CANADIAN TRANSPORTATION RESEARCH FORUM

LE GROUPE DE RECHERCHES SUR LES TRANSPORTS AU CANADA

CROSSING BORDERS:

Travel, Trade, Security and Communication

TRAVERSER LES FRONTIÈRES:

voyage, commerce, sécurité et communication

Ottawa, Ontario • May 11-14 mai • 2003



Proceedings of the 38th Annual Conference
Actes de la 38è Conférence annuelle

CANADIAN TRANSPORTATION RESEARCH FORUM
LE GROUPE DE RECHERCHES SUR LES TRANSPORTS AU CANADA

PROCEEDINGS
of the 38th Annual Conference

ACTES
de la 38è Conférence annuelle

Crossing Borders: Travel, Trade, Security and Communication
Traverser les frontières: voyage, commerce, sécurité et communication

Ottawa, Ontario
May 11-14 mai
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President's Message
Gerry Kolaitis, CTRF President

On behalf of the Board of Directors of the Canadian Transportation Research Forum, I welcome you to the Nation's Capital for the 38th CTRF annual conference. The conference theme "Crossing Borders: Travel, Trade, Security and Communications", strikes both a current and an enduring chord; that is fundamental to the socio-economic well-being of every citizen of this country. This document will give you a permanent record (a hard copy in this electronic age) of the papers that make up the conference program, which you could keep in your library and share with your colleagues. A summary of the opening plenary session, debate and panels, plus all the highlights of the conference will be included in the next issue of Forumation, our newsletter, and will be posted on our website : www.ctrf.ca.

The Board of Directors recognizes the tremendous effort put into organizing our conference by Messrs. Roger Roy (Transport Canada) and Gord Baldwin (Statistics Canada) and their team. I am sure that both the conference content and social activities will meet and hopefully exceed your expectations. I would also like to thank all the sponsors, attendees, presenters, paper contributors, debaters, and panelists who have all made this conference possible.

Many CTRF members will notice that we have something new in the 2003 Proceedings: information on the Canadian Institute for Traffic and Transportation (C.I.T.T.). This is a result of a new alliance that has been struck between the two organizations. The C.I.T.T. and the CTRF were founded around the same time, but with very different mandates. The C.I.T.T. is focused on education and accreditation of transportation and logistics professionals, leading to the CITT designation. The C.I.T.T. has developed alliances with post secondary institutions in all parts of Canada, to teach C.I.T.T. approved courses. The C.I.T.T. has grown steadily,

and as the professional group expands, its members seek further information and research findings.

The CTRF has always been a strong advocate of post secondary education in transportation and logistics, but offers no accreditation program or courses. Instead, the CTRF has operated a scholarship program and awarded prizes for undergraduate and graduate papers. The principal function of the CTRF has been to provide a forum for the sharing and discussion of research in the fields of transportation and logistics. All modes of transport are included, while the emphasis is on the economics, policy and business aspects of the sector.

Under the agreement between the C.I.T.T. and the CTRF, copies of these proceedings are provided at cost to the C.I.T.T. for distribution to their members. The relationship is a win-win situation. The CTRF will more than double the distribution of its proceedings, and will reach a greater number of logistics professionals. The C.I.T.T. members will gain access to very current applied research, and an opportunity to submit their own work for publication in future proceedings of the CTRF. Our expectation is that this relationship can make both organizations stronger, and improve national awareness of what each has to offer to professionals in the field.

As I prepare to hand over the reins of the presidency to my successor, it would be fair to say that it has been a good year for the CTRF in 2002/03. The new President will be selected in that extremely competitive and grueling leadership contest at the CTRF, which is usually completed before you could get your second cup of coffee at our Annual General Meeting, during Tuesday's breakfast.

This organization's good works deserve your continued support. The most important thing you can do to contribute to our success, besides participating yourselves in one or more of the ways that you can (member, sponsor, presenter, attendee, etc.), is to spread the good word about the CTRF.

