ATLANTIC

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

A Partnership of ITS Communities in Europe and North America

SYNOPSIS

And Highlights of

DISCUSSION PAPERS

INTERMODAL FREIGHT, PRE-CLEARANCE & LOGISTICS

Prepared by

Work Group 2.1
WG Leader: Teodor Gabriel Crainic, ESG (UQÀM) & CRT (UdeM)
WG Rapporteur: Lewis Sabounghi, Sabounghi & Associates

In collaboration with Participating Partners and Sponsors

April 2004

(Blank page)

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, research and development in Canada.

The topic of Working Group 2.1 was defined originally by the European partners of the ATLANTIC project as *Intermodal Freight, Pre-clearance and Logistics*. The leadership of the Canadian ATLANTIC network interpreted this topic in its broadest sense of ***Freight ITS***. The activities of Working Group 2.1 resulted in two Discussion Papers, **Freight ITS** and **Intermodal Freight E-Data Issues – Standards and Related Efforts**. The present report constitutes a Synopsis of the two reports. It highlights the main ideas and recommendations.

European Commission Directorate-General
Information Society

Herman Bertrand
ARTTIC in Brussels
Tel: + 32 2 672 33 39
Email: hb@arttic.be

Siegfried Rupprecht
Rupprecht Consult
Tel: +49 221968 130
Email: s.rupprecht@rupprecht-consult.de

Richard Harris
Ian Catling Consultancy
Tel +44 1737 552225
Email: rh@catling.com

Professor Teodor Gabriel Crainic
École des sciences de la gestion
Université du Québec à Montréal
Centre de recherche sur les transports
Université de Montréal
Tel: +1 514 343-7143
Email: theo@crt.umontreal.ca

William Johnson
Consultant, Ottawa
Tel: +1 613 797-1489
E-mail: johnswf@attglobal.net

Isabelle Dussutour
POLIS
Tel. +32 2 282 84 67
E-mail: polis@polis-online.org

Dr. John Miles
Ankerbold International Ltd.
Tel +44 118 975 1566
Email: jcm@Ankerbold.co.uk

Steve Morello
ISIS Consultants
Tel: +33 4 78 71 89 55
Email: s.morello@isis.tm.fr

Dr. Baher Abdulhai
ITS Centre and Testbed
University of Toronto
Tel: +1 416 946-5036
Email: baher@ecf.utoronto.ca

Professor Chelsea White III
School of Industrial & Systems Eng.
Georgia Institute of Technology
Atlanta, GA
USA 30332-0205
Tel: +1 404 894 2307
Email: cwhite@isye.gatech.edu

Professor Kan Chen
2420 Skyfarm Drive
Hillsborough CA
USA 94010
Tel: +1 650 375-8890
Email: kan@kanchen.com

(Blank page)

Acknowledgments

The ATLANTIC Canada network acknowledges the leadership and contributions provided by its partners in Europe and the United States. The principal partners include Dr. John Miles (United Kingdom), Steve Morello (France), Ian Catling (United Kingdom), Isabelle Dussutour (POLIS), Siegried Rupprecht (Germany), Professor Chelsea White III (USA) and Professor Kan Chen (USA).

The ATLANTIC Canada network node is sponsored by Transport Canada, the Ministry of Transportation of Ontario and le Ministère des Transports du Québec, and jointly managed by the ITS Center and Testbed of the University of Toronto and the Centre de recherche sur les transports of the 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 2.1 Intermodal Freight, Pre-clearance & Logistics is jointly managed by a leader, Professor Teodor Gabriel Crainic, École des sciences de la gestion, UQÀM and the Centre de recherche sur les transports, Université de Montréal, and a rapporteur, Dr. Lewis Sabounghi, Principal, Sabounghi & Associates. They provided the intellectual leadership and writing skills to assemble and document the synopsis and discussion papers with input and contributions from a network of Work Group members. The names of Work Group 2.1 members and contributors appear in Annex A. Special recognition is extended to Professor Michel Gendreau, Dr. Denis Lebeuf, Mrs Diane Nash, P.Eng., and Dr. Javad Sadr for their extensive contributions.

The Work Group 2.1 leader and rapporteur can be contacted at:

Teodor Gabriel Crainic, Professor
Management et technologie,
École des sciences de la gestion, UQÀM and
Director, ITS Laboratory
Centre for Research on Transportation
Université de Montréal
514 343 7143 (tel)
514 343 7121 (fax)
theo@crt.umontreal.ca

Lewis Sabounghi, Ph.D.
Principal
Sabounghi & Associates
514 867-5737 or 613 347-7345 (tel)
lewis@sabounghi.com

(Blank page)

ABSTRACT

The topic of Working Group 2.1 was defined originally by the European partners of the ATLANTIC project as *Intermodal Freight, Pre-clearance and Logistics*. The leadership of the Canadian ATLANTIC network interpreted this topic in its broadest sense of ***Freight ITS***. The activities of Working Group 2.1 resulted in two Discussion Papers.

1. **Freight ITS**, authored by Professor Teodor Gabriel Crainic, Work Group Leader. It addresses issues related to freight transportation, Freight ITS and enabling technologies, Commercial Vehicle Operation Systems, including border-crossing issues, Advanced Fleet Management Systems, City Logistics, and e-business. It concludes with perspectives on Freight ITS in Canada and a series of research directions.
2. **Intermodal Freight E-Data Issues – Standards and Related Efforts**, authored by Dr Lewis Sabounghi, Work Group Rapporteur. It addresses issues, challenges, and needs facing intermodal freight movements' electronic data transfer in the current environment of heightened national/International security, and the opportunities offered by the ITS technology. It also summarizes the efforts currently being pursued under the aegis of NAFTA and in cooperation with the rest of the world within the different standards development organizations.

The present report constitutes a Synopsis of the two reports. It highlights the main ideas and recommendations.

(Blank page)

TABLE OF CONTENTS

Preface iii

Acknowledgments v

Abstract vii

Freight ITS **1**

- Introduction 1
- Freight Transportation (in original document) 2
- Intelligent Freight Transportation Systems (summary) 2
- Commercial Vehicle Operations (CVO) (summary) 4
- Advanced Fleet Management Systems (AFMS) (summary) 7
- City Logistics 10
- CVO/AFMS and E-business (summary) 12
- References (in original document)
- Web References (in original document)

Intermodal Freight E-Data Issues – Standards and Related Efforts **14**

- Electronic Data Issues in Intermodal Transportation 14
- Issues, Needs, Goals, Objectives and Expected Benefits 14
- Availability of Standardized Cargo Electronic Documentation 15
- Data Dictionary and Message Set for Tracking of Freight and its Intermodal Transfer – Electronic Manifest 17
- Availability of Standardized on Board Cargo Identification and Dynamic Cargo Condition Data Linked to Mobile Communication 20
- Data Dictionary and Message Sets for Electronic Identification and Monitoring of Hazardous Materials/Dangerous Goods Transportation 20
- Roadside (On Site) Recipient to Emergency Control Centres 22
- Emergency Control Centres to Emergency Control Centres 23

Conclusions: Perspectives, Challenges, Opportunities **25**

Annex A. Work Group 2.1 Participants **29**

(Blank page)

Freight ITS

Introduction

The initial driving force for the development of *Intelligent Transportation Systems* (*ITS*) has been the realisation that further infrastructure construction could no longer be the only answer to address the increase in transportation demand and the various problems that it inevitably creates. The obvious answer to the need to increase significantly the capacity of transportation systems was to try to make them more efficient through an integrated use of the latest developments in various areas, infrastructure and vehicle technologies, electronics, telecommunications, computing hardware, positioning systems, as well as advanced data processing and sophisticated planning and operation methods. Over the past 15 years or so, one has thus witnessed tremendous efforts aimed at creating and deploying a new generation of transportation systems designed to control congestion, increase safety, increase mobility and enhance the productivity and effectiveness of private and public fleets.

In the beginning, ITS research, development, and investment focused on urban automobile transportation and a public organisational structure and management. It has now evolved to include all types and levels of transportation, persons as well as freight, for which private industries offer a variety of extended, adapted and targeted services. Tremendous challenges and opportunities exist for ITS research, development, and business, particularly in the area of freight transportation which, until recently, appeared relatively less prominently on the agenda of ITS stakeholders. Indeed, the development of Freight ITS and the evolution of the freight transportation industry are closely related, particularly relative to the use of information and decision technologies in response to the tremendous shift in commercial and industrial practices of the last decade. This is in stark contrast to most other ITS areas where the needs of people mobility in congested urban centers constitute the overwhelming driving force.

New challenges for the freight transportation industry result from major changes affecting supply chains and logistical processes in trade and commerce. A first factor is the strong impetus toward inventory reduction that led to the "Just-in-Time" procurement practices and, more recently, to just-in-time replenishments of goods in the retail industry. The powerful trend toward the globalization and liberalization of markets and the creation of free trade zones constitutes a second major changing factor. A restructuring of manufacturing and distribution channels worldwide has accompanied the globalization of the economy. Production units are re-located and the components required for final assembly of complex industrial products are often brought in from many distant locations. All the while, trans-national centralized warehousing facilities and value-added distribution centers are changing the flow of goods almost everywhere.

The development of Internet-based electronic business is also strongly contributing to the transformation of the freight transportation industry. The main external factors driving this transformation are the modifications to the logistic chains and practices of major industries and economic sectors, the proliferation of electronic spaces (websites) where shippers and carriers may meet and close deals, and the continuously increasing volume of individual consumer e-commerce activities. These changes have certainly resulted in higher demand for transportation. They have also increased the requirements for freight transportation services in terms of enhanced customer value: reduce transportation and distribution costs, while responding to the customer needs in terms of delivery time and reliability. Moreover, events such as 9/11, the war on terrorism, and the war on drugs have created potential impediments to the flow of goods due to safety and security threats that can only be mitigated through the use of technology and increased efficiency. These factors have put, and continue to put, tremendous pressure on freight carriers and managers of intermodal facilities to reduce and control costs, to plan and operate efficient, timely, and reliable services, and to react rapidly to new customer requests, emerging or shifting business opportunities, and changes in the economic and regulatory environment.

