ATLANTIC

A Thematic Long-term Approach to Networking for the Telematics and ITS Community

A Partnership of ITS Communities in Europe and
North America

DISCUSSION PAPER

USER ACCEPTANCE & IMPACT ASSESSMENT

ITS Benefit Evaluation & Cost
State of the Art & Practice in Canada

Prepared by

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In collaboration with Participating Partners and Sponsors

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PREFACE

ATLANTIC (A Thematic Long-term Approach to Networking for the Telematics and ITS Community) is an international cooperative undertaking that aims to foster information exchange and policy debate related to the application and development of intelligent transport systems (ITS). ATLANTIC originated as a project sponsored by the European Union under the 5th Research Framework with self-sustaining partners in Canada and the United States. ATLANTIC is organized into 8 work groups focused on different topics related to telematics and ITS. This document is the product of one of the Canadian work groups to benchmark and assess the state of ITS practice and research and development in Canada.

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The ATLANTIC Canada network node is sponsored by Transport Canada, Ministry of Transportation Ontario and Ministère des Transports du Québec and jointly managed by the ITS Centre and Testbed, University of Toronto and the Centre de recherché sur les transports, Université de Montréal. The core team providing overall leadership for ATLANTIC Canada includes Professor Baher Abdulhai (Toronto), Professor Teodor Gabriel Crainic (Montréal) and Dr. William Johnson (Ottawa).

The Canadian Work Group 3.1, User Acceptance & Impact Assessment, is jointly managed by Professor Issam Kayssi, University of Toronto (leader) and Dr. William Johnson, Consultant, Ottawa (rapporteur). They provided the intellectual leadership and writing skills to assemble and document this discussion paper with inputs and contributions from a network of Work Group members. The names of Work Group 3.1 members and contributors appear in Annex A. Special recognition is extended to Omar Al-Battaineh, student at University of Toronto, for his extensive contribution.

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1. Executive Summary

This discussion paper is one in a series of 8 reports prepared by the ATLANTIC thematic network on the state of intelligent transportation systems (ITS) practice and research and development in Canada. The focus areas in this paper are to (i) define "dimensions" of ITS user impact / benefits assessment, (ii) identify ITS user impact / benefits assessment studies already undertaken or planned in Canada, (iii) develop a typology of such studies, and, (iv) identify and benchmark against similar efforts by ATLANTIC partners. This document reports on these areas of focus and concludes by identifying future ITS research and development needs in Canada related to user acceptance and impact assessment. A number of experts from public agencies, the research and academic community, consultants, transit operators, and traffic management authorities were identified and contacted in preparing this discussion paper.

2. Overview of Work Group within Scope of ATLANTIC

The scope of ATLANTIC encompasses 3 main theme areas with 8 topics covering all aspects of intelligent transportation systems (ITS). The theme areas and topics are:

- Integrated Transport Services
  - Telematics-based Traffic and Travel Information Services
  - Network Monitoring and Traffic Management and Control
  - Intermodal Collective Transport Information
- Technologies and Services
  - Intermodal Freight Information Pre-clearance & Logistics
  - Intelligent Vehicles and Intelligent Highway Systems
  - Electronic Road User Charging & Integration with Other Payment Systems
- Assessment and Evaluation of ITS
  - ITS User Acceptance and Impact Assessment
  - Human Machine Interface/User Friendly ITS

The scope of this topic area falls into the third theme area and is focused on measuring how well existing ITS applications are functioning and on predicting the potential impacts of planned ITS applications before they become operational. Because knowledge of the functional characteristics of specific ITS applications is needed to conduct socio-economic impact and benefit-cost evaluations, there is overlap between this topic and the other 7 topics.

The ATLANTIC network has established work groups for each topic area to facilitate and coordinate the contributions from interested professionals to the development of knowledge and advice. This topic area is assigned to Work Group 3.1.

3. Overview of ITS Domain/Impact Assessment

Across the country, Intelligent Transportation Systems (ITS) are deployed to get the most out of existing infrastructure, and to deliver more efficient and effective transportation services. The overall objectives of ITS projects include improving traveler safety, improving traveler mobility, improving system efficiency, increasing the productivity of transportation providers, and conserving energy while protecting the environment.

ITS deployments can be broadly categorized as falling into one of the following domains:

- Urban
- Rural
- Commercial Vehicles
- Intelligent Vehicles

The impact of ITS projects is typically assessed along one or more of the following dimensions:

- Safety
- Time and Delay
- Capacity/Throughput
- Cost
- Customer Satisfaction
- Energy & Environment
- Other

A conceptual matrix of ITS domains and systems by potential impacts is presented in Table 1. Clearly, not all impacts may occur with a specific ITS deployment. Moreover, ITS project impacts accrue to different user groups and stakeholders, including government agencies, the private sector, the general public and/or individual users of the implemented system.

This WG has worked on elements of user acceptance of ITS, impacts of user acceptance of ITS (benefits evaluation), and on identifying the elements of a framework for assessing user acceptance and impacts of ITS. In general, the "dimensions" of ITS user impact / benefits assessment can be defined as the following:

- ITS deployment domain (broadly: urban, rural, commercial vehicles - interurban)
- Impact area (capacity/throughput, time and delay, safety, energy and environment, other)
- Users and stakeholders (private users, commercial users, government, community at large, infrastructure operators, etc.)

The WG has also communicated with experts to identify the benefits of different implemented ITS projects in Canada. In particular, the WG has identified studies that have conducted an impact evaluation of implemented ITS projects in Canada, and has conducted a preliminary comparison with the practices of other ATLANTIC partners.

In what follows we introduce the subtopics that are covered in this discussion paper.

Table 1. ITS Domain/Potential Impact – Conceptual Matrix

		Safety	Time and Delay	Capacity/Throughput	Cost	Customer Satisfaction	Energy & Environment	Other
Urban	Arterial Management Systems							
	Freeway Management							
	Transit Management							
	Incident Management							
	Emergency Management							
	Electronic Toll Collection							
	Electronic Fare Payment							
	Highway-Rail Intersection							
	Road Weather Management							
	Information Management							
Rural	Traveler Safety and Security							
	Emergency Services							
	Tourism and Travel Information							
	Public Transit and Mobility Services							
	Infrastructure Operation and Maintenance							
	Road Weather Management							
Commercial Vehicles	Safety Assurance							
	Credentials Administration							
	Pre-clearance							
	Carrier Operations							
Intelligent Vehicles	Driver Assistance							
	Platform Specific							

Impacts accrue to various user groups and stakeholders

Adapted from: Intelligent Transportation Systems Benefits: 2001 Update. US Department of Transportation, Federal Highway Administration.

4. Discussion Paper Outline

In this section, a brief outline of the discussion paper is presented. Before this outline is presented, it is important to note that the discussion paper documents and analyzes the Canadian efforts in ITS impact assessment. Moreover, these efforts present two perspectives: some efforts focus on ITS deployment areas (such as urban traffic management) while others focus on impact categories (such as safety). As such, the totality of these efforts can be roughly mapped into the shaded rows and columns appearing in Table 1.

Section 5 reviews some of the early efforts undertaken primarily by Transport Canada in the period 1996-1999. The aim was to develop a framework for the assessment of benefits and costs of ITS implementations in Canada.

Section 6 reviews the work on impact assessments for two ITS deployment areas, namely, traffic management and commercial vehicles (i.e. rows in Table 1).

Section 7 reviews the work on assessment of two impact categories, namely, environment and safety (i.e. columns in Table 1).

Section 8 reviews six ITS deployments that are currently (or recently) funded by Transport Canada and the plans to evaluate the impacts of these deployments.

