Transportation Development Centre

Annual Review

2000 - 2001

CELEBRATING 30 YEARS

Transport Canada / Transports Canada

Canada

We welcome your comments and questions about the *Annual Review* and our R&D program.

800 René Lévesque Blvd. West
Suite 600
Montreal, Quebec H3B 1X9

Telephone (514) 283-0000
Facsimile (514) 283-7158
E-mail tdccdt@tc.gc.ca
Web site www.tc.gc.ca/tdc/index.htm

Published by authority of the Minister of Transport
Government of Canada

Catalogue No. T47-1/2001
ISBN 0-662-66015-3
ISSN 0840-9854
TP 3230

Annual Review

Fiscal year ended 31 March 2001

Transportation Development Centre
Transport Canada

TDC's 30th Anniversary Reception

TDC marked its 30th year as Transport Canada's centre of excellence for research and development with a reception held on December 14, 2000. More than a hundred people came to toast TDC's past achievements and future success.

Message from the Executive Director

It is my pleasure to present the *TDC Annual Review 2000-2001*, summarizing the activities and accomplishments of Transport Canada's Transportation Development Centre (TDC) for the fiscal year ended 31 March 2001.

TDC's research program responds to the priorities established by the department's R&D Management Board. It addresses policy issues, regulation and safety, and technology development and transfer. The research findings support strategic planning and decision-making in the department, the federal government as a whole, and the Canadian transportation sector.

For the program to be fully effective, a coordinated, strategic approach to R&D is essential. This requires the establishment of a broad range of partnerships with other federal departments, international research organizations, the private sector, the provinces, and academia. This year TDC forged new partnerships in a number of research areas, including runway friction measurement, highway-railway grade crossing safety, school bus safety, and electric vehicle research. In addition, the emphasis on multimodal R&D increased, particularly in fatigue studies and in the development of training programs.

TDC celebrated its 30th anniversary this year. Throughout the years, the challenges have changed, but the commitment to innovation in transportation has remained the same, earning TDC a reputation for research excellence that extends beyond Canada's borders.

In the coming year I look forward to developing TDC's R&D program in support of the department's Transportation Blueprint initiative, which is formulating a federal strategy to respond to the challenges facing Canada's transportation over the next decade and beyond. I know that I can count on the expertise, professionalism, and dedication of TDC staff and on the continuing support of our clients and partners in the department and in the transportation community at large.

Nicole Pageot

Executive Director
Research and Development

1. Guests listen to Bill Elliott's address.
2. John Gratwick (left), founding chairman of the original Transportation Development Agency, reminisces with Pierre Alepin, a former TDC employee.
3. Bill Johnson (left), then TDC's Executive Director, with Gus Pokotylo, formerly Director General, Research and Development
4. Bill Elliott, Assistant Deputy Minister, Safety and Security, Transport Canada, speaks to the guests.
5. Ted Rudback, former Executive Director, shares a joke with Barbara Jamieson Smith, TDC's expert on accessible transportation.
6. Marc Brenckmann (left) and Peter Eggleton, both formerly with TDC, talk about old times.
7. Tony Frayne, former TDC employee.
8. Elizabeth Hollingsworth, consultant, with TDC's Barry B. Myers.
9. Helena Borges, Director, Rail Policy, Transport Canada, with Mike Ball, TDC's Chief, Research Policy and Coordination.

TABLE OF CONTENTS

TDC Profile

TDC's research and development program is aimed at ensuring that Canada's transportation system remains safe, smart, strategic, and sustainable.

TDC, Transport Canada's centre of excellence for research and development, manages a multimodal R&D program aimed at improving the safety, security, energy efficiency, and accessibility of the Canadian transportation system, while protecting the environment. Its mandate is to enhance the department's technological capability, to address the department's strategic objectives and federal government priorities, and to promote innovation in transportation.

TDC is headed by the Executive Director, Research and Development, and staffed by a multidisciplinary team of engineers, planners, economists and ergonomists, who plan and formulate projects in collaboration with departmental clients. A research library and a communications unit document and disseminate information. Financial, administrative, and informatics units provide support services.

R&D Program

TDC's R&D program includes activities in all transportation modes and all stages of the innovation cycle – from concept definition to demonstration and deployment. The projects are contracted out to the agencies best qualified to do the work. Contractors range from consultants, manufacturers, and operators to research groups and universities.

Working closely with these contractors and with Transport Canada clients, TDC's professional staff plan and organize activities throughout a project and facilitate application of the end products in Canada's transportation network. They also provide a range of technology intelligence services for Transport Canada and other Canadian stakeholders.

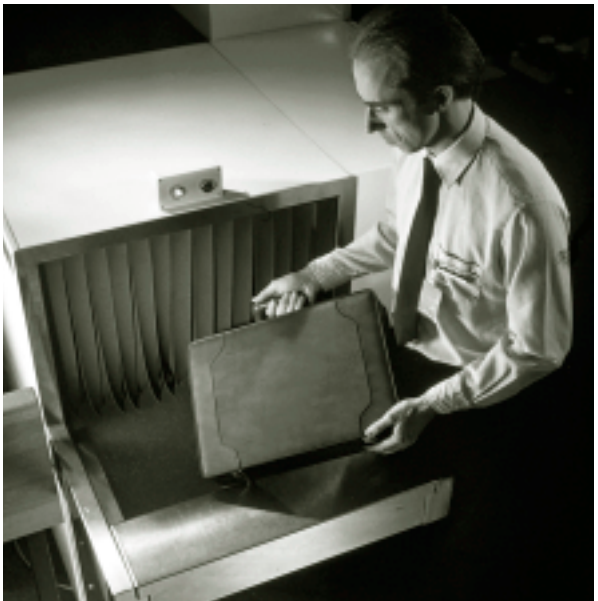
The greater part of the program addresses the specific concerns of the Safety and Security Group. Many projects are part of long-term initiatives with broad objectives, such as research to increase the safety of winter aviation; others are cooperative ventures with various government departments, the provinces, and industry, such as the highway-railway grade crossing research program.

Internationally, TDC cooperates with research groups in the United States, Mexico, South America, Europe, and Pacific Rim countries, as well as with regional economic associations such as NAFTA, APEC, and the European Union. It participates in major cooperative ventures through memoranda of understanding, intergovernmental agreements, and scientific exchanges.

In addition to developing new technology, TDC supports decision-making through its intelligence-gathering activities, providing clients with information and expert advice related to the impact of technology on critical transportation issues. This year, for example, TDC published a report on the effects of two vision enhancement systems on the driving performance of elderly persons.

Program Administration and Funding

The Transport Canada R&D Management Board is responsible for administering research funds, monitoring departmental R&D, and allocating central funding. A Technical Advisory Committee, made up of representatives from across the department and headed by TDC, provides



the Board with specialist and technical input on research priorities.

Special programs augment departmental funding. In 2000-2001 they included:

- the federal Program of Energy Research and Development, administered by the interdepartmental Panel on Energy Research and Development and chaired by Natural Resources Canada
- the New Initiatives Fund of the National Search and Rescue Secretariat, administered by the Department of National Defence

Joint and cost-shared initiatives with other departmental and federal organizations, provinces, municipalities, and industry provide another source of funding. In addition, in 2000-2001, financial support came from NASA, the Federal Highway Administration, and the Federal Aviation Administration for specific activities under joint programs with the U.S.

The *Financial Overview* on page 19 provides a detailed breakdown of TDC's funding and funding sources for 2000-2001.

R&D Highlights

Canadians face the challenges of competing in a faster-paced, technology-driven world economy.
An innovative economy is driven by research and development.

Speech from the Throne, 2001

Air Safety

Tests at Erding Army Base in Germany extended the data acquired in the Joint Winter Runway Friction Measurement Program (JWRFMP), an international initiative managed by TDC on behalf of Transport Canada's Civil Aviation Directorate. The tests were made with a Fairchild/Dornier 328 aircraft and ten ground friction measurement vehicles. To date, the program has collected the results of over 300 valid test runs with aircraft and 15 000 with ground vehicles. The data is being used to develop an **international runway friction index** that will help pilots and airports to determine safe landing distances in winter conditions.