The freight-transportation industry bases a significant part of the answer it offers to these challenges on information and decision technologies: two-way communication, location and tracking devices, electronic data interchange, advanced planning and operation decision support systems, and electronic business. Intelligent Transportation Systems integrate and enhance these technologies within the firm, as well as through the linkages and exchanges between the firm and its environment (customers, partners, regulators, etc.)

This report aims to assess ITS achievements with respect to the transportation of freight and to identify promising research and development directions. While the situation in Canada is our primary concern, we believe that it cannot be isolated from main international developments. We base our presentation on this assumption.

Similar to many other ITS areas, Freight ITS development proceeds along three major, parallel but complementary, directions. The first concerns vehicular and infrastructure developments. While acknowledging the importance of this direction, according to the definitions of the ATLANTIC Working Groups, it was not assigned to Work Group 2.1. Therefore, we address only the second and third directions in this paper. The second direction concerns the electronics, location, tracking, and communication **hardware**, as well as the associated information-technology software. The third targets the **methodologies** – models and algorithms – required to process the data and transform it into timely and meaningful information and intelligent advice for advanced system and fleet planning, management, operations, and control systems. The ultimate performance and long-term success of ITS depends on a balanced and harmonious integration of these two aspects. It appears, however, that governments and industry privileged the second direction to the detriment of the third. While it is true that this phenomenon may be observed elsewhere, it is particularly strong in Canada, though recent initiatives of Transport Canada seem to indicate a change of direction. We hope that these initiatives will continue on a regular basis and that a re-structuring of the financing processes and a strong participation of provincial authorities and industry will accompany them.

Freight Transportation

Detailed in the full document.

Intelligent Freight Transportation Systems (summary)

The core of ITS consists in obtaining, processing, and distributing information for better use of the transportation system, infrastructure and services.

Prior to examining the components of Freight ITS, however, it is important to remember that the ITS idea is not a brand new concept emerging suddenly, but rather a logical evolution of transportation management drawing on old and new technologies. What is new about ITS is the vision of a *globally integrated framework realising a synergy between* previously isolated *systems*. The rapid and concurrent development of electronic exchanges and partnerships is exacerbating the integration requirements. Integration for ITS and e-business alike is not a simple task, however, as it must engage with a large array of disparate entities covering three broad areas: technical, political, and geographical.

At the technical level, ITS brings together the fields of transportation planning, telecommunications, computing, vehicle and electronics manufacturing, and infrastructure construction. Many political entities are involved in the development, deployment, and operation of ITS: government agencies at the national and local levels, highway operators, carriers, equipment manufacturers, system vendors, and service operators, etc. They must all collaborate to implement and run a system that is composed of a mixture of public and private goods and services. A geographical integration must also be achieved at a regional and, in many cases, international levels. An end user, a container carrier for example, does not like to be forced to buy a different set of equipment for each city or country it intends to travel to. ITS is all about mobility, it is not meant to infringe on it! The efforts aimed at the development of standards and national architectures attempt to address these issues.

It is traditional to examine Freight ITS according to the scope of the systems classified in two broad classes: *Commercial Vehicle Operations* (*CVO*) for system-wide, regional, national, or continental applications and *Advanced Fleet Management Systems* (*AFMS*) dedicated to the operations of a particular (group of) firm(s). Although different in scope, both categories of systems require a number of enabling technologies, some of which are already firmly established, some that are still emerging, many of which are also firmly supporting the e-business activities of the firm.

The continuity in the ITS evolution is illustrated by the strong relations between *Electronic Data Interchange* (*EDI*) and freight transportation. One may argue, in fact, that the common ancestor to CVO and AFMS developments is the adoption by the freight transportation industry of EDI, two-way communication, and vehicle (and cargo) location and tracking technologies. This area of development is still going strong.

One can define EDI as the inter-organisation, computer-to-computer exchange of business documentation in a standard, machine processable format (Emmelhainz 1990). Its popularity has grown rapidly due to customer (shipper or large carrier) requirements as well as several benefits associated with its use: minimisation of manual data entry, increased transaction speed and accuracy, lower communication costs, and simplification of procedures. Major shippers (e.g., the auto industry), large carriers (e.g., railways) or infrastructure managers (port authorities) have initially promoted the utilisation of EDI in the transportation industry, and they continue to be among the heaviest users of the technology. Smaller carriers followed, motivated mainly by the need to increase customer service and remain competitive. Pre-clearance activities in CVO-equipped corridors or regions and at maritime and land border crossings require the utilisation of EDI for information transmission among shippers, carriers, and officials. EDI supports advanced fleet management systems not only to enable communications between dispatchers in control centers and vehicle operators in the field, but also to ensure timely and correct data delivery to the planning and monitoring systems of the firm. (Golob and Regan 2000a,b, 2001a,b, 2002a,b, 2003).

The continuous improvement and integration of Global Positioning Systems (GPS) and communication technologies resulted in the improvement in the quality (up) and prices (down) of such systems. This means wider acceptance of these technologies and their utilisation in many modal and inter-modal settings. The current focus of EDI development is on wireless communications, the use of Internet, and the integration of the various technologies and data (Hook, 1998).

EDI, GPS, Automatic Identification Systems and similar technologies are also playing a continuously central role in freight terminals with significant impact on the performance of transportation systems, particularly intermodal transportation, and logistic chains. Significant progress has been accomplished in introducing automation and advanced information and decision technologies to freight terminals, port container terminals in particular (e.g., Arendt and Speidel 1999, Giannopoulos and Shinakis 1999). Considerable efforts are still being undertaken, while many innovative projects are proposed around the world.

It is remarkable, in fact, that EDI was one of the strongest initial enabling factors of partnerships and alliances between large numbers of carriers and shippers, before "electronic commerce" became a household name. This trend is actually leading to the electronic integration of carriers, operators of inter-modal transfer facilities, and shippers with common interests in the movement of certain commodity groups or the utilisation of particular infrastructures. Information technologies and appropriate planning and operating management methods and instruments are required to support and enhance such virtual business-to-business communities of interest (e.g., the *European Cooperative Resource Management of Unit Loads* - *COREM* and the *Trident* - *Transport Intermodality Data Sharing and Exchange Network* within ERTICO [WR19]).

Commercial Vehicle Operations (CVO) (summary)

The Commercial Vehicle Operations (CVO) area of ITS has been defined as "*Advanced systems aimed at simplifying and automating freight and fleet management operations at the institutional level*". National or regional authorities, in collaboration with carriers and firms that propose the required technologies, usually initiate CVO projects. The goal is to increase the performance of the infrastructure (mostly highways) and customs systems, simplify and automate government control-related freight and fleet management operations, and, thus, enhance the efficiency of commercial vehicle activities through seamless operations based on electronic vehicle and cargo identification, location and tracking, pre-clearance and in-motion verifications**.** The importance of CVO applications has been acknowledged quite early on in ITS history, and a significant number of CVO projects have been undertaken or are currently under way.

Initial deployment efforts of CVO technologies have been organised around so-called "corridors". A corridor is typically organised around a major highway, or a system of highways, that cross several regional or national jurisdictions. The goal is to increase the fluidity of truck traffic and to offer seamless interstate or inter-nation border crossings, while ensuring adequate levels of control and reporting relative to regulations on safety, traffic, customs, and so on. Weight-in-motion scales, overweight detectors, EDI, automatic vehicle (and cargo) identification and classification systems, vision technology (to read license plates), and variable message signs are among the main technologies used. Corridor projects usually involve national and local governments and agencies, private technology providers (who, sometimes, also contribute significantly to the financing of the technology deployment), and, obviously, carriers.

Several corridor projects have been undertaken in the second half of the 90's (Crainic, Gendreau, and Lebeuf 2001). In the United States, these efforts have led to the establishment of two major continental systems, the *North American Pre-clearance Automated Safety System* (*NORPASS*) and the *PrePass Program*.

Over 67 000 trucks were registered with NORPASS [WR5] at the time this report was written (March 2004). The system includes several member and partner states in the United States. British Columbia is the only official Canadian member. The PrePass [WR6] network covers a much broader area of the United States. At the beginning of March 2004, 254 495 vehicles were registered with this system. Both systems offer essentially the same services (weight-in-motion and electronic pre-clearance) and are based on transponder technology. The technology now offers transponders that may be used with both systems. A carrier using such transponders and aiming to operate within both systems must register with each system separately, however, and pay the appropriate fees.

The *I-95 Corridor Coalition* brings together state authorities as well as a large gamut of stakeholders in a broad region of the United States, from Main to Florida [WR7]. In Canada, New Brunswick is associated to the coalition. The goal of the coalition is to improve multimodal transportation services in the region through information sharing and coordinated management and operations. The scope encompasses ITS in quite a broad sense to also include CVO.

In Japan, the emphasis is on the real-time collection of truck operational status and its distribution as basic data to operators. A significant effort is also directed toward the development of integrated and automated terminals, also called “logistic centers”. An automated, platoon-based commercial transportation system is also envisioned. The goal is to enhance the efficiency of commercial and logistics activities [WR22].

In the European Community, the European Commission and the member states have embarked on a comprehensive effort of research, development, and deployment of ITS. It is an exemplary effort in its reach and scope, as well as in the framework it established for collaboration and partnership among all stakeholders – government and public agencies, private firms, consulting bureaux, universities, research centers, and so on. The website of ERTICO [WR19] together with those of its members detail the many projects undertook in Europe. Two main directions are defined for Freight ITS in the policy of the European Commission (the White Paper may be found on the site of Directorate General for Energy and Transport [WR20]). The first concerns the connection of the countries of Central and East Europe to the rest of the continent. ITS is seen as an essential tool to achieve this objective. The second direction concerns the development of intermodal transportation as the main mechanism to influence the current mode choice that is heavily biased toward trucks and highways. The document argues that the improvement of infrastructures, such as posts, and the enhancement of information and decision systems, will result in some of the cargo currently “on the road” to move to less environmentally invasive means of transportation such as rail and coastal and fluvial navigation.