Section 9 identifies resources that document efforts by ATLANTIC partners in the domain of ITS impact assessment.

Section 10 provides a broad overview of future research and development needs and opportunities in Canada related to ITS user acceptance and impact assessment.

Annex A is a list of the experts who contributed to Work Group 3.1 and Annex B contains the summary details of the source documents reviewed in Sections 5 to 7.

5. Initial Canadian Efforts at ITS Benefits Assessment

Initial efforts to develop a framework for the assessment of benefits and costs of ITS implementation in Canada were initiated by Transport Canada in the period 1996-1999.

Zavergiu, Johnson, and Sabounghi (1996) proposed a benefit-cost framework that identifies four separate beneficiaries: individual transportation users, transportation infrastructure providers and managers, the community, and potential private investors/ITS technology providers. A hierarchy of benefits and costs was also proposed which identifies three classes of benefits: first order, targeted to individual transportation users; second order, which apply to transportation infrastructure providers and managers; and third order, which directly impact the economy and the environment. To demonstrate how the framework may be applied, the paper included a case study evaluating the benefits and costs of deploying automated vehicle identification systems to improve traffic flows and infrastructure capacity for the Windsor-Detroit Tunnel Border Crossing.

Later, Johnson, Blanchard, Sabounghi, and Zavergiu (1999) presented another example of the early Canadian efforts at the Fifth Annual World ITS Congress. Their presentation provided a brief overview of the results of the Benefit-Cost study of a projected Canada-wide implementation of Intelligent Transportation Systems (ITS) that Transport Canada commissioned in 1997. The study evaluated three ITS technologies, namely, Interurban Freight, Rural Transportation, and Urban Transportation. The authors used a snapshot approach for the assessment of costs and benefits, in which they compared annualized benefits and costs in a specific year on the assumption that the user adoption rate has reached its full market potential. The analysis relied on a sketch planning method to explore causes and effects that link benefits and costs. Benefits from ITS applications were predicted on assumed driver behavioural changes in response to improved knowledge of highway and traffic conditions.

6. Impacts Assessment of Specific ITS Deployments

6.1 Commercial vehicle operations

6.1.1 Electronic Clearance and Roadside Inspection

In 2003, Tri-global Solutions Group Inc. and IBI Group prepared a report for Transport Canada on the potential cost and benefits of Electronic Clearance and Roadside Inspection (ECRI) in Canada. The report establishes benefits of ECRI in terms of reduction in cost related to truck fuel, truck time, accidents (safety), pavement damage, site expansion, staffing levels, and commercial vehicle safety alliance (CVSA) inspection. Geographically, this study covered weigh scales in Canada with at least 100,000 trucks per year.

In evaluating the benefits and costs, three different business models are included in the analysis presented in this report. These models are: public, private/public, and private. The models are characterized primarily by who is paying for each cost component of the ECRI system.

The analysis indicates that, when budgets are fixed, the best business model should seek to maximize the net benefits (from the social perspective) while achieving equity between the costs and benefits to each sector. The study concludes that the best model to achieve this is the Private/Public Model, which is the recommended model.

6.1.2 Border Crossing - Pre-clearance Systems

Pre-clearance systems are one common form of ITS in the USA and Canada. The Ambassador Bridge Border Crossing System (ABBCS) is an example of an implemented system at the Ambassador Bridge international border crossing site between Detroit, Michigan and Windsor, Ontario. The objective of this system was to develop and demonstrate an integrated system that would allow pre-processed vehicles, trade goods, and commuters to pass through international border check points with expedited customs, immigration, and toll collection processing.

As an illustration of the types of benefits that may be accrued, this system provides different potential benefits for each group of users (stakeholders):

Stakeholder	***Expected benefits***
Shipper/Consignees	• Pick up / delivery notification • Improved accuracy of logistics information • Container and truck location at key points
Freight Forwarders/Brokers	• Reduce paperwork • Improved communication with customers • Reduced cost due to improved truck operations
Terminal Operators	• Increase gate moves/throughput • Pre-notification of truck arrival • More efficient use of labour/equipment • Enhanced customer service • Reduced paperwork
Truck drivers	• Reduced wait times at border and port terminals • Fuel savings from reduction in wait times • Increase capacity for additional moves • Reduced paperwork
Regional Transportation Agencies	• Improved planning for freight transportation • Increase in commercial vehicle safety
U.S. and Canada Customs/U.S. and Canadian Governments	• Improved security through E-Seal verification • Improved security through truck tracking • Improved throughput of trucks at border crossing • Reduced paper works
Customers	• Improved tracking and visibility of cargo • Improved ability to support just-in-time logistics • Lower costs due to efficiency improvements

6.2 Urban traffic management

6.2.1 Freeway management

A freeway management system consists of a set of resources (e.g. electronic systems, people, objects, and strategies) that are used to accomplish a set of goals to improve the operation of the freeway network. One such system is COMPASS, a Freeway Traffic Management System developed by the Ontario Ministry of Transportation (MTO) and featuring advanced technologies to respond to traffic congestion problems on urban freeways. Potential COMPASS benefits include:

- Improved emergency assistance for motorists in the case of collisions or vehicle breakdown.
- More detailed and timely traffic information available to help motorists anticipate conditions ahead.
- Decreased number and severity of motor vehicle collisions on the highway.
- Increased safety assurance in highway travel particularly around construction zones.
- Reductions in congestion and the associated delay during rush hour periods and emergency situations.
- Adjacent communities benefit from more effective utilization of available road capacity.
- Commercial traffic benefits from reduced travel times and more uniform traffic flow
- Less time spent idling in traffic leads to reduced fuel consumption and vehicle emissions.

In 2001, IBI group evaluated different potential projects for geographic expansion of COMPASS. The study included 400 series highways and the QEW throughout Ontario. Benefits included in the study were reduction of vehicle delay, reduction in fuel consumption, and reduction in secondary collisions. Delay, fuel, and collision benefits were summed up to calculate the year 2005 total benefits of system deployment. Costs, on the other hand, were evaluated based on MTO experience whereby it was assumed that a “light” COMPASS deployment costs $125,000 per kilometre and full COMPASS deployment costs approximately $600,000 per kilometre. Evaluation of the candidate segments was conducted in terms of cost, congestion and environmental priority, safety priority, benefit/cost ratio, segment length, proximity to existing COMPASS projects, and special situations. Each of the candidate segments was evaluated, for each of these criteria, on a scale of one to five.

6.2.2 Urban Traffic Control Systems

Identifying the impacts of ITS-based urban traffic control systems represents the third area being addressed within urban traffic management. One of the ITS systems used to control urban traffic is SCOOT. It is an adaptive system that responds automatically to fluctuations in traffic flow through the use of on-street detectors embedded in the road. Beginning in September of 1990, the SCOOT system implemented in Toronto covered 3 signal networks encompassing 75 signalized intersections. An on-street evaluation conducted from May-June 1993 found an 8% average decrease in travel time, a 22% average decrease in vehicle stops, a 17% average decrease in vehicle delay, a 5.7% average decrease in fuel consumption, a 3.7% average decrease in hydrocarbons, and a 5.0% average decrease in carbon monoxide emissions.

6.3 Rural transportation

6.3.1 Rural safety systems

Benefit-cost assessment of ITS implementation in Canadian rural transportation was the subject of a report prepared by IBI Group. One part of this report covers rural safety systems which include portable construction zone traffic management, Mayday/emergency request, and intersection/railway crossing collision avoidance. Benefits considered in this study were reduction of accidents, reduction of congestion due to incidents, reduction of travel times, reduction of fuel consumption and harmful emissions, and enhancement of traveler security and stress reduction.

