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 PAPER

ELECTRONIC ROAD USER CHARGING SYSTEMS AND SMART CARDS

Prepared by
Work Group 2.3

Leader: Muhammad Mustafa, IBI Group
Rapporteur: Baher Abdulhai, University of Toronto

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 practise and research and development in Canada.

This Synopsis report is a summary of the discussion paper prepared by Work Group 2.3 on the topic of "Electronic Road User Charging Systems and Smart Cards". It is intended to provide readers with a brief overview of the research results of Work Group 2.3. The Synopsis follows the same structure as the discussion paper so that one can easily find the more complete discussion and treatment of subtopics in the corresponding section of the discussion paper. This is particularly true of lists of references and descriptions of projects.

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)

ACKNOWLEDGEMENTS

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 (USA) and Professor Kan Chen (USA).

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

The Canadian Work Group 2.3, Electronic Road User Charging Systems and Smart Cards, is jointly managed by Dr. Muhammad Mustafa of IBI Group (leader) and Dr. Baher Abdulhai, of the University of Toronto (rapporteur). They provided the intellectual leadership and writing skills to assemble and document this discussion paper with inputs and contributions from a network of Work Group members. The names of Work Group 2.3 members and contributors appear in Annex A.

The Work Group 2.3 leader and rapporteur can be contacted at:

Muhammad A. Mustafa, P.Eng. Ph.D. (leader)
IBI Group
230 Richmond St. West
Toronto, Ontario M5V 1V6, Canada
+1.416.5961930
Email: mmustafa@ibigroup.com

Baher Abdulhai, Ph.D. (rapporteur)
Assistant Professor and Director of ITS Centre, University of Toronto
35 St. George St.,
Toronto, ON, M5S 1A4, Canada
+1.416.946-5036
E-mail: baher@ecf.utoronto.ca

(Blank page)

Table of Contents

(Blank page)

(Blank page)

List of Exhibits

(Blank page)

1 Introduction

Work Group 2.3 'Electronic User Charging Systems and Integration with Smart Cards and Other payment Systems' is one of eight work groups of the Canadian ATLANTIC project.

In the context of the overall objectives of the Canadian ATLANTIC project, the main objectives of Work Group 2.3 are the following:

- Involve Canadian stakeholders;
- Provide description of the state-of-the-art and state-of-practice of electronic road user charging and smart cards system in Canada;
- Benefit from experience from implementations in Canada and worldwide;
- Identify issues and opportunities for future research, development and deployment in Canada.

The report is structured into two main parts; Road User charging Systems and Smart Cards. Each of these parts is presented in a summary format that summarizes the current status of technology (or state-of-the-art) and implementations of these systems in Canada (or state-of-practice). Finally the last sections of the report identify issues to be addressed in future research and opportunities to be captured in deploying such systems in Canada.

2 Electronic Road User Charging Systems

2.1 Road User Charging Technology

The electronic road user charging system is based on the principles of detecting a vehicle entering a tolled zone, facility or areas, classifying and applying respective toll rate and registering data and/or images for subsequent billing or enforcement.

There are several technologies utilized for electronic road user charging system; among others the following is a list of technologies being implemented in the world:

- Dedicated Short Range Communication (DSRC);
- Global Positioning System;
- License Plate Recognition (LPR) or Automatic Number Plate Recognition (ANPR).

The following sections provide a summary of these technologies.

2.2 Dedicated Short Range Communication

In a DSRC system, vehicles are usually equipped with a tag (e.g. transponder) and the entrance points of the system area are equipped with tag readers. When a vehicle passes by the tag reader at the entrance point, the reader reads the coded data, perform actions of identifying or charging, and the information is passed on to the roadside controller. The data is then checked for integrity and transmitted to a central computer system for processing and storage.

Sections 2.2.1 through 2.2.4 provide an overview of the DSRC technology and subsystems.