Several CVO projects have been completed in Canada, including (Fu, Henderson, Hellinga 2003)

- Weight-in-motion station with Automatic Vehicle Identification System, to allow compliant vehicles to bypass, in Port Man, Vancouver - Surrey, British Columbia;
- The *CoastView* project in British Columbia to monitor hazardous materials transportation in the coastal waters and ports of the province;
- The virtual station, weight in motion, Saskatoon, Saskatchewan;
- Weight-in-motion and pre-clearance system at Long Creek Station, New Brunswick; The Atlantic Provinces are currently working toward an integrated ITS/CVO development and deployment plan.
- The I.R.I.S. (*Infra Red Inspection System*) in Ontario to screen commercial vehicles while in motion for brake defects.

A major class of CVO projects, particularly widespread in North America, concerns the operations of border crossings. This area has acquired a sense of urgency and high priority following the terrorist attacks on the United States and the continuing terrorist threat. Ports have thus become prime targets for ITS and e-business projects with security issues as the driving objective. While the urgency has been primarily felt in the United States [WR3] (Transportation Research Board 2002), border CVO systems are being developed worldwide. The main goal is to clear drivers, vehicles, and cargo in order to speed up the passage of vehicles carrying manufactured and agricultural goods through the border inspection facilities, within the parameters set by the border control requirements in terms of security, immigration, illicit cargo, agricultural controls, etc.

The current state of the world affairs and the U.S. response has elevated these issues at a level of urgency and complexity never felt before. The creation in the United States, Canada, and elsewhere of new government structures dedicated to security issues including customs and border control illustrates this urgency. The U.S. Customs Container Security Initiative [WR3] that requires the inspection and pre-clearance of a certain proportion of containers **before** they leave the port of origin or the last major transhipment port illustrates the increased complexity of ITS/CVO border issues. The requirement by the U.S. Customs and Border Protection agency for advanced transmission of cargo information for shipments destined for the United States [WR3] emphasizes the central role and major challenges for Freight ITS in this context.

The delays at United States ports as well as at borders with Canada and Mexico have increased tremendously and are influencing the efficiency of commerce and supply chains. In Canada, the border ITS/CVO response comes from both the provincial and federal government levels. Provincial authorities are major players in the installation of Advanced Traveller Information Systems (ATIS) at major border control points. Further illustration of the interest and involvement of provincial governments in ITS as an enabling factor for efficient and secure custom operations is found in the resolution (28-5) adopted by the New England Governors and Eastern Canadian Premiers at their September 2003 conference. This resolution included directives for the Standing Committee on Trade and Globalization to "*continue work toward improvement and increase of cross-border trade by […] promoting standardized and compatible ITS technologies and the accelerated deployment of customs clearance and pre-clearance initiatives.*"

The Canadian Government created in December 2003 the Canada Border Services Agency for an integrated Canadian response to the needs and challenges of contemporary international travel and trade on the one hand and the corresponding international inter-agency collaboration, on the other hand [WR11]. As of 2002, Canada has participated in the project initiated by the United States to inspect containers before the beginning of the journey. Canadian agents are now in place at a number of U.S. ports (similarly, U.S. agents are stationed at Canadian ports). Canada is also actively participating in the *Free and Secure Trade* (*FAST*) program (from 2003 on) that aims to align the U.S. and Canadian customs commercial programs to support moving pre-approved goods quickly across the border for enhanced supply chain management and operations. The program is based on registering and pre-approving import/export firms (shippers), carriers, and drivers. The project is already in various stages of applications at several border-crossing points. It is planned major commercial border-crossing points will be part of FAST by the end of 2004.

For border ITS/CVO, as for most other ITS areas, the development of the "intelligence" part must accompany that of the hardware and the availability of information. This has led to the creation in 2003 of a first Homeland Security Center for Excellence at the University of Southern California [WR9]. The Homeland Security Center for Risk and Economic Analysis of Terrorism Events is planned as the first of a web of university-based research centers aimed at preventing terrorist threats and minimizing the consequences of an attack. It is noteworthy that the network of centers of excellence of the U.S. Homeland Security Department will complement the network of centers of excellence created in the 90s' at the initiative of the U.S. Department of Transportation.

Many other issues are associated with border Freight ITS and require the development of new methods and software tools. The determination of the optimal number of containers to be inspected to satisfy the security requirements and to limit the delays in ports is an example of such a topic (Lee, Song, and Raguraman 2003, Lewis, Erera, and White 2002, 2003). The Transportation and Logistics Security Group of The Logistics Institute of Georgia Tech [WR8] is pursuing this line of research dedicated to secure and efficient port and maritime transportation.

Advanced Fleet Management Systems (AFMS)

This type of Freight ITS applications corresponds to "*Advanced systems aimed at simplifying and automating freight and fleet management operations at the carrier or business-to-business level*", or AFMS for short.

Once the fleet is equipped and linked to the dispatchers' computers and company's data processing and storage infrastructure a huge quantity of data becomes available for immediate decisions and background analysis and planning activities. Advanced Fleet Planning and Operation Systems aim to process this information and to integrate it to the current transportation plan to achieve a more timely operation, efficient allocation and utilization of the fleet, and satisfaction of customer requests. Differently put, similarly to other ITS areas, there is the need to infuse these systems with **intelligence**. This need is more and more widely acknowledged and it is directly reflected in the national ITS architecture proposals.

Developments, challenges, and opportunities occur at the level of a carrier or of groups of carriers, shippers, and agencies joined through business-to-business networks both in urban centers and over large areas. A number of applications already exist. Some are implemented. Most still appear as proposals and prototypes out of research centers and laboratories. Much more may still be accomplished, however. A multi-disciplinary effort is required for successful development and deployment of these systems. Operations research offers the methodologies to represent the problem and to identify solution strategies through various optimization and simulation techniques. Computer science offers the means to address large, realistically sized problem instances in times adequate for the contemplated decision level. Information technologies ensure the adequate flow of data, while operations management build the conditions for the proper undertaking of the plans and strategies. Other management disciplines address the challenges of introducing advanced technologies in the concerned organizations. In this document and the Discussion paper, we focus on the issues and the corresponding operations research methodologies that are at the core of the intelligence of ITS. Séguin *et al.* (1997) present a general framework for operations research methodologies in real-time decision-making. Bodin, Maniezzo, and Mingozzi (2003), Crainic (2003), Crainic and Kim (2004), Crainic and Laporte (1997), Powell (2003), Powell, Bouzaïene-Ayari, and Simaõ (2004), Powell, Jaillet, and Odoni, (1995), Christiansen *et al*. (2004), Toth and Vigo (2002), etc. present general survey of operations research methodologies for freight transportation planning and operations. Crainic and Gendreau (2004; see also Crainic, Gendreau, and Lebeuf 2000, 2001) present a more detailed analysis of the links between ITS and operations research.

Most current developments and a significant part of contemplated future applications address operational issues, load matching and resource allocation, dispatching, and routing, in particular. The principal goal of these systems developed for fleet operating in cities or ensuring interurban, long haul transportation services is to offer the possibility to control and co-ordinate operations in *real-time*. Indeed, the deployment of ITS technologies, in particular accurate positioning devices and in-vehicle computing and communication equipment, opens up the possibility of enhanced customer service and increased productivity by real-time dispatching, routing, and re-routing of vehicles in response to changes in demand, travel time, congestion, or other conditions of travel conveyed via Advanced Traveller Information Systems, as well as wireless or on-board communication devices.

The class of dynamic vehicle routing formulations offers a methodological framework to many real-time routing problems encountered in the Freight ITS domain. These are difficult problems to solve. This fact, coupled with real-time requirements, explains to a large extent the reliance up to now on human dispatchers. Fortunately, recent developments in the area of algorithmics, in particular the emergence of powerful meta-heuristics, and advances in computing technology, in particular distributed and parallel computing, now make it possible to contemplate tackling in real-time large combinatorial problems in a reasonably effective way. Much research is still needed, however, in particular related to the handling of dynamic and stochastic data, the relations between the information context and the impact of stochastic assignment rules, as well as the development of models that account for the future consequences of current decisions to yield policies that incorporate look-ahead capabilities.

Many issues mentioned in the preceding paragraph belong to the large class of dynamic fleet management problems (Crainic 2003, Crainic and Laporte 1997, Powell, Jaillet, and Odoni 1995). Here, limited resources are dynamically allocated to requests and tasks: empty vehicles, trailers and rail cars are allocated to the appropriate terminals, motive power tractors and locomotives to services, crews to movements or services, customer loads to driver-truck combinations, empty containers from depots to customers and returning containers from customers to depots, and so on. Dynamic and stochastic network formulations have been, and continue to be, extensively studied for these problems. This has resulted in important modelling and algorithmic results, a number of which have been transferred to industry (e.g., Powell *et al*. 1992, Armacost *et al.* 2004). Moreover, recent methodological advances allow to simultaneously manage, in real-time when required, several resources (Powell 2003, Powell, Bouzaïene-Ayari, and Simaõ 2004). This is an extremely rich field for research, development, and application, and it naturally dovetails the Freight ITS and E-logistics areas.

Dynamic traffic simulation offers an alternate approach. Simulation certainly offers the tools to explore and validate operating strategies and appears as part of the core methodology for predicting travel times for Advanced Traffic Management and Traveller Information systems (ATMS). Its precise role in actual real-time dispatching and routing of vehicles has yet to be assessed, however. The challenges here are very similar to those of the ATMS area. A very limited initial exploration of the subject is an encouragement to further pursue research in this direction.

A critical issue in real-time settings is that of response time. In situations such as emergency vehicle management, or when a customer is waiting for a decision, there is no time to compute an “optimal” response when a call is received. This does not preclude, however, the use of deliberate decision-making to optimise the response: one simply has to find ways of anticipating future events in an effective fashion. Thus, for example, one may combine data processing and forecasting methods, optimisation-simulation models, and decision heuristics into comprehensive decision-support systems: The optimisation-simulation models continuously generate and evaluate future conditions and deployment scenarios, while rapid, simpler heuristics respond in real-time to customer requests or changing conditions (congestion, accidents, and so on). Note, however, that this may result in significant computational requirements, since one has to prepare for many potential outcomes. Parallel computing may help address this issue as well as provide more robust solutions.

