TP 14783E

Transit Intelligent Transportation Systems (ITS) in Small Canadian Communities:

Opportunities and Challenges

Prepared for:

Transportation Development Centre
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Transport Canada

By

Brendon Hemily

December 2007

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NOTICES

This report reflects the views of the author and not necessarily those of the Transportation Development Centre of Transport Canada.

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16. Abstract

The concept of transit Intelligent Transportation Systems (ITS) encompasses a wide range of technologies, including voice and data communications, automatic vehicle location, computer-assisted dispatching, real-time customer information systems, transit signal priority, on-board data collection and video surveillance systems, and smart card electronic payment systems. Although these technologies offer a wide range of potential applications, transit systems face difficult questions when trying to assess the benefits of, and plan for, advanced technology. Small transit systems have perhaps the greatest difficulty and face considerable challenges, including lack of information, lack of staff and specialized expertise, lack of models to guide the planning/implementation process, lack of interest from the supplier community, and uncertainty over objectives, benefits, and costs.

This study explores opportunities and challenges related to transit ITS in small Canadian communities, particularly conventional transit systems with fleets of between 10 and 90 buses. The approach used for this study involved a North American literature search and review of sources of information, a national survey of small transit system managers in Canada, and interviews with transit system managers and other experts. The report provides several recommendations and identifies areas for future research.

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16. Résumé

Les systèmes de transport intelligents pour le transport en commun (STI-TC) comprennent un large éventail de technologies, y compris les communications de données et les communications vocales, la localisation automatique des véhicules, la répartition assistée par ordinateur, les renseignements aux voyageurs en temps réel, la signalisation prioritaire pour le transport en commun, la collecte de données embarquée et la vidéo-surveillance, ainsi que le paiement électronique par carte à puce. Toutes ces technologies se prêtent à une foule d'applications, mais il est difficile pour les réseaux de transport en commun d'évaluer les avantages de ces technologies de pointe et d'en planifier le déploiement. Les petits réseaux de transport en commun sont peut-être ceux qui rencontrent le plus de difficultés et font face à des défis considérables, dont : le manque d'information, le manque de personnel et de connaissances spécialisées, l'absence de modèle à suivre pour la planification/mise en œuvre, le manque d'intérêt de la part des fournisseurs, et l'incertitude quant aux objectifs, bénéfices et coûts associés aux STI.

Cette étude a examiné les possibilités et les défis que représentent les STI pour le transport en commun dans les petites collectivités du Canada, notamment dans les réseaux de transport régulier exploitant des parcs de 10 à 90 autobus. La démarche a comporté une recherche documentaire et un dépouillement des sources d'information à la grandeur de l'Amérique du Nord, une enquête nationale auprès des gestionnaires de petits réseaux de transport en commun du Canada, et des entrevues avec des gestionnaires de réseaux et d'autres experts. Le rapport formule plusieurs recommandations et propose des axes de recherche future.

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EXECUTIVE SUMMARY

The concept of transit Intelligent Transportation Systems (ITS) encompasses a wide range of technologies, including voice and data communications, automatic vehicle location, computer-assisted dispatching, real-time customer information systems, transit signal priority, on-board data collection and video surveillance systems, and smart card electronic payment systems. Although these technologies offer a wide range of potential applications, transit systems face difficult questions when trying to assess the benefits of, and plan for, advanced technology. Small transit systems have perhaps the greatest difficulty and face considerable challenges, including lack of information, lack of staff and specialized expertise, lack of models to guide the planning/implementation process, lack of interest from the supplier community, and uncertainty over objectives, benefits, and costs.

This study explored opportunities and challenges related to transit ITS in small Canadian communities, particularly conventional transit systems with fleets of between 10 and 90 buses. The approach used for this study involved a North American literature search and review of sources of information, a national survey of small transit system managers in Canada, and interviews with transit system managers and other experts.

A wide range of Canadian and U.S. sources of information were identified and reviewed. There are relatively few sources of information or studies in Canada that have focused specifically on transit-related ITS. Although there are many resources on transit ITS in the U.S., the majority of these are aimed at large transit systems and do not address the specific needs or concerns of small transit systems.

Several studies have been conducted to identify the benefits derived from transit ITS, and it is generally agreed that these systems can be used to:

- Improve safety and security for transit operators and customers
- Improve dispatching operations and scheduling
- Reduce the cost per passenger trip
- Provide better passenger information and on-time performance
- Promote open, interoperable systems in ITS
- Enhance the amount and quality of the data available for planning and analysis

However, these studies typically were based on a system design that was extremely sophisticated and expensive in terms of both capital cost and resources required for planning, deployment, and maintenance. Such a system design may be viewed as unaffordable for many small Canadian transit systems.

The survey for this study was distributed to all Canadian transit systems with a fleet of 10-90 conventional buses. The survey response rate was 41%. Only two

small communities had actually deployed transit ITS at the time of the survey*.* Significant findings from the survey were as follows:

- The overall level of interest in transit was surprisingly high, with one third of respondents defining themselves as *extremely interested* in transit ITS. Another third of respondents defined themselves as *very interested*. Significantly, the respondents who were *not interested* in deploying transit ITS were the only three who operated fleets with fewer than 20 buses.

- There was no single dominating factor driving interest in transit ITS among respondents. The most frequently cited factor, somewhat surprisingly, was the *need for data*, cited by 33% of respondents. Correspondingly, *Automatic Passenger Counting* (APC) was the most frequently cited "high priority" feature (mentioned by 83% of survey respondents). This was followed very closely by interest in *obtaining real-time location information* and *providing pre-trip information to customers*.

- On the subject of potential benefits, *increasing the availability of data on passenger activity and running times* was viewed as of very high benefit, as was *improved service control and reliability*.

- The transit ITS features of least interest included bus mechanical alarms, wireless internet access, and silent security alarms.

- In terms of challenges, 76% of respondents ranked *lack of funding* as the number one obstacle. *Lack of staff* and *lack of knowledge* were mentioned by 50% of respondents as one of the top three obstacles.

- When asked to assess their own knowledge of ITS, 65% of respondents perceived themselves as *lacking in knowledge*, 35% perceived themselves as *knowledgeable*, and none perceived themselves as *very knowledgeable*. This finding emphasizes the challenge related to the lack of expertise.

- Among the 24% of respondents located in a large metropolitan area, 66% felt that they benefited from regional smart card projects in terms of sharing of expertise.

- It was hypothesized that federal programs and initiatives could be viewed as facilitators for ITS deployment. The survey, however, indicated that, at least among managers of small transit systems, Transport Canada's ITS Deployment Program lacked visibility.

- Awareness among transit managers in small communities concerning the Canadian ITS Architecture was also extremely limited.

Transit systems in small communities are unique in many ways, and there may be less benefit to the standard “all-in-one” transit ITS system design that has been traditionally deployed in larger transit systems. There needs to be more exploration of the opportunities that correspond to the scale of ITS technologies that is appropriate in small transit systems with limited financial and staff resources. Recent developments in the U.S. and the recent experience of Guelph Transit illustrate the type of creative approaches that are emerging.

Small Canadian transit systems will therefore need to reflect in a more focused way on the functionalities that have most value to them. At the same time, technology is evolving rapidly, and a host of new business models are evolving that offer reduced functionality and may lower capital costs.

Some of the lessons learned from the literature review and discussions with experts are as follows:

- Strong leadership / commitment is critical in ITS projects.
- Persistence and long-term vision for the system is necessary.
- Project management is key, and ITS projects often require more resources than typically envisioned.
- ITS projects require a commitment to systematic information technology procedures and data systems.
- Human factors should not be underestimated, and training of staff, operators, drivers, and users is crucial to allay fears.

Several recommendations are suggested, including:

- Funding: Cost sharing programs are powerful tools for transit managers to leverage local resources.
- Information Dissemination: There is an important need to fill the current void of technical information related to transit ITS through studies on the benefits of transit ITS and on related best practices.
- Federal and Provincial Role in Dissemination and Technology Transfer: Federal and provincial government agencies should re-examine the entire issue of dissemination and technological transfer to ensure a Canadian-specific dissemination mandate.

The study also identified a need for research and development in the following areas:

- APC Data Systems and Utilization Methodologies for Small Transit Systems
- Impacts of Emerging Municipal Fibre Optic and Wi-Fi Communications Networks on Transit ITS in Small Cities
- Ridership Benefits from Transit ITS in Small Canadian Cities

Other useful initiatives were identified in the following areas:

- *Federal ITS Programs*. There is a need to improve the awareness of federal ITS initiatives in the transit industry.
- *The Canadian ITS Architecture as Resource*. It would be useful to clarify how the Architecture can be used as a resource by transit systems.
- *Professional ITS Capacity Building*. There is a need for the development of special-purpose workshops and/or training courses focusing on the planning and deployment of transit ITS in smaller Canadian transit systems.

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GLOSSARY

APC	Automatic Passenger Counting
APTS	Advanced Public Transportation System
ATMS	Advanced Transit Management System (Guelph Transit's ITS)
AVL	Automatic Vehicle Location
BRT	Bus Rapid Transit
CAD	Computer-Assisted Dispatch
GPS	Global Positioning System
IT	Information technology
ITS	Intelligent Transportation Systems
MOST	Moving on Sustainable Transportation
MSAA	Mobility Services for All Americans (program of US DOT)
PRTC	Potomac and Rappahannock Transportation Commission
SCAT	Sarasota County Area Transit
SHIP	Strategic Highway Infrastructure Program
TSP	Transit Signal Priority
TRB	Transportation Research Board (U.S.)
TRIS	Transportation Research Information Services, a bibliographical database funded by sponsors of the TRB
US DOT	United States Department of Transportation
UTSP	Urban Transportation Showcase Program (of Transport Canada)
UWM	University of Wisconsin-Milwaukee

1. INTRODUCTION

1.1. Background

The concept of transit Intelligent Transportation Systems (ITS) encompasses a wide range of technologies, including voice and data communications, automatic vehicle location (AVL), computer-assisted dispatching (CAD), real-time customer information systems, transit signal priority (TSP) systems, on-board data collection and video surveillance systems, and smart card electronic payment systems.

These technologies offer a wide range of potential applications and potential benefits, including:

- providing real-time information to all customers regardless of location and conditions,
- enhancing incident handling,
- enhancing security
- improving operational control of conventional or specialized transit,
- collecting valuable data on vehicle utilization and passenger activity that can be used for management and planning purposes, and
- introducing more versatile and seamless fare collections systems.

Transit systems, however, face a common set of difficult questions when trying to assess the benefits of, and plan for, advanced technology. These include:

- What are the goals and priorities for advanced technology in a transit system?
- What is the business case?
- How should the planning and implementation process be structured?
- What are the likely implications of the deployment of advanced technology for the organization in terms of:
  - required expertise and staffing
  - management of technology
  - impacts on operations
  - impacts on maintenance
  - uses and management of information created by the technology

Transit ITS was deployed by a half dozen early leaders in Canada in the late 1980s to mid 1990s, but interest in the transit industry has been growing rapidly in recent years. In particular, several new transit ITS projects have recently been implemented, or are under development; many of these involve advanced technology as part of new Bus Rapid Transit (BRT) corridors. In addition, many of these projects were aided by funding provided under the federal Urban Transportation Showcase Program (UTSP) or ITS deployment contribution program (part of the Strategic Highway Infrastructure Program).

However, *small transit systems* (defined as fleets of fewer than 100 buses) have not been deploying advanced technology. This situation is in stark contrast to that of Europe or the U.S., where there is a growing number of small transit systems that have implemented transit ITS.

There are 50 small transit systems across Canada with fleets between 10 and 100 buses, and many of these should be able to benefit from advanced technology. Anecdotal evidence suggests that there is considerable interest in transit ITS in small transit systems, especially in conjunction with the recent availability of new funding sources (e.g. gas taxes for transit capital infrastructure and vehicles).