Canadian partners in the JWRFMP include the National Research Council Canada and the Canadian Department of National Defence. International members include the U.S. Federal Aviation Administration; NASA; the U.S. Air Force; the International Civil Aviation Organization; the European Joint Aviation Authorities; U.K., French, Norwegian, Swedish, and German civil aviation authorities; airport administrations; airlines; and aircraft and aviation equipment manufacturers.

An **emergency locator transmitter (ELT) integrated with Global Positioning System (GPS) information** has been approved by COSPAS-SARSAT for international use in aircraft. COSPAS-SARSAT maintains an international satellite system for search and rescue that provides distress alert and location information to rescue authorities anywhere in the world.

The innovative ELT, developed in a TDC project, uses an interface circuit to extract location data from the aircraft's own GPS and incorporate it into the distress signal. A bank of rotary switches allows for setting of the aircraft's 24-bit address. This new system increases the speed of signal reception and the accuracy of target location, thus greatly facilitating search and rescue operations.

TDC has received a recognition award from the European Organization for Civil Aviation Equipment for its outstanding contribution to the development and writing of minimum **performance specifications for ground ice-detection systems**. Undetected frozen contamination may pose a serious hazard to aircraft at takeoff; ground ice-detection systems provide ground and flight crews with accurate information on the condition of aircraft surfaces just prior to takeoff.

As chair of the working group responsible for the work, TDC provided critical technical input based on its long-term research on such systems.

R&D Highlights


Canadian Steamship Lines

The specifications are the culmination of three years' work with the international aviation community.

Marine Safety

In response to recommendations by the Transportation Safety Board of Canada, TDC investigated the problem of **fire safety on self-unloading bulk carriers**. Preventing, detecting, and extinguishing fires on these carriers can be challenging because of the unloading system's confined tunnel spaces and open elevator casings.

A research team surveyed the Canadian self-unloader fleet, analysing the risks associated with different types of cargoes and reviewing current fire-safety systems, recent trials of such systems, and applicable North American regulations. The survey focussed on the unloading tunnel area, which is difficult to reach with some firefighting equipment. In addition to the risk assessment, the team prepared situational and consequence analyses.

Transport Canada's Marine Safety Directorate and other stakeholders are studying the survey findings. If deemed necessary, the research team will develop risk mitigation methods and fire-safety arrangements for specific situations.


Sample screen of the ice navigation simulator

An **ice navigation simulator** developed in a TDC project is now ready for operational use. Designed for entry-level ice navigators, the PC-based, low-cost simulator uses virtual reality, interactive techniques, and multimedia hardware and software to facilitate training and to reduce the requirements for on-board experience. Its visual rendering rivals that of much more expensive models. The simulations cover a broad range of specific ice navigation scenarios and incorporate data on ice regime rules and ice climatology.

As part of its commitment to technology transfer, TDC is now promoting use of the simulator through Canadian marine training institutes and the International Maritime Organization.

Road and Rail Safety

Forewarn

A survey of pedestrian **safety equipment on school buses** in Canada and the United States was initiated this year. It was designed to assess the use, operation, and reliability of equipment such as crossing arms, video cameras, radar and acoustic detection systems, and skirts.

The survey was posted on Transport Canada's Web site and responses were solicited from provincial school transportation ministries, school boards, school bus operators, and safety equipment manufacturers and distributors. The U.S. National Association of State Directors of Pupil Transportation Services is coordinating the U.S. portion of the survey. After analysing and interpreting the responses, the survey team will report on operational experience with the various devices.

This project is part of a larger school bus safety program guided by TDC, Transport Canada's Road Safety Directorate, the Ontario and Quebec ministries of transportation, other provincial authorities, and the Société de l'assurance automobile du Québec. Canadian authorities responsible for the transportation of school children are kept up to date with the group's findings.

The first project under the Highway-Railway Grade Crossing Research Program was completed in March 2001. The program, sponsored by Transport Canada, major Canadian railways, and several provincial authorities, is a component of *Direction 2006*, a cooperative initiative with the goal of halving grade crossing accidents by 2006.

The study investigated the way Canadian federal and provincial authorities treat **contraventions at grade crossings involving heavy commercial vehicles**, such as cube vans, tractor semi-trailers, and passenger buses. The researchers found that drivers, operators, and regulators all take crossing contraventions seriously and would welcome measures to improve safety. They recommended improving the contravention database, standardizing treatment across the country, and raising awareness of safety measures among commercial drivers and operators.

Operation Lifesaver

R&D Highlights

Security

TDC works in close cooperation with the United States to continually improve the security program through technological innovation. This year work continued on advanced technologies for detection of explosives and other threats, development and evaluation of an integrated security system, and improvement of the human-machine interfaces of civil aviation security systems.

Intelligent Transportation Systems (ITS)

To achieve the maximum benefits from ITS, common standards for basic hardware, data formats, and communication protocols are essential. TDC and other Transport Canada representatives are active members of the International Organization for Standardization (ISO) Technical Committee 204, the international forum for development of such standards. Recent achievements include the acceptance of a **common standard for dedicated short-range communications** (DSRC) for commercial vehicle applications and approval of a system that will allow the DSRC equipment to support a wide variety of functions using a single transponder.

Related work includes the development of a draft standard for a data dictionary and message sets for the **electronic identification and monitoring of dangerous goods**. The standard will help to speed up emergency response times as well as to improve the tracking of dangerous goods in transit.

In January 2001 stakeholders reviewed the draft at a workshop organized by TDC in Washington, D.C. Participants included representatives of Canadian, U.S., and Mexican government transportation authorities; rail and trucking industries; ITS America and ITS Canada; the U.S. Chemistry Council; and the U.S. Uniform Code Council.

The standard is now being amended to address the concerns voiced at the workshop. The revised draft will then be submitted for approval to the ISO working group responsible for defining standards for systems that facilitate commercial vehicle operations.

Port of Montreal Authority

Port of Montreal Control Centre

In continuing work to streamline the multimodal operations at the Port of Montreal, researchers completed a **design for an Extranet system**, a private electronic network separated from the Internet by a firewall. The system will facilitate communication among all those involved in the port's activities: shipping lines, terminal operators, freight forwarders, trucking and rail companies, and government authorities.

The design takes into account the needs of the many users and is flexible enough to easily accept new functions and changes to business practices or regulations. It also ensures security of information and allows for development of a comprehensive database on port operations.

A **feasibility study of STARS**, a System for Technological Applications in Road Safety developed by the Société de l'assurance automobile du Québec (SAAQ), confirmed that it could effectively meet the needs of other provinces. A computer- and communications-based traffic safety system, STARS facilitates the work of police officers by automating data entry, data retrieval, and the issue of citations and reports. It can also provide access to provincial and national police information services.

The investigators assessed the system's capacity to meet user and operational requirements in Alberta and Manitoba and identified potential technical problems. They also estimated the benefits and costs of using STARS within existing systems and of alternative approaches that may require modification or replacement of existing systems.

The work was done in cooperation with Transport Canada's Road Safety Directorate, Alberta Transportation, the Manitoba Department of Highways and Government Services, and SAAQ.

William F. Johnson, then TDC's Executive Director, received an **award for continuing support of ITS development** at an ITS Canada reception in Toronto on October 23, 2000. The award underlines the association's appreciation of Dr. Johnson's work as Treasurer-Secretary from 1996 to 2000 and his contribution to the success of the 6th World Congress on Intelligent Transport Systems.

R&D Highlights

Engineered Casting Solutions

MMC brake rotor

Energy and the Environment

Researchers are investigating the technical and economic feasibility of using lightweight **metal-matrix, composite (MMC) materials in brake drums and rotors** for heavy-duty vehicles.

