



Editor: Alberto Broggi
University of Parma, Italy
broggi@ce.unipr.it

ITS, Eh! Meet Canada's Flagship ITS Centre and Testbed

Baher Abdulhai, *Intelligent Transportation Systems Centre and Testbed,*
University of Toronto

This installment provides an example of Canadian joint research and deployment efforts in ITS. The University of Toronto and Toronto Transportation Authorities have defined a common testbed for studying and validating possible joint actions to reduce travel time and improve transportation quality, therefore saving on fuel as well.

If you have any comment on this department, feel free to contact me. I also seek contributions on the current status of ITS projects worldwide as well as ideas on and trends in future transportation systems. Contact me at broggi@ce.unipr.it; www.ce.unipr.it/broggi.

—Alberto Broggi

Ontario has always been a Canadian leader in recognizing the importance and potential of applying emerging technologies to address significant mobility, environmental, and economic challenges in transportation.

The first large-scale application of computerized signal control systems, Torontonians brag, was in Metropolitan Toronto during the early 1960s. More recently, changeable-message-sign driver information systems (such as COMPASS, www.mto.gov.on.ca/english/traveller/compass) for freeway control have been introduced in the Greater Toronto area. Also, an imaginative public-private sector initiative has introduced North America's first comprehensive electronic tolling system, the 407 Express Toll Route, on Highway 407.

Although Toronto is a leader in ITS deployment, an equally large-scale research focus has been absent. The "intelligence" in ITS stems not only from high-tech gear but also from high-end intelligent systems—the computer programs that make the high-tech gear tick. To meet the need for such ITS research and development, the University of Toronto recently established the state-of-the-art Intelligent Transportation Systems Centre and Testbed (www.civ.utoronto.ca/its).

Defining ITS

At the University of Toronto, our definition of ITS is broad and inclusive. It involves applying information technology and other advanced methods and techniques to improve transportation system performance and to increase these systems' contribution to our economic and

social well-being. We're interested in all transportation forms: private road-based (cars, trucks), public transit (buses, subways, and so on), and nonmotorized (walking and bicycles). The transportation system is highly multi-dimensional. Addressing transportation problems involves a complex interplay between technology; human perception; cognition and behavior; and social, economic, and political systems. So, transportation research is inherently multi- and interdisciplinary.

The heart of ITS undoubtedly lies in gathering and using system information in real time to improve real-time control of the system. In so doing, the intention is to reduce both delay due to congestion and other unwanted system "externalities" such as accidents and pollution. Developing such real-time information and control systems involves a wide variety of interconnected research problems that can be

- Technical (sensor, communication, and computing hardware; automated vehicle technology; and so on)
- Methodological (control systems theory, traffic flow theory, AI, very-large-scale database management and other software requirements, simulation methods, image processing, and so on)
- Behavioral (driver-vehicle interactions, traffic controller-control display interactions, user decision making in response to information and other stimuli, and so on)

In addition, system design and transportation policy development must address longer-term issues that affect transportation system performance, including

The Challenge of Canadian Transportation

Transportation plays a fundamental role in societal fabrics and national economies worldwide. Canada is no exception. The efficient, safe, cost-effective movement of people and goods is so central to our daily lives that we tend to take the transportation system for granted until it fails. The main reason for such failure is that demand outpaces supply, for numerous good and bad reasons.

Renewed worldwide interest recognizes the importance of transportation infrastructure investment and maintaining an efficient, cost-effective transportation system to support economic and social well-being. In addition, advances in information technology, vehicle technologies, and industrial production systems, as well as increased understanding of our technological systems' local and global environmental impacts, are creating opportunities for and challenges to transportation system planning, design, and operation that we must address. In the US, for example, the TEA-21 program is investing 217.9 billion dollars in transportation infrastructure renewal and expansion over the next several years. In Canada, the challenge is to find fiscal and other means by which

we can upgrade our transportation systems to remain competitive in the North American and global marketplace and to maintain our quality of life.

Congestion is typically the most visible transportation issue for both the general public and decision makers, especially in large urban areas such as Greater Toronto. It costs businesses billions of dollars annually in lost productivity, and it generates considerable frustration, inconvenience, and stress among travelers attempting to move about the urban area during the course of their daily activities.

Congestion, however, is but one of many important issues regarding the transportation system. Safety is equally important; over 3,000 deaths occur annually on Canadian roads, along with huge economic and personal losses due to injury, property damage, and lost productivity. The environment and sustainability are also burning issues; the transportation sector produces 25 to 30 percent of Canadian greenhouse gas emissions. Other issues include the economic impact on and interaction with land use and urban forms, not to mention the impact on social and interpersonal interaction and on the quality of life.