Unfortunately, small transit systems have perhaps the greatest difficulty in addressing issues related to setting goals, developing a business case, and overseeing the planning and implementation of advanced technology. Potential obstacles for these systems are considerable: lack of information, lack of staff and especially of specialized expertise, lack of models to guide the planning/implementation process, lack of interest from the supplier community, confusion over objectives, benefits, and costs, lack of training, etc. At the same time, new opportunities are occurring; for example, several communities are exploring implementation of municipal-wide fibre optic or wireless communications networks, and this is creating both opportunities and confusion among transit managers.

1.2. Objectives and Approach

This study aimed to explore issues surrounding *Transit ITS in Smaller Canadian Cities*. Specific objectives of the research effort included the following:

- Identify, from the perspective of the small transit system manager, potential benefits, obstacles, and issues related to the deployment of transit ITS.
- Explore current best practices and potential or documented benefits related to transit ITS in small transit systems.
- Identify key obstacles related to the planning and implementation of transit ITS in smaller Canadian transit systems.
- Develop recommendations related to potential research, development, and other activities by Transport Canada and other entities that might help to address the identified obstacles.

The scope for the study concerned conventional transit systems with fleets of between 10 and 90 buses. Transit systems with fewer than 10 vehicles are likely to be too small to plan or deploy advanced technology, while transit systems with more than 90-100 buses tend to have more, and more specialized, internal staff resources available to them, and were excluded from the scope of the study.

The approach used for this study involved:

- A literature search and review of sources of information,
- A national survey of small transit system managers, and
- Interviews with transit system managers and staff, and other experts.

This report discusses the results from these efforts. Section 2 provides a brief summary of Transit ITS functionalities. Section 3 outlines the findings from the review of sources of information. Section 4 presents the results of the survey of transit systems in small communities. Section 5 summarizes some key issues, and Section 6 outlines conclusions from the research. Section 7 presents recommendations from the study, including areas for future research and development.

The appendices to this report contain: definitions of Public Transport User Services, an annotated bibliography, the survey form, and a list of survey respondents.

2. TYPICAL COMPONENTS AND FUNCTIONALITIES OF TRANSIT ITS

The concept of ITS comprises a very wide range of technologies, systems, and concepts, and has evolved considerably over the years. There is a vast array of documents that present and discuss ITS. However, *Intelligent Transportation Systems Architecture for Canada* (Transport Canada, undated) is a good introductory document, and provides an overview of ITS concepts in general, and how they need to be integrated through a systems architecture approach.

This study focuses specifically on those ITS technologies that are specific to bus transit.

2.1. Transit ITS Components

From a simplified point of view, the essence of Transit ITS is the integration of three key components:

1. a “smart” bus (with on-board data logging systems and computing power),
2. location tracking capabilities (typically through the use of a satellite-based Global Positioning System (GPS)), and
3. the capability for voice and especially data communications between vehicles, wayside systems, and centrally located computers and centres.

These three components create a considerable synergy that can be used for a wide range of potential applications.

The U.S. Department of Transportation’s (US DOT) Federal Transit Administration has produced, on a periodic basis, a reference document titled *Advanced Public Transportation Systems: The State of the Art*. The term, “Advanced Public Transportation Systems” (APTS) is equivalent to “transit ITS”.

The most recent updates of this reference were produced in 2006 and in 2000, and can be found in the US DOT’s electronic library database. These documents may be of considerable interest to transit system managers interested in finding out more about transit ITS. The 2000 Update (Casey et al., 2000), although slightly out of date in terms of the current state of the art, provides a useful introduction to transit ITS technologies, illustrated with transit systems that have applied these technologies. The 2006 Update (Hwang et al., 2006) is perhaps truer to the title of “state of the art” and provides a comprehensive discussion of the cutting edge of transit ITS technologies, and of the lessons learned to date from the experience with the range of applications.

Transit ITS, when applied to buses today, can potentially involve an extensive range of technologies, and this is illustrated in Figure 1. One of the key problems facing small transit systems is to determine which of these technologies have value in any given specific context.

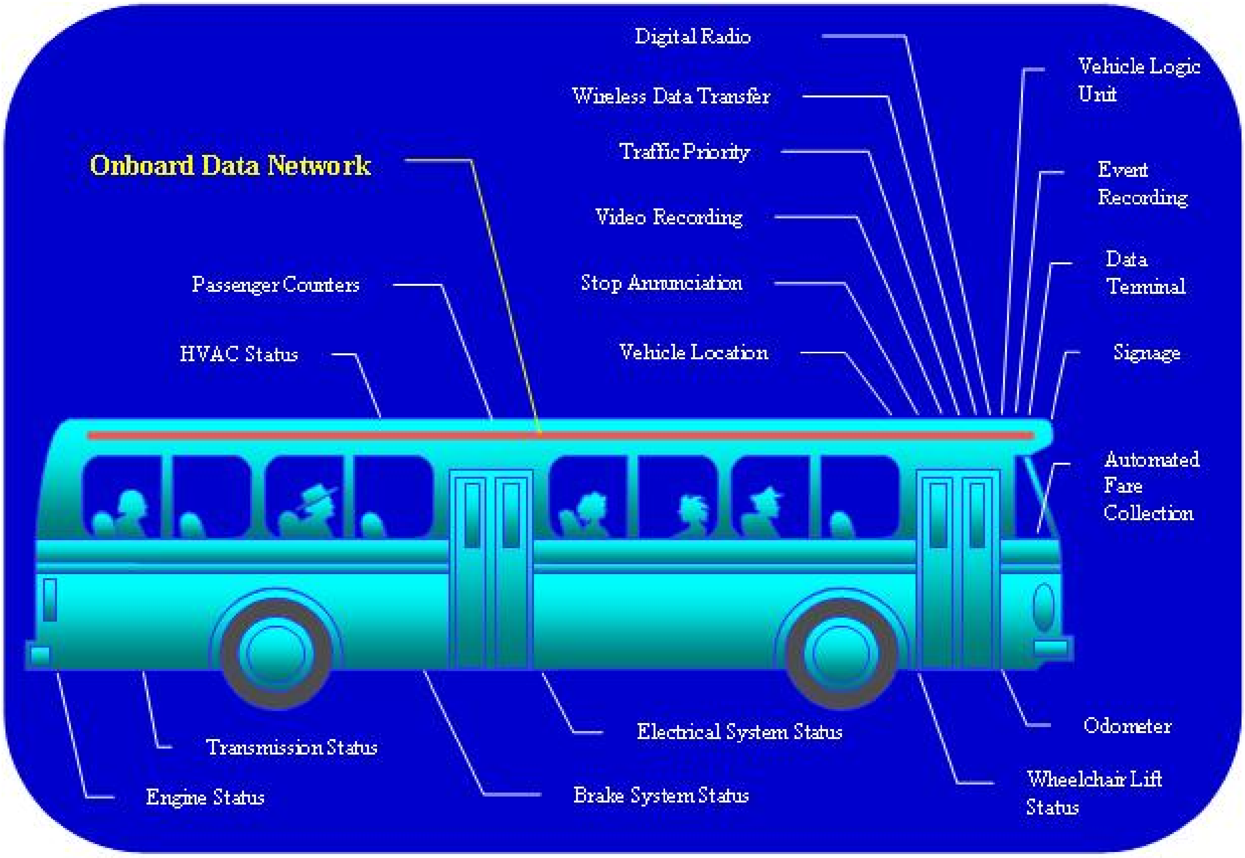

Figure 1. Fleet Management In-Vehicle Technologies
(Source: Hwang et al., 2006)

2.2. Transit ITS Functionalities

Intelligent Transportation Systems Architecture for Canada (Transport Canada, undated) defines "User Services" that may benefit from the application of ITS technologies, and this provides a high level understanding of the many uses of ITS. Appendix A contains definitions of the User Services for Public Transport in general, as defined in *ITS Architecture for Canada*.

For the purposes of this study, it was useful to focus more specifically on the following basic functionalities being pursued through the deployment of transit ITS technologies in buses.

Communications (Voice and Data)

- Voice communications between control centre, individual buses, and/or field inspectors
- Two-way data messaging to minimize voice traffic (including user-defined standard "canned" messages). This is particularly useful when the number of available radio channels is limited.
- Voice and message calls to single and multiple (e.g. by route or for all) vehicles
- Public address capabilities to single and multiple (e.g. by route or for all) vehicles

Computer-Assisted Dispatch

- Automatic display of operator identification, vehicle identification, and route/run information
- Sorting, filtering, and prioritizing of incident queues
- Incident form templates with auto-fill option
- Extensive reporting tool for historical data review, documentation, trend analysis
- User-defined priority, colour, and audible characteristics of incidents

Automatic Vehicle Location

- Real-time vehicle location tracking
- Vehicle route information display
- Ability to zoom in/out to selected routes and vehicles
- Display of landmarks, street names, time-points, exact latitude/longitude coordinates
- Provision of specific location information to facilitate expedient response by emergency services

Security

- Silent emergency alarm
- Emergency covert on-board audio monitoring
- Automatic emergency alarm map
- Emergency public address message capabilities

Schedule Adherence Monitoring

- Automatic polling/reporting of vehicle location on a regular basis (e.g. 90-120 seconds)
- Comparison to scheduled location
- Display of vehicle schedule and route adherence (based on polling rate)
- Sorting and filtering of vehicle performance queues

Traveller/Customer Information (pre-trip, en-route)

- Real-time information on arrival/departure times at desired stops; this information can be potentially delivered via different media (e.g. telephone, web page, personal digital assistants)
- Information to customers to assist them with the planning of their itinerary (i.e. trip planning)
- Information at stops or terminals concerning next departure times
- Audio and/or visual announcements in vehicles concerning next stops and/or other information

Automatic Vehicle Monitoring (of bus mechanical features)

- Monitoring of the performance of various mechanical components or systems (e.g. engine, transmission, brakes, electrical); this monitoring may be used to identify critical performance thresholds, to diagnose mechanical problems, or as input to maintenance processes

Analysis Using Archived Data, typically captured through an Automatic Passenger Counting (APC) System

- Logging of boardings (on’s) and alightings (off’s) by stop to monitor passenger activity and route profiles
- Detailed calculation of exact schedule adherence at timepoints or stops
- Over time, identification of distribution of running times by route segment, by time of day, day, and month that can be used to reflect actual experience and refine schedules
- Monitoring of vehicle utilization and/or performance (e.g. hours, kilometres, speed, stop dwell times, intersection delays, layovers)
- Use of archived data to research/respond to customer complaints

Management Reporting

- Summaries of incident reports by type of incidents, route, etc.
- Summary of missed pull-outs and missed trips by division, route, etc.
- Summaries of road calls and bus replacements
- Summary of on-time performance by division, route, etc.
- Use of archived data to monitor performance of operating contractors
- Processed information may be incorporated into an executive information system (e.g. Key Performance Indicators, Dashboard)

Transit Signal Priority

- Request to intersection traffic controller to initiate control strategy that extends green phase, truncates red phase, inserts transit-only phase for queue jump or left-hand turn, etc.
- Request may be conditional on schedule adherence or headway separation from previous bus

Advanced Fare Collection

- Use of smart card as media for electronic payment system
- Placement of periodic passes on smart card
- Introduction of stored value payment system to reduce/replace cash and/or tickets

3. REVIEW OF NORTH AMERICAN SOURCES OF INFORMATION

A comprehensive search was made to identify sources of information that were pertinent to the study. Sources of information consulted included:

- The library of the Canadian Urban Transit Association
- The Transportation Research Information Service (TRIS) database maintained by the US DOT
- Papers of the TRB Annual Meetings
- Web-based resources including:
  - Transport Canada's ITS Office
  - US DOT-Federal Transit Administration
  - US DOT-ITS Electronic Library
  - CalTrans-PATH Program
  - Various university transportation research centres

Pertinent documents were identified, reviewed and summarized, and an annotated bibliography was prepared (see Appendix B).