While custom-service transportation firms, such as truckload, container, and express courier companies, appear as prime beneficiaries of ITS, consolidation-type carriers, railroads, LTL motor carriers, and intermodal facilities, may also attain substantial gains by using advanced information and decision technologies. Of course, the local, pick up and delivery operations of these firms are similar to those described earlier on and would enjoy the same benefits. Similarly, the control in real-time of vehicles during their long-haul journeys (trucks speeding on highways or the pacing of trains) may be significantly improved by the use of ITS technologies.

A very promising research and development avenue consists in a better integration of the information obtained in real-time and the planning and dispatching tools and systems available to consolidation-type carriers. We have already mentioned the possibility to re-route a vehicle already dispatched to serve a new customer or to avoid a congested area (due to an incident, for example). The timely availability of accurate data may enhance the planning of other important activities such as driver and vehicle assignment and empty vehicle management. The connection of port, Customs, and carrier intelligent information and decision systems could enable the scheduling and smooth operation of advanced transportation systems, such as the scheduled-with-booking rail intermodal services currently being developed.

Another area of potential benefits for consolidation carriers resides in a more efficient scheduling of terminal operations and resources. Thus, for example, a terminal working schedule that smoothes out the workload and reduces overtime and terminal congestion could be produced through an analysis of dispatch decisions at the various terminals in the network, combined to real-time data on the location and load of the vehicles and the results of the optimisation-based scenario analysis described above. Similarly, data that is more accurate is available for adjusting the maintenance planning process to real-time events during actual operations. Not many studies have been dedicated to these promising areas yet.

A more challenging area concerns the interactions between the planning of operations, the availability of real-time data, and the actual implementation of transportation plans in an ITS environment. A number of methodologies and decision support systems to assist the planning and operations of freight carriers exist (see Crainic 2003 or Crainic and Kim 2004 for a review). Most are based on static formulations using the carrier's historic data and forecasts. The advent of ITS location and communication technologies offers the possibility to dramatically enhance the quantity and quality of the data available for the forecast and planning processes. This should translate into better plans and operations that are more profitable.

Parallel and distributed computing is an enabling factor for ITS in general and CVO-AFMS in particular. Its challenges are of two different but complementary natures. On the one hand, parallel computing offers the possibility to design data analysis and decision support system architectures to answer efficiently complex requests in real or quasi-real time. Thus, processors may be dedicated to the various tasks of receiving, validating, and formatting data, analysing and aggregating it, forecasting, background simulation-optimisation, real-time selection of the appropriate strategy, etc. On the other hand, parallel computing also offers a challenging perspective with potentially great rewards: to solve realistically formulated and dimensioned problem instances within reasonable times. Each class of problems and algorithms presents its own challenges. It appears clearly, however, that research efforts have to be dedicated both to the decomposition and distribution of tasks corresponding to one particular problem instance and algorithm, and to the development of co-operating search mechanisms that bring to bear on any given problem instance the combined power of several exact methods and meta-heuristics. These ideas that have just begun to be considered have a great potential for the development of intelligent and efficient decision support tools for ITS and other real-time transportation systems.

City Logistics

The transportation of goods constitutes an extremely important activity within urban areas. For people, it directly ensures adequate supplies to stores as well as delivery of goods at home. For firms established within city limits, it forms a vital link with suppliers and customers. There are few activities going on in a city that do not require at least some commodities being moved. Moreover, the urban freight transportation industry is a major source of employment. Yet, freight transportation is also a disturbing activity in urban centres. Vehicles carrying freight move on the same streets and arteries as the private and public vehicles transporting people. These vehicles make a significant contribution to congestion and environmental nuisances, such as emissions, noise, and so on, that impact adversely the quality of life in urban centres. Freight traffic also contributes to the belief that "cities are not safe," which pushes numerous citizens to move out of the city limits. Moreover, the problem is not going to go away any time soon. In fact, the already significant volume of freight vehicles moving within city limits is growing and is expected to continue growing at a fast rate. Major contributing factors to this phenomenon are the current production and distribution practices based on low inventories and timely deliveries (the much talked about "just-in-time" paradigm), as well as the explosive growth of business-to-customer electronic business activities that generates significant volumes of personal deliveries.

One is thus witness to the emergence of an acknowledged need to analyze and eventually control the movements of freight vehicles in cities. The goals are:

- Reduce congestion and increase mobility;
- Reduce pollution and noise; Contribute to reach the Kyoto targets; Improve the life conditions of the city inhabitants;
- Do not penalize the city centre activities such as not to "empty" it.

New organizational models for the management of freight movements within the city limits are called for. The fundamental idea of *City Logistics* is to stop considering each shipment, company, and vehicle in isolation. Rather, one should consider them as components of an integrated logistics system and optimize the entire system accordingly. Coordination and consolidation are at the basis of this idea: Coordination of shippers and carriers and consolidation of different shipments of various shippers, carriers, and customers by the same (energy efficient and environmentally friendly) vehicle. City Logistics aims to optimize this system.

Clean city logistics implies the utilization of clean-emission vehicles, at least for part of the operations. Efficient city logistics passes through freight consolidation of various shippers within the same vehicles and an integrated planning of operations and deliveries. These models therefore challenge the city authorities, businesses, carriers, and citizens and require public-private understanding, collaboration, and innovative partnerships. Intelligent Transportation Systems should prove a significant enabling factor towards the conception and deployment of such advanced urban freight management policies and systems.

Historically, one finds a brief period of intense activity at the beginning of the 70's dedicated to urban freight transportation issues. This period yielded traffic regulation to avoid the presence of heavy vehicles in cities to limit the impact of freight transport on automobile movements. Very little activity took place from 1975 to the end of 80's. The increased traffic-related problems and the associated public pressure have revived the interest from 1990 on and have resulted in significant research activities and experimental deployments, some of which continue to operate [WR23, WR24, WR25].

The concept of *City Distribution Center* is instrumental in most city logistics proposals and developments. A city distribution center is a facility where shipments are consolidated prior to distribution. It is noteworthy that the concept of city distribution center as physical facility is close to that of intermodal *logistic platforms* (and *freight villages*) that link the city to the region, country, and the world. Intermodal platforms receive large trucks and smaller vehicles dedicated to local distribution, and offer storage, sorting, and consolidation (de-consolidation) facilities, as well as a number of related services such as accounting, legal counsel, brokerage, and so on. Intermodal platforms may be stand-alone facilities situated close to the access or ring highways, or they may be part of air, rail or navigation terminals. The city distribution center may then be viewed as an intermodal platform with enhanced functionality to ensure coordinated and efficient freight movements within the urban zone. Intermodal platforms are thus an important step towards a better city logistics organization.

Most city-distribution-center projects involve only one such facility and a limited number of shippers and carriers. Different strategies have been tested. Strict licensing practices in use in several Dutch cities impose restrictions on vehicle loads and the total number of trips, and encourage the use of electric vehicles. This has resulted in carriers initiating collaboration activities to consolidate shipments and reduce the number of trips. There is a significant involvement of local and central government and traffic regulations (e.g., delivery hours) were modified to account for the project. The “City Logistik” concept developed in Germany corresponds to “spontaneous” groupings of carriers for coordination and consolidation activities with very light government involvement. Traffic regulation is not modified and the project being a private initiative is supposed to become profitable over a short period. The city logistics system in Monaco is considered a public service. Large trucks are banned from the city. Thus, freight destined to the city is first delivered to the city distribution center, a single carrier taking charge of the final distribution with special vehicles. More details of these ideas and concepts may be found in Duin (1997), Kohler (1997, 2001), Ruske (1994), Taniguchi *et al*. (2001), Taniguchi, Kawakatsu, and Tsuji (2000), Thompson and Taniguchi (2001), etc., as well as on [WR24, WR25].

The licence-based systems have not gained much acceptance outside of Holland. The private city logistic projects have yielded mixed results. It is clear that consolidation in the city distribution center results in extra cots and delays. The hands-off policy of authorities combined with a short-term profitability requirement was not suitable for such innovative projects. Moreover, the use of ITS and advanced fleet management methods was very limited in these initial projects. The system in Monaco performs as planned. Yet, for some time, it was the only one of its kind.

The field is still going strong, however. The new generation of projects integrates ITS technology and advanced fleet management methods. The city distribution center is still at the core of the system, but the private-public partnerships are stronger. Some projects have adopted the Monaco approach. Crainic, Ricciardi, and Storchi (2003, 2004) recently proposed a two-tiered system of distribution centers that aims to cover most (all) carriers and shippers operating over a large urban area by using advanced communication, computing, and decision technologies, as well as environmentally-friendly urban vehicles.

Many research directions must be explored related to the previous ideas. Other than the technical aspects, one needs to focus on the organizational and managerial framework of such systems. The involvement of the local and central governments must be clarified. Business models are required. Advanced models and methods are needed to decide the design and optimization of city logistics systems. Challenging issues include the location, layout, and operation of the distribution centers as well as of the entire city logistics network and services, the planning and scheduling of services, and the real-time operations. In fact, all the decision issues associated with the design and operations of an advanced transportation system must be addressed within the city logistics framework.

Other challenging research directions concern the utilization of existing infrastructures, such as rail or subway tracks, for city logistics activities, and the construction of new infrastructures, such as completely automatic underground systems (Ooishi and Taniguchi 1999, Taniguchi *et al*. 2001).

Methods are also required to evaluate city logistics designs, policies, and impacts. Very few efforts have been dedicated to this issue (Taniguchi and Thompson 2002, Taniguchi and van der Heijden 2000, Taniguchi *et al*. 2001). The same can be said for city logistics and for most ITS components. This makes the issue all the more urgent.

CVO/AFMS and E-business

The current volatility of the stock exchange notwithstanding, the development and utilization trend of e-business is clear and strong. This signals that significant opportunities exist for transportation firms, as for other economic agents, in terms of larger and stronger business partnerships, more streamlined, rapid, and demand-responsive decision processes, improved operations and service levels, enhanced customer satisfaction and, ultimately, profitability. To reap the benefits of these opportunities, transportation carriers may take advantage of the convergence between ITS and e-business technologies.