2.2.1 Vehicle Detection and Communication

The DSRC utilizes spot (or point) based charging systems. DSRC is the high-level term generally used to describe the process of direct communication between the vehicle tag and the reader. Radio Frequency ID (or RF) systems are microwave-based communications; North America communications are primarily in the 900 – 928 MHz range of the electromagnetic spectrum. There are two forms of RF communication: (1) Active RF and (2) Passive RF. Active RF systems employ microwave frequencies for communication to and from the vehicle; this system uses an active tag that requires a power source. Passive RF systems use a passive tag to communicate with the reader. The transmitter transmits a continuous signal that is intercepted by the tag and reflected to the receiver. Passive RF communication is also referred to as the 'backscatter' method. The electronic tag located in the vehicle is available in three types: (1) Read only (Type I) (2) Read/Write (Type II) (3) Smart Tags (Type III). With the use of Type I tags the information is fixed, with Type II tags the information is updateable (point of entry, date/time, etc.) and with Type III tags the reader and tag may communicate identifying information about the vehicle, customer and account balance. Examples of RFID systems are the Highway 407 Electronic Toll Route in Ontario and the Confederation Bridge in PEI. RFID technologies are currently the most widely used technology for electronic toll collection systems in North America.

Similarly to RFID, infrared systems are a form of DSRC but the communications are in the infrared range of the electromagnetic spectrum. An infrared read for roadside to vehicle communication is consistent and accurate in dense city applications with its well-focused and long operating distance. The technology is used in multilane free flow toll collection as well as stop and go traffic due to its precise, easily defined communication zone avoiding missed reads due to windshield and weather conditions or other characteristics particular to RFID. There are some examples of Infrared systems implemented in Malaysia.

2.2.2 Vehicle Classification

Some of the popular vehicle classification technologies include:

- Treadles and Weigh-In-Motion Devices;
- Light Beams and Light Curtains;
- Scanning Devices.

Treadles are pressure-sensitive devices placed in frames installed over the road surface and used to determine the number of axles, number of wheels and direction of a vehicle. Similarly, weigh-in-motion devices are pressure sensitive but are used to determine axle weight. Light beams consist of a single infrared beam that is broken as a vehicle passes through the beam providing vehicle presence and height information. Light curtains emit multiple horizontal light beams to determine vehicle presence and profile. Scanning devices generate radiation at various frequencies to detect vehicle presence and profile.

2.2.3 Vehicle Enforcement

Essentially there exist two main video enforcement technologies:

- Video Imaging;
- License Plate Recognition (LPR) or Automatic Number Plate Recognition (ANPR).

In either case the primary objective is to capture an image that is clear enough to determine the information on the vehicles license plate. Video imaging is a video based system that captures and stores digital images that are later manually examined to extract the desired information. LPR uses an automated system to extract the license plate information from digital images. The video technology can be used to register license plate information and verify status with a central system. This technology can be used as a stand-alone system or combined with infrared or RFID technologies for purposes of enforcement only. Example of this implementation is the ETR 407.

2.2.4 Central System

All filed systems for communication; classification, charging and enforcement are connected to a central system. The central system provides the following main functions:

- Transaction data and image collection, processing and storage;
- Revenue management and system auditing;
- System reporting;
- Field equipment monitoring;
- Customers account maintenance,
- Customer service.

2.3 Global Positioning System

The GPS/GSM technology allows for wide area charging systems, which includes all routes within a selected area. A vehicle o-board unit uses an autonomous positioning system such as a global positioning (GPS) system to locate itself within a charge area or network. The on-board unit will contain the appropriate charge structure as well as information concerning when the vehicle should be charged. Charges are applied at specific "virtual" locations via satellite. The charge can either be deducted directly from a smart card located in the On-Board Unit or stored for later debiting by servers that centralize all accounts. Corridors can be defined around specific zones in urban or rural areas where all vehicles (or specific categories) using the roadway will be subject to charges. This technology is being used for the truck tolling systems in Germany and Switzerland.

For enforcement purposes, the On-Board Unit may have a DSRC (Dedicated Short Range Communication) module to communicate with stationary and/or permanent enforcement system via infrared or microwave signals.