MESSAGE DU PRÉSIDENT

Au nom du Conseil d'administration du Groupe de recherches sur les transports au Canada, je vous souhaite la bienvenue dans la Capitale nationale pour la 38è conférence annuelle du GRTC. Le thème de la conférence « Traverser les frontières : voyage, commerce, sécurité et communication », traite d'un thème à la fois actuel et constant, fondamental pour le bien-être socio-économique de chaque citoyen de ce pays. Le présent document vous fournira un registre permanent (une copie papier à l'ère de l'électronique) des articles qui constituent l'ossature du programme de la conférence, que vous pouvez garder dans votre bibliothèque et partager avec vos collègues. Un résumé de la séance plénière d'ouverture, des débats et panels, en plus de tous les points saillants de la conférence, sera présenté dans la prochaine édition de Forumation, notre bulletin, et sera disponible sur notre site web : www.ctrf.ca

Les membres du conseil d'administration expriment leur reconnaissance pour le grand effort méritoire de MM. Roger Roy (Transports Canada) et Gord Baldwin (Statistique Canada) et de leur équipe. Je suis sûr que le contenu de la conférence autant que les activités sociales combleront, voire dépasseront vos attentes. Je voudrais également remercier tous les commanditaires, les congressistes, les présentateurs, les auteurs d'articles, les participants aux débats et les panélistes.qui, ensemble, ont rendu cette conférence possible.

Beaucoup de membres du GRTC remarqueront quelque chose de nouveau dans les Actes de 2003 : de l'information sur le l'Institut canadien du trafic et du transport (C.I.T.T.). Il s'agit là du résultat d'une nouvelle alliance conclue entre les deux organisations. Le C.I.T.T. et le GRTC ont été fondés à peu près à la même période, mais avec des mandats différents. Le C.I.T.T. met l'accent sur la formation et l'accréditation de professionnels en transport et en logistique donnant droit au titre C.I.T.T.. Il a développé des

alliances avec des institutions post-secondaires à travers tout le Canada, permettant d'y dispenser des cours approuvés par le C.I.T.T.. Ce dernier a connu une croissance soutenue et, du fait que le nombre de professionnels augmente, les membres sont en quête de plus d'information et de recherche.

Pour sa part, le GRTC a toujours été un partisan déterminé de la formation post-secondaire en transport et logistique, mais n'offre ni programme ni cours accrédités. En revanche, il a gère un programme de bourses et accorde des prix pour des articles d'auteurs étudiants gradués et non gradués. La principale fonction du GRTC a été de fournir un forum de discussion et de partage de la recherche dans les domaines du transport et de la logistique. Tous les modes de transport y sont inclus, alors que l'emphase est mise sur les volets économique, des politiques et des affaires dans le secteur.

Aux termes de l'accord passé entre les deux institutions, des exemplaires de ces Actes sont cédés au prix coûtant au C.I.T.T. pour distribution à ses membres. Cette sorte de relations fait que les deux parties sont gagnantes. Le GRTC va plus que doubler la distribution de ses Actes et atteindra ainsi un plus grand nombre de professionnels de la logistique. Les membres du C.I.T.T. auront l'avantage d'accéder à la recherche appliquée la plus à jour et à la possibilité de publier dans les prochains Actes du GRTC. Nous nous attendons à ce que ces relations renforcent les deux organismes et améliorent, au niveau national, la prise de conscience de ce chacun a à offrir aux professionnels dans leurs milieux.

Au moment où je m'apprête à céder les rênes de la présidence à mon successeur, on peut honnêtement affirmer que 2002-2003 a été une bonne année pour le GRTC. Le nouveau président sera sélectionné dans cette épuisante et très compétitive course au leadership du GRTC, qui prend fin d'habitude avant que vous ayiez eu votre deuxième tasse de café à notre Assemblée générale annuelle, lors du petit déjeuner de mardi.

Le bon travail de cette organisation mérite amplement notre support continu. Ce que vous pouvez faire de plus important pour contribuer à notre succès, en plus de votre participation personnelle à quelque titre que ce soit (membre, commanditaire, présentateur, participant...), c'est de continuer à répandre la bonne parole sur le GRTC.

Meilleures salutations,

G. Kolaitis, MBA
Président

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This list was updated March 18, 2003. Additional sponsors will be acknowledged in the Forumation, on the CTRF Website, and at the conference.

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The scholarship winners for 2002-2003 were announced at the CTRF Annual Conference held in St. John's, Newfoundland, May 12-15, 2002. The winners have been matched to their corporate sponsors for the "named" scholarship. Recipients of the 2002 - 2003 Scholarship are:

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Feng Deng, M.Sc. Transportation and Logistics, University of British Columbia

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First Prize Undergraduate Category ($1,000)
Past Presidents Award

Trevor Hanson, University of New Brunswick
Faculty Supervisor: Dr. James Christie, Department of Civil Engineering, University of New Brunswick
"Effects of Highway Traffic Diversion on Roadside Businesses from Long's Creek to Fredericton, NB"

Second Prize Undergraduate Category ($ 500)