6.3.2 Rural traveler information systems

Another part of the report on ITS implementation in Canadian rural transportation by IBI Group covers rural traveller information systems which include hazardous road condition warnings, intermodal traveller information, tourist information kiosks, and road weather information systems. Benefits considered in this study were improvement in intermodal transportation utilization, reduction of number and severity of accidents, reduction of congestion due to incidents, reduction of traveler stress and uncertainty, reduction of road and intermodal travel times, and reduction of travel costs incurred by fleet operators, operating agencies and individuals.

6.3.3 Electronic transactions

Another part of the report on ITS implementation in Canadian rural transportation by IBI Group covers rural vehicle electronic transaction systems. Technologies covered under this category are electronic toll collection and border crossing clearance systems. Benefits considered in this study were reduction of accidents, increased capacity at toll plazas and border crossings, improved convenience of toll payments, reduction of fuel consumption and harmful emissions, reduction of travel time, reduction of costs incurred by fleet operators, toll agencies, customs agencies and individuals, and enhancement of traveler security and reduction of traveler stress.

7. Assessment by Impact Category

7.1 Environment and energy

7.1.1 GHG reduction benefits

A 1999 report prepared by IBI Group 1999 for Public Works and Government Services Canada; Climate Change – Transportation Table, discusses the GHG reduction benefits of the deployment of Intelligent Transportation Systems on Canada's road network. The study focuses on seven ITS areas and evaluates the GHG reductions for each one of these areas. These areas are incident management, traffic control, en-route and pre-trip traveller information, transit automated vehicle location (AVL), electronic payment systems, commercial vehicle electronic clearance, and advanced vehicle control system (AVCS). If all options are adopted, the study concludes that the total annual GHG reduction in year 2010 is estimated to be 775 kt. This figure represents 0.5% of the total GHG output attributed to transportation in 1991 and 2% of the GHG reduction target for transportation in 2010.

7.1.2 Emissions implications of ITS deployments

A 2003 study prepared by Issam Kayssi for Intelligent Transportation Systems Policy Branch-Transport Canada, discusses the emissions implications of ITS deployments in Canada. This ongoing study consists of two phases.

The study indicates that, in evaluating emissions impacts of contemplated ITS interventions, there is need to identify specific transport operational improvements that are most indicative of such emissions impacts. Phase I of the study focuses on the identification of such operational improvements and relating them to emissions implications in the context of specific ITS deployments currently being funded by Transport Canada (TC). The work in Phase I is conducted within the context of ongoing Canadian ITS deployment studies, and develops emissions/environmental performance measures for these deployments. On the other hand, On the other hand, Phase II focuses on the development of longer-term guidelines for integrating environmental impact evaluation in future ITS deployment studies.

7.2 Safety benefits of ITS

A paper published by Vahidi and Sayed in the Canadian Journal of Civil Engineering (2003) develops a framework for assessing the safety benefits of ITS. The framework identifies evaluation metrics, and maps these metrics to market packages in the Canadian ITS Architecture.

The metrics have been grouped into two categories called "Cause Metrics" and "Effect Metrics". Cause metrics include driver errors and driving violations (under the driver factor contributing to crash occurrence), congestion and exposure to hazards (under the road/environment factor), and mechanical failures (under the vehicle factor). The effect metrics basically relate to number of accidents and accident severity. These metrics are selected to support the evaluation of market packages in the Canadian ITS Architecture.

8. Ongoing ITS Deployments Funded by Transport Canada

The ITS deployments currently being funded by TC fall into two main User Services Bundles within the Canadian ITS Architecture, namely:

- Traffic Management Services
- Public Transport Services

Tables 2 and 3 present a summary of the ITS deployments being considered and featuring Traffic Management and Public Transport Services, respectively. The tables identify the following elements for each Deployment case:

- Agency/Entity Involved
- Deployment Project
- Physical Deployment Elements
- Extent of Deployment
- Enabled Operational Measures
- User Services
- Anticipated Operational Impacts
- Other Anticipated Benefits

Empty cells in the tables signify either the inapplicability of a specific deployment element to the deployment project being considered or a lack of information. It is to be noted that all information in the tables is based solely on available documentation provided by Transport Canada.

In general, the tables indicate that the main anticipated operational impacts of the planned ITS Deployments consist of the following:

- Reduced incident-related or roadway disruption-related delays in the case of Traffic Managements Services
- Reduction in transit delays at intersections, improvements in transit route travel times and delays, and/or maintenance of transit service reliability in the case of Public Transport Services

Once completed, these deployments are expected to provide a rich basis for ITS impact assessment. Some positive impacts have already been identified. For instance, Calgary Transit reports that its findings from this preliminary study were very encouraging. For the segment of the transit route where the new system has been installed, the average number of traffic signal stops per trip has decreased by 25% and the average time delay at traffic signals was reduced by 40% (about 3 minutes on a round trip).

Table 2 – Summary of ITS Deployments featuring Traffic Management Services

Agency	City of Edmonton	City of Saskatoon	City of Toronto
Deployment Project	Video-Based Traffic Management & Traveler Information Project	Advanced Traffic Management System	Road Access and Disruption Management Program
Physical Deployment Elements	• CCTV field and central equipment • Communications services • Web-link software	• Modern traffic signal controllers • New ATMS software	• Communication and computing infrastructure • Software
Extent of Deployment		• 40-80 controllers	
Enabled Operational Measures	• Response of various agencies to video information • Traffic and incident management	• Response of other departments to road condition and road maintenance alerts	• Manage disruptions to arterial and expressway road network (avoid multiple closures on parallel routes)
User Services	• Internet-based traveler information (live and still traffic data) for pre-trip planning	• Internet-based congestion and road condition information provided to public	• Provision of information in advance of planned disruptions
Anticipated Operational Impacts	• Reduced incident-related delays		• Minimize delay
Other Anticipated Benefits	• Increased safety • Decreased greenhouse gas emissions	• Reduced accident risk • Improved safety and security	• Maximize road space utilization • Minimize user frustration • Improve interagency coordination • Reduce fuel consumption and vehicle emissions

Table 3 – Summary of ITS Deployments featuring Public Transport Services

Agency	**Calgary Transit**	**City of Ottawa**	**Regional Municipality of York**
Deployment Project	Traffic Signal Priority and Automatic Vehicle Tracking System	Intelligent Transit Vehicle Subsystem	Transit Priority System (TPS) – Integration and Deployment Initiative
Physical Deployment Elements	• Traffic signal controllers • Transit signal priority detectors • GPS vehicle locators for transit buses	• Wireless data network • GPS units, smart processors, and mobile data terminal in transit vehicles • Automatic Passenger Counters (APC) • Electronic fare system	• Communications sub-systems • Software • TPS operation center
Extent of Deployment	• 30 intersections • 20 buses (GPS)	• Phase I: 20 vehicles	• One or more routes
Enabled Operational Measures	• Transit priority measures	• Vehicle tracking	• Transit priority measures
User Services		• Vehicle status information	
Anticipated Operational Impacts	• Improvements in route travel times and delays • Maintenance of service reliability		• Reduction in transit delays at intersections
Other Anticipated Benefits	• Monitoring of schedule adherence	• Monitoring of schedule adherence	

9. Proposed Typology of User Impact – Benefit Assessment Studies

Based on the review presented in the sections above, one may conclude that a number of benefits evaluation studies of actual or potential ITS deployments in Canada have been conducted. These studies span a range of ITS deployment domains (urban, rural, commercial vehicles) as well as impact areas (travel time and delay, safety, energy and environment).