2.3.1 System Elements

The GPS-GSM tolling system includes the following elements (refer to Exhibit 2-1):

- The On-Boar Unit (OBU);
- Global Positioning System;
- GSM network, wireless system towers and repeaters;
- Central system; including servers and operators workstations;
- Enforcement system.

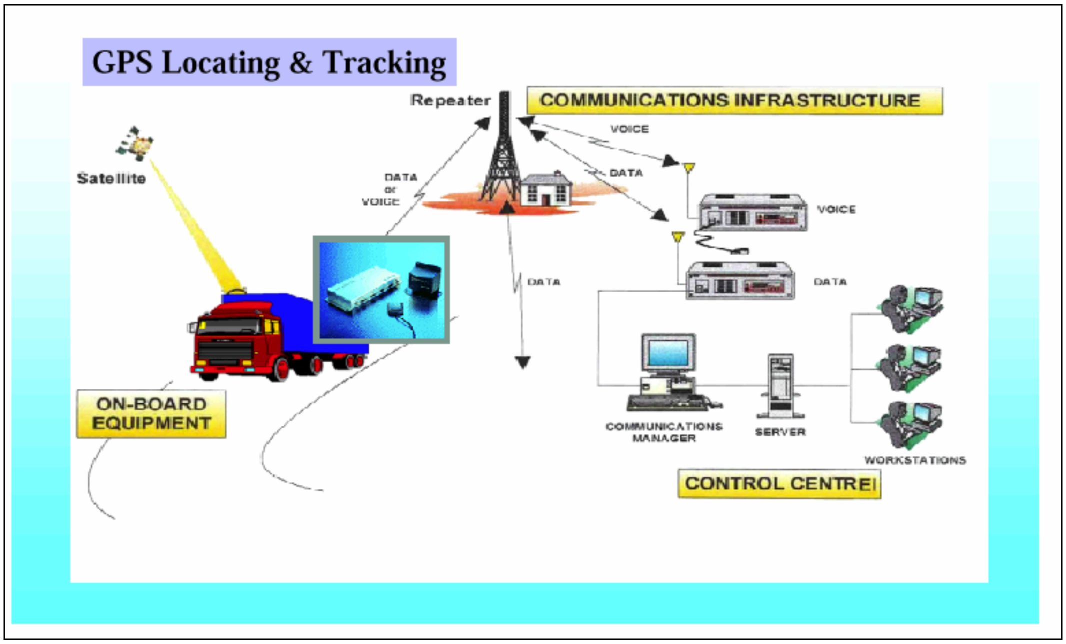


Exhibit 2-1: GPS/GSM System Components (the German Truck Tolling System)

Most GPS/GSM-based ETC systems include a mobile link that can:

- Update the stored charging system;
- Transmit charging or payment data at appropriate times and locations;
- Transmit digital "certificates" for enforcement ;
- Provide system diagnostics and a communication medium for integration of other ITS services and applications.

So far, the GPS-GSM technology has been tested in pilots and small scale implementations. The first large scale implementation was anticipated to start in August 2003 for the truck tolling in Germany. This system has experienced some technical challenges and has not started commercial operation yet.

2.3.2 Enforcement

The enforcement system is based on stationary and mobile enforcement controls. The combination of the two ensures a reasonable level of enforcement of the toll requirements and the ability to adapt the enforcement system to changing conditions.

Stationary enforcement is carried out selected locations (parking areas, rest centres, etc.). If a vehicle has not paid the required toll, the vehicle information is transmitted via radio to mobile enforcement points, which will stop the vehicle for a more detailed check. If the toll has not been paid a potential fine will be collected on the spot.

Stationary control personnel are supported by mobile toll enforcement officers deployed in control vehicles. Using DSRC communication, the officers in the enforcement vehicles determine whether passing trucks have logged on automatically and the vehicle data has been properly entered. In addition, a PC installed in the vehicle and connected to Central by GSM communication.

