbotica, AXA, international law firm Wragge-Lawrence-Graham, the Transport Systems Catapult, the University of Oxford, University of Cambridge, and the Open University.

12.5. NETHERLANDS

12.5.1. TU Delft - Transport, Infrastructure and Logistics

http://ocw.tudelft.nl/courses/transport-infrastructure-and-logistics/

- Transportation and Spatial Modelling
- Traffic Flow Theory and Simulation

TU Delft - Transport Institute

http://www.tudelft.nl/en/research/thematic-cooperation/research-institutes-tu-delft-institutes/transport-institute/

- Clusters of Research:
  - Coordinated and cooperative traffic management
  - Transport policy
  - Spatial Planning & Mobility
  - Logistics & Freight transport
  - Railway systems