3.1. Canadian Sources of Information

Transport Canada has a long-standing interest in ITS, and has conducted a number of related studies. Most reports from these studies can be found on the web sites of:

- The Transportation Development Centre: http://www.tc.gc.ca/tdc
- The ITS Office: http://www.its-sti.gc.ca

The review of Canadian sources of information for this study revealed that there are relatively few sources of information or studies in Canada that have focused specifically on transit-related ITS.

In the 1980s until the mid-1990s, Canadian federal and provincial agencies conducted a range of activities related to the research, development, and demonstration of advanced technologies in the transportation sector, and several projects supported activities related to AVL, APC, electronic fare payment, and other transit-related technologies. Canadian transit systems of the time enjoyed a world-wide reputation for technological innovation, as was evident with the holding of the International Conference on Automatic Vehicle Location in Urban Transit Systems in 1988 in Ottawa, organized by the Canadian Urban Transit Association, and co-sponsored by Transport Canada and the provinces of Ontario and Quebec (Hemily, 1988).

Unfortunately, public policy changed dramatically in the mid-1990s, resulting in major reductions in public sector programs between 1992 and 2000. During this period, government agencies (both federal and provincial) drastically reduced, or totally eliminated, their activities of research, development, and demonstration, in particular as it related to transit ITS.

In more recent years, government agencies have renewed interest in public transportation, and public funding support has occurred through various ad-hoc contribution programs. In parallel, Transport Canada has undertaken three rounds of the ITS Deployment contribution program through its Strategic Highway Infrastructure Program (SHIP). This program involved a competitive call for proposals, and provided to approved projects a matching contribution of up to $250,000 for innovative ITS deployments. Though the absolute value of these contributions is small, it has created a local incentive to explore and deploy ITS technologies. A number of the funded projects have focused specifically on transit ITS, including TSP and traveller information. Brief descriptions of these projects can be found on the ITS Office web site.

In addition, Transport Canada has funded in recent years the UTSP, which encouraged broad innovative urban transportation deployment initiatives, such as BRT, and some of these projects have included transit ITS components. Transport Canada has also funded a number of transit-related projects under its Moving on Sustainable Transportation (MOST) program. Overview descriptions of the UTSP and MOST projects are available on Transport Canada's web site.

To date, little of the above activity has resulted in technical documentation of experience or best practices that is specifically related to transit ITS. There have also been no technical reference documents or guides created, nor industry-wide studies to evaluate the benefits or challenges of ITS technologies in transit applications. This is somewhat in contrast to the U.S., where government-funded studies have created basic references on transit ITS, such as the previously mentioned *APTS State of the Art* report and other technical guides that can be found in the US DOT's ITS Library electronic database.

However, transit is increasingly seen as an important component in efforts to develop a more sustainable transportation system, and technology is a key aspect in enhancing transit. It would be desirable to develop more documentation of experience and best practices, aimed at providing guidance to assist Canadian transit systems in their deployment of transit ITS technologies.

3.2. U.S. Sources of Information

A substantial body of sources of information on transit ITS exists in various forms in the U.S., including:

- Basic references and handbooks,
- Research project reports, and
- Evaluation studies of federally funded operational tests.

It should be noted, however, that the majority of U.S. references are aimed at large transit systems, and do not address the specific needs or concerns of small transit systems. The documents that do focus on transit ITS in small transit systems can be found in Appendix B, which provides a summary of the references that were identified.

One interesting finding of the U.S. literature review concerns the concept of "Coordinated Transportation" as it relates to ITS technologies. Coordinated transportation refers to the coordination of services provided by multiple transportation providers operating in the same or adjacent geographic areas. These different services are aimed at providing mobility to different "transportation disadvantaged" clientele groups, for different purposes, funded by different public (federal or state) programs with different mandates. This is particularly relevant for small urban centres or rural areas, where there is often a concentration of transportation disadvantaged, and typically severely limited public transportation options that are available to these users.

Each publicly funded service caters to its own clientele, with different criteria of eligibility, subsidy or reimbursement formulas, and operating conditions or requirements. Unfortunately, the target clienteles often overlap, creating confusion for users, and costly duplication of services. The objective of the coordination is to reduce the duplication of mobility services provided under different federal and state programs for the transportation disadvantaged. The issue of coordinated transportation has always been of substantial concern in the U.S., but has gained even more prominence under a current major policy initiative of the U.S. federal government, entitled "United We Ride" (Helfer et al., 2007).

ITS is intended to play a significant role in these efforts in various respects. Technology can help to coordinate clientele databases, which in turn can facilitate the reservation of trips based on the various eligibility criteria. Technology can also be used by jointly funded "transportation brokers" for purposes of vehicle dispatching; and ITS can be used to enhance the efficiency of the actual demand-responsive transportation service provision through the combined use of AVL, on-board mobile data terminals, interactive voice response systems, etc. There are significant efforts under way, such as Mobility Services for All Americans (MSAA), to demonstrate the use of ITS technologies to improve the coordination of transportation services, in particular in small urban and rural settings.

It should be noted that there is little equivalent in Canada to this focus on coordinated transportation, except for the sporadic attention that has been paid to the concept of "community transportation" over the past decade, and there has not been any link between community transportation and ITS technologies. At present, the use of ITS for this purpose is not on the radar screen in Canada.

However, this focus may become more pertinent to Canadian transit systems in the future as these U.S. initiatives lead to technological developments and deployments of ITS for specialized transit involving multiple service providers. These are the types of technologies that would be required to coordinate multiple providers of specialized transit in a metropolitan area like Toronto or Montreal, and enable the delivery of seamless service for cross-boundary trips of persons with disabilities.

3.3. Benefits of Transit ITS

One important consideration emerging from the review of the U.S. literature concerns the benefits of transit ITS.

3.3.1. Example of Benefits and Needs Assessment in a Small Transit System

Several studies have been conducted that try to identify the benefits derived from deployment of transit ITS. A few of these focus specifically on the benefits for small or medium-sized transit systems. One such study (National Center for Transit Research, 2002) involved a pre-deployment Needs Assessment for the Sarasota County Area Transit (SCAT). SCAT serves an area in Western Florida with a population of 325,000 (52,000 in the city of Sarasota), and operates a fleet of 40 buses. In 2002, a study was made of the needs and potential benefits that might be derived from introducing APTS/Transit ITS to SCAT. The Needs Assessment reviewed the transit system's goals and mapped them against potential technologies.

This study found that typical transit agency objectives in deploying Transit ITS are to:

- Improve dispatching operations and scheduling
- Reduce the cost per passenger trip
- Provide better passenger information and on-time performance
- Promote open, interoperable systems in ITS
- Improve safety and security for transit operators and consumers

These were defined in the report as follows:

Improving Dispatching Operations

Receiving and displaying accurate vehicle locations should enhance the operations of the fleet. Dispatchers will have the ability to track a vehicle, compare its location to a prescribed route and time point, and advise an operator of late or early running on a route. On the basis of this information, the operator can make necessary run adjustments. In addition to the field supervisors and the vehicle operators knowing that a vehicle is running off schedule, the dispatchers have the ability to see the extent of the problem and how it may impact other routes or blocks.

Reducing the Cost per Passenger Trip
APTS technologies will reduce operating costs by providing greater control and accountability of fleet and resource management. A growing interest has been savings in moving passengers from Para-transit service to fixed-route service, which is less expensive on a per-ride basis and can accommodate additional trips at little or no cost.

Providing Better Passenger Information
This can easily be done through an on-line customer information system that would provide the real-time location of vehicles and information about all types of transportation and trip itinerary planning using off-the-shelf technology.

Promoting Open, Interoperable Systems in APTS
The US DOT is increasingly requiring that ITS implementations use open system architecture to encourage innovation and interoperability. Issues still remain. For example, to compare the scheduled versus real-time location of vehicles, a typical system would require an interface between the scheduling software and the Automatic Vehicle Location (AVL) software, created by the software vendor. This is usually made available for an additional charge.

Improving Safety and Security for Transit Operators and Consumers
Finally, improved safety and security for transit operators and customers is one of the primary objectives of all public transportation agencies. The ability of AVL to pinpoint the location of any vehicle in the fleet provides an additional security feature that will make operations safer.

In order to identify the specific needs at SCAT, the study reviewed the agency's goals and objectives, and mapped the potential application of transit ITS technologies against these goals and objectives. Based on this analysis, the study prioritized those technologies that would be most useful to the transit system, and this is presented in Table 1.

Table 1. SCAT Needs Assessment
Potential ITS Components and Priority Ranking (1, 2, 3)

Transit Management Systems – *improve service*	
• Automatic Vehicle Location (AVL) System – *backbone of APTS*	1
• Automated Passenger Counters (APC) – *improves transit info.*	2
• Transit Operations Software (Fixed route and Para-transit) – *improves operating efficiency*	1
• Vehicle Component Monitoring – *improves operating efficiency*	3
• On Board Safety Features – *increase safety*	2
• Advanced Communication System – *improves information*	2
• Bus Signal Priority (congested corridors) – *improves operating efficiency*	2/3
Advanced Traveler Information Systems – *increase reliability*	
• Itinerary Planning Systems – *increase reliability*	2
• Real-time Information Systems – *increase ridership*	2
• Transit Accessibility Systems - *improve customer convenience*	3
• Website - *improves customer convenience*	2
• CSR/IVR – Telephone System - *improves customer convenience*	3
Electronic Fare Payment Systems – *improve security of revenue*	1
Transportation Demand Management – *better management*	3
• Automated Service Coordination	3
• Transportation Management Centers	3
• Manage park and ride lots	3
Transit Intelligent Vehicle Initiative – *increase safety*	3/2

(Source: National Center for Transit Research, 2002)

It should be noted that the types of benefits identified and discussed in the National Center for Transit Research (NCTR) SCAT report are similar to those identified in other benefit assessment efforts, typically performed with larger transit systems in mind.

3.3.2. AVL in Small and Medium Transit Systems: The Benefits Tree

Researchers at the University of Wisconsin in Milwaukee (UWM) have carried out several research projects (Peng et al., 1999; Peng et al., 2005) in recent years to explore the issue of AVL in small and medium transit systems on behalf of the Department of Transportation of Wisconsin. In particular, they were interested in assessing the benefits that might be derived from deployment of AVL technology in small transit systems in Wisconsin.

The researchers conducted a survey of small and medium transit systems across the U.S. that had implemented AVL. From this research, they were able to lay out the various types of benefits that might be created for the organization and for users. This was visualized in a very interesting approach known as a “Benefits Tree” (see Figure 2).

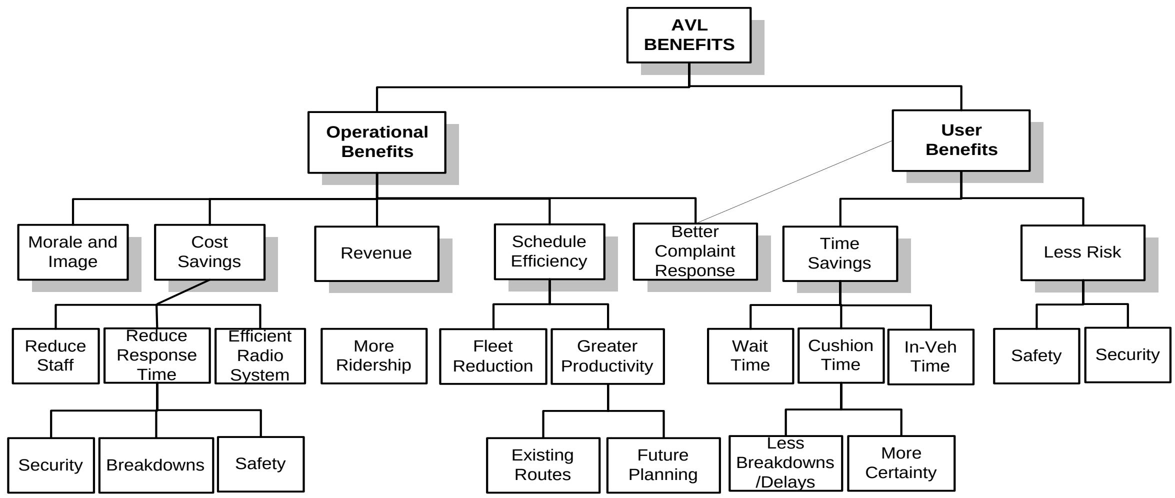

Figure 2. UWM AVL Benefits Tree

Table 2 contains descriptions of the various components of the AVL Benefits Tree.