2.4 Automatic License Plate Recognition (ANPR)

Automatic Number Plate Recognition (ANPR) technology is based on vide imaging that records license plates and other information, process recorded information to identify the vehicle owner to collect the appropriate toll or fine.

This technology is used for the London Congestion Charging project which is briefly described in the following sections.

2.4.1 System Elements

A typical ANPR system is comprised of a video image-acquisition subsystem, a CPU for image processing and control, a hardware- or software-based character recognition engine, and storage or transmission subsystem for electronically recording plate contents and data such as date, time, and location. In specific, the following is a description of main system elements:

- Camera(s) - that take the images of the vehicle (front or rear side)
- Illumination - a controlled light that can bright up the plate, and allow day and night operation. In most cases the illumination is Infra-Red (IR) which is invisible to the driver.
- Computer - normally a PC running Windows or Linux. It runs the ANPR application which controls the system, reads the images, analyses and identifies the plate, and interfaces with other applications and systems.
- Software - the application and the recognition package.
- Hardware - various input/output boards used to interface the external world (such as control boards and networking boards)
- Database - the events are recorded on a local database or transmitted over the network.
- Central system which monitors all field equipment, receive all above information from field, process statements and analyse images which can’t be processed automatically by the system.

2.5 State-of-Practice in Canada

The Canadian Electronic Road User Charging System implementations that are discussed in this report are:

- Confederation Bridge (PEI);
- Angus Macdonald & Murray Mackay Bridges (Nova Scotia);
- Saint John Harbour Bridge (New Brunswick);
- Cobequid Pass (Nova Scotia);
- Highway 407 ETR (Ontario);
- Pearson Airport (Ontario);
- Winnipeg Airport (Manitoba);
- Nexus Border Crossing (Across Canada).

A summary of basic characteristics of these systems is provided in Exhibit 2-2 and Exhibit 2-3.

Exhibit 2-2: Canadian Implementations of Road User Charging Systems using DSRC Technology

	Confederation Bridge	Angus Macdonald & Murray Mackay Bridges	Saint John Harbour Bridge	Cobequid Pass	Highway 407 ETR
Location	Borden, Prince Edward Island (to New Brunswick)	Halifax, Nova Scotia (to Dartmouth)	St. John, New Brunswick	Highway 104, Nova Scotia	Greater Toronto Area, Ontario
Operator	Strait Crossing Bridge Limited	Halifax – Dartmouth Bridge Commission	Saint John Harbour Bridge Authority	Highway 104 Western Alignment Corporation Atlantic Highway Management Corporation	407 ETR
Commercial Name	StraitPass	MacPass	Bridge Pass	E-Pass	407 ETR
Initial ETC Operation Date	2002	1998	1996	1997	1997
Function	Transponder ID linked account & credit card for immediate charging. Initially for commercial vehicles.	Transponder ID linked to account for pre-paid charging.	Transponder ID linked to account for pre-paid charging.	Transponder ID linked to account for pre-paid charging	Transponder ID and license plate recognition, statement mailed out.
Customer Service	No billing required. Statement is available on Internet.	No billing required. Account Pre-paid in-person, by telephone or on-line.	No billing required. Account Pre-paid in-person, by telephone or on-line.	No billing required. Account Pre-paid in-person, by telephone or on-line.	Billing Required. Statement is mailed out to account holder or vehicle owner.
Plazas – Lanes	1 plaza – 7 lanes. 2 lanes have ETC.	ETC all lanes, eight exclusive lanes.	1 plaza – 10 lanes. All lanes ETC accessible, 2 lanes ETC exclusive.	ETC lanes	Free flow at all entry and exit ramps
Gates	Yes	Yes	Yes	Yes	No
Video Enforcement	No	No	No	No	Yes
Classification	Via database or toll collector and Automated check.	Via database or toll collector.	Via database or toll collector.	Via database or toll collector.	Automated
Toll Amount	\$38.50 to \$219.25	\$0.75 to \$5.25 ETC discount	\$0.25 to \$1.75	\$3.50 to \$20.00 ETC Discount	\$0.1295 to \$0.3885 per km