Table 4 summarizes the ITS Domain/Potential Impact coverage in the Canadian context based on the conceptual matrix presented in Section 3. The coverage of the various studies referred to in previous sections is broadly presented as “shaded” columns, rows, or cells in the Table.

It is to be noted that the extent of this coverage varies among shaded cells depending on the study approach and the emphasis of columns (studies focussing on ITS deployment domains) and rows (studies focussing on impact areas) on specific cells (specific impact area for a certain ITS deployment). Nevertheless, the Table is useful in identifying general trends of coverage, and in pointing out areas where future user impact and benefit assessment studies are needed. In this regard, many ITS deployment domains falling under the “Urban” category are in need of further attention, including transit management, incident management, electronic toll collection, and electronic fare payment. In addition, carrier management within “Commercial Vehicles” is another area where future effort is required for benefits assessment.

Table 4. ITS Domain/Potential Impact – Conceptual Matrix for Canadian Context

		Safety	Time and Delay	Capacity/Throughput	Cost	Customer Satisfaction	Energy & Environment	Other
Urban	Arterial Management Systems							
	Freeway Management							
	Transit Management							
	Incident Management							
	Emergency Management							
	Electronic Toll Collection							
	Electronic Fare Payment							
	Highway-Rail Intersection							
	Road Weather Management							
	Information Management							
Rural	Traveler Safety and Security							
	Emergency Services							
	Tourism and Travel Information							
	Public Transit and Mobility Services							
	Infrastructure Operation and Maintenance							
	Road Weather Management							
	Electronic Transactions							
Commercial Vehicles	Safety Assurance							
	Credentials Administration							
	Pre-clearance							
	Carrier Operations							
Intelligent Vehicles	Driver Assistance							
	Platform Specific							

10. Overview of Efforts by ATLANTIC partners

10.1 International Workshops at World Congresses

The international evaluation community has come together to sponsor ITS evaluation-focussed workshops at the ITS World Congresses every year since the 6th World Congress in 1999 at Toronto. The content of these workshops present an overview of the issues and activities that the international ITS community has considered important to develop the knowledge base in the domain of ITS benefit, evaluation and costs. They are therefore a useful benchmark against which to compare similar efforts in Canada.

The initial workshop in this series was a one-day event held in conjunction with the 6th World Congress on Intelligent Transportation Systems in Toronto in October 1999. One of the presentations at the workshop was a paper from Canada based on initial work on ITS benefits assessment (refer to Section 5. Initial Canadian Efforts at ITS Benefits Assessment for background). This early contribution to international dialogue on the subject demonstrates that Canadian researchers were recognizing the importance of this subject in parallel with other international researchers. That early effort focussed on methodology rather than measured costs and benefits, reflecting a similar bias in the published efforts of other countries at the time. This was due to the general lack of field data on which to base before and after studies.

The workshops at the World Congresses take the form of a full day with four separate sessions on different topics. The topics are selected by a workshop planning committee that identifies issues of international interest and appeal. For example, the workshop in 2002 in Chicago included a session on "Evaluating the Security of Transportation Systems", a high priority issue one year after September 2001. The membership of this committee includes representation from the ATLANTIC European partners who in 2001 and 2002 were also responsible for documenting the workshop results.

To illustrate the scope of the workshop coverage, a summary of the workshop session topics is given in Table 5 for 2001, 2002 and 2003. In this table, the home country of the presenters in each session is also indicated (note that the name of a country indicates one presentation). The titles of the presentations are not included for brevity although this information can be obtained from the source references 15, 16 and 17. Based on this table, the following general observations can be made:

- Session topics include a wide variety of subjects: measuring user wants (opinion, needs, best practises), measuring system performance (benefits, costs), evaluating outcomes (security, risk, examples), comparative analysis (Europe versus USA),
- Training in ITS performance measures and evaluation techniques is recognized as a topic deserving its own dedicated session,
- The USA contributed the largest number of presentations at 15 (fully one third of the total), the United Kingdom the second largest number at 7, and Japan the third largest number at 5; all other countries contributed from 1 and 3 presentations each,
- Canada contributed 1 presentation out of a total of 46 presentations over 3 years.

It is not appropriate to draw general conclusions from such a small sample of papers and presentations on the subject of ITS benefits, evaluation and costs but it is interesting to note the following:

- Canada has contributed in the past (1999) and in the present (2003) to the accumulation of global knowledge on this subject,
- The countries with the greatest apparent interest and knowledge to contribute in this subject area are the USA, Europe (EU and member countries excluding UK), the United Kingdom, and Japan in terms of the largest concentrations of information to exchange and partners to work with,
- Other countries of similar size and stage of ITS development compared to Canada, such as Brazil, Australia, South Africa, Chile and China are also contributors to the global knowledge base for ITS benefits, evaluation and costs and deserve close attention as well.

In conclusion, Canada can learn a great deal from the extensive experience of other countries related to ITS benefits, evaluation and costs. It should also be more proactive to accumulate its own experience in this important field of study and to share this with partners and countries.

Table 5 Summary - International Workshops on ITS Benefits, Evaluation and Costs

Year	No.	Session Topics	Presenters Home Countries
2001	1.	What Does The Public Want? Part 1 – Use of Public Opinion Surveys in Transportation	USA, USA, Japan, UK
	2.	What Does the Public Want? Part 2 – How Decision-Makers are Responding to the Public's Needs	Brazil, Japan, UK
	3.	How Are We Doing? Setting and Using Transportation Performance Measures	Australia, Finland, UK
2002	1.	Costs of ITS – Project Inception (e.g. building political support) to Operations	Sweden, France, Brazil, USA
	2.	Evaluating the Security of Transportation Systems – How to Evaluate and Risk Analysis	UK, USA, Japan, Japan, USA
	3.	Measuring User Response to ITS – Best Practises for Measuring Customer Response	USA, UK, UK, Australia
	4.	Measuring Travel Time Reliability – An Increasingly Important Measure of Performance	France, USA, Spain, USA
2003	1.	How Do the Yanks Do It? Overview of ITS Evaluation in the United States	USA, USA, USA, USA
	2.	How Do Europeans Do It? Examples of ITS Evaluation Results	EU, Finland, EU
	3.	Show Me the Benefits: Examples of ITS Evaluation Results	South Africa, Finland, USA, Japan, Chile
	4.	Now I Know the Benefits of ITS … So What? How Are ITS Evaluation Results Used?	China, USA, Canada, Spain UK
	5.	ITS Evaluation 101: Training Course on ITS Performance Measures and Evaluation Techniques	USA, France

Source documents – References 15, 16 and 17.

10.2 IBEC

International Benefits Evaluation and Costs (IBEC) Cooperative Working Group.
www.ibec-its.org

IBEC is a co-operative working group for the Intelligent Transport Systems (ITS) community set up to exchange information and techniques used to evaluate the costs and benefits of Intelligent Transport Systems throughout the world. IBEC was launched in October 2002 at the 9th World Congress on ITS held in Chicago, USA. It grew out of the preceding co-operative efforts to organize the benefit-cost workshop sessions initiated at earlier World Congresses with help of ATLANTIC members. The Secretariat is provided by TRL Limited, in the UK, with funding from the UK Department for Transport.

The objectives of IBEC are to:

- Provide advice and oversight globally on cost-benefits and cost-effectiveness analysis to government agencies, Intelligent Transportation Systems (ITS) researchers, planners, producers, and implementation of ITS technologies,
- Promote development of consistent and more reliable methodologies for the evaluation and deployment of ITS products and services,
- Provide information to transportation professionals, decision-makers, and the general public on the measured costs and benefits of ITS deployment,
- Share information regarding non-technical and institutional issues and lessons learned based on ITS project evaluations.