Table 2. Benefits from the UWM AVL Benefits Tree

OPERATIONAL BENEFITS
The advantage of AVL to the operation and management of a transit agency is centered on its ability to provide a more efficient service and to reduce costs. The benefits from an AVL system may include cost reductions by the elimination of staff and reducing response time to incidents. Also AVL systems potentially can increase the efficiency of existing routes and provide greater productivity without increased staff or vehicles. Both of these areas may lead to greater revenue generation through cost savings and the increase of potential ridership. The unmeasurable benefits of AVL to an agency have to do with the ability to use AVL to increase awareness and pride in the existing service.

Cost Savings
AVL may be effective in reducing the cost of managing a transit system in several ways. The first is the ability to reduce or reassign existing staff if their function can be handled by the AVL. For example, systems may no longer need field personnel to do on time performance checks. AVL provides an opportunity to evaluate and reassess existing staff positions. The next area of cost savings comes from the reduction in response time to incidents which may require police, fire, medical, insurance personnel, or maintenance. In this case the ability to pinpoint a location, takes much of the guesswork out of directing these people. The final area of cost savings can come in a more efficient use of radio systems. In many cases AVL reduces the need for direct communication between the base and the vehicle. Thus it saves airtime and its related expenses.

Additional Revenues
Better efficiency and reliable service may also lead to additional revenue. AVL allows the agency to provide a better service that may attract more use. This better service gives it the ability to offer higher standards of service and a means to promote the system.

Schedule Efficiency
Shorter headways, better productivity, and possibly fewer vehicles are a few of the ways that AVL improves an agency through improving its schedule performance. By tracking vehicles as they move, an agency can locate ways of modifying existing routes and schedules. Relocating existing routes may also help attract more riders while modifying transfer times and headways. It can also help with signal preemption in busy intersections for transit vehicles.

Better Complaint Response
An important part of dealing with the public is having the answers to their questions. Many of these questions come in the form of complaints about the service or possible damage to personal property. AVL gives an agency a tool to validate complaints. In this fashion the management can acknowledge or dismiss claims with the documentation that AVL can provide. For example, complaints such as “the vehicle did not show up” can be verified and handled appropriately.

Morale and Image There may be perceptions by the general public that waiting and riding on the bus is not safe, too much time is wasted waiting for the vehicles to arrive (which are never on time), and that it costs too much to ride. AVL can address many of these perceptions as well as give the agency a modern appeal, which helps to improve morale of agency staff and improves the image of the service offered. For instance, on-time performance can be shown in kiosks, display units in bus shelters or even on the Internet.

USER BENEFITS
Benefits to transit riders are classified as those that reduce their risk and or provide time savings. Risk is reduced because communication is quicker with security personnel. Reduced incident response times as well as reducing the amount of time one waits for a vehicle are positive benefits. Time saving benefits come from a reduction in the wait-time at a stop. AVL keeps the vehicle on time and reduces uncertainty so users may need less cushion time for waiting.

Time Savings
It has been demonstrated that a rider’s perception of time as they wait for a vehicle is longer than the actual time. Thus, many people believe that they are waiting more time than they really are for the transit vehicle to arrive. This is compounded by the riders arriving at transit locations early to avoid the chance of missing their ride. By providing better on time performance and increased reliability, AVL can reduce the time needed by a user to arrive early to a stop and gives them more confidence that a vehicle will arrive at its posted time.

Less Risk
Security can be an issue with many users. AVL can provide a sense of security on the vehicle when riders are made aware of how the system can pinpoint the vehicle in emergencies. Furthermore, more rapid response time with the AVL can lessen the severity of any incidents that may occur.

(Peng et al., 1999)

3.3.3. Benefits of Transit ITS in the Canadian Context

In the UWM research, estimates of the potential operational benefits to the transit system were relatively modest, in particular because of the cost of the systems. However, the estimates of the potential benefits accrued to transit users, in terms of reduced wait time, were extremely significant.

Unfortunately, these benefits are “societal” in nature, and there is no easy way to capture them from a narrow business case point of view. This is particularly true in small transit systems where there is less congestion, and where reliability may be less of a problem. Although small improvements in reliability and decreased wait times may yield significant economic benefits, users may have difficulty perceiving the improvements in reliability.

In addition, the benefits of AVL systems identified by UWM researchers are chiefly a direct function of annual system ridership, while costs tend to vary only slightly with ridership. In addition, benefits are also most likely to occur on systems that have problems maintaining schedules and service reliability.

Both the SCAT Needs Assessment and the UWM research were based on the transit ITS system design that has traditionally been prevalent in the U.S. This system comprises a totally integrated architecture, with a wide range of features, including:

- private radio system with voice and data capabilities,
- sophisticated on-board computer processing power,
- data logging from many sensors,
- frequent polling (60-120 seconds),
- a control centre with full Computer-Assisted Dispatch (CAD)/AVL,
- real-time information available on web sites, at stops and in-vehicle.

Although such a system offers many benefits, it is extremely sophisticated and expensive in terms of capital cost, and also in terms of resources required for planning, deployment, and ongoing maintenance. It may be viewed as currently unaffordable for many small Canadian transit systems.

Small Canadian transit systems will need to reflect in a more focused way on the functionalities that really have most value to them. At the same time, technology is evolving rapidly, and a host of new business models are evolving that offer reduced functionality, but make transit ITS systems feasible at a much lower cost.

4. NATIONAL SURVEY OF TRANSIT IN SMALL CANADIAN COMMUNITIES

4.1. Survey Methodology

A list of transit systems in small communities was assembled from the Directory of the Canadian Urban Transit Association, and then supplemented with information gained from the web sites of the Agence métropolitaine de transport and the Ministère des Transports du Québec. The defined scope included transit systems with fleets of more than 10, and fewer than 90 conventional buses.

A survey form was prepared in English and French. The objective was to identify the perspectives of transit managers on five areas of interest:

1. Background information
2. Level of interest in ITS
3. Benefits and opportunities
4. Obstacles and facilitators
5. Regional ITS projects (questions aimed specifically at transit systems located in metropolitan regions that might be participating in such projects)

The survey forms can be found in Appendix C.

The survey was distributed to the managers of the 51 identified small transit systems across Canada. Follow-up e-mails were sent to encourage response.

4.2. Survey Respondents

Responses were received from 21 transit systems or departments, representing a 41% response rate. The list of organizations that responded to the survey can be found in Appendix D.

4.2.1. Background

From a *geographic location* perspective, the distribution of the respondents was as follows:

- Maritimes: 19%
- Quebec: 19%
- Ontario: 43%
- West: 19%

In terms of respondents' fleet size:

- The conventional fleet size range was between 14 and 81 buses.
- The average fleet size was 36 buses.

Eighty-one percent of respondents also operate *specialized transit service*.

4.2.2. Human and IT Resources

One of the unique challenges facing small transit systems in planning for and implementing transit ITS is the lack of human resources available. Respondents were asked about their total number of employees; their management and support staff; their planning staff, who often become the project managers for special projects; and the level and nature of support in the area of information technology (IT).

Respondents provided the following information with respect to human resources in the organization:

- Total Employee Workforce:
  - Number of employees ranged from 21 to 206
  - Average workforce size: 80 employees

- Management and Support Staff (defined as any staff that were neither operators or mechanics):
  - 9 on average (11% of total employees)

- Planning/Scheduling Staff:
  - 2 on average (3% of total employees)

- IT Support:
  - 31% have internal IT staff resources
  - 68% receive IT support from the municipality

- Level of IT Support:
  - 40% felt that IT support received was good
  - 20% felt that IT support received was minimal

The survey responses confirmed that small transit systems have few managerial resources or specialized staff to dedicate to the formulation of technological objectives, project planning, or project implementation oversight.

4.3. Level of Interest in Transit ITS

The next set of survey questions sought to assess the level of interest in transit ITS technologies among small transit systems.

4.3.1. Overall Level of Interest

The survey defined different levels of interest based on concrete activities that transit managers have engaged in with respect to transit ITS (see the survey in Appendix C). The overall level of interest in Transit ITS among managers of small transit systems was surprisingly high:

- 33% of respondents defined themselves as *extremely interested* in transit ITS. All of these respondents had already secured approval to place ITS in their multi-year capital budget. However, only one respondent had secured budget approval to engage a consultant for the project planning, which is in most cases the next concrete step in project planning.

- 33% of respondents defined themselves as *very interested* in transit ITS. Of these, 86% had visited a transit ITS operation; however, less than half had immediate plans to include transit ITS in their capital budget.

- 19% of respondents defined themselves *as somewhat interested*, which is basically a monitoring mode.

- 14% percent of respondents stated that they were *NOT interested* in transit ITS. Significantly, the respondents who were not interested in deploying transit ITS corresponded to the only three respondents who operated fleets with fewer than 20 buses.

In the definition of the study scope, it was hypothesized that there was an organizational threshold below which organizations could not contemplate deployment of advanced technology. Using fleet size as a proxy for organizational size and capabilities, this organizational threshold had been defined as 10 buses; however, based on the survey responses, it may be somewhat higher (i.e. 20 buses).

4.3.2. Factors Driving ITS

In response to the question concerning factors or objectives driving managerial interest in transit ITS, no single dominating factor was discernable.

The most frequently cited factor (33% of respondents), somewhat surprisingly, was the need for data. Other driving factors included:

- To meet local policy objectives related to ridership
- To take advantage of availability of capital funding
- To improve security
- To take advantage of local municipal technological opportunities (e.g. the planned deployment of fibre optic / wireless communications networks)

This last point is of considerable interest. There appear to be initiatives in a small number of cities to develop fibre optic networks for municipal purposes, or to deploy public wireless access networks. Both introduce a higher level of IT sophistication in the municipality that transit systems may be able to benefit from. Unfortunately, the transit managers in these situations are generally only peripherally involved in these initiatives since they lack the personal knowledge, access to expertise, or financial resources that could help them define desirable objectives and outcomes from their point of view. Without an understanding of potential applications or desirable objectives, they are unable to influence the definition of functional requirements of these new communications networks. Hopefully, the systems are conceived to provide some limited benefits for transit in the short term, and are sufficiently modular to allow transit to benefit at a later date, but this is not guaranteed. This is clearly an area for future research.

4.4. Transit ITS Features of Interest and Perceived Benefits

4.4.1. High Priority Features

Survey respondents were presented with a list of transit ITS features and asked to select those that were of highest priority to them. The following lists the top eight features and the percentage of respondents that ranked each feature as “high priority”.

- APC 83%
- AVL (conventional fleet) 72%
- Pre-trip customer information 72%
- Schedule adherence monitoring 61%
- AVL (specialized transit) 61%
- Customer information at stops 55%
- Advanced fare collection 55%
- Customer information on board 50%

The fact that APC was ranked as a high priority by the highest number of respondents is somewhat surprising. APC systems provide data on passenger activity (i.e. boardings and alightings by stop), as well as vehicle utilization (e.g. running times, dwell times, layover times). The priority for APC was followed very closely by interest in obtaining real-time vehicle location information and in providing pre-trip information to customers.

4.4.2. Transit ITS Features of Least Interest

At the other end of the spectrum, the following features were ranked lowest by respondents:

- Mechanical alarms for engine
- Wi-Fi access for customers
- Silent alarms

Not only did engine alarms not receive a single “high priority” ranking, but 50% of respondents actually rated this as “not important”.