	Confederation Bridge	Angus Macdonald & Murray Mackay Bridges	Saint John Harbour Bridge	Cobequid Pass	Highway 407 ETR
Standard	RF Proprietary Backscatter	RF Proprietary Backscatter	RF Proprietary Backscatter	RF Proprietary Backscatter	RF Proprietary
Frequency	915 MHz	915 MHz	915 MHz	915 MHz	915 MHz
Transponder	Amtech	Amtech	Amtech	Amtech	Mark IV
Antenna	Overhead Amtech	Overhead Amtech	Overhead Amtech	Overhead, Amtech	Overhead, Mark IV
Interoperability – Transponder	Confederation, Macdonald, St. John, Cobequid	Confederation, Macdonald, St. John, Cobequid	Confederation, Macdonald, St. John, Cobequid	Confederation, Macdonald, St. John, Cobequid	None
Web Site	www.confederationbridge.com/	www.hdbc.ns.ca/	www.saintjohnharbourbridge.com/index.html	www.highway104.ns.ca/index.html	www.407etr.com/

Exhibit 2-3: Other Applications of the DSRC Technology

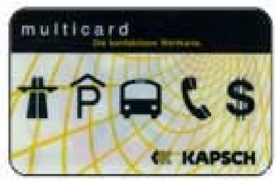
	Pearson Airport	Winnipeg Airport	Nexus Border Crossings
Location	Toronto, Ontario	Winnipeg, Manitoba	Canada & USA Border
Commercial Name	Toronto Lester B. Pearson Vehicle Monitoring and Control System	Winnipeg International Airport Ground Transportation Management System	NEXUS
Initial Operation Date	1996	1998	2003
Function	Automates the airport's dispatching and related operations for Commercial Vehicle Holding Areas and Terminal Curbs.	Automates the airport's dispatching and related operations as well as apply trip fees and dwell time charges.	The NEXUS ID cards allows pre-screened frequent travelers between the two countries to use special border crossing lanes.
Customer Service	N/A	N/A	Application process completed via mail, fax, phone or web. Approved applicants must complete process in person.
Video Enforcement	N/A	N/A	Yes
Standard	RF Proprietary	RF Proprietary	RF Proprietary
Frequency	915 MHz	915 MHz	N/A
Web Site	www.gtaa.com/	www.waa.ca/waa_what.htm	www.ccra-adrc.gc.ca/nexus/

3 Smart Card Systems

3.1 Smart Card Technology

A smart card can be defined, as a card with standard dimensions, is a portable programmable device containing an integrated circuit and stores and processes information. Smart Cards are available in three forms: (i) contact (ii) contactless and (iii) Dual Interface (combi card).

a) Contact



b) Contactless

c) Dual Interface

Contact cards commonly use a magnetic stripe to magnetically encode the required information and require the smart card to be inserted into the smart card reader. Contact cards can be seen in use for public telephone prepayment and automated banking applications. Contactless cards use RFID technology to communicate with a reader without making any physical contact. Contactless cards have been implemented throughout a variety of public transit and security access applications. A combination card combines the features of contact and contactless technologies but adds a very high level of security.

The primary use of a smart card is the storage and retrieval of information. Therefore, the fundamental component of a smart card is the memory module. The following list indicates the more commonly used memory types:

- ROM – Read Only Memory
- PROM – Programmable Read Only Memory
- EPROM – Erasable Programmable ROM
- EEPROM – Electrically Erasable PROM
- RAM – Random Access Memory

A memory module may have one or more of these memory types in order to provide the required functions of a given application. The memory module is then combined with control logic to process the required communication protocols and offer some protection of the memory against fraudulent use.

Therefore, for each form of card there exists three methods for memory storage: (i) Memory (ii) Memory with Security Logic and (iii) Memory with CPU.

Memory cards use a chip or other electronic device to store authentication information. In their most secure form, memory cards store a unique serial number and include the ability to permanently lock sections memory or allow write access only through password-protected mechanisms.