The study began with a literature review, database searches, and interviews to determine the current market and regulatory situation. The researchers developed an analytical model to identify the physical properties required for MMC materials that could withstand the demanding braking duty cycle of many heavy vehicles. They also prepared a cost-benefit analysis of various MMC brake options, taking into account the manufacturing processes involved and the weight saved.

Preliminary results indicate that MMC materials are more suitable for drums than for rotors. They also suggest that the best approach may be to focus on markets where reduced weight offers the most benefits, e.g., urban buses and garbage trucks.

In a joint Canada-U.S. project, shakedown tests of an innovative, **accessible, hybrid electric taxi** began this year. The taxi has a GSM E-series body shell combined with a hybrid electric powertrain developed with funding from the New York State Energy Research and Development Authority.

GSM Vehicles

It features an energy-efficient propulsion system; lightweight, composite material construction; monocoque design; and capacity for two wheelchairs. It can also accommodate a driver in a wheelchair.

Following controlled tests to measure its dynamic performance, fuel consumption, and emission performance, the prototype taxi will be demonstrated to taxi operators in Montreal and New York City.

TDC collaborated with the Centre d'expérimentation des véhicules électriques du Québec and several other partners in ***Electric Bike 2000***, an evaluation of electric bikes conducted in four Canadian cities from June to October 2000. Over 360 volunteers travelled a total of 25 200 km on 15 different models and completed questionnaires related to the bikes' performance.

The positive results formed a sound basis for Transport Canada's revision of the Motor Vehicle Safety Regulations related to electric bikes, which now permit their importation and sale. In addition, Quebec plans to authorize the use of electric bikes and low-speed vehicles on public roads by 2002 and other provinces are expected to follow suit.

In work to help Transport Canada establish a Canadian strategy for reducing locomotive emissions, TDC studied the **effects of diesel-fuel quality on locomotive exhaust emissions**.

The research showed that 60 percent of the railway diesel fuel used in Canada comes from tar sands in Western Canada. The remainder is derived from conventional crude oil. Although they differ in viscosity, density, and cetane number, both types produce emissions well below the agreed-upon cap for nitrogen oxides.

The project report notes that since older locomotives produce 50 percent of total emissions, considerable reductions can be expected when they are replaced with new, higher-horsepower, fuel-efficient models.

Another study is investigating technologies that could **reduce locomotive emissions without a fuel consumption penalty**. The work involves ranking candidate technologies, not only by their ability to reduce emissions and their effects on fuel consumption, but also by technological readiness, cost of implementation, and applicability to Canadian conditions.

The results will assist the Canadian railway industry, particularly engine makers, engine component manufacturers, and retrofit kit suppliers, in complying with recently implemented U.S. Environmental Protection Agency (EPA) emission standards. Canadian locomotives operating in the U.S. on more than a casual basis must meet these standards.

An **evaluation of prototype steered-frame freight car trucks** is showing promise. Two trucks have been modified to fit under a lightweight aluminum coal car. Following vehicle dynamics and curving simulations, the prototypes were successfully tested at the National Research Council Canada's Centre for Surface Transportation Technology. Further tests are now in progress in Pueblo, Colorado, under the American Association of Railroads' Advanced Freight Car Truck Program for Bulk Commodity Cars.

Early results show that because the trucks are 3600 lb. lighter than conventional models, the cars can safely carry this weight in extra coal. In addition, the steering feature of the trucks reduces lateral wheel-rail forces, thus improving stability and lowering the risk of derailment. The tests also indicate that the trucks have improved rolling resistance, a quality that significantly reduces fuel consumption and decreases wear and tear on wheels and track.

Surface mining of tar sands in Alberta

R&D Highlights

Accessibility

A cross-Canada survey provided data for research on **facilities to assist travellers with disabilities in boarding small aircraft**. Airport authorities, aircraft carriers, and equipment manufacturers answered questions on the numbers of different devices (boarding chairs, lifts, ramps) in use; their compatibility with the different types of small aircraft; and their cost, ease of use, and acceptability to travellers with disabilities.

At a workshop held in November 2000, the researchers presented their preliminary findings and solicited the opinions of stakeholders, particularly wheelchair users. After analysing the data acquired, they recommended the development of an ergonomically improved boarding chair and of in-cabin features to improve accessibility. They also stressed the importance of training staff in the use of boarding equipment.

A committee of representatives from 13 countries is developing International Organization for Standardization (ISO) **standards for accessible pedestrian traffic signals** designed to assist people who are blind or visually impaired. TDC is supporting Canadian participation, to ensure that the specific concerns of Canada's government and advocacy groups will be addressed.

The Canadian National Institute for the Blind formed a working group, made up of members of the Canadian Council of the Blind, mobility and orientation practitioners, and traffic professionals, to formulate Canada's position for presentation at the ISO meetings. The committee hopes to complete the standards within two years.

Driver rehabilitation specialists, ergonomists, drivers, manufacturers, and installers provided input to a recent **evaluation of left-foot accelerator pedals**. The investigators assessed a variety of designs and installations, and gathered data on their use and misuse.

The work included analysis of the driving task with these pedals, development of a technical database, and ergonomic and engineering analyses. The results indicated that while the pedals are generally safe, they are not all easy to install and use.

The study report is intended to provide a basis for the establishment of guidelines governing the design and installation of left-foot accelerator pedals. It stresses the importance of gaining the cooperation of industry organizations.

Human Factors

In response to recommendations from the Transportation Safety Board and the Ministerial Review of Outstanding Pilotage Issues, development of a **fatigue management program (FMP) for marine pilots** began this year.


Rhodes & Associates Inc.

A meeting held in January 2001 gave marine pilots, pilotage authorities, ship operators, and other stakeholders an opportunity to air their concerns, to learn about the objectives of the research, and to examine U.S. practices. Participants then established a framework for an FMP that would meet their needs.

Program development will take into account pilots' tasks, schedules, and working environment, as well as other factors that can cause fatigue. The program will include training modules on coping strategies related to circadian rhythm, sound sleeping and napping habits, and lifestyles.

To assist Transport Canada in establishing policies for the implementation of marine FMPs, the research team will also develop guidelines and evaluation procedures.

A TDC study is investigating the **factors contributing to the high number of accidents at intersections among elderly drivers**. The aim is to determine the difficulties and the compensatory strategies of older drivers.

The investigation includes discussions with focus groups, driving simulation tests, an eye movement study, and a survey. To allow comparisons, both older and younger drivers are participating. The research team will use the results to identify intelligent transportation systems that could alleviate the difficulties of older drivers.

Recognizing the high stress and irregular hours associated with the work of aircraft maintenance engineers (AMEs), TDC and Transport Canada's Civil Aviation Directorate initiated a project to develop **fatigue management guidelines for air carrier maintenance services**. The guidelines will take into account scheduling, working environment, sleep cycles, and proven fatigue countermeasures.

Having completed a preliminary literature review and a detailed survey of AMEs, the researchers are now analysing the data. The results will help them to determine the best approach to fatigue management in this field.


Airbus


Marine Atlantic

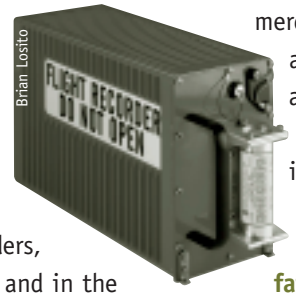
Outcomes

Our goal should be nothing less than the best transportation system in the world.
New technology … will help to make our transportation system more efficient and more environmentally friendly.

David M. Collenette, Minister of Transport

TDC's research program serves to increase the understanding of complex technology issues in all modes, often providing the basis for continuing innovation by industry, government, and research organizations. Many projects also develop advanced technologies and improved designs that lead to further applications and new developments. The following examples illustrate the ongoing benefits of TDC's work for the Canadian transportation sector.