Silent alarms were also features of lesser importance, with only 28% of respondents citing this a “high priority”, and 50% of respondents citing this as “not important”. Security appears to be a lesser concern generally in smaller communities.

4.4.3. Greatest Perceived Benefits

Survey respondents were also asked to identify the functionalities that were of highest benefit. The findings were consistent with the responses concerning technologies of highest priority. Increasing the availability of data on passenger activity and running times was viewed as of very high benefit, as were improved service control and reliability.

Functionalities of highest perceived benefit:

• Data on passenger activity	83%
• Improved service control	83%
• Improved service reliability	77%
• Data on running times for scheduling	72%
• Better pre-trip customer information	66%
• Data for market research	66%
• Improved security	61%
• Reduced fare evasion	61%

4.4.4. Least Perceived Benefits

Functionalities of least perceived benefit:

- Reduced breakdowns
- Improved maintenance
- Reduced abuse/fraud by public/operators in the case of accidents
- Improved incident reporting

Similar to the previous finding, functionalities related to maintenance were those of least perceived benefit.

Reduced abuse/fraud by public/operators in the case of accidents was cited by 38% of respondents as a “non-priority”.

4.5. Challenges

4.5.1. Top Three Obstacles

The survey question asking respondents to identify the top three obstacles that hinder their ability to deploy transit ITS elicited expected responses:

- Lack of funding 76%
- Lack of staff 50%
- Lack of knowledge 50%

Other obstacles cited by respondents included:

- Lack of political will
- Competition with other departments for resources
- Employee resistance
- Software compatibility

When asked what was needed, one respondent provided the following response:

> *Need to provide funding, including exorbitant consultant costs, to assist in researching what is needed, and then helping put the plan together for presentation to local Board of Directors, so that projects can get off the ground. Too few resources to take on more even though it would benefit entire system, improve access, and quality of service to customers.*

4.5.2. Lack of Knowledge

The survey sought to explore challenges beyond the most obvious issue of funding. To that purpose, respondents were asked to assess their own knowledge of ITS. The responses were as follows, and re-emphasize the challenge related to the lack of expertise:

- 65% of respondents perceived themselves as *lacking in knowledge*
- 35% perceived themselves as *knowledgeable*
- 0% perceived themselves as *very knowledgeable*

Respondents made a variety of comments concerning what kind of information was needed or suggestions concerning ways to overcome the lack of knowledge:

- Need information on benefits of equipment.
- Need knowledge of system functions to justify expenditures.
- Need research to find best vendors, find transit systems currently using what we are looking for, and talk to them about improvements they've seen.
- We are not aware enough of the technology that would be the right fit for a system our size, and its costs.
- Lack administrative time available to research ITS options applicable to our service.
- Would be useful to have access to a "Research Office".
- Pooled purchase of technology.

4.5.3. Internal Resources for ITS Planning/Implementation

Survey respondents were also asked to assess the internal staff resources they had available for different stages of an ITS project. Table 3 presents the results.

Table 3. Internal Resources Available for ITS Planning and Implementation

INTERNAL RESOURCES AVAILABLE TO:	NO	YES
Plan for a Transit ITS project	65%	35%
Develop the **justification** to seek capital budget approval	45%	55%
Oversee project development and implementation	40%	60%
Oversee external consultants hired to assist	15%	85%

It is interesting to note that respondents perceived their greatest hurdle to be in the early stages of the project development. This illustrates the barrier they perceive in order to initiate a project. However, it may also indicate that, because of their lack of experience in the industry, transit managers may be underestimating the staff time required during the implementation stages.

4.6. Regional Transit ITS Projects

A distinction was made for transit systems located in or adjacent to metropolitan areas; it was hypothesized that the presence of larger transit systems or regional agencies may provide expertise or resources not available to stand-alone communities.

It was found that 24% of respondents were located in or adjacent to a metropolitan area.

All of the small systems in a metropolitan context were participating to some extent in regional smart card projects. The respondents ranked their level of involvement as:

- 17% very involved
- 50% involved
- 33% peripherally involved

In terms of benefits accruing from their involvement in the regional ITS project, 66% of respondents felt that they benefited from their involvement. However, it was noted that these benefits might exist in terms of access to expertise, but did not necessarily translate into benefits in terms of actual support for planning/deploying an individual transit ITS project.

4.7. Canadian Federal Programs and Initiatives

It was hypothesized that federal programs and initiatives could be viewed as facilitators for ITS deployment. Respondents were therefore asked about the ITS Deployment Contribution program (SHIP) and the ITS Architecture for Canada.

4.7.1. ITS Deployment Contribution Program

In terms of awareness of the federal ITS Deployment Program, which has had three competitive Requests for Proposals (i.e. 2000, 2002, and 2005):

- 65% of respondents were NOT aware of this program.
- 35% were aware of the program.

Of the 7 transit systems that were aware of the program:

- 2 had submitted proposals.
- 4 had considered submitting proposals and had not.
- one chose not to submit (this was one of the transit systems *Not interested* in transit ITS).

The survey indicates that, at least among managers of small transit systems, Transport Canada's ITS Deployment Program lacked visibility.

4.7.2. Awareness of the ITS Architecture for Canada

The development of the ITS Architecture for Canada has been a major ITS-related initiative of the federal government. The responses with respect to awareness among transit managers in small communities concerning the ITS Architecture for Canada were even more dramatic than for the ITS Deployment Program:

- 95% of transit system respondents had NO knowledge of the ITS Architecture for Canada.
- Only one respondent was aware of the initiative.

5. ISSUES

The review of sources of information (see Appendix B) identified a number of U.S. evaluation reports that document experiences with the implementation of ITS in small transit systems (e.g. Bruun, 2005; Cambridge Systematics Inc, 2003; Harris et al., 2002; Rephlo and Woodley, 2006; Rieck and Carter, 2002). Interviews were conducted with several transit managers, staff, and experts in Canada. This section summarizes some of the most pertinent issues related to transit ITS in small Canadian communities.

5.1. Opportunities and Challenges

The discussion of benefits in Section 4.4 identified a wide range of benefits that might be derived from the deployment of transit ITS. However, documenting these benefits in ways that can be used in business cases has proved more challenging. In addition, much of the discussion on benefits to be derived from the deployment of transit ITS has been developed from the experience of larger transit systems. For sophisticated and integrated ITS deployments, the payback period may be lengthy. There needs to be more exploration of the opportunities that correspond to the scale of ITS technologies that can be deployed in small transit systems with their limited financial and staff resources.

Recent developments in the U.S. and the recent experience of Guelph Transit illustrate the type of creative approaches that are emerging.

5.1.1 U.S. Experiences

In the U.S., as mentioned in Section 3.2, considerable focus is being aimed at the issue of coordinating mobility services for the transportation disadvantaged through the U.S. United We Ride program. ITS technology is playing an important role in these efforts. The MSAA is a major initiative to explore the role of ITS technologies in supporting the coordination and enhancement of services provided by small urban transit, rural transit, or community transportation providers. It will involve a number of demonstration sites using ITS technologies, a synthesis of the results from these demonstrations, and the identification of best practices and guidance. Although the focus is primarily on the issue of coordination, it should nonetheless also lead to a better understanding of the potential role of ITS in small transit systems.

The other development that illustrates future opportunity is the emergence of new technological tools to improve the integration of different service delivery strategies, including fixed route, route deviation, and demand responsive. The Potomac and Rappahannock Transportation Commission (PRTC) has been a leader in this area (Bruun and Marx, 2006; Bruun, 2005). This approach involves a combination and integration of various technologies, including interactive voice response, reservation and scheduling software, CAD, and on-board mobile data terminals.

In both the MSAA and PRTC cases, the integration of numerous ITS systems is complex, and raises many technical, organizational, and human factors issues. However, as experience increases, the approaches are slowly becoming more mature, and will open up many new opportunities for small transit systems in the use of ITS over time.

5.1.2 Guelph Transit

Another interesting example of emerging opportunities and challenges is illustrated by the deployment of ITS at Guelph Transit, which is one of the extremely few deployments of transit ITS in small Canadian cities. Guelph is a rapidly growing city that in 2004 had a population of 110,000 and operated 51 buses and 6 specialized transit vans. In July 2004, the City of Guelph submitted a proposal to Transport Canada's ITS Deployment Program for an Advanced Transit Management System (ATMS). The proposal had been developed internally by the Manager of Guelph Transit. The goals for the ATMS were based on Guelph Transit's overall goals:

- Reach 2011 transit modal split target of 10 percent in downtown Guelph and help achieve Smart Growth principles.
- Improve system reliability, accessibility, and overall customer service.
- Increase operating efficiencies.

The specific objectives for the project were:

- Improve schedule adherence.
- Create efficiency in dispatching and service and schedule planning.
- Improve customer service and pre-trip information.
- Strengthen partnerships and service integration (in particular with the University of Guelph, and intercity carriers).
- Improve safety and security for drivers and passengers.
- Improve reliability, capacity and integration of accessible transit services (in particular by helping wheelchair users find low floor buses).

The proposed ATMS envisioned the use of GPS receivers to track the location of vehicles and monitor schedule adherence. This information would be transmitted in real time via the existing radio network to the transit operations centre and to transit customers using large display monitors at three key locations, web-based communications, and customer service representatives. The system would be deployed on both the conventional and specialized transit fleets. The data would also be captured for later analysis to improve planning and schedules. Other sensors (e.g. passenger counters, vehicle diagnostics) would be added at a later date. The proposed budget for the project was $600,000, of which $350,000 would be the local contribution; this met the ITS deployment program criteria.

The proposal was accepted for funding by Transport Canada. A Request for Proposals was issued in the summer of 2005, and a supplier was selected in late 2005. The project was initiated in early 2006.

Various events, however, affected the project's deployment:

- In 2005, a bus operator was seriously assaulted on a late night service. The Health and Safety committee developed a list of potential strategies, only some of which were included in the ATMS. In particular, the decision was made to deploy video recorders on board all buses. This was a major project in its own right, and the two parallel projects strained the resources of a small transit system.

- A major reorganization was instituted in the City of Guelph that affected both the Transit and IT departments.

- Staff changes occurred at Guelph Transit, including a new Transit Manager and Transit Planner.

The above circumstances considerably increased the difficulty of implementing new technologies in Guelph Transit. However, it was fortunate that at least one key IT manager who had been involved in the early stages of the ATMS project was able to remain involved during this entire period, which created at least some continuity. Both the ATMS and video deployments are nearing completion.

Despite the challenges, the Guelph Transit deployments included some innovative features:

- The ATMS is being deployed as a web-based application. This approach is emerging as a new business model in a number of technological areas. In this case, the core system is developed and maintained by the supplier in its own premises. Access to the information occurs via the internet and its use is made available to the transit system under a multi-year leasing agreement. Communications between the on-board equipment and the central server is accomplished through cellular communications. In traditional AVL system business models, the entire system is acquired by the transit system as a capital acquisition, which it owns and is responsible for maintaining. The business model used for Guelph's ATMS involves a mix of capital and operating costs: the transit system acquires on-board vehicle equipment and some standard computer equipment (for the dispatcher and road supervisors), but the supplier owns the core system, which is made available to the transit system through a long-term leasing agreement. The supplier is responsible for system maintenance and upgrades.

- The video and ATMS systems were procured in parallel, but the current management has insisted that the two systems are designed in an integrated fashion and incorporate some technological innovations. For example, activation of the emergency alarm on the ATMS is planned to activate a higher resolution of the video system (by increasing the number of frames per second). In addition, activation of the alarm will activate a flashing bus icon on the monitor and sound an audible alarm for the benefit of the dispatcher in the operations centre.