Security Logic cards have a special purpose electronic circuit designed on the chip and use a fixed method to authenticate themselves to readers, verify that readers are trusted, and encrypt communications. This is usually accomplished with some form of access code.

CPU cards implement authentication/encryption methods in software or firmware. Contactless smartcards with an embedded CPU have more sophisticated security capabilities, such as the ability to perform their own on-card security functions and interact intelligently with the card reader.

3.2 State-of-Practice in Canada

This section presents an overview of several existing smart card system implementations in Canada. As well, this section describes the progress of other cities currently considering smart card technology for transit fare collection.

The systems that are examined in this report are:

- Barrie, Ontario;
- Gatineau, Quebec;
- Burlington, Ontario;
- Edmonton, Alberta (in development);
- GTA Region, Ontario (in development);
- Montreal, Quebec (in development).

Exhibit 3-1 and Exhibit 3-2 summarize the current status of smart card implementations in Canada.

Exhibit 3-1: Smart Card Systems Implemented in Canada

	Barrie	*Hull-Gatineau*	*Burlington Transit*
Location	Barrie, Ontario	Hull/Gatineau, Quebec	Burlington, Ontario
Initial Smart Card Implementation Date	1997	1998	1996
Applications	Retail Shopping and Transit Fare Collection	Transit Fare Collection and staff access control	Community Pool Entrance and Transit Fare Collection
Technology and Standards	Contact smart card	Contactless Mifare technology	Contactless Mifare technology
No. of Cards Distributed	50,000 (approximately)	58,000 (approximately)	35,000 (approximately)
Modes of Transportation	Buses	Buses	Buses

Exhibit 3-2: Examples of Smart Card Systems under Implementation

	Edmonton Transit System	*Greater Toronto Area*	*Greater Montreal Area*
Location	Edmonton, Alberta	Greater Toronto Area, Ontario	Montreal, Quebec
Initial Smart Card Implementation Date	In Development	In Development	In Development
Applications	Transit Fare Collection Student cards, parking, other	Transit agencies in the GTA	Transit agencies in the GMA

4 Issues and Challenges

Through discussions with the Work Group experts and stakeholder experience of existing electronic road user charging and smart card systems, the following issues and challenges were identified:

- Technology;
- Business case analysis;
- Business models and governance.

The following sections describe these issues and challenges which are common to both road user charging and smart card systems.

4.1 Technology

4.1.1 Standards and Specifications

With an ever-changing technological environment it is important for system standards and specifications to be established providing a simplistic approach to component and application integration. The international Organization for Standardization (ISO) has developed standards for use by multiple industries. In addition individual industries are developing proprietary versions of these standards with more detailed specifications to support their own specific system applications.

For both system types, ERUC and Smart Card, standards have been slow to develop however; both standards and interoperability are advancing. Continuing efforts by the IMS Group and Transport Canada are on-going to help set sufficient industry guidelines for issues such as technology selection, system design, multi-applications and interoperability. Current progress is evident with a Transport Canada proposal concerning the development of revenue collection standards and specifications. IMS Group members continue activities on ‘best practice’ case studies that will summarize experience in adopting existing specifications and standards.

A wide-range of standards organizations and groups are currently working towards standards and specifications for the ERUC and Smart Card system industries.

4.1.2 Integration of Systems

In the ERUC and Smart Card systems a commonality is necessary in the choice of system architecture for multiple applications. The introduction of multi-application single user accounts will reduce future implementations and enhance user applications. For example, sharing of toll collection ‘back-office’ operations could reduce costs and increase automation. Similarly, smart cards can be shared between agencies and with the private sector to expand operations. A transportation system with integrated tolling and transit systems will allow agencies to enhance existing networks and provide individuals with a more efficient approach to their daily travel.