As part of a review of aviation safety regulations, Transport Canada and the U.S. Federal Aviation Administration are now considering recommendations for the most **effective locations for flight data recorders**. The recommendations, based on a 1995-96 TDC study, call for the use of combined flight data recorders and cockpit voice recorders, both in the cockpit and in the rear of an aircraft. The U.S. and Canadian Transportation Safety Boards agree that this could help to avoid loss of data and thus facilitate accident investigations.



Brian Losito

A new risk-assessment **method for determining the safety of ro-ro ferries** is now available. It marks the culmination of a long-term TDC program to provide a realistic basis for ro-ro safety standards. The method uses a computer-modelling tool – the Static Equivalence Method (SEM) – developed at the University of Strathclyde, Scotland, and enhanced in TDC work. Combined with route-specific wave climate data and, potentially, with traffic data, the SEM can determine reasonably consistent risk levels for all Canadian ferry services. Where risk is assessed as unacceptably high, it allows for operating restrictions if ship replacement is impractical or excessively costly.

Since the late eighties TDC has conducted studies and participated in cooperative research on operator fatigue with national, provincial, and U.S. authorities; industry; and research organizations. The work covers commercial vehicle drivers, marine and airline pilots, air traffic controllers, and ship's crews. The research has led to many improvements in fatigue management. This year TDC published a **compendium of best practices for fatigue countermeasures** in transport operations. The compendium contains key facts, implementation strategies, and results related to the most effective use of various countermeasures in all transportation modes.

Recommended practices include education programs on shift work, work and rest schedules, and proper regimens of health, diet, and rest; implementation of fatigue management programs; and avoidance of 12-hour shifts. The compendium will assist operators, carriers, and regulators in planning for optimal safety and efficiency.

Technology Transfer

A current pilot test of **safety incentive programs** in several commercial vehicle fleets is based on guidelines developed in earlier TDC work. The pilot test is a cooperative undertaking with the U.S. Federal Motor Carrier Safety Administration, Transport Canada's Road Safety Directorate, the Canada Safety Council, the Canadian Trucking Alliance, the Société de l'assurance automobile du Québec, the Université de Montréal, trucking companies, and insurance providers.

Participating commercial fleets (buses and trucks) in Canada and the U.S. are being assisted in implementing and monitoring the safety incentive programs. A research team will evaluate the results and modify the guidelines if necessary. The pilot test is intended to show trucking companies how incentive programs can increase both safety and productivity.

We have made great advances through technological innovation … we must continue to stay ahead.
No one player … is able to solve on their own problems as complex as safety [and] sustainable transportation.

David M. Collenette, Minister of Transport

The acquisition and dissemination of technology intelligence are high priorities for TDC. Professional staff monitor developments of potential interest to the department; host international delegations; initiate and participate in seminars, workshops, and conferences; and serve on national and international committees. Some highlights from 2000-2001 follow. Listings of committee and association memberships, presentations, and papers begin on page 24.

On April 4, 2000, TDC hosted the **spring meeting of the Society of Naval Architects and Marine Engineers (SNAME)** Montreal chapter. The Society, founded in 1893, is dedicated to advancing the art, science, and practice of naval architecture, shipbuilding, and marine engineering. Through its technical and research program, SNAME encourages and sponsors maritime research.

The highlight of the meeting was a paper on predicting ship performance in Labrador ice conditions, presented by the leader of the Ship Technology Research Group at the Institute for Marine Dynamics (IMD), St. John's, Newfoundland. Navigation in ice is an important concern for Canadian shipping.

Following the meeting, the IMD representative and TDC's marine research team discussed current and proposed cooperative projects.

Drive 2000, the **Fourth National Workshop for Driver Rehabilitation Specialists** working with elderly persons and persons with disabilities was held on May 5-6, 2000, at the Bloorview MacMillan Centre in Toronto. Sponsored and organized by TDC, the workshop attracted more than 100 driver rehabilitation specialists, driving instructors, vehicle modifiers, equipment manufacturers, and representatives of regulatory and licensing authorities, advocate groups, and funding agencies.

This year the workshop provided more than the customary forum for exchanging ideas and information. In addition to the usual presentations and exhibitions, a half-day Association of Driver Rehabilitation Specialists-accredited seminar was offered on how vision deficits in elderly persons and persons with disabilities can affect their driving.

At the closing dinner, TDC's *Barbara Jamieson Smith* was honoured with a special award in recognition of her pioneering efforts and long-term contribution to driver rehabilitation.

The **Fourth Global Aviation Information Network (GAIN) World Conference** took place in Paris from June 14-15, 2000. GAIN, an international group representing government, airlines, and research organizations, is dedicated to promoting worldwide sharing of aviation safety information.

At the conference, TDC presented the Aviation Safety Data Sharing System, an Internet-based tool developed as part of TDC's participation in GAIN. The system allows aviation personnel to submit a query to several airline safety databases at the same time and to receive a response derived from the previous experiences stored in these databases.

Technology Transfer

Canadian team at EVS 17

As part of Transport Canada's International Cooperation Program, TDC was host to a **delegation from the Hong Kong Transport Department** in September 2000. Presentations covered TDC's research role, rail-safety research, intelligent transportation systems, transportation accessibility, and Transport Canada's commitment to providing a safe and innovative transportation system.

The delegation was in Canada to study our railway industry, particularly the responsibilities and challenges facing both rail regulators and operators.

TDC also welcomed **visitors from Russia's Merchant Marine Research and Project Development Institute**. The Russians were in Canada to study various aspects of port administration, including research and development, aids to navigation, and handling facilities.

The visit included a trip to the Port of Montreal, where TDC is managing an intermodal technology project designed to improve the efficiency of container movement through the port. The ultimate goal is to achieve fully integrated electronic data interchange among port stakeholders and trading partners.

TDC was among the 1600 participants from 32 countries gathered in Montreal for EVS-17, the **17th International Electric Vehicle Symposium**. The symposium, held from October 15-18, 2000, covered technical advances, environmental and political issues, energy supply concerns, and marketing strategies. A brochure on TDC's EV program attracted considerable interest.

At a ride and drive session that was one of the highlights of the event, two Transport Canada EVs were in the line-up. They are part of *EV Project – Montreal 2000*, a TDC-initiated demonstration to evaluate about 20 EVs in commercial and institutional vehicle fleets.

The **Second Annual Workshop on Highway-Railway Grade Crossing Research** attracted twice as many participants as the kick-off workshop, indicating increasing support from Canadian and U.S. governments; rail carriers, suppliers, and associations; and research institutes.

The workshop, held in Montreal on November 15, 2000, was sponsored by Transport Canada's Rail Safety Directorate and organized by TDC. It gave stakeholders in the Highway-Railway Grade Crossing Research Program (see page 5) an opportunity to discuss the latest developments, resolve problem areas, and guide the evolution of the program.

Presentations covered a wide variety of subject areas, from development of accident databases to human factors analysis of crossing accidents.

Canada's situation regarding locomotive emissions was presented at a U.S. Department of Energy (DOE) **Workshop on Locomotive Emissions and System Efficiency**, organized by the Argonne National Laboratory in Illinois and held January 30-31, 2001. The presentation was based on recent TDC studies.

The workshop was held to allow U.S. and Canadian government agencies, locomotive manufacturers, suppliers, and rail operators to develop a sound framework for a proposed DOE research program. Topics included advanced technologies, aftertreatment techniques, fuels and lubricants, and modifications to systems and engines. The DOE plan calls for a major cooperative effort to find cost-effective means of reducing locomotive emissions without increasing fuel consumption.

TDC co-chaired an **Arctic Ship Technology R&D Workshop** hosted by the National Research Council Canada's Canadian Hydraulics Centre (CHC) in Ottawa on March 22, 2001. At the workshop, research partners from government and industry discussed the results of recent full-scale trials on the CCGS *Louis S. St-Laurent*. Part of long-term work on propeller blade

ice loads, these trials mean that Transport Canada now has comprehensive data on ice loads from pole to pole.