- Furthermore, a special video camera was requested by the transit manager to be located on the front right of the bus, looking toward the rear. This will help monitor what happens along the side of the bus, as well as the rear door exit, which is a source of accidents.

The two systems are still being deployed, but Guelph’s experience has already raised various issues, and some lessons learned have already become clear:

- Leadership is critical. The original proposal would not have occurred without the personal commitment of the Transit Manager of the time, and the deployment of the systems could not have taken place without the commitment of the current Transit Manager.

- Internal resources need to be identified and dedicated. It is easy to underestimate the internal resources required, especially because there is extremely little experience of peers on which to base an estimate. However, deployment of technology requires someone internally who is responsible for the project, and has the time to both monitor the deployment and work with the supplier to resolve issues.

- Politicians need to be educated about technology. Local politicians may fund capital projects (if there is a matching contribution from senior government, or a propelling reason, such as the assault on an operator), but are very reluctant to approve extra internal resources. There is a need for more education of politicians about what is required to deploy technology. It doesn’t happen by itself.

- The new business models offer promise for small transit systems, but the experience needs to be monitored and evaluated. The web-based application business model being used for the ATMS in Guelph offers several potential advantages to small transit systems: less complex projects, more rapid deployment, less capital equipment to maintain, less staff to maintain equipment, etc. However, the benefit-cost tradeoffs of capital versus operating, as well as the implications for re-procurement after the initial period, need to be better understood.

5.2. Leadership and Organization

Transit ITS projects require considerable perseverance, and leadership is absolutely critical to carry these projects from conception through funding and planning to deployment and ongoing maintenance. To maximize the value of transit ITS, the transit agency must have a long-term vision for the system.

This requires a strong commitment not only from the project leader, but from the entire transit system; an investment in knowledge base and most likely staff resources will be required. The human factors and management issues should not be underestimated.

A commitment to data quality is critical; this requires the development of systematic procedures and oversight to ensure they are followed. Training of staff, operators, drivers, and users is crucial to allay concerns and ensure complete and accurate use of the system.

Project management of these systems remains critical, and requires more resources than usually envisioned or often available in small transit systems.

5.3. Maturity of Technology

The evaluation reports listed in Appendix B concerned projects that were viewed as demonstrations, and detail many of the technological challenges faced by the respective transit systems. In addition, the more complex the technological approach, the more difficult the technological challenges, and the longer the time until successful implementation. This was particularly true for the case of the OmniLink Transit ITS project that integrates fixed route service with flexible service delivery through the use of advanced scheduling software, AVL, and on-board mobile data terminals to create a quasi-real-time demand-responsive service for customers. The relatively recent success of OmniLink is perhaps a hopeful sign that this technology is slowly becoming more reliable and robust (Bruun and Marx, 2006; Bruun, 2005).

A similar pattern was evident for larger transit system deployments starting in the mid-1990s, and it is only recently that transit ITS technologies for larger systems can be described as mature. It appears that technologies aimed at small transit systems are now going through a similar maturing process, so start-up bugs must be expected for the foreseeable future.

From a technological point of view, small transit systems deploying ITS will need to expect to upgrade some basic IT infrastructure (e.g. local area network, redundant servers) if they have not already done so. Design, development, and installation of basic IT infrastructure is critical, and can represent a significant cost.

6. CONCLUSIONS

This study has provided a first effort to better understand the specific issues related to the development and deployment of transit ITS in small Canadian communities. The survey highlighted the considerable interest in transit ITS among managers of smaller transit systems across Canada. However, it also identified several related issues. This section outlines some of the conclusions of the study, in particular as they relate to the uniqueness of small transit systems, considerations in the design of transit ITS for smaller communities, and the availability of information on transit ITS.

6.1. Uniqueness of Small Transit Systems

Transit managers in small communities face some unique conditions:

- Funding constraints are severe, but at the same time the availability of modest capital funding from ad-hoc grant and contribution programs or gas tax funds may have more of an impact on policymakers' decisions to implement technology in smaller transit systems than in large ones.

- The lack of staff and expertise is a more acute constraint than in larger systems, which have specialized staff that can be used to conduct background research, prepare budget justifications, plan projects, and oversee implementation. The learning curve to initiate a transit ITS project is very steep, and the lack of staff and expertise creates a major obstacle from the very outset. The lack of technical support from government agencies and the lack of available information only compounds this obstacle.

- The lack of planning and operational data that is available to transit managers in small communities is clearly a critical concern.

- Most small transit systems in Canada (with the exception of the intermunicipal transit agencies in Quebec) are municipal departments. This means that they are generally more dependent on support from other municipal departments (IT in particular) than larger transit systems. In addition, they must compete for resources with other departments. Initiating a special project, such as a transit ITS deployment, requires competing with other departments for special resources, and therefore careful justification and a sound business case. Once approved, such special projects also require considerable inter-organizational cooperation, which needs to be built on existing trust and communications.

- The land use characteristics, operating conditions and clientele for transit in small communities can be considerably different than those for transit in large communities. For example:
  - Congestion may be minimal and service reliability may be less disrupted.
  - Security may be less of a concern.
  - There may be no resources for inspector supervision in the evenings or on weekends.
  - The proportion of elderly customers may be greater.
  - There may be fewer pedestrian facilities.
  - Parking may be free everywhere and travel times by car minimal, making it difficult to attract customers with cars.
  - The relative importance of a university or a college in the community may be much greater. Post-secondary students are more technologically savvy and have higher expectations in terms of available information.

- Under the unique conditions facing smaller transit systems, there may be less benefit to the standard "all-in-one" transit ITS system architecture that has been traditionally deployed in larger transit systems. However, there has been little or no examination of the implications of these unique characteristics in terms of design of ITS technologies for small transit systems. It may be valuable to re-examine the potential functionalities and design lower-cost systems with fewer, but more relevant, functionalities.

6.2. Issues for Consideration in Designing Transit ITS for Small Communities

Following up on the above concept, it may be worthwhile reflecting on the following issues as they affect the design of transit ITS:

- How critical is it to have an integration of voice and radio communications as has been traditional in transit ITS designs to date? Integration offers many benefits over stand-alone applications, but adds considerable cost and complexities.

- Similarly, is an integrated CAD/AVL including schedule monitoring really needed if service reliability is not a concern?

- What are the benefits of real-time customer information systems in small transit systems, and where should they be deployed (e.g. terminals, universities)?

- Are there incremental and modular deployment paths for transit ITS that are more appropriate for small transit systems?

- Are there inexpensive, easy-to-use and easy-to-deploy technologies available to address the issue of lack of operational and planning data in small transit systems?

- How can the widespread use of cellular phones in the population and the emergence of low-cost technologies for real-time customer information be leveraged to meet the needs of small transit systems?

- What are the capital vs. operating cost trade-offs in comparing the deployment and use of private radio vs. cellular phone communications?

6.3. Availability of Information on Transit ITS

The only sources of information freely available to small transit systems in Canada are:

- Suppliers, in particular at trade shows: as all transit managers know from personal experience, this information must be viewed cautiously.

- Industry association conferences and workshops: limited presentations (and technical tours) provide snapshots at best of the experience with transit ITS technologies.

- Colleagues: this unfortunately remains a limited resource since actual experience with transit ITS in small transit systems is virtually non-existent in the Canadian transit industry.

- Consultants: the primary source of expertise on transit ITS is limited to a small number of consultants who are typically beyond the affordability range of small transit system budgets.

There are some potential solutions for this dilemma:

- Government agencies could play a critical role, as they did in the 1980s to mid-1990s, but they would need to develop a more explicit technical information and dissemination role as discussed in Section 7.2.

- Training courses or more intensive workshops could be developed by industry associations (e.g. Canadian Urban Transit Association, Ontario Public Transit Association, ITS Canada).

- Several universities have experts in the field of ITS, and could provide a resource that transit systems may be able to build on, but it is clear from past experience that this is always easier said than done.

7. RECOMMENDATIONS

7.1. Funding

Funding constraints are a critical consideration for all transit systems in Canada, but are especially so for small transit systems. The availability of cost sharing, either from capital funding sources such as gas taxes, or ad-hoc contributions like the ITS deployment program, are powerful tools for transit managers to leverage local resources.

7.2. Information Dissemination

As mentioned in Section 4.5, the lack of information is an especially critical hurdle for managers of small transit systems with a desire to deploy transit ITS technologies. Federal and provincial government agencies have a critical role to play in this respect.

- There is an important need to fill the current void of technical information related to transit ITS, in particular to provide guidance to small to medium-sized transit systems that lack internal expertise and resources. This should include studies specifically related to transit ITS to document existing experience and identify best practices; as well as industry-wide studies to evaluate the benefits or challenges of ITS technologies in transit.

- *Federal and Provincial Role in Dissemination and Technology Transfer*. In the future, federal and provincial government agencies should re-examine the entire issue of dissemination and technological transfer, in which they can, and used to, play a critical role. The current situation is characterized by a lack of dissemination, creating huge barriers to further deployment of transit ITS. Although some resources are available from U.S. sources, there remains an important need for a Canadian-specific dissemination mandate.

7.3. Areas for Future R&D

The study identified three areas for future research and development (R&D).

7.3.1. APC Data Systems for Small Transit Systems

The study highlighted the lack of planning and operational data as a key issue for managers of small transit systems. This suggests two related R&D needs:

1. *Development of a Simple Low-Cost Data Technology Specifically Designed for Small Transit Systems*. It is recommended that such a technology be developed with the following requirements: 1) have a modest capital cost; 2) be able to be purchased in small numbers of units; 3) be robust; and 4) require minimal effort to deploy and maintain. Current commercial suppliers may be able to offer such technological solutions with modest redesign.

2. *Development of Archived ITS Data Utilization Methodologies and Related Training Modules*. In some sense, this may be the more difficult aspect of this issue. Current APC technologies offer a wide array of potential applications, but require internal staff to have sophisticated expertise in both the use of relational databases and database report-writing tools, such as Crystal Reports, and in the actual application of the data for planning purposes. Larger transit systems can have separate staff for each task; smaller systems cannot, and in most cases do not even have access to planning staff with the required expertise. In order to use a low-cost APC system, new methodologies need to be designed that create simple and standard data processing routines, and that clarify how this information can be used to enhance scheduling, route design, etc. Training modules can then be developed in the application of these new tools.

7.3.2. Impacts of Emerging Municipal Fibre Optic and Wi-Fi Communications Networks on Transit ITS in Small Cities

There appear to be initiatives in a small number of cities to develop fibre optic networks for municipal purposes, or for the deployment of public wireless access networks. There is a need to conduct research to define how transit can benefit from these municipal communications deployments, and to define desirable transit-related objectives and functional requirements to be incorporated in these new communications networks.

7.3.3. Ridership Benefits from Transit ITS

There has been considerable research to define benefits that might be derived from transit ITS technologies; however, there has been little research to explore more specifically the potential ridership benefits from deploying transit ITS. This is an even more challenging need in the specific context of small transit systems, where the proportion of seniors, students, and economically disadvantaged may be typically higher. At the same time, some market segments in small communities may be very sensitive to the availability of real-time information (e.g. post-secondary students). In addition, smaller communities often lack pedestrian facilities (e.g. sidewalks) and passenger amenities (e.g. bus shelters), and initiatives to reduce wait times through the provision of real-time information, especially in harsh weather conditions, might generate considerable ridership benefits. This needs to be more carefully assessed.

7.4. Other Initiatives

Federal ITS Programs. There is a need to improve the awareness of federal initiatives in the transit industry.

The ITS Architecture for Canada as a Resource. The Architecture can be a valuable asset, but it is unknown among small transit managers. It would be useful to clarify how it can be used as a resource by transit systems.