4.1.3 Compatibility/Interoperability of systems

Compatibility and Interoperability of systems is a complex issue that can be understood very differently between business organizations. Compatibility is defined here as the ability to use different technological forms with one another. The most common example of compatibility concerns involves the use of products from multiple vendors. Interoperability is understood in this report as the capacity to provide operations between different systems. Generally, interoperability issues revolve around agreements between agencies, operators and companies involved with different revenue collection applications. Some important compatibility and interoperability points to consider include:

- How new technologies interoperate with installed physical or logical systems (i.e. backward compatible);
- How available products from multiple vendors interoperate with one another;
- How the interaction of applications is affected by the system components;
- How the applications may interact with each other;
- How agencies establish a minimum level of service; and
- How agencies determine a fair and efficient cost and revenue allocation method.

As discussed earlier, the answers to these issues need to be addressed within a set of national standards and specifications.

4.2 Business Case Analysis

A business case analysis involves the assessment of business needs and justification regarding implementation of modern revenue collection systems. A business case analysis provides insight into the potential for benefits with a particular venture. For example, Edmonton Transit wants to meet directions set out in its policy plan but would like to address any concerns or issues with the implementation of a smart card system. A business case enables agencies to review current practices and investigate improvement and growth opportunities.

4.2.1 Cost Benefit Considerations

Implementation of ERUC and Smart Card systems tend to be costly but the benefits developed commonly justify the project costs. In each system there are quantitative and qualitative benefits that can be assessed.

Quantitatively, ERUC systems commonly have associated tolls that correspond to revenue for the stakeholders involved. The number of road users plays a big role with ERUC toll system implementations since the number of users provides a direct correlation to the revenue generated by a toll network. Conversely, Access Management, Border Crossings and Smart Card implementations do not provide a new source of income but instead a more sophisticated and controlled approach to traffic management and revenue collection. The quantitative benefits are usually developed from a large reduction in vehicle delay, in the case of access management or border crossings, or a large reduction in fraud and increased ridership for smart card applications.

Qualitatively, ERUC and smart card systems enable a more organized and structured approach to revenue collection and vehicle or consumer management. When each system is implemented a new look and marketing platform is developed for the issuing agency. Businesses can enhance their public image with the implementation of a more technological approach.

4.2.2 Justification of Implementation

Agencies and businesses need to assess their current business functions or forms of vehicle management and determine if they are satisfied with their existing processes. For example, the 407 ETR involved the need to provide a fast and efficient alternative for traffic traveling the

North end of Toronto in the east-west directions. The system installed on the 407 called for a free flow approach that was acceptable in public opinion. Public opinion usually results in political pressure forcing agencies to renew or expand aging or inefficient systems. Furthermore, system modifications provide agencies additional options to users generating additional appeal and therefore consistent or increased use. Some questions to consider are:

- Will the new technology reduce operating costs, increase productivity, and/or improve security?
- What is the cost of replacing an existing system?
- What types of technologies are appropriate and cost-effective for the application?
- What level of security is required?
- Will users use/accept the new system?

4.3 Business Models

A business model is a generic approach to defining applications available and to agree on system functions. A business model also sets up roles of agencies involved in providing services in a multi-application revenue collection system.

4.3.1 Partnerships

Partnerships have been essential in the completion of major system implementations all across Canada. In a multi-application venture all stakeholders must agree on all aspects of the system design and implementation. All groups need to ensure their needs are addressed and their list of wants can be accommodated, with all being completed using a cost-effective approach. From project conception to initiation and completion each group must work together to fairly assign relevant system capabilities and components. For example, a transit and toll combination smart card project may experience cost allocation difficulties since the toll application may require an extensive central system with account maintenance functionality while the transit application may only need a small-sized central system for a pay-as-go system.

The development of National and/or International standards must address this issue in order to facilitate a fair and organized approach to multi-application partnerships.

4.3.2 Potential Applications

The potential exists for a large variety of interoperable and stand-alone systems and applications; some examples are listed below. The following lists indicate potential ERUC and Smart Card systems under Transportation and Service industry headings.

Services and Payment

- Municipal services
- Identification and access
- Tourism and "city cards"
- Campus cards
- Loyalty programs
- Retail payment and loyalty

Transportation

- Toll systems
- Car sharing and travel demand initiatives
- Regional transit fare coordination
- Parking payment
- Access Management
- Border Crossings
- Ferry Systems

It is more likely that multi-application systems will develop within one of the major industry headings, Service or Transportation, but opportunities exist for multi-application systems between each of the two groups.