The activities of IBEC include:

- Organizing thought-provoking and informative sessions at the annual ITS World Congresses,
- Hosting e-mail discussion groups where members can post questions and get answers,
- Networking opportunities at regional ITS conferences, such as ERTICO, ITS America and ITS Japan.
- Internet, phone and e-mail enabled chats on hot topics in ITS evaluation (in development).

IBEC is a relatively new institution with an ambitious agenda. Its members represent active and progressive organizations, both national and international, that wish to cooperate in the fields of benefits, costs and evaluation. These topics are well suited to cooperative learning and sharing of knowledge and experience because they require extensive accumulation of measured data and repeated applications of methodologies that can only be obtained from a large community of users. This is an international activity in which Canadians can profitably participate to both gain access to a growing global knowledge base as well as to contribute Canadian experience to the wider good.

10.3 DOT – ITS Benefits Database

U.S. Department of Transportation's ITS Benefits and Unit Costs Database.
http://www.benefitcost.its.dot.gov/ITS/benecost.nsf/byLink/home

Since December of 1994, the United States Department of Transportation's Joint Program Office for Intelligent Transportation Systems has been actively collecting information regarding the impact of ITS projects on the operation of the surface transportation network. Data collected under this effort is available in the ITS Benefits Database.

The ITS Joint Program Office (JPO) also collects information on ITS costs, and maintains this information in the ITS Costs Database. The costs database contains two types of cost data: unit and system. The database is a central site for estimates of ITS costs that can be used for policy analyses, benefit/cost analyses, and project planning.

Several reports and other documents related to the ITS Benefits and Costs Database are also available for viewing and downloading. Mitretek Systems Inc. maintains and analyzes the information collected for each of these efforts.

Efforts in the US on benefits, evaluation and costs are generally channelled to the ITS community through a new ITS America special interest group. However, senior staff from the ITS Joint Program Office of the U.S. Department of Transportation play an active role in IBEC. This linkage enables the US DOT to play an influential role in facilitating the global sharing of ITS benefits and costs data and methodologies.

11. Future R&D Needs in Canada

The discussion paper has compiled a significant body of relevant material regarding ITS impact assessment in Canada. Nevertheless, there is need for more input from various sources and experts, notably along the following dimensions:

- Other benefits/impacts assessment studies
- Studies reporting on other ITS deployment domains or impact areas
- Studies comparing pre-deployment and post-deployment conditions

As such, the proposed ongoing focus in the short term needs to (i) continue to solicit input from experts regarding other Canadian examples of benefits assessment, (ii) define Canada's future R&D needs in the context of ITS benefits assessment, and, (iii) suggest/formulate means through which ITS benefits assessment can be "institutionalized" as an ongoing function in support of ITS development and deployment in Canada. Initial suggestions regarding these last two points are presented next.

Proposed R&D Tracks

Based on the analysis and synthesis of the trends and observations from the impact assessment material presented in this report, Canada's future R&D needs in the context of ITS benefits assessment may be identified to be along the following three proposed tracks:

1. Gaps exist in the benefits assessment "matrix", and such gaps need to be covered through field studies and theoretical efforts
2. There is a need to establish a Canadian benefits assessment database
3. There is need to develop guidelines for integrating impact evaluation in future ITS deployment studies. In this regard, common definitions and measurements of benefits are called for since simple variations in the evaluation methodology can affect the benefits estimate. One example of such an effort is the ongoing development of a "Guidelines Document" for Integrating Environmental Impact Evaluation in Future ITS Deployments Studies, as described in subsection 6.1.2 of this discussion paper.

Institutionalizing Benefits Assessment

ITS benefits assessment needs to be "institutionalized" as an ongoing function in support of ITS development and deployment in Canada. Towards that end, it is recommended that a Canadian ITS "benefits assessment network" be established in order to (i) share experiences and knowledge, (ii) maintain a benefits database, (iii) assist in development of guidelines for impact evaluation, and (iv) support public agencies & ITS technology providers.

This national network should be linked with international organizations such as IBEC to facilitate cooperative sharing with partners in other countries.

Annex A: Experts in Work Group 3.1

The WG has identified and contacted a number of experts from public agencies, the research and academic community, consultants, transit operators, and traffic management authorities. The following individuals have agreed to participate in the WG activities:

Mr. Milton Harmelink, M. D. Harmelink Consulting (mdharmel@pathcom.com)
Prof. Bruce Hellinga, University of Waterloo (bhellinga@uwaterloo.ca)
Mr. Chris Philps, iTrans Consulting (cphilp@itransconsulting.com)
Prof. Tareq Sayid, University of British Columbia (tsayed@civil.ubc.ca)
Mr. Derek Sims, Director, IBI Group (dsims@ibigroup.com)

Other individuals who have indicated their willingness to contribute to the Work Group knowledge database are:

Mr. Les Kelman, City of Toronto (lkelman@city.toronto.on.ca)
Mr. Jeff Balon, Traffic Engineering Manager, City of Saskatoon (jeff.balon@city.saskatoon.sk.ca)
Mr. Neil McKendrick, Coordinator, Strategic Transit Planning, Calgary Transit (neil.mckendrick@gov.calgary.ab.ca)

Annex B: Source Document Summaries

Section 5. Initial Canadian efforts at ITS benefits assessment

Paper Title:
Development of an ITS Benefit-Cost Framework (1996)

Author:
Richard M. Zavergiu, William F. Johnson, and R.L. Sabounghi

Summary:
This paper proposes an alternative benefit-cost framework that identifies four separate beneficiaries:

- Individual transportation users;
- Transportation infrastructure providers and managers;
- The community;
- Potential private investors/ITS technology providers.

A hierarchy of benefits and costs is proposed that identifies the following classes of benefits:

- Benefits of the first order are targeted to individual transportation users;
- Benefits of the second order apply to transportation infrastructure providers and managers;
- Benefits of the third order which directly impact the economy and the environment.

A case study evaluating the benefits and cost of deploying automated vehicle identification systems to improve traffic flows and infrastructure capacity for the Windsor-Detroit Tunnel Border Crossing is included to demonstrate how a framework would work in real world ITS applications. The authors identified four groups of beneficiaries, namely, users (passenger and commercial travellers), infrastructure operators or owners, the Windsor-Detroit economic community, and private sector ITS suppliers. Costs and benefits in this case study are summarized as follows:

1. In the first order, there are two groups of beneficiaries: commercial vehicles and private automobiles. By assuming a two minutes saving, valued at $9 an hour, daily and weekly automobile travellers would experience a benefit-cost ratio of 1.33 and 0.29 respectively after the first year of operation. For commercial vehicles, time savings, estimated at $38 an hour, will result in a benefit-cost ratio exceeding 4:1.
2. In the second order, benefits for infrastructure operators/owners were measured, including deferred capacity upgrades and recovered revenues from traffic that would otherwise have been diverted to adjacent border crossings, with benefit-cost ratio of 25.3 and 4.5 respectively. Another benefit in this order is the benefit for Customs and Immigration which is

derived from labour productivity improvements.
3. In the third order, the Windsor-Detroit community will receive significant benefits.

The authors indicate that the findings of this case study are an illustration, and the results should not be interpreted as definitive, but as an indication of how a comprehensive study could be developed.

Paper Title:
Benefit-Cost Assessment of Intelligent ITS Implementation in Canada (1999)

Author:
William F. Johnson, Ghislain Blanchard, R.L. Sabounghi, and Richard M. Zavergiu

Summary:
This paper provides a brief overview of the results of the Benefit-Cost Study of a projected Canada-wide implementation of Intelligent Transportation Systems (ITS) that Transport Canada commissioned in 1997. Seven ITS options grouped into three groups of ITS technologies were evaluated; these groups are: Interurban Freight; Rural Transportation; and Urban Transportation.