Professional ITS Capacity Building. There is a need for the development of special-purpose workshops and/or training courses focusing on the planning and deployment of transit ITS in smaller transit systems. The US DOT has identified Professional Capacity Building as a major mandate for the federal government in order to encourage deployment and best use of ITS technologies. One such effort is the National Transit Institute, which has developed and offers several programs on Transit ITS Planning and Implementation and ITS Technology Procurement. However, these are U.S.-centred, and are typically based on the paradigm of the integrated transit ITS architecture. Once a better understanding is developed concerning the specific needs of small transit systems, and of the emerging business models and technological models, there would be considerable benefit to pursue the development of training courses as a means to encourage deployment of ITS technologies by small Canadian transit systems.

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APPENDIX A DEFINITION OF PUBLIC TRANSPORT SERVICES IN ITS ARCHITECTURE FOR CANADA

From the Intelligent Transportation Systems Architecture for Canada, Release 1.1 (Transport Canada, http://www.its-sti.gc.ca/Architecture/english/static/content.htm)

User Services document what ITS should do from the user's perspective. A broad range of users are considered, including the travelling public as well as many different types of system operators. Thirty-five user services form the basis for the Canadian ITS Architecture. The concept of User Services allows a system or project definition to begin by establishing the high level services that will be provided to address identified problems and needs. User Service Bundles divide User Services into logical groups that provide a convenient way to discuss the range of requirements in a broad stakeholder area. In the Canadian ITS Architecture, the User Services are grouped into the following bundles:

- **Traveller Information Services**
- **Traffic Management Services**
- **Public Transport Services**
- **Electronic Payment Services**
- **Commercial Vehicle Operations**
- **Emergency Management Services**
- **Vehicle Safety and Control Systems**
- **Information Warehousing Services**

Public Transport Services

Relates to public transportation, which includes urban, suburban and rural transit in fixed route, route deviation and demand-responsive modes and operated by bus, heavy rail, light rail, commuter rail and van or carpool or shared ride taxi. All forms of short distance transportation not involving a single occupant automobile should benefit from these services.

3.1 Public Transport Management

The Public Transport Management user service applies advanced vehicle electronic systems to various public transportation modes and uses the data generated by these modes to improve service to the public. It includes operation of vehicles and facilities, planning and scheduling, and personnel management.

3.1.1 Transit Vehicle Tracking

Provides for an Automated Vehicle Location System to track the transit vehicle’s real time schedule adherence and updates the transit system’s schedule in real-time. Vehicle position may be determined either by the vehicle (e.g., through GPS) and relayed to the infrastructure or may be determined directly by the communications infrastructure. A 2-way wireless communication link with the

Transit Management Subsystem is used for relaying vehicle position and control measures. Fixed route transit systems may also employ beacons along the route to enable position determination and facilitate communications with each vehicle at fixed intervals. The Transit Management Subsystem processes this information, updates the transit schedule and makes real-time schedule information available to the Information Service Provider Subsystem via a wireline link.

3.1.2 Transit Fixed-Route Operations
Performs automatic driver assignment and monitoring, as well as vehicle routing and scheduling for fixed-route services. This service uses the existing AVL database as a source for current schedule performance data, and is implemented through data processing and information display at the transit management subsystem. This data is exchanged using the existing wireline link to the information service provider where it is integrated with that from other transportation modes (e.g. rail, ferry, air) to provide the public with integrated and personalized dynamic schedules.

3.1.3 Passenger and Fare Management
Allows for the management of passenger loading and fare payments on-board vehicles using electronic means. The payment instrument may be either a stored value or credit card specific to the application, or as supported by a broader banking network. This user sub-service is implemented with sensors mounted on the vehicle to permit the driver and central operations to determine vehicle loads, and readers located either in the infrastructure or on-board the transit vehicle to allow fare payment. Data is processed, stored, and displayed on the transit vehicle and communicated as needed to the Transit Management Subsystem using existing wireless infrastructure.

3.1.4 Transit Maintenance
Supports automatic maintenance scheduling and monitoring. On-board condition sensors monitor critical system status and transmit critical status information to the Transit Management Subsystem. Hardware and software in the Transit Management Subsystem processes this data and schedules maintenance activities.

3.1.5 Multi-Modal Co-ordination
Establishes 2-way communications between multiple transit and traffic agencies to improve service co-ordination. Multi-modal co-ordination between transit agencies can increase traveller convenience at transfer points and also improve operating efficiency. Co-ordination between traffic and transit management is intended to improve on-time performance of the transit system to the extent that this can be accommodated without degrading overall performance of the traffic network. More limited local co-ordination between the transit vehicle and the individual intersection for signal priority is also supported by this user sub-service.

3.1.6 Multi-Modal Connection Protection
This Canadian user sub-service supports the co-ordination of multimodal services to optimize the travel time of travellers as they move from mode to mode (or to different routes within a single mode). A near term function supported by this user sub-service is for transit agencies to co-ordinate crossing routes so that passengers on one route would have the opportunity to transfer with minimum wait time to another route within the same transit system. The next level of complexity of this user sub-service is for this co-ordination to occur across transit agencies, or between transit agencies and other modes of transportation. The most advanced functions of the Canadian user sub-service would be to track the route of an individual traveller and ensure that connections are most efficiently scheduled. This final capability represents a very long-term functionality, which could be managed either through an Information Service Provider or through a Transit Management subsystem.

3.2 En-Route Transit Information

The En-Route Transit Information user service provides travellers with real-time transit and high-occupancy vehicle information allowing travel alternatives to be chosen once the traveller is en-route. The single sub-service of the En-Route Transit information user service provides three major functions which are (1) Information Receipt, (2) Information Processing, and (3) Information Distribution. This capability integrates information from different transit modes and presents it to travellers for decision making.

3.2.1 En-Route Transit Information
Provides transit users at transit stops and on-board transit vehicles with ready access to transit information. The information services include transit stop annunciation, imminent arrival signs, and real-time transit schedule displays that are of general interest to transit users. Systems that provide custom transit trip itineraries and other tailored transit information services are also represented by this user sub-service.

3.3 Demand Responsive Transit

The Demand Responsive Transit user service involves the use of flexibly routed transit vehicles offering more convenient service to customers. These transit vehicles include small buses, taxicabs, or fixed-route transit buses that are detoured from their pre-established route to pickup or discharge passengers.

3.3.1 Demand Responsive Transit
Performs automatic driver assignment and monitoring as well as vehicle routing and scheduling for demand response transit services. This user sub-service uses the existing AVL database to monitor current status of the transit fleet and supports allocation of these fleet resources to service incoming requests for transit service while also considering traffic conditions. The Transit Management

Subsystem provides the necessary data processing and information display to assist the transit operator in making optimal use of the transit fleet. The Information Service Provider Subsystem may either be operated by transit management centre or be independently owned and operated by a separate service provider. In the first scenario, the traveller makes a direct request to a specific paratransit service. In the second scenario, a third party service provider determines which paratransit service is a viable means of satisfying a traveller request and uses wireline communications to make a reservation for the traveller.

3.4 Public Travel Security

The Public Travel Security user service supports innovative applications of technology to improve the security of public transportation. Security concerns include protecting transit patrons and employees from street crime, maintaining an environment of actual and perceived security, and developing innovative technical measures to respond to incidents.

3.4.1 Public Travel Security

Provides for the physical security of transit passengers. An on-board security system is deployed to perform surveillance and warn of potentially hazardous situations. Public areas (e.g. stops, park and ride lots, stations) are also monitored. Information is communicated to the Transit Management Subsystem using the existing or emerging wireless (vehicle to centre) or wireline (area to centre) infrastructure. Security related information is also transmitted to the Emergency Management Subsystem when an emergency is identified that requires an external response. Incident information is communicated to the Information Service Provider.

APPENDIX B ANNOTATED BIBLIOGRAPHY

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This interim report documents the lessons learned to date from the Smart Flex-route Integrated Real-time Enhancement System (SaFIRES) implemented by PRTC on its OmniLink service. This route deviation *service proved to be popular with county residents as ridership on this small system exceeds 1,000 passengers per weekday. However, the report documents the technical and institutional difficulties that prevented the successful integration of AVL, mobile data terminals, and automated scheduling and dispatching in the first phase of this project.*

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Mobility Services for All Americans, US DOT Program:
http://www.its.dot.gov/msaa/index.htm

The goal of the Mobility Services for All Americans (MSAA) initiative is to improve transportation services and simplify access to employment, healthcare, education, and other community activities by means of advanced technologies of Intelligent Transportation Systems (ITS) and *through extending transportation service partnerships with consumers and human service providers at the federal, state, and local levels. This ITS initiative is related to the United We Ride national campaign that implements the Executive Order on Human Service Transportation Coordination (#13330) issued by President Bush in February 2004 that requires federal agencies to work together to enhance transportation access, minimize duplication of federal services, and facilitate the most appropriate, cost-effective transportation for older adults, people with disabilities, and low-income populations. MSAA and United We Ride envision a coordinated one-stop, customer-based travel reservation, information, and trip planning service. Several ITS technologies will be applied, including:*

- *Geographic information systems (GIS)*
- *Integrated vehicle dispatching and scheduling*
- *Automatic vehicle location (AVL)*
- *Communications systems*
- *Electronic payment systems/financial tracking and billing systems*
- *Advanced traveller information systems (ATIS)*

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This report documents the deployment of an AVL system and on-board mobile data terminals on part of the fleet of MART, an agency that provides both fixed-route service using 26 buses, and paratransit service in a large rural geographic area using 120 vans, operated under contract. MART serves a variety of institutional clients in eastern Massachusetts, including Councils on Aging, Welfare to Work programs, and veteran's organizations. The project included the introduction of an AVL system but deployment on only 15 vehicles. The report documents technical issues, in particular related to the communications system and the partial system deployment, as well as institutional issues related to deploying ITS when private contractors are involved, training, and dealing with legacy systems and procedures.

National Center for Transit Research, University of South Florida, *APTS Needs Assessment for Sarasota County Area Transit: Final Report*, SCAT, Sarasota, FL, October 2002

This report provides a needs assessment related to APTS technologies for a small transit system (45 buses and 31 demand-responsive vehicles) in western Florida. It reviews the potential application of transit ITS technologies in meeting the transit agency's goals and in addressing the current issue. It ranks the priority of the technologies for deployment in order to recommend a phased strategy.

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This reports investigates the use of AVL to enhance transit performance, management and customer services in medium-sized transit agencies, based on surveys conducted in Racine and Waukesha, Wisconsin, before and after AVL implementation and in Manitowoc, Wisconsin, a small city without AVL. The research found that transit systems with AVL had improved schedule adherence and on-time performance significantly. Surveys of perceptions of the transit service and the importance of AVL characteristics showed little change, comparing with before the AVL was implemented. Features like improving on-time performance, knowing when the bus will arrive, knowing that another bus will be dispatched in case of breakdown are still valued as important to transit users and their decisions to ride more often. The surveys also indicate that more passenger trips might be realized if better information were offered to users.

Peng, Z-R., E. Beimborn, S. Octania and R. Zygowicz, *Evaluation of the Benefits of Automated Vehicle Location Systems in Small and Medium Sized Transit Agencies*, Center for Urban Transportation Studies, University of Wisconsin-Milwaukee, January 1999

This research study provides a comprehensive assessment of the state of the art of APTS technologies in 1999, and analyzes the benefits that could accrue in particular to small to medium-sized transit systems through the deployment of APTS. It concludes that much of the benefit was derived from providing better information to transit customers that would translate into reduced waiting times.

Rephlo, J., and D. Woodley, *South Lake Tahoe Coordinated Transit System (CTS) Project - Phase III Evaluation Report*, Science Applications International Corporation (SAIC), McLean, VA, April 2006

This report presents the comprehensive evaluation of the South Lake Tahoe Coordinated Transit System (CTS) Project. The CTS Project involved combining transit services offered by private and public sector stakeholders in South Lake Tahoe into one centrally dispatched operation that uses intelligent transportation system (ITS) technologies to improve transit efficiency and to create a more visitor-friendly transit system. The coordinated transit system spans the jurisdictions of two counties in two states as well as one city, and incorporates the private transit resources of five casinos and one ski resort. The evaluation assessed impacts of the new ITS-supported system on ridership, customer satisfaction, and operating efficiency. It also conducted a review of the institutional issues affecting planning and deployment of the system. Lessons learned in *deploying and operating the technologies and the system were also gathered.*

Rieck, T., and M. Carter, *Lessons Learned: Evaluation of Intelligent Transportation Systems (ITS) Implementation at Santee Wateree Regional Transportation Authority*, FTA-TR-11-02.3, Federal Transit Administration, U.S. Department of Transportation, Washington D.C.