Participants discussed the application of the research results through development of standards and improvements to propeller design and shipping routes. They also explored opportunities for future collaboration.

Library and Information Centre

Library staff provide in-depth research services to support TDC projects. They screen information from the Internet, scientific databases, and journals, and relay it to TDC project managers. Relevant information is indexed in the library catalogue. The catalogue provides staff with access to the library's collection, as well as to electronic documents and Web sites.

Over the past year, the library's growing collection of digital images related to TDC projects has been made accessible through the catalogue. The library is evolving as part of a network as it collaborates with other members of the transportation community to provide global access to transportation technology resources.

Communications

The Communications Unit is responsible for the documentation and dissemination of technical and general information on TDC's research program. It produces reports, papers, presentations, exhibits, and conference literature.

The unit also maintains TDC's Web site. The site, which is updated monthly, includes project descriptions, report summaries, TDC news, and a list of publications. This year, work began on adding electronic versions of reports and presentations.

Support Services

TDC's Corporate and Informatics services work in close cooperation with research staff to ensure successful delivery of the R&D program.

Corporate Services

Financial Services provides consulting and advisory services to TDC's research staff and performs a full range of financial functions. The unit ensures compliance with the financial requirements for TDC's contracts through cost controls, auditing, and financial analyses. It also prepares the monthly reports needed for decision-making and effective financial management.

Administrative Services offers a complete range of office services: managing records and supplies; handling mail and other communication services; procuring equipment and supplies; and distributing TDC publications. This unit also manages a $1 million inventory of supplies and equipment.

Informatics Services

The responsibilities of TDC's Informatics Services include development of applications, maintenance and support of users' workstations, computer security, and the purchase of data-processing equipment and software. This unit also provides support and consulting services to TDC staff and maintains the daily operations of the local area network.

This year, Informatics personnel actively pursued the development of a project information management system (PIMS). Implementation of this key TDC application should be completed next year.

Financial Overview

This section provides a review of TDC's expenditures and funding sources for fiscal year 2000-2001, as well as a statistical analysis of its research program.

Financial Overview

Table 1 lists operating and program expenditures from Transport Canada funding sources. Departmental R&D program funding, $6.2 million in 2000-2001, was used to leverage substantial support from external sources, as seen in Table 2. This support increased the funding of TDC's research program by more than $2.7 million, bringing total R&D funds managed by TDC to over $9 million. Additional contributions from industry, government, and other sources increased the overall value of the program by another 47 percent, for a total value of $13.2 million. These contributions represent shared cost, in-kind, and other R&D expenditures that did not flow through TDC.

Table 1

2000-2001 Expenditures: Transport Canada Funding Sources

(Thousands of dollars)

Operating Costs	
Salaries*	1 710
Base operating costs	600
	2 310
R&D Program Expenditures	
R&D Management Board	4 705
Other departmental sources	1 540
	6 245

Table 2

2000-2001 R&D Expenditures: All Funding Sources

(Thousands of dollars)

All Transport Canada Sources	**6 245**
External Sources	
Program of Energy R&D – Natural Resources Canada	1 450
Other federal sources	255
Other Canadian sources	130
U.S.-Canadian Agreement on Cooperative Counter-Terrorism R&D	300
U.S. DOT	425
Other foreign sources	220
	2 780
Total TDC R&D Expenditures	**9 025**
Additional Contributions (estimated)	
Industry	2 340
Government & other sources	1 915
	4 255
TOTAL VALUE OF R&D PROGRAM	**13 280**

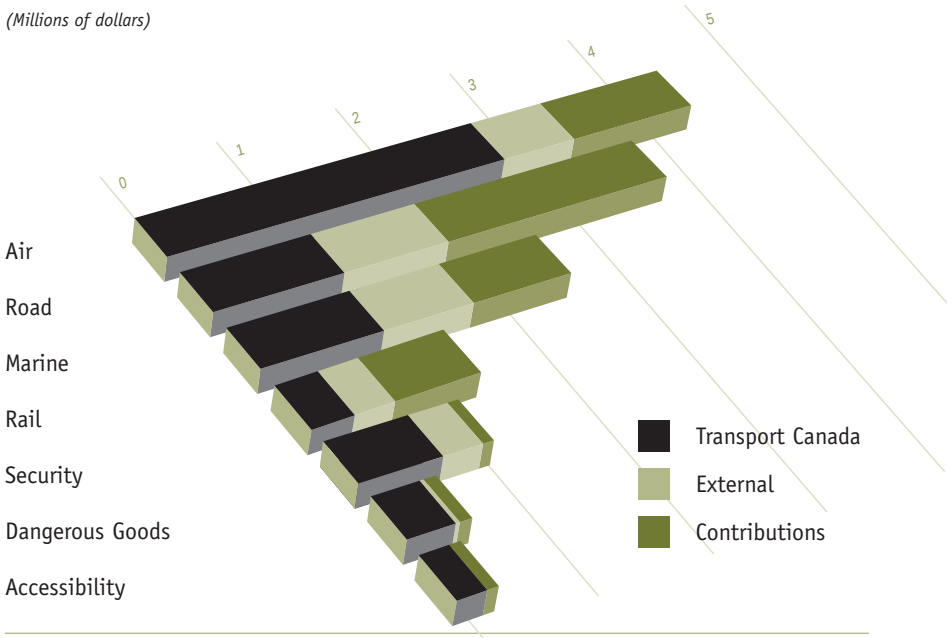
** Includes funds from the Program of Energy R&D – Natural Resources Canada*

The breakdown of R&D expenditures by program area and funding source presented in Figure 1 illustrates the importance of external funds and contributions to TDC's research program. Funding from external sources and in-kind contributions totalled more than $7 million in 2000-2001, serving to boost the value of the research program to more than double its Transport Canada funding base.

Figure 1

R&D Expenditures by Program Area and Funding Source

(Millions of dollars)



NOTE: ITS and Human Factors expenditures are rolled into the various modal areas.

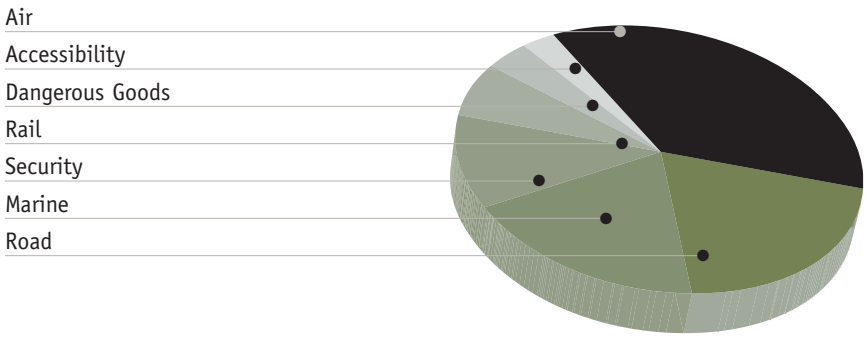
Total R&D expenditures: $9.03 million

Figure 2 provides a breakdown of R&D expenditures by program area. Expenditures in the air mode reflect TDC's leading role in international winter aviation research.