The definition and development of Intelligent Transportation Systems concepts and technologies started well before the business community realized the potential of Internet-based operations, and electronic commerce started to penetrate the business-to-consumer and business-to-business exchange world. The two application domains share several characteristics and enabling technologies, including information and decision technologies, two-way communications, electronic data interchange, computing and data handling technologies, advanced planning and operation decision support systems (Crainic and Gendreau 2003, 2004).

These links appear even more clearly when one observes that the vast majority of business transactions are part of logistics activities. *E-logistics* aim to perform the traditional logistics goals (plan, manage, and control the efficient movement of goods, information, and money) within the "new" environment of partner integration and seamless electronic exchanges. The technologies required to manage the fleets and interact with the external partners (e.g., intermodal terminals and border crossings) are similar to those encountered in Freight ITS.

An interesting development that may directly and significantly affect the operations and performances of freight carriers and their customers is the emergence of Internet-based community of interests and electronic auction mechanisms. The virtual market places that implement freight exchanges offer carriers the perspective of an easier access to loads and smoother operations. This is certainly true for full-load carriers, but it also presents significant opportunities for consolidation-type companies, LTL motor carriers in particular. By accessing the market, loads could be obtained, thus reducing the need to move empty vehicles to balance the operations. Such markets complement the more traditional auctions of distribution routes of major industrial of retail firms (Ledyard *et al.* 2000).

A number of such markets has started to appear. The market mechanisms do not appear very sophisticated, however. Significant research is required in this area, particularly concerning the possibility to bid on a bundle of loads or routes simultaneously (combinatorial bidding).

Participants to combinatorial auctions also face serious challenges. Yet, not much research has been dedicated to these issues up to now. The first and foremost challenge faced by participants in electronic auctions is clearly to identify which items are of interest to them and acceptable price ranges for these items. This is obviously further compounded in the case of combinatorial auctions by the need to build attractive bundles and to price them. A very promising research direction is offered by the development of specialized decision-support software, so-called *advisors*, based on enhanced Advanced Fleet Management Systems and specifically designed to support participants in the complicated negotiation processes involved in the most sophisticated electronic markets, such as simultaneous auctions for several goods, sequences of sequential auctions or combinatorial auctions.

Intermodal Freight E-Data Issues – Standards and Related Efforts

Electronic Data Issues in Intermodal Transportation

Freight movement is guided by operational imperatives namely Security, Safety and Efficiency. ITS technologies and processes offer the means to enhance the level of achievement in meeting these needs. Freight movement/transportation are heavily regulated environments due to their important national impact. All levels of governments, whether federal, provincial or municipal, regulate the movement of goods from dangerous goods to customs, from vehicle weights and dimensions to authorities to operate, from road safety to national security. All of these regulations add to the operational requirements of freight and fleet management. To avoid totally stalling commerce, these functions have to be streamlined and standardized, interoperability becomes primordial, and data collection, manipulation and exchange has to be computerized.

ITS standards both for applications processes and communication systems as well as information concepts leading to dialogues, messages, data frames and data elements are essential to achieve interoperability and deployment.

As safety and security are regulated by the federal government, and efficiency is also a national objective, it is natural that governments have been behind the wave of standardization in non commercial consumer ITS standards. Although carrier licensing, registration, operating authorities and Vehicle Weights & Dimensions (VW&D) have traditionally been the realm of provincial authorities, Transport Canada has historically provided leadership by acting as a catalyst in achieving national interoperability and jointly funding many projects with the provinces and the private sector.

Freight and Fleet operators have a basic interest in profitability, in streamlining their operations, and in reducing the burden of regulation. It is in their interest to take advantage of ITS technologies and applications. Government led development of national and international standards that regulate the freight movers' interaction with ~~the~~ governments are welcome, needed and relatively easy to implement as part of the regulatory process. Standards affecting their internal operations are, on the other hand, difficult to produce and implement as competing software and equipment manufacturers do not necessarily find it to their advantage to standardize.

Issues, Needs, Goals, Objectives and Expected Benefits

The freight safety and security issues: Since 9/11 the issue of national security has become a major driving force towards the efficient and timely identification and monitoring of goods (that could be misused) entering or moving in North America. The root of the problem is basically the lack of standard data formats for cargo information. Trading partners use "customized" specifications and individual nations as well as different modes of transportation use different terminologies. Currently we have information exchange that requires extensive manual intervention and data reentry, and information systems that are developed and operated independently resulting in lack of interoperability hampering safety, security, efficiency and emergency response. What is needed is end-to-end freight flow visibility through linked information systems. The security hazard is obviously greater in the case of dangerous goods and cross-border intermodal freight.

The objectives are to promote road safety and national security in the area of dangerous goods and multimodal/intermodal Freight Operations while facilitating the interaction between the vehicles/freight/operators and the local, national and international authorities.

The end goal would to eliminate the need for manual re-entry or extensive conversion of data as freight moves through the supply chain by developing standard data definitions and message sets. To translate these objectives and goals into reality, this first effort should work to achieve:

1. The availability of a standardized cargo electronic documentation (electronic manifest)
2. The availability of standardized on board cargo data collection (cargo identification and dynamic cargo condition) transmitted in real time via mobile communication.

The expected benefits would be:-

- Improved visibility throughout the supply chain
- Enhanced security through more efficient and accurate verification
- Reduced paper documentation
- Reduced manual intervention
- Simplified, more cost effective communication
- Support for proliferation of standardized IT solutions
- Improved international cooperation

Availability of Standardized Cargo Electronic Documentation

The procedures active within the international supply chain are complex and often cumbersome. At work are numerous interactions between different parties which are guided by many factors including type of product, country, terms of business, and the methods of operation of both the buyer and the seller. Given the broad range of activities possible, it is hardly surprising that within the context of actually transporting goods, a single transaction may involve many languages (both electronic and human), standards, and operational practices. If a supply chain is to operate efficiently and effectively, the relationships, actions, and terms used by the different participants to effect trade must be understood.

Seamless exchange of accurate, complete, and timely data at transportation hand-offs has always been important for efficiency and accountability. In addition there is now a growing understanding of a need for security of transport information, and for transfer of information related to security against terrorism as well as theft and traditional contraband. It is imperative that standards be developed to address and facilitate dealing with these needs.

Preliminary investigations suggest that there is no single international organization responsible for data standards through the intermodal supply chain. No international standards development organization other than ISO-TC 204 (which deals exclusively with ITS) focuses specifically on motor carrier transportation data exchange needs for the international supply chain, and those needs are essential for road transport information and control systems.

Some international shipments are made entirely by the road mode, but most begin and end with motor carrier service and travel on other modes in the course of the shipment. Therefore, the interfacing modes' data structures and formats must accommodate each other to ensure efficiency and security from end to end. Coordination and liaison with other modal standards development organizations is important so that, while meeting the needs of land transport, ISO-TC204 international standards accommodate the needs of interfacing modes.

The current international standard development efforts specify the data concepts applicable to the movement of freight and its intermodal transfer. These data concepts include data elements and messages that comprise information exchanges at road transport interfaces along the chain of participants responsible for the delivery of goods from the point of origin through to the final recipient.

To achieve a coherent set of standards requires coordination among the various international organizations working on pieces of these standards. TC204 has advanced the idea of close coordination among other ISO technical committees, the UN Centre for Trade and Electronic Business, and the World Customs Organization. Contact has been initiated and interest has been expressed in cooperating on the development of intermodal data exchange standards that fully cover the supply chain. These major efforts are taking place in ISO-TC204-WG7 (fleet and freight management), which is Canadian lead.

The scope includes motor transport data needs within the international supply chain to satisfy the requirements of both businesses and governmental organizations. These international standards would be applicable to highway shipments that originate in one country and terminate in another. It may also be applied to highway shipments that originate and terminate in a single country. This motor carrier based international standard does not establish requirements for other modes. Further, this international standard does not constrain the data requirements of Customs, regulatory, and safety bodies at border crossings. However, this standard does include the data elements most likely to be required by such agencies and modes and provides for the interfaces to those modes and agencies.

Standards for ITS two way communication and data exchange between the supply chain and the regulating/managing authorities as well as the standards describing the related applications architectures cut across all subtopics. They will be addressed in each of the following sections as they are dealt with.

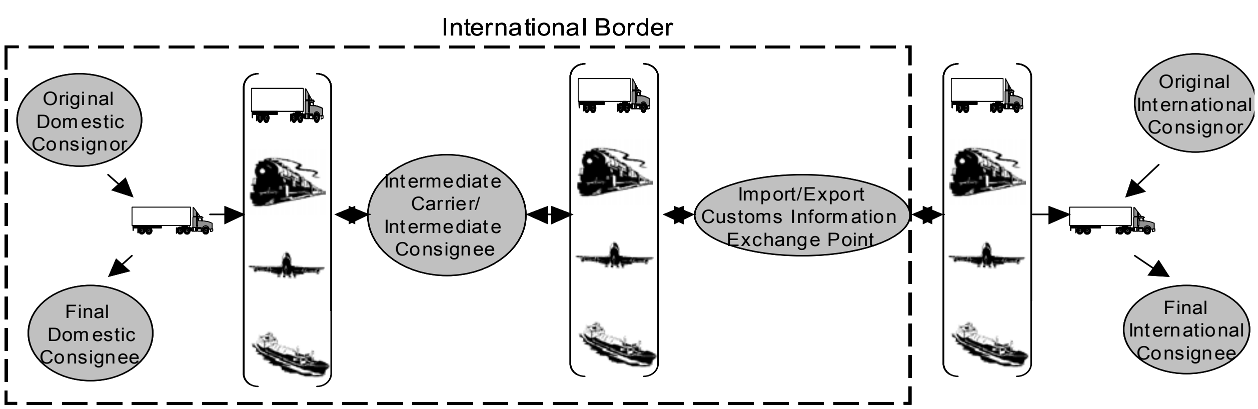

Figure 1 Information exchanges at intermodal interface.

It should be noted that the development of the two complementary standards covered herein have been financially supported by the US DOT for the electronic manifest and by Transport Canada for the dangerous goods monitoring.