- Long-term location choices of people and firms (such as where to live, where to locate a business, or where to work)
- Land development processes that influence the location choices
- Household auto ownership or transaction decision making
- The daily activities and travel behavior of households and individuals

These longer-term issues intersect with the real-time control problem in that decisions regarding location, activity, and travel manifest themselves as trips within the transportation system that must be managed in real time. (For more on the challenges of Canadian transportation, see the related sidebar.)

The Testbed

The Testbed provides an instrumented, multijurisdictional, multiagency transportation operations environment linked to university laboratories for real-world development, testing, and evaluation of ITS technologies and applications. It is also a meeting ground or melting pot for public, academic, and private practitioners and researchers to explore new approaches to transportation system management. It offers a site for private industry to demonstrate and evaluate its prototype technologies under live traffic conditions and an ongoing testing ground for Canadian ITS efforts. The Testbed will

- Accelerate ITS deployment through advanced R&D
- Demonstrate ITS deployment readiness before systemwide investments
- Identify and help resolve potential institutional barriers to assure seamless operation of an integrated multijurisdictional, multiagency transportation system
- Showcase Canadian ITS and boost the Canadian share of the international ITS market

Such a multistakeholder environment will facilitate an integrated approach to the development and deployment of advanced technologies for operating and managing urban transportation based on real-time, computer-assisted traffic management and communication.

Components

The Testbed has two major components:

- The University of Toronto research center (the ITS Centre)
- The physical Toronto transportation network, including surface streets, freeways, and the transit network

The ITS Centre, the Testbed's heart, includes workstations tied directly to the instrumented Toronto transportation network via *traffic management centers*, a

computer network for research and development, and a variety of software systems for transportation engineering and control. The Centre is establishing fast two-way communication via dedicated fiber-optic connections for collecting data from the transportation network and for possibly feeding back feasible control and management strategies to that network.

The Centre's R&D program focuses on the modeling and development of ITS modules that would enable real-time optimization, control, and management of dynamic, intermodal transportation networks. Because ITS application development relies on real-time knowledge of dynamic network conditions, real-time surveillance and control data are crucial. (For more on ITS and dynamic transportation, see the related sidebar.) However, although real data is extremely important, it is unlikely to cover all traffic scenarios necessary for comprehensive algorithmic development and validation. So, the Centre is developing an advanced, scalable traffic simulation model to provide a virtual replica of the Toronto transportation network.

ITS modules under development will communicate with real and virtual data sources and with each other through a *central communicator* module (see Figure 1). This module uses Fortran Traffic Systems' *Fastracs*, an advanced transportation man-

Dynamic Transportation and ITS

The aging “static” perspective of transportation systems has proven useless for both research and practice. Congested transportation systems involve time-dependent dynamic demands, time-varying supply (think of incidents), and imperfect knowledge of systems conditions for both operators and users. ITS can help capture the dynamic demand, detect the varying supply, communicate system state knowledge to operators and users, and formulate control and management strategies.

agement system. All modules and the central communicator will be “plug and play” to enable continuous development and the replacement of older modules with newer ones as they emerge. Upon completion of the first generation of these modules, the overall system will offer an integrated transport control and management solution. This system will be subject to continuous development to benefit from advances in knowledge and in computing, communication, and information technologies.

The founding partners

Transportation generally is a public commodity. Public agencies usually fund the research. Private organizations are usually consultants and contractors whose activities