Figure 2

R&D Expenditures by Program Area

(Percentage of 2000-2001 expenditures)



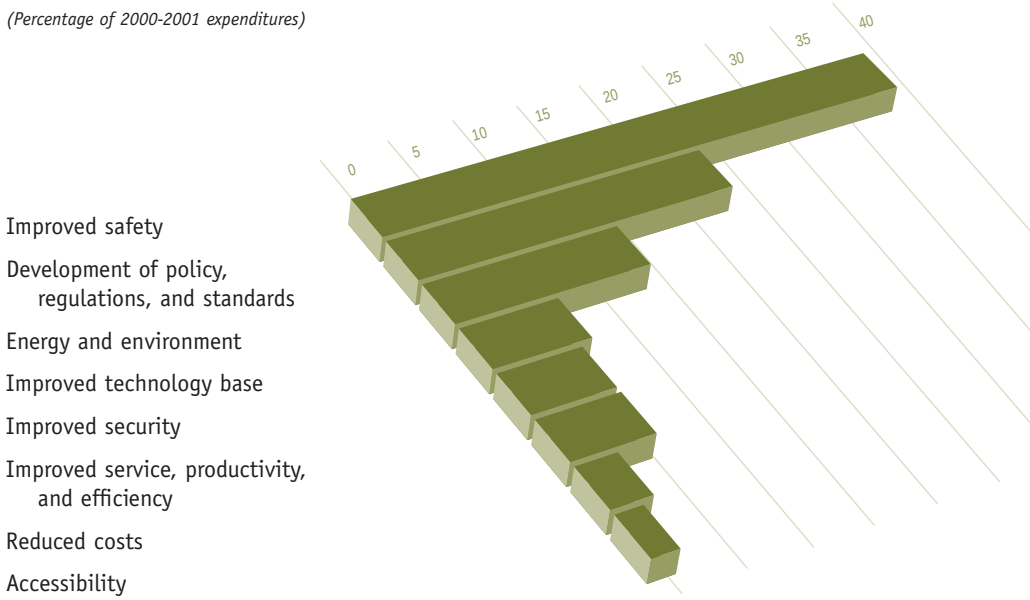
NOTE: ITS and Human Factors expenditures are rolled into the various modal areas.

Financial Overview

Figure 3 provides a breakdown of R&D expenditures by targeted benefit. Nearly 40 percent of 2000-2001 expenditures went towards research primarily aimed at improving transportation safety, while another 23 percent focussed on R&D supporting the development of policy, regulations, and standards. Research related to energy and the environment accounted for a growing portion of the program, increasing from 10% to 14% this year.

Figure 3
R&D Expenditures by Targeted Benefit

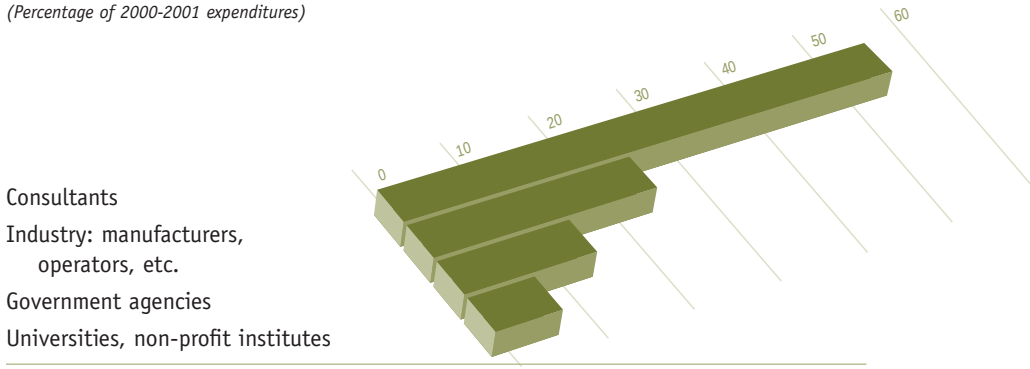
(Percentage of 2000-2001 expenditures)



TDC contracts out its research program to a variety of organizations in the public and private sectors. Figure 4 shows the distribution of R&D expenditures in 2000-2001 by type of R&D performer.

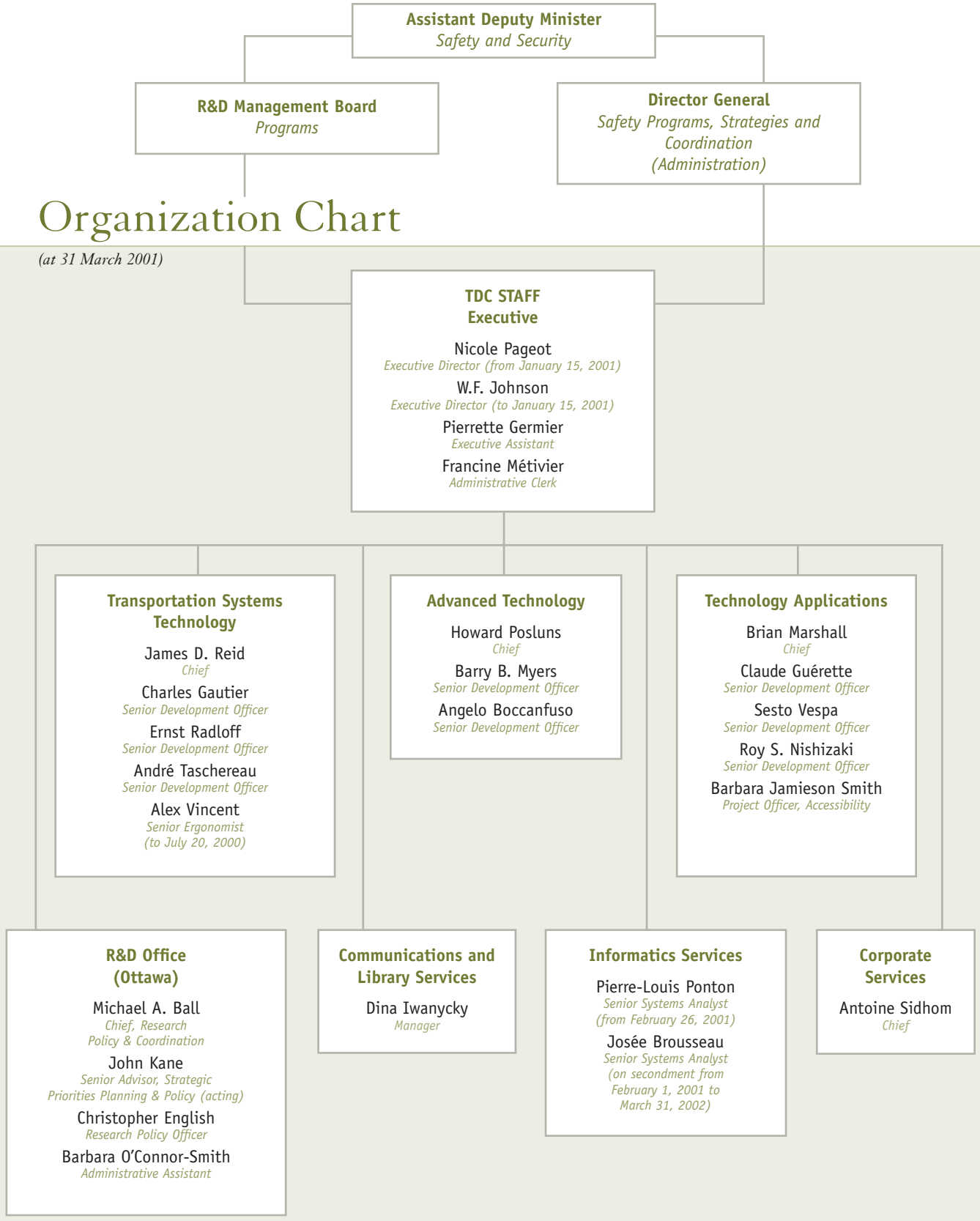
Figure 4
R&D Expenditures by Performing Organization

(Percentage of 2000-2001 expenditures)



Organization Chart

(at 31 March 2001)



Professional Activities

TDC staff serve on many scientific and professional committees and associations, on a national and international level. In 2000-2001 they were active in the following organizations.