Data Dictionary and Message Set for Tracking of Freight and its Intermodal Transfer – Electronic Manifest[1]

The vision is to create, together with other stakeholders, an end-to-end electronic supply chain manifest to improve the productivity, efficiency and the security of the multi-modal movements of freight, and satisfies the needs of transport businesses and government organizations that regulate the flow of business. This manifest would complement the WCO Data Set on Surface Transport of goods transiting multiple bordering countries. It will also consider the work of UN/CEFACT and other e-Business MOU participants. The international standard would specify:

- Data concepts applicable to the movement of freight and its intermodal transfers.
- Messages for information exchanges at road transport interfaces from origin to destination.
- Data needs that satisfy the requirements of both business and government.

Introduction

As freight movement becomes more international and intermodal in nature, as security concerns increase, and as the potential of e-Business transactions becomes apparent and feasible, standardized data formats are needed among stakeholders to facilitate the efficient, productive and secure movement of that freight. ISO Technical Committee 204, Intelligent Transport Systems (ITS), is addressing one area in which a standards gap exists – freight movement involving truck and air modes. ISO Work Item 24533 was approved in February 2003, and an effort is proceeding to create a working draft standard.

A variety of freight ITS operational tests within this business domain have taken place among various government and industry segments. The committee recognized that adopting the best practices from past tests and working to infuse elements of a draft standard in future tests enhances the successful deployment of a standard. One successful field test completed in 2002 that is viewed as a backbone for the standard being developed provided for the use of an electronic supply chain manifest between supply chain partners in the U.S. and in Canada for transporting time-sensitive freight among truck and air modes

The concept of operations provides a functional context and description of the business environment in which the various freight supply chain stakeholders would apply the standard. This material is to be adapted into the draft standard. The combination of the concept of operations plus use case diagrams will form the basis for the functional description to be included in the standard.

[1] *ISO AWI 24533 - Data Dictionary and Message Set for Tracking of Freight and its Intermodal Transfer - Concept of Operation – July 203*

This standard will include a unified standard Data Dictionary and Message Set, all elements of which will be harmonized with the United Nations Trade Element Directory (UN/TDED) and United Nations Trade Data Interchange Directory (UN/TDID). The standard will be recognized, understood and used by international customs agencies and international trade organizations. This adoption will enable the streamlining of the movement of international inter-modal freight to make it more efficient and cost-effective, as well as to increase the abilities of all customs agencies to operate more efficiently and assure the security of countries they represent. This concept will need to be replicated and embraced by the national standards institutes of countries represented in the ISO, by the member countries of the World Customs Organization (WCO), the Group of Seven Industrialized Countries, and put into practice by the world's customs agents, trade and financial industries, and international shippers and freight-forwarders.

Operational Scope

Activities in the international freight supply chain are complex; they involve many stakeholders and types of information exchanges. Interactions between any two or more stakeholders may be guided by country, prior relationship, technology implementation, terms of business, product type, etc. Given the breadth of activities and the factors surrounding these activities, it is not surprising that there are so many languages (electronic and human), operating standards and operational practices involved.

The standard described here addresses a portion of this chain: the transport of goods from a seller (or "consignor") to a buyer ("consignee"), using intermodal transport that includes motor carrier and air links. It is appropriate for supporting operational freight movements that occur worldwide, whether that freight travels from point of origin to destination domestically or internationally. While the standard is not focused on unimodal movements, and any unique requirements therein, it is considered complementary to standards of unimodal freight movement.

Rail and ocean transport are vital components of intermodal freight movements. The adoption of motor carrier/air modes is a starting point; it is recognized that a robust intermodal standard must include these other modes.

Freight that is transported by motor carrier and air links can be generally categorized as delivery time-sensitive. Examples of freight that might be so categorized include:

- Inbound parts or assemblies for just-in-time (JIT) manufacturing operations
- Perishable goods
- Particularly high-value freight
- Expedited postal packages and documents

Dangerous goods (considered, for the purpose of this discussion, synonymous with the term hazardous materials) may also be transported within this chosen class of supply chain. This standard does not address the particular unique requirements of this special freight type. They are however addressed by different regulations and complementary standards particularly the "Data Dictionary and Message Sets for Electronic Identification and Monitoring of Dangerous Materials/Dangerous Goods" also being developed by ISO TC204-WG7 and dealt with later in this document.

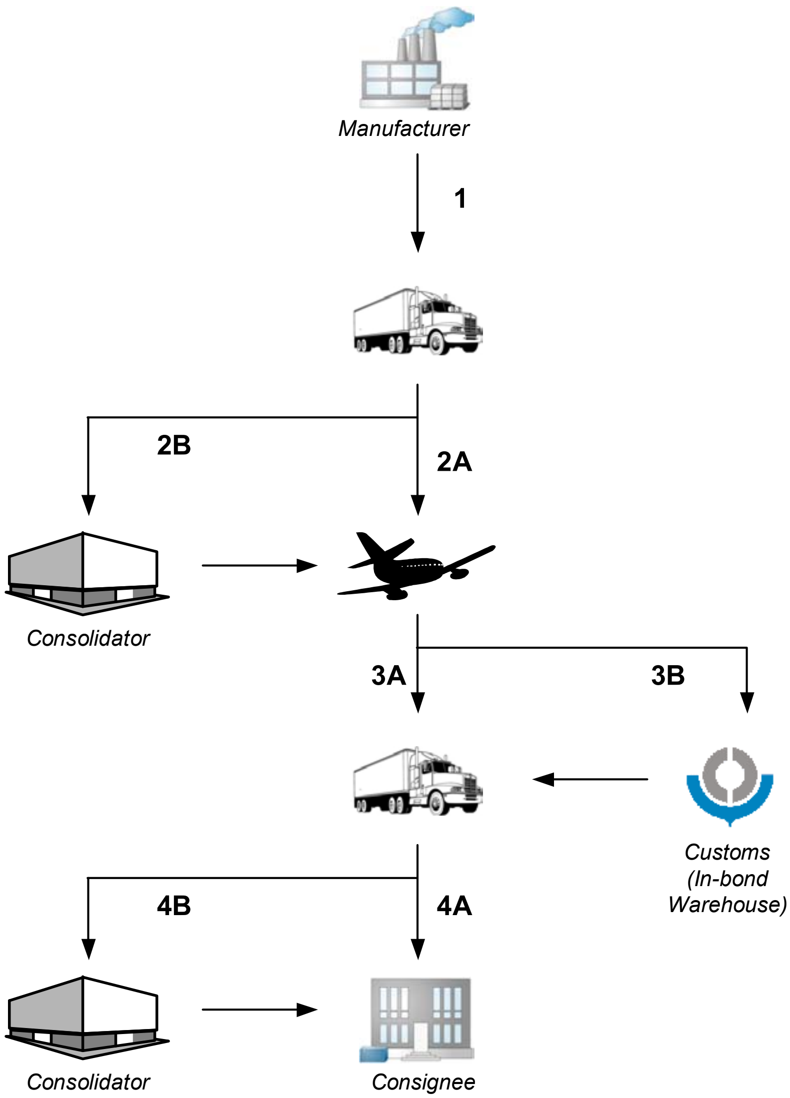

Figure 2. Simplified Depiction of Physical Freight Flow for Time-Sensitive Freight.

Availability of Standardized on Board Cargo Identification and Dynamic Cargo Condition Data Linked to Mobile Communication

There are many types of devices that can be used for the purpose of data collection on board mobile equipment and there are also a number of communication media to carry this information from the mobile equipment to the roadside and to the control centers. The efforts, reported on in this document, neither cover the equipment nor the media used but simply the messages and their content. There are other standards in existence or in the making that would address such complementary topics. ISO TC204-WG7 has dealt strictly with non-commercial, non-competitive issues that would have an international, national and regulatory value. The availability of static and dynamic data on board the vehicle in a standardized format will no doubt enhance the identification and monitoring of freight.

If the transport vehicle were involved in an accident, the emergency responder would seek or receive from the vehicle's on-board device the vital information remotely from a reasonable and safe distance. The on board device would provide the appropriate identification number (ISO, UN, or otherwise) of the hazardous materials/dangerous goods and other important information. Such device would be designed to comply with the "Data Dictionary and Message Sets for Electronic Identification and Monitoring of Dangerous Materials/Dangerous Goods" ISO standard. This Draft International Standard (DIS) is much more advanced than the "Electronic Manifest" and is ready to go for balloting in May 2004.

Data Dictionary and Message Sets for Electronic Identification and Monitoring of Hazardous Materials/Dangerous Goods Transportation[2]

This standard identifies the data dictionary and message sets to be used for the automated electronic Identification and Monitoring (I&M) and exchange of information regarding dangerous goods. These definitions may apply to multiple forms of communications; the specific form of communications used is beyond the scope of this standard. Also, there may be multiple recipients of such messages and this standard is intended to be applicable to a broad range of potential recipients and does not attempt to define all possibilities. Also, many of the data definitions and message sets are common with, or related to, those defined within other standards. When such definitions already exist elsewhere, there is no intent to either modify or nullify these existing definitions.

Introduction

This standard supports the automated Identification and Monitoring (I&M) and exchange of information regarding dangerous goods carried on board transport vehicles. Such information may include the identification, quantity, and condition of such goods as well as information regarding incidents involving such goods. Reporting this information may occur prior to or during transportation of the goods in a manner that allows all interested parties to access and correctly interpret the information. If equipped with appropriate electronics and communications capabilities, vehicles carrying such goods may respond to queries regarding the status or they may self-

[2] *ISO - N 17687 - Data Dictionary and Message Sets for Electronic Identification and Monitoring of Hazardous Materials/Dangerous Goods Transportation – Draft International standard- Version 6*

initiate a message. This standard does not specify nor even imply that any particular on-board or off-board systems be capable of performing such monitoring, data retention, or communications. Where such capability does exist, then this standard would apply.

It is intended that the information defined here is to be carried on-board the transport vehicle and may then be transferred to interested roadside systems by whatever means are appropriate to that roadside system.

Although this standard is intended for the transport of dangerous goods, it can be referred to for the transport of any goods simply by the appropriate identification of the goods. In this document, dangerous goods may be referred to as "DG". Also, in order to maintain worldwide terminology compatibility the terms "hazardous material" and "dangerous goods" will be used interchangeably in this document.