A snapshot approach was used for the assessment of costs and benefits. This approach compares annualized benefits and costs in a specific year on the assumption that the user adoption rate has reached its full market potential. The analysis relied on a sketch planning method to explore causes and effects that link benefits and costs. Benefits from ITS applications were predicted on assumed driver behavioural changes in response to improved knowledge of highway and traffic conditions.

The quantified benefits included time savings, vehicle operating cost reductions, safety improvements, and environmental impact abatement. The results reflect a national deployment strategy extrapolated from site-specific evaluations.

Costs were generously estimated at current prices, and have not accounted for anticipated declines in the costs of electronic communications, information processing and control, and navigation technologies. In-vehicle operation and maintenance costs have been assumed to be negligible. Anticipated savings from the sharing of common infrastructure and in-vehicle equipment costs among ITS applications are not fully reflected in the cost estimate.

Note: This paper was presented at the Fifth Annual World ITS Congress that was held in Toronto in 1999. It is closely related to the following report:

Parviainen J., Sabounghi L., Sims D., Nasserdine I, Zavergiu R., and Waltho A. Benefit-Cost Assessment of Intelligent Transportation Systems (ITS) Implementation in Canada – Summary Report, Transport Canada, TP 12936, October 1997.

Results:

	Interurban Freight		Rural Transportation			Urban Transportation	
	Electronic Roadside Clearance	Automated Roadside Safety Inspection	Traveller Information systems	Electronic Transactions	Road Safety Systems	Traffic Manag.	Traveller Information Services
Annualized Costs (in $ millions $ Cdn)							
Service Provider Costs							
Capital	3.3	1.6	22.3	7.7	45.5	212.2	51.6
O&M	2.0	1.3	13.7	5.8	10.4	147.4	58.3
Sub-total	5.3	2.8	36.1	13.5	55.9	359.6	109.9
In-Vehicle Costs							
Capital	4.3	123.9		1.7			369.6
O&M		7.6					
Sub-total	4.3	131.5	0.0	1.7	0.0	0.0	369.6
Total Costs	9.6	134.3	36.1	15.2	55.9	359.6	479.5
Annualized Benefits (in $ millions $ Cdn)							
Time Savings	13.0	36.3	58.5	3.1	3.8	2 050.0	630.0
VOC	0.06	5.7	5.8	0.6	0.8	63.0	13.0
Safety		53.0	1.0		58.3	81.0	54.0
Other		7.7	26.0	15.8	0.4	128.0	27.0
Total Benefits	13.0	102.7	91.2	19.5	63.3	2 322.0	724.0
Benefit-Cost Ratios							
Aggregate	1.28	0.76	2.66	1.27	1.12	6.46	1.51
Service provider & Society	1.21	23.0	0.77	1.18	1.05	0.4	0.6
User	1.36	0.27	N/A	1.82	N/A	N/A	1.78

Section 6.1.1 Electronic Clearance and Roadside Inspection

Report Title:

Cost-Benefit Study of Electronic Clearance and Roadside Inspection (ECRI) for Canada (2003)

Author:

Tri-global Solutions Group Inc. and IBI Group for Transport Canada

ITS area of Technology:

CVO

Benefits:

Reduction in cost related to:

- Truck fuel
- Truck time
- Accidents (safety)
- Pavement damage
- Site expansion
- Staffing levels
- Commercial vehicle safety alliance (CVSA) inspection.

Stakeholders:

Report evaluates the business case alternatives from the perspective of:

- Society
- Government
- Carriers
- Concessionaire (where appropriate)

Geographic scope of B/C assessment:

Scope includes scales in Canada with at least 100,000 trucks per year. There are 86 weigh scales in this category.

Approach:

Three different business models are included in the analysis. These models are: public, private/public, and private. They are characterized primarily by who is paying for each cost component of the ECRI system.

- **Costs:**

Costs are assigned differently depending on perspective and model used.

Perspective	Model		
	Public	**Private/Public**	**Private**
Government	System and station level costs, on-board unit (OBU), marketing, auditing	System and station level costs, marketing, auditing	Station registration fee, auditing
Carrier	None	OBU sales	OBU sales, pass fees
Concessionaire	No Concessionaire in this model	OBU costs	System, station, marketing, OBU costs
Social	System and station level costs, OBU, marketing, auditing	System and station level costs, OBU, marketing, auditing	System and station level costs, OBU, marketing, auditing, building costs

- **Benefits**:

Benefits of ECRI considered as a reduction in costs of:

- Truck fuel from carrier and social perspective under the three considered models
- Truck time from carrier and social perspective under the three considered models
- Accidents (safety) from carrier and social perspective under the three considered models
- Pavement damage from government perspective. With exception of private sector toll highways, pavement benefits accrue only for government account.
- Site expansion from government and social perspective under the three considered models
- Staffing levels from government and social perspective under the three considered models
- Commercial vehicle safety alliance (CVSA) inspection from government and social perspective under the three considered models

There are also permit revenue and transient fine revenue benefits from the government perspective under the three considered models. The private/public model assumes that a concessionaire undertakes OBU sales and the private model assumes that the private sector undertakes OBU sales and implements and operates the ECRI system.

Conclusions (numerical results):

	Business Model										
	Public			Private/Public				Private			
Perspective	Govt	Carrier	Social	Govt	Carrier	Conces-sionaire	Social	Govt	Carrier	Conces-sionaire	Social
Total Present Value of Cost	$50.3	$0.0	$50.3	$27.9	$22.4	$22.4	$50.3	$10.7	$150.6	$73.1	$82.3
Total Present Value of Benefits	$53.7	$167.1	$219.2	$53.7	$167.1	$24.4	$219.2	$53.7	$167.1	$154.1	$219.2
B/C	1.1	>10	4.4	1.9	7.5	1.1	4.4	5.0	1.1	2.1	2.7
Net Present Value	$3.4	$167.1	$168.9	$25.9	$144.7	$2.0	$168.9	$43.1	$16.6	$81.0	$136.9

In millions

When budgets are fixed, the best business model should seek to maximize the net benefits (from the social perspective) while achieving equity between the costs and benefits to each sector. The best model to achieve this is the Private/Public Model. Therefore, it is the recommended model.

Section 6.2.1 Freeway Management

Report Title: Ontario ITS Strategies Framework and COMPASS Implementation Plan (2001)

Author: IBI Group

ITS area of Technology: Traffic Management System

Benefits:

- Reduce vehicle delay;
- Reduce fuel consumption;
- Reduce secondary collisions.

Stakeholders:

Geographic scope of B/C assessment:

All 400 series highways and the QEW throughout Ontario, excluding:

- Highway 407
- QEW from Hwy. 420 to Hwy 406 and from Hwy 20 to Evans Ave Interchange
- Highway 401 from 403-Brock Road
- Highway 404 end of DVP to Sheppard Ave. Interchange

Approach:

1. Benefits:

- **Annual Lane Blocking Events (LBE)**: Based on assumption that the ratio of collision to LBE is 3:1 and 60% of all LBE occur during the peak periods.
- **Annual Delay Saving**: Based on applicable capacity and demand volumes, queuing diagrams have been developed for single and double lane blockage events (LBE) for each V/C level and the two levels of COMPASS system deployment (i.e. Light, and Full), as well as the "do nothing" alternatives. These diagrams were used to calculate the resulting vehicle delays from incident and scenario combinations.
- **Delay Benefits:** Value of passenger time was assumed to be $10.5/hr and $57.60/hr for commercial vehicle time. Weighted value for vehicle time of $15.21/hr, assuming 10% of commercial vehicles, was calculated. This weighted value of time was used to determine the benefits resulting from the delay savings.
- **Fuel Benefits:** weighted fuel consumption rate of 3.6L/veh hr was calculated. This rate was applied to the vehicle delay savings in order to estimate the annual fuel savings for each of the COMPASS concept designs.
- **Collision Benefits:** Weighted accident value is applied to the number of reduced

collisions in order to calculate the benefits, in dollars, associated with reduced secondary collisions.