National and International Committees

Aircraft Icing Research Alliance
Barry B. Myers

Airport Council International – Europe
Angelo Boccanfuso

American Society for Testing and Materials (ASTM)

Subcommittee E-17.22/96.1, Task Group on Preparation of Standard – International Runway Friction Index:
Secretary – Angelo Boccanfuso

Subcommittee E-17.22/97.2, Task Group on Preparation of Standard – Pavement Surface Classification:
Angelo Boccanfuso

Subcommittee E-17.14, Task Group on Terminology of Standards:
Chairman – Angelo Boccanfuso

Asia Pacific Economic Cooperation (APEC) ITS Special Interest Group
Transport Canada R&D contact – W. F. Johnson

Association québécoise du transport et des routes (AQTR)

Environment Committee: Claude Guérette

Goods Transportation Committee: Sesto Vespa

Canada-France Science and Technology Agreement
W. F. Johnson

Canada-Japan Science and Technology Agreement
W. F. Johnson

Canada-U.S. Counter-Terrorism R&D Group
Howard Posluns

Canada's National Climate Change Process

Technology Issues Table:
TC Representative – Michael A. Ball

Canadian Aviation Regulation Advisory Council
Barry B. Myers

Canadian Marine Advisory Council
Charles Gautier, Ernst Radloff, James D. Reid, André Taschereau

Canadian National Wind and Waves Committee
André Taschereau

Professional Activities

Canadian Standards Association

Subcommittee on Automotive Adaptive Driving Controls for Persons with Physical Disabilities:
Barbara Jamieson Smith

Subcommittee on Transportable Mobility Aids:
Barbara Jamieson Smith

Technical Committee Z301 – Technology for Persons with a Disability:
Roy S. Nishizaki, Barbara Jamieson Smith

Subcommittee on Mobility Aid Securement and Occupant Restraint Systems for Motor Vehicles:
Vice-Chair – Roy S. Nishizaki

Canadian Strategic Highway Research Program

Executive Committee: Brian Marshall

Canadian Working Group on Evaluation of School Bus Safety Devices

Coordinator – Claude Guérette

Centre d'expérimentation des véhicules électriques du Québec

Board of Directors: Claude Guérette

Centre for Marine Simulation Technical Advisory Group

Ernst Radloff

Direction 2006

Research Committee: Sesto Vespa

Electric Vehicle Association of Canada

Claude Guérette

Vehicle Standards Working Group: Michael A. Ball

ENTERPRISE Group

Executive Board: Brian Marshall

Federal Aviation Administration-Transport Canada Committee

Security Bilateral Research and Development Working Group: Howard Posluns

Global Aviation Information Network (GAIN)

Working Group C on Global Information Sharing Prototypes: Howard Posluns

Intelligent Transportation Society (ITS) of America

Angelo Boccanfuso

Intelligent Transportation Systems Society of Canada (ITS Canada)

Nicole Pageot

Treasurer-Secretary – W.F. Johnson


B.C. Ministry of Transportation and Highways

International Aviation Snow Symposium
R&D Committee
Secretary – Angelo Boccanfuso

International Electrotechnical Commission/TC 80
Maritime Navigation and Radio Communication Equipment/Systems:
Charles Gautier, André Taschereau

Marine Pilotage Certification Directors' Committee
Secretary – André Taschereau

Minister's Advisory Committee on Accessible Transportation (ACAT)
Brian Marshall, Barbara Jamieson Smith

NAFTA Land Transportation Standards Subcommittee/ Transportation Consultative Group/Working Group on Science & Technology
Co-Chair – W.F. Johnson

National Search and Rescue 121.5 MHz Phase-Out Planning Committee
Howard Posluns

Railway Research Advisory Board
W.F. Johnson, Sesto Vespa

SAE – International Committee on Aircraft Ground De/Anti-icing (G12)
Steering Committee: Barry B. Myers
Holdover Time Subcommittee:
Chair – Barry B. Myers
Fluids Subcommittee Working Group:
Host – Barry B. Myers
Liaison for ICAO and IATA – Barry B. Myers

Standards Council of Canada
Canadian Advisory Committee ISO/TC 204 – Intelligent Transportation Systems:
Chair – W.F. Johnson
WG7 – General Fleet Management and Commercial/Freight Operations:
Brian Marshall
WG15 – Dedicated Short Range Communications:
Brian Marshall

U.S. Aviation Regulation Advisory Council
Working Group on Ice Protection Harmonization: Barry B. Myers

U.S. Ship Structure Committee
André Taschereau

Professional Activities

U.S. Transportation Research Board (TRB)

Aircraft/Airport Compatibility Committee: Barry B. Myers
Alternative Transportation Fuels Committee: Michael A. Ball
Committee on Surface Properties-Vehicle Interaction: Angelo Boccanfuso
Transportation Energy Committee: Michael A. Ball
Board Member – Angelo Boccanfuso

Intra/Interdepartmental Committees

Assistant Deputy Minister's Committee on Science and Technology

W.F. Johnson, Nicole Pageot
Alternate Member – Michael A. Ball

Canadian Transportation Agency Accessibility Advisory Committee

Brian Marshall, Roy S. Nishizaki, Barbara Jamieson Smith

Climate Change Technology Early Action Measures (TEAM)

Management Committee:
TC Representative – Michael A. Ball
Industry Working Group:
TC Representative – Michael A. Ball

Container Tracking and Monitoring – TDC-Port of Montreal

Ernst Radloff, James D. Reid

Council of Science and Technology Advisors

Working Group: Michael A. Ball

Federal Partners in Technology Transfer

TC Representative – Michael A. Ball
Intellectual Property Management: W.F. Johnson, Nicole Pageot

Federal Science and Technology Annual Report

Steering Committee: Michael A. Ball

Global Positioning System Intradepartmental Advisory Committee

Howard Posluns

Industry Canada Interdepartmental Core Working Group on Clean Car (PNGV)

Michael A. Ball

Interdepartmental Committee on Federal Disability Strategy

Barbara Jamieson Smith

Interdepartmental Committee on International Science and Technology Relations
Michael A. Ball

Interdepartmental Committee on Sustainable Transportation
Michael A. Ball

Interdepartmental Steering Committee on Ballard/Ford Fuel Cell Engine Development
Michael A. Ball

Interdepartmental Steering Committee on Ethanol (ISCE)
Michael A. Ball

Natural Sciences and Engineering Research Council Industrial Advisory Research Group
Ernst Radloff

Program of Energy R&D Committees

Panel Members – W.F. Johnson, Nicole Pageot

Alternate Panel Member – Michael A. Ball

Industrial Energy R&D Advisory Board: Michael A. Ball

Advanced Fuels and Transportation Emissions Reduction:
Michael A. Ball, Roy S. Nishizaki, James D. Reid

Canadian Lightweight Materials Research Initiative (CLiMRI): Claude Guérette

Steering Committee: Michael A. Ball

Fuel Cells, Electric and Hybrid Vehicles: Claude Guérette

Marine Transportation and Safety: Charles Gautier, Ernst Radloff

Optimization of the Energy Efficiency of Transportation Systems:
Objective Leader – Michael A. Ball
Brian Marshall

Professional Activities

Transport Canada Committees

R&D Management Board: W.F. Johnson, Nicole Pageot

Technical Advisory Committee to R&D Management Board:
Chair – Michael A. Ball
Brian Marshall, James D. Reid

Joint Winter Runway Friction Measurement Program – Technical Steering Committee:
Angelo Boccanfuso

Standing Committee on Operations in Icing Conditions:
Angelo Boccanfuso, Barry B. Myers

Sustainable Development Strategy Committee:
R&D Alternate Member – Michael A. Ball

Director General's Climate Change Group – Safety Programs, Strategies and Coordination Directorate:
Alternate Member – Michael A. Ball

Transportation Blueprint for the Next Decade and Beyond – Innovation and Environment Teams:
Michael A. Ball

Other Societies and Associations

Air Transport Association

American Institute of Aeronautics and Astronautics

American Society of Mechanical Engineers

Association for Driver Rehabilitation Specialists

Canadian Aeronautics and Space Institute
Alternate Council Member – W.F. Johnson

Canadian Association for Composite Structures and Materials

Canadian Hydrogen Association

Canadian Operational Research Society

Canadian Owners and Pilots Association

Canadian Transportation Research Forum

Human Factors Association of Canada

Institute for Operations Research and the Management Sciences

Institute of Electrical and Electronics Engineers (IEEE)

International Marine Transit Association

Materials and Manufacturing Ontario

National Mobility Equipment Dealers Association

Radio Technical Commission for Maritime Services

SAE International

Society of Manufacturing Engineers

Society of Naval Architects and Marine Engineers (SNAME)

Through the delivery of papers and presentations on the Centre's research projects and related topics at national and international conferences, TDC staff ensure the effective transfer of technology. Highlights of 2000-2001 are listed here.