The information contained in an electronic I&M system and the use of this information includes that provided by the traditional visual placards but can be expanded to include additional information and thus to also expand the uses of this information over time. Implementation of this standard does not replace or eliminate the existing placards, nor does it replace any existing standard. The following levels of I&M systems are possible:

1. Direct supplement to existing product identification placards (which are visually oriented, non-electronic)
2. Added data beyond that contained in existing placards
3. Interface with on-board systems
4. Intelligence to react to product or goods conditions

With a suitable communications interface, it is possible to transmit the information to and between remote sites such as emergency service systems and centres. This information transfer may occur during normal operations or in emergency modes of operation.

This standard applies to the elements identified as "Data Dictionary and Message Sets" which exist within the communications links between the various sources and users of the dangerous goods information. This illustration is not restrictive in any way, it is intended to reflect the potential uses for the information that will be available. There is at least one other standard (IEEE P1512.3) that defines the data dictionary and message sets to be used between emergency control centres and between these centres and on-site emergency personnel. The scopes of this and the IEEE standard are related but sufficiently different as to not be redundant with each other. The complete report summarizes the critical differences between these two standards. Since the primary difference derives from who is communicating and the sources of the data, the majority of the data itself should be based on either common or compatible definitions.

On-Board Systems

In this context the term “transport unit” refers to all modes of transport as well as the containment or storage systems for the dangerous goods. The modes of transport include straight trucks, truck tractors, trailers, rail cars, and ships. Combination vehicles may have individual monitoring and/or reporting systems for the tractor itself and for each trailer and/or container. Containment and storage systems can include multimodal containers as well as pallets, and even individual packages. They fall into two major classes, the loads or goods to be transported, and the actual transport means.

There are multiple options for the on-board transport unit systems and capabilities. Vehicles may be equipped with any of a variety of trip recorders, navigation systems, and electronic tachographs that can be used to record and report vehicle location and the occurrence of an accident, including accident severity. No assumptions are being made regarding which of these may or may not exist. A basic on-board system might consist solely of data memory containing information entered when the cargo was loaded. In the future, more complex systems might include active cargo monitoring systems, such as temperature, pressure, volume, or weight sensors depending upon the cargo involved. This standard does not specify nor require such systems, but their use in conjunction with the electronic placarding is anticipated for the future. This standard applies only to the transfer of such information to or from the transport unit and not to the manner in which the information is generated, stored, or used on the transport unit. The specifications provided herein are intended to support such future systems when they do come into use.

The transport unit may have multiple options for communicating with the roadside systems. In some cases, the local roadside system may be a person standing beside or in close proximity to the transport unit. For access by emergency service personnel at an incident scene a direct-wired connection with on-board data networks or devices may be used to obtain the information. With the ability to transmit the information over wireless RF devices, there is an expanding range of options available. If the RF device is DSRC, the local system is truly local, being either a hand-held reader or a reader mounted nearby. It is also possible to use RF transitions over long-range communication devices such as cell phones or satellite systems, sending the data to a facility very far away. In such a case, the "local roadside system" may be a trucking fleet dispatcher or a remote Emergency Control Centre. Even though the primary intent of this standard is to support local on-site needs in the same manner as conventional visual placards, the long range reporting is also supported by this standard.

This standard does not require nor support any specific operational scenario, though the following are examples of what may exist:

- Periodic reporting.
- When requested by dispatcher.
- One event, either a dangerous goods situation (e.g. exceeding temperature or pressure threshold) or a transport unit situation (accident).
- On-site information gathering by emergency services personnel.
- Deviation from route, different route, loss of contact, theft.

Roadside (On Site) Recipient to Emergency Control Centres

Once the message has been received by a roadside system, it may be transferred to any/all other appropriate monitoring or response centres. In non-emergency situations, this may be from a trucking fleet dispatcher to the local police or fire department or to any other control centre that has been identified as responsible for the immediate situation.

Such communications are beyond the scope of this standard but the data dictionary/message sets defined in this standard are intended to be compatible with known standards that would apply (one example being IEEE P1512.3). If no such standards exist or would apply to the situation, then the data dictionary/message sets defined herein should be used.

Emergency Control Centres to Emergency Control Centres

There will be a need to send data between centres. In addition to incident related data, this may also include pre-shipment data. An example of such communications is when a trucking company needs to obtain permits and pay fees to a government organization in advance of the trip itself. After an incident has occurred there will be the need to transfer pertinent data to the appropriate investigative agency.

Such communications are beyond the scope of this standard but there are other standards, which may apply. An example of a centre-to-centre communications standard that may apply is NTCIP. Every attempt has been made to ensure that the definitions and message sets defined herein are fully compatible with those defined in IEEE P1512.3.

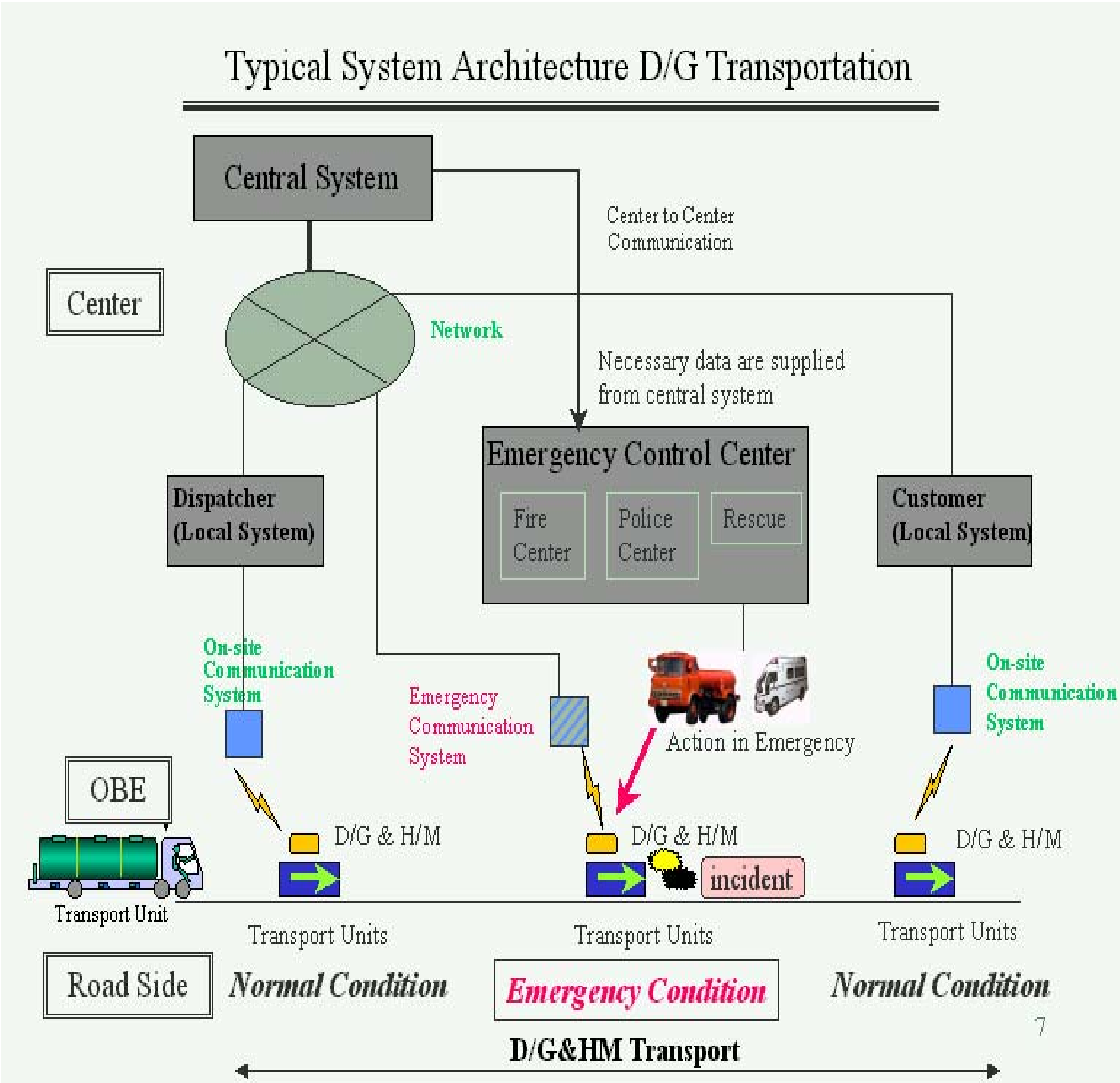

Figure 3. Electronic Identification And Monitoring Concept.

Conclusions: Perspectives, Challenges, Opportunities

The discussion papers aim to assess ITS achievements with respect to the transportation of freight and to identify challenges, opportunities, and promising research and development directions. The situation in Canada is our primary concern. We strongly believe, however, that it cannot be isolated from the main international developments.

We examined the Freight ITS field from several complementary points of view: enabling technologies including Electronic Data Interchange, Commercial Vehicle Operations including border-crossing issues, Advanced Fleet Management Systems, the City Logistics concept for integrated urban freight management, the links and convergence of Freight ITS and e-business, and the standardization efforts regarding the electronic exchanges of data. We also illustrated how the introduction of better decision-support software may very significantly improve the ultimate performance of Intelligent Freight Transportation Systems. We conclude with a series of research directions for Freight ITS in Canada.

Similar to many other ITS areas, Freight ITS development proceeds along three major, parallel but complementary, directions. The first concerns vehicular and infrastructure developments. This topic is addressed by the ATLANTIC Work Group 2.2 *Intelligent Vehicles and Vehicle-Highway Systems*. Therefore, the discussion papers address the second and third directions only.

The second direction concerns the electronics, location, tracking, and communication **hardware**, as well as the associated information-technology software. The third targets the **methodologies** – models and algorithms – required to process the data and transform it into timely and meaningful information and intelligent advice for advanced system and fleet planning, management, operations, and control systems. The ultimate performance and long-term success of ITS depends on a balanced and harmonious integration of these two aspects.