Delay, fuel, and collision benefits were summed up to calculate the year 2005 total benefits of system deployment. Assuming that growth rate for traffic volume is linear over the 10 year design life, the year 2005 benefits were assumed to be representative of the average benefits between 2001 and 2010. Therefore, present value is calculated based on 10 equal benefits and a discount rate of 5.95%.

2. Cost: Based on MTO experience, it was assumed that a light COMPASS deployment costs $125,000 per kilometre and full COMPASS deployment costs approximately $600,000 per kilometre. Costs for candidate segments were calculated using these values.

3. **B/C analysis** (sample of results)

Segment	B/C
Hwy. 410: Hwy. 401 – Williams Pkwy.	6.5
Hwy. 404: Hwy. 401 – Hwy. 407	6.5
Hwy. 401 Kingston Area	2.5
Hwy. 405 Lewiston/Queenston Bridge	0.1

4. Comparative evaluation:

Evaluation of the candidate segments has been conducted in terms of cost; congestion and environmental priority; safety priority; benefit/cost ratio; segment length; proximity to existing COMPASS projects; and special situations. Each of the candidate segments is evaluated, for each of these criteria, on a scale of one to five. Initial weighting has been assigned to each of the evaluation criteria in order to normalize the evaluation. A sample of the final evaluation results is presented in the table below.

Project	Cost	C&E Priority	Safety Priority	B/C	Length	Proximity	Special Situations	Eval.
Hwy. 410: Hwy. 401 – Williams Pkwy.	2	5	4	5	3	5	1	355
Hwy. 404: Hwy. 401 – Hwy. 407	3	3	3	5	2	5	3	355
Hwy. 401 Kingston Area	4	1	2	2	5	1	1	220
Hwy. 405 Lewiston/Queenston Bridge	5	1	1	1	1	4	5	255

Section 6.3.1 Rural safety systems

Report Title: Benefit/Cost Assessment of ITS Implementation in Canada Rural Transportation

Author: IBI Group

ITS area of Technology:

Rural Safety Systems:

- Portable Construction Zone Traffic Management System
- Mayday/Emergency Request System
- Intersection/Railway Crossing Collision Avoidance

Benefits (described as goals in report) considered:

- Reduce the frequency and severity of accidents and other incidents;
- Reduce congestion due to incidents;
- Enhance traveler security/reduce stress;
- Reduce travel times;
- Reduce fuel consumption and harmful emissions.

Target:

- All intercity/rural travelers for the Portable Construction Zone Traffic Management System and Collision Avoidance at Intersection/Railway Crossing
- All travellers with equipped vehicles for the Mayday/Emergency Request System

Stakeholders:

- **Road Users:** all intercity travellers; road maintenance and construction crews/contractors; emergency response agencies; commercial vehicle operations companies.
- **Others:** rail system operators; communications service providers; vehicle manufacturers and equipment suppliers; federal, provincial and municipal governments (transportation agencies).

Geographic scope of B/C assessment:

- Portable Construction Zone TMS: major construction zones on rural roadway sections with a moderate to heavy traffic and restricted cross section/geometry.
- Mayday/Emergency Request System: isolated rural highway sections.
- Intersection/Railway Crossing Collision Avoidance: rural highway sections with a history of intersections and/or grade crossing collisions.

Approach:

- Portable Construction Zone TMS: a two-lane section of the Trans Canada Highway (TCH) undergoing upgrading (e.g. New Brunswick Hwy 2) is recommended for B/C assessment.

- Mayday/Emergency Request System: a section of TCH in northern Ontario (Hwy 11 or 17) is recommended for B/C assessment.
- Intersection/Railway Crossing Collision Avoidance: a highway section with multiple intersections and at least one heavily-used railway grade crossing is recommended foe the B/C assessment.

Assumptions for the B/C assessment will be developed once a specific study site has been selected. Assumptions known to date include:

- 45% of commercial vehicles and 25% of private vehicles will be equipped with vehicle to roadside communications (VCR) and a simple display device;
- All vehicles are equipped with an AM/FM radio which receive HAR broadcasts
- Expected benefits include reduced accidents, travel time, fuel consumption and emissions.

No further details regarding the proposed benefits assessment approach are provided

<u>Section 6.3.2 Rural traveler information systems</u>

Report Title: Benefit/Cost Assessment of ITS Implementation in Canada Rural Transportation

Author: IBI Group

ITS area of Technology:

Rural Traveller Information Systems:

- Hazardous Road Condition Warnings;
- Intermodal Traveller Information;
- Tourist Information Kiosks;
- Road Weather Information Systems.

Benefits (described as goals in report) considered:

- Reduce the number and severity of accidents and other incidents;
- Reduce congestion due to incidents;
- Reduce traveler stress and uncertainty;
- Reduce road and intermodal travel times;
- Improve intermodal transportation utilization;
- Reduce travel costs incurred by fleet operators, operating agencies and individuals

Target:

All intercity/rural travellers. Particular target groups are:

- Multi-modal travellers for intermodal Traveller Information Systems
- Tourist travellers for tourist Information Kiosks

Stakeholders:

- **Road Users:** all intercity travellers (including tourists and truckers) ; road maintenance and emergency response agencies; commercial vehicle operations companies.
- **Others:** rail, air, marine and bus system operators; local area business/tourist attraction operators; local area broadcasters, TV and radio; federal, provincial and municipal governments (transportation and tourist agencies)

Sites:

- Hazardous Road Condition Warnings and Road Weather Information Systems: isolated road segments with moderate to heavy traffic and a history of problematic weather/road conditions;
- Intermodal Traveller Information Systems: intermodal exchange points, i.e. rail, air, marine and bus terminals;
- Tourist Information Kiosks: gas stations, rest areas, community centers, parks, etc. at or near tourist attractions.

Approach:

A section of the Trans-Canada highway in rural Ontario is recommended for B/C assessment. The section will include at least one intermodal exchange point and significant tourist attraction(s). Assumptions for the B/C assessment will be developed once a specific study site has been selected. Assumptions known to date include:

- 15% of commercial vehicles and 10% of private vehicles will be equipped with vehicle to roadside communications (VCR) and an enhancement display device;
- All vehicles are equipped with an FM/AM radio which receives HAR broadcasts
- Expected benefits include reduced accidents, travel time, fuel consumption and emissions.

No further details regarding the proposed benefits assessment approach are provided

Section 6.3.3 Electronic transactions

Report Title: Benefit/Cost Assessment of ITS Implementation in Canada Rural Transportation

Author: IBI Group

ITS area of Technology:
Rural Vehicle Electronic Transaction Systems
Two modules: Electronic Toll Collection and Border Crossing Clearance Systems

Benefits (described as goals in report) considered:

- Reduce number of accidents;
- Increase capacity at toll plazas and border crossings;
- Improve convenience of toll payments;
- Reduce fuel consumption and harmful emissions;
- Reduce travel time;
- Reduce costs incurred by fleet operators, toll agencies, customs agencies and individuals;
- Enhance traveler security and reduce traveler stress;

Target: Toll users and international travelers

Stakeholders:
Toll users; international travelers; international cargo shipment by truck; toll agencies and private highway operators; Canadian customs and immigration; automobile manufacturers and equipment suppliers; departments responsible for vehicle registration, vehicle safety, customs and immigration information, security; financial community

Geographic scope of B/C assessment:

- Electronic Toll Collection: Toll facility through Canada including Northumberland Strait Bridge, Highway 407, bridges and tunnels connecting the United States and Canada , and various other major bridges and tunnels as well as ferries.
- Border Crossing Clearance Systems: more than 20 major border crossing sites between Canada and United States.