Papers and Presentations

Joint Winter Runway Friction Measurement Program

Presentation at a meeting of the International Aviation Safety Association R&D Committee
Buffalo, New York, April 2000

and at the Seventh Annual NASA Tire/Runway Friction Workshop
Wallops Island, Virginia, May 2000

and at an American Society for Testing and Materials Workshop
Orlando, Florida, December 2000

Angelo Boccanfuso

Update – Joint Winter Runway Friction Measurement Program

Presentation at Erding Airport
Munich, Germany, February 2001

Angelo Boccanfuso

Professional Activities

Oceanex

Ice navigation simulator

Presentation at the Workshop on East Coast Offshore Technologies
St. John's, Newfoundland, September 2000

and at the SNAME Marine Software Forum
Nepean, Ontario, January 2001

Charles Gautier

Shuttle tanker trials

Presentation at the Workshop on East Coast Offshore Technologies
St. John's, Newfoundland, September 2000

Charles Gautier

Improving pedestrian safety around school buses

Presentation at the Canadian Pupil Transportation Conference
St. John, New Brunswick, April 2000

Claude Guérette, Jim White

Global Aviation Information Network (GAIN)

Presentation to the National Air Carriers Association
Indianapolis, Indiana, May 2000

Howard Posluns

Arctic ship technology

Presentation at the Arctic Ship Technology Workshop
Ottawa, Ontario, March 2001

Ernst Radloff

Full-scale measurement of global loads and propeller-ice impacts

Presentation at the Program of Energy Research and Development Policy at Objective Level Meeting
St. John's, Newfoundland, September 2000

Ernst Radloff

Port community extranet for gate automation and enhanced terminal management

Paper presented at the Seventh World Congress on Intelligent Transport Systems
Turin, Italy, November 2000

Ernst Radloff

ITS: Intermodal container applications

Presentation to the Canadian Transportation Research Forum
Charlottetown, Prince Edward Island, June 2000

James D. Reid

Ship performance monitoring and emissions

Presentation to the Company of Master Mariners of Canada
Hamilton, Ontario, February 2001

James D. Reid

Canadian cooperative program of rail-highway grade crossing research

Paper presented at the Sixth International Symposium on Railroad-Highway Grade Grossing Research and Safety
Knoxville, Tennessee, October 2000
Sesto Vespa

Commercial vehicle safety in a competitive North American environment

Presentation at the Mexican National Congress on Prevention of Road and Highway Accidents
Veracruz, Mexico, May 2000
Sesto Vespa

Proceedings of the second workshop on rail-highway grade crossing, TP 13536
Sesto Vespa (contributing editor)

Other Activities

In addition to the above, TDC participated in the following events.

Airports Council International – European Airport Operators Meeting

Oslo, Norway, December 2000
Angelo Boccanfuso

Alco Owners' Group Meeting

Denver, Colorado, June 2000
Charles Gautier

Annual Assembly Meeting of the Radio Technical Commission for Maritime Services

San Diego, California, May 2000
James D. Reid

Canada-U.S. Counter-Terrorism R&D Bi-Annual Meetings

Ottawa, Ontario, June 2000
Washington, D.C., December 2000
Howard Posluns

Canadian Council of Motor Transport Administrators Annual Meeting

Toronto, Ontario, June 2000
Sesto Vespa

Canadian Lightweight Material Research Initiative Workshop

Mississauga, Ontario, May 2000
Claude Guérette

Professional Activities

Competitive Intelligence Workshop – Canadian Technology Network, Canadian Institute for Scientific and Technical Information, and Federal Partners in Technology Transfer

Ottawa, Ontario, February 2001
Michael A. Ball

Electronic Commerce Forum

Orlando, Florida, March 2001
Ernst Radloff

Global Aviation Information Network (GAIN) Fourth World Conference

Paris, France, June 2000
Global Information Sharing Prototypes Workshop Leader – Howard Posluns

Global Aviation Information Network (GAIN) Working Group C Meetings

Washington, D.C., May 2000
Ottawa, Ontario, November 2000
Washington, D.C., January 2001
Howard Posluns

Global Positioning System Intradepartmental Advisory Committee Meetings

Ottawa, Ontario, June 2000
Ottawa, Ontario, October 2000
Washington, D.C., February 2001
Howard Posluns

Ice Protection Harmonization Working Group Meetings

Paris, France, May 2000
Seattle, Washington, July 2000
Reno, Nevada, January 2001
Barry B. Myers

ITS Canada Annual General Meeting

Montreal, Quebec, March 2001
Michael A. Ball, Brian Marshall, Nicole Pageot

International COSPAS-SARSAT Search and Rescue Meeting

Laval, Quebec, October 2000
Howard Posluns

International Society of Air Safety Investigators Seminar

Bunratty, Ireland, October 2000
Howard Posluns

JAA/FAA/Transport Canada Joint Harmonization R&D Committee, Human Factors Working Group Meeting

Atlantic City, New Jersey, February 2001
Howard Posluns

NAFTA Land Transportation Standards Subcommittee/Transportation Consultative Group/Working Group on Science & Technology, Plenary Meeting

Querétaro, Mexico, October 2000
Acting Co-Chair – Brian Marshall

National Mobility Equipment Dealers Association Annual Conference

Daytona Beach, Florida, February 2001
Brian Marshall

National Search and Rescue SARSCENE 2000 Conference

Laval, Quebec, October 2000
Howard Posluns

PRECARN-IRIS (Institute for Robotics and Intelligent Systems) Conference

Montreal, Quebec, May 2000
Charles Gautier

Program of Energy R&D Workshop 2000

Ottawa, Ontario, September 2000
Michael A. Ball

Rural Advanced Technology and Transportation Systems International Conference

Branson, Missouri, August 2000
Brian Marshall

SAE G-12 De/Anti-Icing Task Force and Steering Committee Meetings

Toulouse, France, May 2000
Barry B. Myers

SAE G-12 Ice Detection Subcommittee Meeting

Toronto, Ontario, July 2000
Barry B. Myers

Seventeenth International Electric Vehicle Symposium

Montreal, Quebec, October 2000
Claude Guérette

Strategies for Canadian Shipping

Toronto, Ontario, October 2000
Technology Breakout Group:
Chair – James D. Reid

Teledyne Users' Avionics Workshop

Santa Monica, California, March 2001
Howard Posluns

Professional Activities

Transportation Research Board Annual Meeting

Washington, D.C., January 2001
Barbara Jamieson Smith

U.S. Department of Energy Workshop on Locomotive Emissions and System Efficiency

Argonne, Illinois, January 2001
Roy S. Nishizaki

U.S. National Association of Pupil Transportation – 26th Annual Conference and Trade Show

Buffalo, New York, November 2000
Claude Guérette

U.S. National Oceanic and Atmospheric Administration 1999 Beacon Manufacturers' Workshop

San Diego, California, May 2000
Howard Posluns

U.S. Transportation Research Board Meetings

80th Annual Meeting – Session Chair, Topics in Personal Vehicle Choice and Energy Use

Meeting of Committee on Transportation Energy

Meeting of Committee on Alternative Transportation Fuels

Washington, D.C., January 2001
Michael A. Ball

Visiting Delegations

Hebei Provincial Communication Department, China, July 2000

Hong Kong Transport Department, September 2000

Russian Merchant Marine Research and Project Development Institute, September 2000

Windsor Workshop on Transportation Fuels, 2000

Toronto, Ontario, June 2000
Michael A. Ball