This report documents the experience of the Santee Wateree Regional Transportation Authority (SWRTA) in attempting to deploy ITS. SWRTA is a rural transit system (24 peak fixed-route buses and 54 demand-responsive vehicles) serving central South Carolina as well as the City of Sumter. SWRT's objective was to deploy CAD/AVL associated with flexible service delivery, mobile data terminals, and GIS. The project encountered major problems, including critical hardware and software compatibility problems, and was never successfully deployed. Some of the lessons learned include: the need for comprehensive technology planning, strong and committed project management, employee "buy-in" and development, and budgeting sufficient implementation time with contingencies.

Ripplinger, D., and D. Peterson, *ITS Transit Case Studies: Making a Case for Coordination of Community Transportation Services Using ITS***,** Small Urban & Rural Transit Center, Upper Great Plains Transportation Institute, North Dakota State University, Fargo, ND, September 2005

This report reviews the experiences of three case study agencies that planned, implemented, and operated intelligent transportation systems (ITS) to meet the mobility needs of the communities they serve through improved coordination. The case study sites were: the Suburban Mobility Authority for Regional Transportation (SMART) serving the suburban Detroit region; Reach Your Destination Easily (R.Y.D.E.) in Nebraska; and NDinfo.org in North Dakota. The report outlines for each of the case study sites, technical and institutional issues, requirements, benefits and costs, and lessons learned. Lessons learned described relate to: the issue of developing an ITS architecture, staying focused on outcomes, user friendliness, centralization, scalability, and redundancy and backup. In addition, the SMART case study highlights some of the difficulties of being a leader in the deployment of new and unproven technologies.

Schmauk, David, *Planning – The Key To Successful Implementation of a Bus Automation Project*, Presentation, Bus Conference, American Public Transportation Association, May 1999

This paper presents keys to success in planning and implementing a transit ITS system.

U.S. Department of Transportation, ITS Applications for Coordinating and Improving Human Services Transportation: A Cross-Cutting Study, Washington D.C., August 2006

This report reviews technologies that improve accessibility for the transportation disadvantaged, with a special emphasis on those technologies that improve coordination of agencies, services, functions, or modes since coordination can result in greater efficiency and service delivery improvements. This report profiles six diverse case study sites that have successfully deployed ITS technologies to improve transportation options for the transportation disadvantaged. The report outlines lessons learned, including:

- *Technologies should be phased in incrementally, ironing out the problems with each technology before adding another layer of complexity.*
- *Training of staff, operators, drivers, and users is crucial to allay apprehensions and ensure complete and accurate use of the system.*
- *Regular meetings between system providers, subcontractors, policy makers, special interest groups, and agency managers allow stakeholders to share problems and ideas and to build consensus.*
- *ITS technologies produce a massive amount of data, and a commitment to data quality is essential. There is usually more than one use for a data set. Mining and reusing the data can lead to insights that form the basis for operational improvements.*
- *It is important to be a "smart client" for vendor-supplied software. It is particularly important to assess the vendor's longevity and integration capability, avoid excessive modifications of the software's functionality, and insist on on-site training and support.*

APPENDIX C SURVEY FORM

SURVEY
Transit Intelligent Transportation Systems (ITS) in Small Canadian Cities: Opportunities and Obstacles

The Transportation Development Centre (TDC) of Transport Canada is currently conducting a research project entitled ***Transit ITS in Small Canadian Cities: Opportunities and Obstacles.*** The concept of Transit ITS encompasses a wide range of technologies, including: automatic vehicle location (AVL), real-time customer information systems, on-board data collection, security and/or video surveillance systems, Transit Signal Priority (TSP) systems, smart card payment systems, etc.

The purpose of this survey is to identify, from the perspective of the small transit system manager, potential benefits, obstacles, and issues related to the deployment of Transit ITS. This survey is being distributed to all Canadian transit systems with between 10 and 100 buses in their fleet.

> **NOTE**: Please let us know if your organization is ***already actively engaged in deploying a Transit ITS project***[1] (i.e. your organization has already conducted a strategic ITS plan or formal business case, developed specifications for a Transit ITS system, issued an RFP for system integration, deployed an ITS system, etc.). We will forward a separate survey form for transit systems with projects actively underway. Thank you.

Instructions:	All transit systems:	*Please complete Parts A-D*
	Transit Systems in Metropolitan Regions	*Please complete Part E as well*

A. BACKGROUND ON ORGANIZATION

Organization ______________________________
Contact Name ______________________________
E-mail ______________________________
Telephone ______________________________

What is the size of your active **conventional transit fleet**? __________

Do you operate **specialized transit**? Yes _____ No _____
If yes, how many dedicated specialized transit buses do you operate? ________
Do you contract with taxi or other operators? Yes _____ No _____

What is the **total number of employees** in your organization? ______
What is the size of your managerial, supervisory, and administrative staff (i.e. all staff excluding drivers and mechanics)? ______
How many staff are involved in planning and scheduling? ______

[1] Excluding regional smart card projects in the Montreal or Toronto areas

Who provides **support for Information Technology** (IT)?
___ Internal? Number of staff assigned? ______
___ Another Municipal Department?

Would you consider the **current level of IT support**:
___ Very good? ___ Good? ___ Adequate? ___ Minimal?

B. LEVEL OF INTEREST IN TRANSIT ITS

What is your **level of interest in Transit ITS**:

____ Extremely interested *(check all that apply)*
- ____ Included Transit ITS system in your approved 5-year capital budget
- ____ Scoped out a system development process
- ____ Have obtained budget approval to engage external
- ____ Other ______________________________

_____ Very interested *(check all that apply)*
- ____ Have obtained information from system vendors
- ____ Visited transit systems that already have Transit ITS in place
- ____ Am planning to include in capital budget in near future
- ____ Other ______________________________

_____ Interested *(check all that apply)*
- ____ Am monitoring developments in trade journals
- ____ Have attended sessions at conferences
- ____ Have discussed with colleagues/experts
- ____ Other ______________________________

______ Not Interested in Transit ITS
(Please explain reasons for lack of interest ***and skip to Part F***)
____

C. BENEFITS AND OPPORTUNITIES

Is there a **single specific factor driving** the planning for Transit ITS (e.g. capital funding opportunity, local policy objective, local communications technology opportunity, specific local problem, etc.). *Please specify:* ______________________________

Is there a **primary system objective** resulting from the above driving factor? ______________
____

What **Transit ITS features** are you most interested in?
(P-primary; S-secondary, NI-not interested at moment)

____ Replacing an existing voice radio
____ Silent alarms
____ On-board video surveillance systems
____ Computer-Aided Dispatch (CAD)
____ Automatic Vehicle Location (AVL) for conventional buses
____ Real-time schedule adherence monitoring
____ Real-time customer information systems (on-board next stop announcements/display)
____ Real-time customer information systems (at stops)
____ Real-time customer information systems (pre-trip on web or by telephone)
____ Engine and mechanical alarms
____ Automatic Passenger Counting (APC)
____ Transit Signal Priority (TSP) systems
____ Wireless internet access for customers
____ Smart card payment systems
____ AVL for specialized transit fleet
____ Automated computer-aided dispatching for specialized transit
____ Other ____

What do you see as **potential benefits**?
(P-primary; S-secondary, NP-Not pertinent)

____ Enhanced communications with bus operators
____ Enhanced operator and passenger security
____ Enhanced incident management and recovery
____ Systematic incident reporting
____ Improved service control
____ Improved service reliability
____ Reduced break-downs
____ Improved maintenance
____ Better handling of customer complaints
____ Better customer information (pre-trip)
____ Better customer information (on-board)
____ Better customer information (at stops)
____ Better market research data on customers (general)
____ Better data on customer activity (by route, by stop) for planning
____ Better data on running times for scheduling
____ Management of route deviation/demand responsive service
____ Reduced fare evasion
____ Reduced abuse/fraud by public/operators in case of accidents
____ Faster travel times through Transit Signal Priority
____ Other ____

D. OBSTACLES AND FACILITATORS

What are the **three top obstacles** hindering your ability to deploy transit ITS *(1-greatest obstacle*)

____
____
____

Were you aware of **Transport Canada's ITS Deployment Contribution Program** (that provided small ad-hoc competition-based contributions to assist in the planning/deploying of ITS projects) Yes ____ No ____

Did you submit a proposal in the three previous programs (2000, 2002, 2005)
Yes ____ No ____

Did you consider but not submit a proposal? ____ No ____ Yes
If yes, why not? ____________________

Would the existence of **incentive funding** in the future help to encourage launching a project in your transit system?
Yes ______ No ______

In terms of **knowledge of Transit ITS**, would you consider yourself (or staff):
____ Very knowledgeable and up-to-date on Transit ITS?
____ Knowledgeable
____ Lacking in knowledge
Comments? ____________________

Do you have the **internal resources** to: *(Indicate Y-Yes or N-No)*
____ Plan for a Transit ITS project
____ Develop the justification to seek capital budget approval
____ Oversee project development and implementation
____ Oversee any external consultants that would be hired to assist you

Are you aware of the **Canadian ITS Architecture**? Yes ____ No ____

Are there **any actions by federal or provincial governments** that would help overcome obstacles and facilitate planning or implementing Transit ITS projects? ____________

____

Can you suggest **any topics for research** or areas where you would like to see **more information**?
____

____

E. REGIONAL TRANSIT ITS PROJECTS

Is your transit system **located in a metropolitan area** (Toronto, Montreal, Quebec, Edmonton)?
Yes _____ No _____ (If "No", **skip to part F**)

Is your agency **participating in a region-wide Transit ITS project** (e.g. Smart Card, Traveler Information)
No ____ Yes *(If yes, what type of project(s)?)* ____________________
____

What is the level of your involvement in this project?

____ Extremely involved (e.g. participation in frequent meetings, staff dedicated to the project)

____ Involved (will benefit from activities of larger or regional agencies)

____ Peripherally involved

Do you feel that the **presence of regional agencies or larger transit systems has benefited your transit system** in terms of knowledge, support, etc? (*Please explain)*

____

Are there any **specific issues that arise from the multi-agency regional context** that affect Transit ITS?

____

F. OTHER COMMENTS?

Do you have any **other comments**?____

____

____

____

____

Thank you for your participation in this survey.

Please feel free to call (**Brendon Hemily, Tel: 416-466-5635**) if you have any questions.

Please return the completed survey to **brendon.hemily@sympatico.ca**
by JANUARY 5, 2007

APPENDIX D SURVEY RESPONDENTS

(Bus fleet size indicated in parentheses)

Alberta
Lethbridge Transit (37)
Strathcona Transit (71)

British Columbia
Kelowna Regional Transit (47)
Nanaimo Regional Transit (41)

New Brunswick
Codiac Transit Commission (28)
Fredericton Transit (26)
Saint John Transit Commission (49)

Nova Scotia
Kings Transit Authority (11)

Ontario
Barrie Transit (37)
Cornwall Transit (19)
Kingston Transit (36)
Niagara Transit (23)
North Bay Transit (28)
Sarnia Transit (25)
Sault Ste. Marie Transit (28)
Stratford Transit (14)
Thunder Bay Transit (49)

Quebec
CIT Vallée du Richelieu (31)
MRC de l'Assomption/Ville de Repentigny (28)
Société de transport de Sherbrooke (STS) (69)
Société Gestrans (75)