Canada enjoys a world-class presence in Freight ITS regarding both directions. Canadian firms are present all over the globe performing studies, selling technology, and deploying systems. Canadian university research is cutting edge, in Freight ITS as in several other ITS domains. It is troubling, however, to notice that the quality of Canadian ITS university research is often better known and appreciated outside the country than within. Particularly as far as the methodological – the **intelligence** – aspects of ITS are considered. It appears that governments and industry privileged up to now the hardware aspect to the detriment of the methodological one. In many cases, data provided by very sophisticated devices and relayed through advanced communication technologies is still being processed and acted upon by human operators with little, if any, decision-support tools. There is thus a challenge to drastically increase the intelligence of ITS. While it is true that this phenomenon may be observed elsewhere, it is particularly strong in Canada. Recent initiatives by Transport Canada seem to indicate a change of direction. We hope that these initiatives will continue on a regular basis and that a re-structuring of the financing processes and a strong participation by provincial authorities and industry will accompany them.

Freight ITS deployments in Canada are not numerous yet. One may conclude that the current level of freight-related ITS deployment is significantly more modest than what the activity level of Canadian ITS industry and university sectors might indicate. The situation is evolving, however. The current security concerns and the significant impact border controls have on freight and logistics activities and performance seem to have broadened the awareness of the need for ITS at the federal, provincial, and industry levels. A certain acceleration of the pace of system study and deployment at the Canada-U.S. border illustrates this trend.

Many challenges and opportunities for ITS research and development may be identified. Thus, while many technologies are now accepted and deployed on a regular basis, several issues must still be addressed:

- Standardisation and inter-operability are still a challenging issue, particularly when examined at the continental and world-wide level. The Canadian highway network is not yet completely integrated into the North-American network. Moreover, the level of integration varies widely from province to province. Technological choices should be made carefully to avoid imposing excessive costs to carriers and facilitate not only the North-South integration but also the inter-provincial, East-West, trade. A similar argument may be made with respect to port and container technology. Canada and the provinces should enforce their collaboration as well as their presence to international ITS, transport, and standards organizations.
- Particular attention should be paid to the long-term maintenance of deployed ITS infrastructure and data processing systems at all levels. Unfortunately, recent history seems to indicate that we tend to neglect the maintenance of our public transportation infrastructure. Such an approach would spell disaster when applied to ITS.
- An important research field that should be explored addresses the exchanges and integration of Freight ITS deployed at border crossings and ports, the Advanced Traffic Management and Advanced Traveller Information Systems of the corresponding cities and regions, and the AFMS of the shippers and carriers that use the systems. This involves not only the integration of electronics and communication systems, but also those of the planning and scheduling activities. Being pre-approved means nothing if one must still wait for hours together with other pre-approved vehicles because everybody desires to cross simultaneously!
- An important related research field is that of the management of ITS and security-equipped borders and ports. The efficiency of these facilities is tributary of their design and management methods and processes. The whole field, including the previous topic, is not yet sufficiently addressed and the Canadian research community may make a significant contribution.
- Freight ITS change the way transportation activities are performed. This is exactly what is expected. On the other hand, however, freight vehicles interact with private and public vehicles carrying passengers. Moreover, Freight ITS, CVO systems for example, also interact strongly with logistics activities and industrial value chains. These impacts are not well understood. One lacks the knowledge and tools to evaluate and compare alternate systems, policies, and investments One should be able to evaluate these interactions and the impact of Freight ITS on the general mobility within a given zone or on the logistic activities of particular industrial sectors. Such developments require a multi-disciplinary effort: a thorough representation of the economic, operations, and information and decision technologies used by the various actors, sophisticated optimization and simulation methodologies, parallel or distributed computing environments. The resulting systems would be used not only for policy assessment but also for experimentation and training at the university and industry levels.
- The success of Freight ITS (similarly to most ITS components) is also strongly dependent on the awareness and willingness of its users, producers, shippers, and carriers in particular. How well CVO/AFMS concepts, technologies, and practices are understood and accepted by the various actors constitutes a worthy research area.

The electronic data exchanges associated to intermodal freight movements and Freight ITS in general face many challenges in the current environment of heightened national/International security. There is currently a lack of international standards defining the relevant information messages and data sets. Efforts are being pursued in North America, under the aegis of NAFTA, and within various international standards development organizations. Canada is already participating to this effort, but additional and broader participation is needed.

City Logistics – the integrated management of freight movements within urban area – constitutes a fascinating research domain, still largely unexplored in North America. Compared to most cities in Europe and Asia, in Canada, we still enjoy the benefits of relatively high capacity street networks and "low" levels of urban congestion. This is rapidly changing. Moreover, the Canadian population is becoming increasingly environment-conscious and demanding regarding the impact of transportation on the environment and the quality of life. City Logistics is still a very young research domain. Even less is known about the applicability of such concepts in North American cities. An intensive research program is required on the technical, design, operational, management, policy, etc., aspects of City Logistics in Canada and North America in general.

The emergence and rapid growth of electronic business both challenges and offers freight carriers great opportunities for improved operations and profits. The convergence of information, communication, and decision technologies used in CVO and AFMS and in advisors for e-markets constitutes a significant advantage in this context.

Significant research is still required in this area, however. We identify several avenues of particular interest. On the market side, one should study the advantages, the development and implementation barriers, and the possible business models for freight electronic markets in Canada and their interaction with the North-American and international markets. On the carrier side, research is required to develop efficient and comprehensive advisors. Three particularly challenging aspects of this issue are the (1) Enhancement of the modeling capabilities and the efficiency of solution methods for the complex, stochastic and dynamic formulations related to identifying profitable bundles; (2) Development of methodologies to address the contingency issues when bundles have to be negotiated in parallel or non-combinatorial markets; (3) Determination of bidding strategies (e.g., estimation of probabilities of winning, of competitor behaviour, price and bid modification, etc.) in various settings, parallel and continuous markets in particular. Strongly related to this is the area of coordination of various information sources, agents, and negotiations.

The various applications described in the Discussion Paper illustrate the key role *operations research* models and methods play in the analysis of ITS needs and projects, as well as in the development of the software component of ITS. Such methodologies transform the huge amount of data provided by ITS technologies into useful information that may be either distributed to the various ITS users or transformed into operating policies and instructions. Operations research-based data processing and decision support systems may explore and evaluate the behaviour of the transportation system under various conditions and develop contingency plans, predict the state of the system over the next time periods, generate general or user-tailored itineraries or guidance instructions, plan operations and assist the real-time management of fleets.

Research and development efforts are currently under way in several of these areas, as illustrated in the AFMS section. The methodological developments of recent years in the various fields of operations research, combined to recent advances in computer science, in particular in parallel and distributed computing, put the required models and methods within our reach. More efforts are still needed, however, in particular relative to:

- Real-time allocation of resources and management of operations, including real-time fleet management and vehicle re-routing. The issues are different but equally challenging whether urban or interurban transportation is considered, or whether the real-time decisions depend on the congestion and demand conditions only, or must account for and coordinate with the decisions of other agents (e.g., Customs or port operations).
- Planning and management of integrated logistics networks (chains) and the links to ITS, AFMS (and real-time management) in particular.
- Trade-offs between accuracy of results and response time in real-time settings.
- Development of the next generation of planning models and methods for carrier or shipper operations that integrate the stochastic and dynamic aspects of ITS.
- Development of the next generation of urban/regional planning systems that reflect the utilization of CVO and AFMS technologies.
- Arbitration between central processing and the utilisation of the computing power of on-board computers and the next generation of transponder devices.

The Canadian ITS R&D community is ready to take on these challenges and opportunities. **The financing of research, particularly university research is probably the most important hindering factor**. There is almost no funding specifically targeted at transportation research and even less for university-based research.

It is true that Transport Canada has announced recently a number of initiatives for ITS research. A major issue is that this funding is largely considered as contracts. This implies that 1) Only half the funding is offered (this excludes fundamental research); 2) Delays for realization are extremely short, not compatible with a long-term vision of sustained research and development; 3) The evaluation and announcement processes are not transparent and seem to obey political considerations. Moreover, this financing seems limited in time. There is no long-term commitment. The situation appears similar at the provincial level.

A coordinated effort and leadership of federal and provincial ministries, bringing together the industrial and university communities in required. A program of research funding with precise and transparent rules and schedules should be created. Funding should be made available both for large scale cooperative projects and for focussed developments. The ITS network of centers of excellence initiative should be pursued in a more proactive mode. The program should be defined, and funding should be secured, over a period of time compatible with the requirements of innovative, value-creating research. Research projects should be defined for 3-year periods, while Centers of excellence should be supported for 5-year periods (renewal rules should be specified).

Canada has the people and institutions to address the Freight ITS challenges and issues. We need the support and financing to undertake this effort.

Annex A. Work Group 2.1 Participants

Kevin L. Bebenek, Assoc. Director
IBI Group
(416) 596-1930 t (416) 596-0644 f
kbebenek@ibigroup.com

Michael De Santis, President
LYNX Technologies
(514) 830-5969 t (514) 457-5655 f
mdesantis@lynx-technologies.ca

Eric Labrie, Technical Advisor
Daktronics Canada
(450) 492-1003 t (450) 402-6066 f
elabrie@daktronicscanada.com

Michel Gendreau
Centre de recherche sur les transports
Université de Montréal
(514) 343 7575 t (514) 343 7121 f
michelg@crt.umontreal.ca

France-Serge Julien
Service modélisation des systèmes de transport (Montréal)
Direction du partenariat, de la modélisation et de la géomatique
Fsjulien@mtq.gouv.qc.ca

René Martel
Service de normalisation technique
Direction de transport routier des marchandises
Rmartel@mtq.gouv.qc.ca

Diane Nash, Policy Officer
New Brunswick, Transportation
(506) 453-2802 t (506) 453-3701 f
Diane.Nash@gnb.ca

Yves Paquet
Service des liaisons avec les partenaires et les usagers
Direction de Laurentides-Lanaudière
Ypaquet@mtq.gouv.qc.ca

Daniel Soucy
Service des inventaires et du plan
Direction de Québec
Dsoucy@mtq.gouv.qc.ca

Brian Taylor, VP, Tech. Sales & Bus. Dev.
IRD (International Road Dynamics Inc.)
(306) 653-6611 t (306) 242-5599 f
brian.taylor@irdinc.com