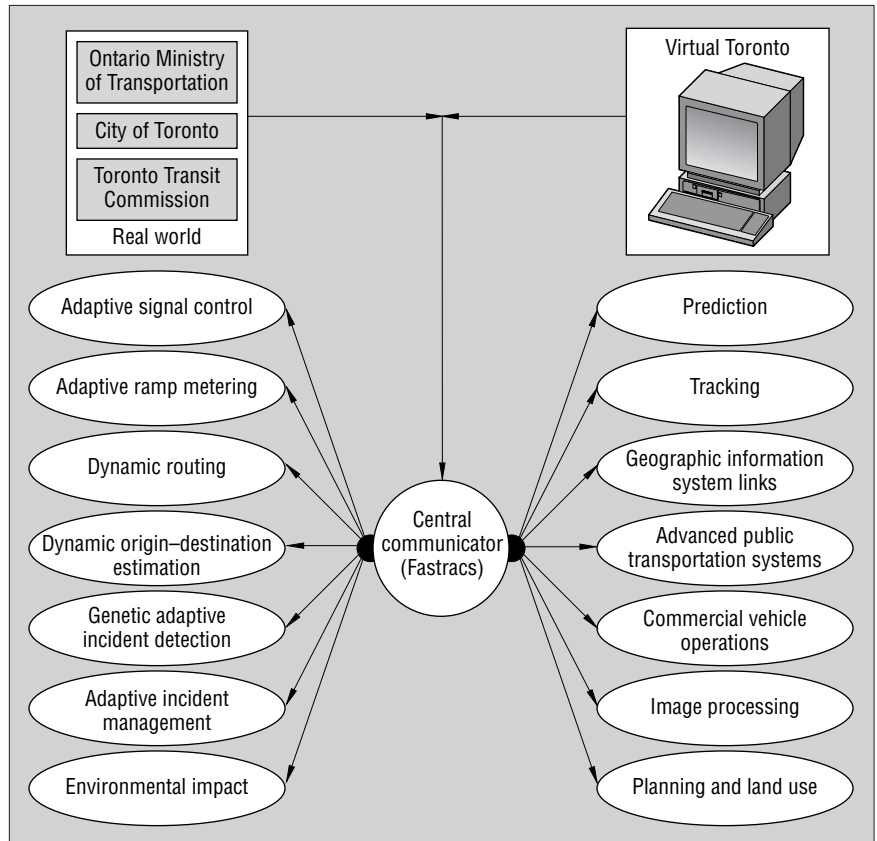


Figure 1. Ongoing research.

include infrastructure construction as well as system and software development for public transport agencies. Academics focus on pushing the envelope, expanding the frontiers of knowledge through intensive research.

Recently, however, the field has been

moving toward employing sophisticated technology that calls for collaboration between the public, private, and academic sectors. The Testbed partners (see Table 1) cover these three sectors, offering monetary and in-kind contributions to the Testbed. In return, a dynamic Canadian ITS industry will undoubtedly enhance the level of service and increase the partners’ share of the ITS market, nationally and internationally.

Researchers

Currently, an ITS research “cluster” involves 16 faculty members in five departments from two faculties (see Table 2). Eventually, we could expand the cluster, both within the currently committed departments and to other departments such as the Department of Geography and the Department of Economics, as well as to the Faculty of Architecture, Landscape, and Design (for example, urban design issues); the Faculty of Law (for example, legal issues in real-time control of transportation systems); and the Faculty of Management (for example, logistics issues).

Table 1. Current Testbed partners.

Sector	Participant
Academic	Univ. of Toronto
Private	Toronto Hydro Toronto and Area Road Builders Assoc. Heavy Construction Assoc. of Toronto Fortran Traffic Delcan Corp. IBI Group iTrans Consulting ITS-Canada Canadian Urban Transit Assoc.
Public	Canada Foundation for Innovation Ontario Innovation Trust Transport Canada Ministry of Transportation of Ontario City of Toronto Toronto Transit Commission Ontario Research and Development Challenge Fund


Table 2. Testbed partners.

Faculty and department	Focuses
Faculty of Applied Science and Eng.	
Dept. of Civil Eng.	Real-time control of freeway operations ITS architecture Air quality impact ITS freight applications Traveler behavior and urban simulation modeling ITS public-transit applications
Edward S. Rogers Sr. Dept. of Electrical and Computing Eng.	Hybrid systems and control of automated vehicle systems Sensor technology for driver assistance and automated control Ambient intelligence systems Mobility and traffic analysis Multimedia processing Adaptive signal processing, control, and fault diagnosis for ITS
Dept. of Mechanical and Industrial Eng.	Information communication between people and networks Sensors and actuators for driver assistance and automated control Operations research applications in ITS and logistics Influencing driver responses through visual perception
Faculty of Arts and Science	
Dept. of Computer Science	Human-computer interface design and mobile-interface design Computer vision, object recognition, object tracking, mobile robotics, and vision-based navigation
Dept. of Psychology	Visual attention, eye movements, and aging Eye tracking, and perception and cognition

Our vision is for the university community, public agencies, and the private sector to consolidate their expertise and innovative capacities to solve growing transportation problems nationally and internationally. As transportation problems grow increasingly complex and become global, and with the advent of ITSs that reach beyond the con-

ventional civil-engineering approach to transportation, the time has come for Canadian universities to expand and create a

truly multiagency, multijurisdictional R&D capacity. The ITS Centre and Testbed is the first step in this direction. ■



Baher Abdulhai is the director of the University of Toronto's Intelligent Transportation Systems Centre and Testbed. His research interests are Advanced Traffic Management and Information Systems, modeling and simulation for dynamic transportation networks, and the application of emerging technologies and advanced computer techniques to ATMISs and infrastructure. He received his BSc and his MSc in civil engineering from Cairo University and his PhD in civil engineering from the University of California, Irvine. Contact him at the Intelligent Transportation Systems Centre and Testbed, Dept. of Civil Eng., Univ. of Toronto, 35 St. George St., no. 105, Toronto, ON M5S 1A4, Canada; baher@ecf.utoronto.ca; www.civ.utoronto.ca/its.

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