4.3.3 Governance

Governance issues revolve around the role and responsibilities of the different agencies and groups involved. Some of the main points to consider for governance of multi-application systems are as follows:

- **How to share common functions of a multi-application system**. An example of a common function is issuing a multi-application smart card and load applications by each service provider. In this case, service providers need to set up and agree on procedures to issue the card to achieve acceptance at all service locations provided by the system.

- **How to operate a multi-application system and provide services.** Business rules define rights to access and update functions and interfaces of the systems. For example, how can each service provider download data from and upload data to a common processing function, such as a clearinghouse. Another example is lists of fare structure and blocked 'black listed' cards that require updating by each service provider.

- **How to access and manage services by customers**. Customers also require guidance on how and where to access services, which services are allowed on the card, how and where to manage applications on the cards (download, terminate application, etc.). An analogy in the financial system is how to manage payment services from a bank account through pre-authorized payment, Internet banking, etc.

5 Opportunities in Canada

A wide-range of opportunities exists throughout Canada for both Electronic Road User Collection and Smart Card Systems. More specifically, the following describes opportunities identified by the work group.

Multiple Applications
Agencies and private groups are increasingly forming greater interest in multi-application systems. Canadian organizations have historically kept with or gone beyond global technological standards. Furthermore, understanding that Canadian systems have not reached their potential establishes a need to expand current systems.

Involvement of Financial Industry and Other Sectors
Collaboration with financial sector members (banks, credit card companies, etc.) and vendor groups may ease implementation burdens such as cost and resources and therefore, provide additional opportunities for agencies and private groups interested in ERUC and/or Smart Card systems. Multiple application design concepts may interest a variety of potential stakeholders allowing for faster application progression. The Barrie, Ontario pilot program discussed in section 2.3.1, is an example of financial sector involvement.

Interoperability of Systems
Discussion between major groups and organizations will help in ascertaining some of the many multi-agency and multi-application opportunities available that are not being sought due to

insufficient standards and specifications with respect to interoperability. The companies and agencies that want to expand their current range of services must be prepared to work together with the needs and wants of other interested parties.

Address End User Requirements

Development of stand-alone or multi-application systems will help maintain user satisfaction and loyalty with increased system options. End user benefits may include:

- Frequent use of service discounts;
- Availability of multiple services;
- Event-based discounts and customer loyalty programs;
- Customer service.

The final goal of any system implementation is to improve service and therefore, the most important group to satisfy is the system users.

6 References

1. IMS2, state of smart card industry http://www.movingtheeconomy.ca
2. IMS2, experience of smart card systems implementation worldwide
3. IMS1, final report
4. e-Europe smart card initiative, (http://eeurope-smartcards.org/)
5. ITS Canada (http://www.itscanada.ca/)
6. ITS-Canada, 1999: "*Intelligent Transportation Systems (ITS) Plan For Canada: En Route To Intelligent Mobility*
7. London congestion charging http://www.cclondon.com
8. The German Truck Charging System www.toll-collect.de

Annex A Work Group 2.3 Members and Contributors

Name	**Organisation**
Dr. Muhammad Mustafa	IBI Group
Dr. Baher Abdulhay	University of Toronto
David Smith	Ontario Ministry of Transportation
Martin Rosen	Ontario Ministry of Transportation
Keenan Kitasaka	TransLink, Vancouver
Imad Nassereddine	407 ETR Concession Company Ltd
Steven Snider	Halifax-Dartmouth Bridge Commission;
Elizabeth Penrice	Visa Canada
Amer Shalaby	University of Toronto
Brendon Hemily	Independent Consultant
Sue Zielinsky	Moving the Economy
Jean Meyssonnier	AMT, Montreal
Patricia Waisman	Edmonton Transit System
Jerry Davidson	Edmonton Transit System
Scott Stewart	IBI Group