Approach:

- Electronic Toll Collection: Northumberland Strait Bridge is recommended as a typical or B/C assessment site.
- Border Crossing Clearance Systems: Peace Bridge connecting Ontario and Buffalo along the QEW Highway is recommended as the typical or B/C assessment site.

No further details regarding the proposed benefits assessment approach are provided.

Section 7.1.1 GHG reduction benefits

Report Title: GHG Reduction Benefits of the Deployment of Intelligent Transportation Systems on Canada's Road/Highway Network (1999)

Author: IBI Group for Public Works and Government Services Canada; Climate Change – Transportation Table

Approach:

1. Incident Management
   Delay reduction benefits identified from COMPASS experience have been extrapolated to other large and medium urban centers based upon vehicle kilometres. These benefits with parameters of freeway incident management penetration, estimated fuel consumption ratios, and GHG factor are used to calculate GHG reduction for private automobiles, gas trucks, and diesel trucks.

2. Traffic Control
   Fuel saved annually/intersection, based upon the Toronto experience in deploying the SCOOT system, has been extrapolated to other Canadian large and medium sized urban areas. This value with parameters of assumed number of traffic signals per 1000 population, assumed system penetration rate, and GHG factor for gasoline are used to calculate the GHG reduction for large and medium urban areas.

3. En-Route and Pre-Trip Traveller Information
   An intuitive approach has been utilized to estimate the reduced delay resulting from temporal, spatial and modal shifts in travel patterns. These delay reduction benefits with parameters of peak period factor, assumed penetration rate, consumption fuel ratio, and GHG factor are used to calculate the GHG reduction for private automobile, and gas and diesel trucks.

4. Transit Automated Vehicle Location (AVL)
   Fuel consumption savings, intuitively assumed, have been used with parameters of assumed penetration rates, fuel consumption ratio, and GHG factor to calculate the GHG reduction for diesel buses.

5. Electronic Payment Systems
   Fuel consumption improvements, based upon an intuitive approach, have been used with parameters of vehicle-kms of travel on urban freeways, assumed penetration rates, estimated fuel consumption ratios, freeway users (private automobile, gas trucks, and gasoline trucks) ratios, and GHG factor to calculate GHG reductions for the three freeway user categories.

6. Commercial Vehicle Electronic Clearance
   Fuel consumption savings, based upon the assumption that trucks could on average save a total of 20 minutes per trip as a result of being pre-cleared at the border, have been used with parameters of percent of total trucks crossing to Canada with electronic clearance, and GHG factor to estimate GHG reduction.

7. Advanced Vehicle Control System (AVCS)
   Fuel consumption savings, based upon the assumption that AVCS reduces collision occurrence which reduces incident delay, have been used with parameters of collision rate on freeways, average delay/collision, freeway users (private automobile, gas trucks, and gasoline trucks) ratios, estimated fuel consumption ratio, and GHG factor to calculate GHG reductions for the three freeway user categories.

Conclusions (numerical results):

The following table summarizes the year 2010 GHG reduction benefits and costs for the seven ITS options

ITS Option		2010 GHG Reduction (kt)	2010 Costs ($000)	
			Public	Private
Incident Management		151	192,000	-
Traffic Control		100	21,100	-
Traveller Information		154	-	191,700
Transit AVL		4	2,400	-
Electronic Payment	Toll Collection	253	37,500	191,000
	Transit Fare Payment	46		
Commercial Vehicle Pre-Clearance		20	14,800	18,400
Vehicle Control & safety Systems		47	-	130,000

If all options are adopted, the total annual GHG reduction in year 2010 is estimated to be 775 kt. This figure represents:

- 0.5% of the total GHG output attributed to transportation in1991
- 0.4 % of the expected 2010 GHG transportation output
- 2% of the GHG reduction target for transportation in 2010

Section 7.1.2 Emissions implications of ITS deployments

Report Title: Evaluating Emissions Implications of Proposed Intelligent Transportation Systems Deployments (2003)

Author: Issam Kayssi for Intelligent Transportation Systems (ITS) Policy Branch, Transport Canada

Approach: (This study is ongoing)

Phase I – Basic Environmental Impact Evaluation in Ongoing ITS Deployment Studies

In evaluating emissions impacts of contemplated ITS interventions, there is need to identify specific transport operational improvements that are most indicative of such emissions impacts. Phase I of the study focuses on the identification of such operational improvements and relating them to emissions implications in the context of specific ITS deployments currently being funded by Transport Canada (TC). These deployments are the following:

- City of Saskatoon – Advanced Traffic Management System
- Regional Municipality of York – Transit Priority System
- City of Ottawa – Intelligent Transit Vehicle Subsystem
- City of Toronto – Road Access and Disruption Management Program
- City of Edmonton – Video-Based Traffic Management & Traveler Information Project
- Calgary Transit – Traffic Signal Priority and Automatic Vehicle Tracking System

Phase II – Development of "Guidelines Document" for Integrating Environmental Impact Evaluation in Future ITS Deployments Studies

The work in Phase I shall be conducted within the context of ongoing ITS deployment studies, and shall develop, to the extent possible, emissions/environmental performance measures for these deployments currently being funded by TC. On the other hand, Phase II shall focus on the development of longer-term guidelines for integrating environmental impact evaluation in future ITS deployment studies. In particular, specific ITS deployments falling within the following three major areas of ITS shall be considered:

- Advanced Traffic Management
- Traveler Information
- Advanced Transit Systems

Section 7.2 Safety benefits of ITS

Paper title: Using the Canadian ITS Architecture for Evaluating the Safety Benefits of Intelligent Transportation Systems

Author: H. Vahidi and T. Sayed

Source: Canadian Journal of Civil Engineering (2003)

Approach:

This paper develops a framework for assessing the safety benefits of ITS. The framework identifies evaluation metrics, and maps these metrics to market packages in the Canadian ITS Architecture.

As part of the problem definition exercise undertaken for this research, the authors undertook an evaluation of an existing ITS application in order to demonstrate issues and deficiencies with current ITS safety evaluation practices. The ITS project selected for this case study was the City of Toronto's Road Emergency Services Communications Unit (RESCU), which incorporates real-time traffic and road monitoring capabilities, along with incident detection and management, and traffic information dissemination. This case study helped to provide a relative comparison of how simple variations in the evaluation methodology can affect the benefits estimate.

The paper goes on to develop a set of metrics that can be used for evaluating the safety benefits of ITS. The metrics have been grouped into two categories called "Cause Metrics" and "Effect Metrics". Cause metrics include drive errors and driving violations (under the *driver* factor contributing to crash occurrence), congestion and exposure to hazards (under the *road/environment* factor), and mechanical failures (under the *vehicle* factor). The effect metrics basically relate to number of accidents and accident severity. These metrics are selected to support the evaluation of market packages in the Canadian ITS Architecture. Metrics are identified for various categories falling under the following Canadian ITS Architecture Bundles: ATIS, ATMS, CVO, Emergency Management, and Vehicle Safety and Control Systems. For instance, Traveller Information is considered to be related to the traffic volumes, congestion, and crashes metrics.

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