Philip Seo, Mary Sie; University of British Columbia
Faculty Supervisor: Prof. Tae H. Oum, College of Commerce, UBC
"Policy Proposal: The Future of Air Transport for Small Communities"

Albert Stevens Award (First Prize Masters Category) ($ 750)
TIE BETWEEN TWO PAPERS

T. Nixon Chan, University of Waterloo
Faculty Supervisor: Professor Bruce Hellinga, Department of Civil Engineering, University of Waterloo
"Real-Time Identification and Tracking of Recurrent Traffic

Queues Based on Average Link Speed Using Loop Detector Data"

and

Yuval Grinspun, University of Toronto
Faculty Advisor: Professor Eric J. Miller, Department of Civil Engineering, University of Toronto
"Taxiway Delay and Predictability at Lester B. Pearson International Airport"

Jim Davey Award (First Prize Ph.D. Category) ($1000)
No award
No papers were submitted in the Ph.D. Category

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CTRF is ...
a broadly based network of transportation professionals with an interest in research and commentary on public policy issues. Membership is open to anyone interested in any aspect of transportation.

CTRF's objectives are ...
- to encourage transportation research in those disciplines which address themselves to the economic, managerial, technical, political, and social aspects of transportation
- to provide a common meeting ground to exchange ideas and research results
- to provide a forum for presenting and discussion transportation issues
- to bring together persons involved with Canada's transportation systems.

CTRF's program consists of ...
- a national conference with research papers, panel discussions, and invited speakers held annually in a different Canadian location
- published proceedings of the national conference
- a one-day semi-annual conference on a topic of national interest
- regional seminars promoted and co-sponsored with other organizations
- an annual CTRF student paper competition
- an annual CTRF scholarship competition
- a newsletter published five times a year.

Le GRTC est ....
un groupe de professionnels(les) en transport intéressés(ées) à la recherche et aux questions de politiques publiques. Etre membre du GRTC convient à quiconque s'intéresse aux transports.

Les objectifs de GRTC sont ...
- d'encourager la recherche dans les domaines suivants liés aux transports: économie, gestion, technologie, politique et aspect social
- de fournir un lieu de rencontre pour échanger idées et résultats de recherche
- de créer un forum pour présenter et discuter de questions de transport
- de réunir les personnes intéressées au système canadien de transport.

Au programme du GRTC ....
- une conférence nationale annuelle avec site variable au Canada, qui consiste en une présentation de textes, tables rondes, conférenciers invités
- la publication des textes présentés à la conférence nationale
- une conférence semi-annuelle d'une journée sur un juget d'intérêt national
- la promotion et le parrainage de colloques régionauz avec d'autres organismes
- un coucours annuel de textes d'étudiants(es)
- un fonds permettant de décerner des bourses
- un bulletin de nouvelles publié cinq fois l'an

..... ANNOUNCING .....

2003 CTRF SEMI-ANNUAL CONFERENCE TO BE HELD IN VANCOUVER, B.C. (dates and location to be announced)

- 2004 CTRF ANNUAL CONFERENCE TO BE HELD IN CALGARY, ALBERTA (dates and location to be announced)

WATCH FOR CALL FOR PAPERS COMING IN SEPTEMBER 2003

For further information, contact:

Gail Sparks
(306)242-6199
e-mail: gail.sparks@ctrf.ca

CTRF website: www.ctrf.ca

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Established in 1958, the C.I.T.T. (Canadian Institute of Traffic & Transportation) is a not-for-profit organization with a membership of over 2,000 transportation, distribution and logistics management professionals across Canada.

Members of the C.I.T.T. include leaders, managers and directors in industry, operations and company executives in transportation companies, freight forwarders, customs brokers, government representatives, and consultants.

Recognized by industry as an identifier of the people with the core knowledge and heightened level of professionalism, the path to success starts with earning the CITT designation. In achieving the CITT designation, individuals stand out as leaders whose professional credentials and competencies are based on a solid, industry-based educational foundation.

The C.I.T.T. Program of Study which leads to the CITT designation provides education in the field of integrated trade and transportation logistics. C.I.T.T. courses are not only theoretical, but provide practical skills training, and offer a diversity of knowledge that is crucial to acquiring the skill-set necessary to meet the challenges of today's marketplace.

Throughout the program, participants are challenged to develop research and analytical skills that will help them in their careers to see the big picture and to make sound business decisions. Students acquire essential industry knowledge throughout the program including distribution principles, economic principles that drive an economy and the supply chain that feeds it, the laws of transportation and relevant statutes, as well as the fundamentals of marketing, customer service, finance, and administration which are all required to develop and maintain an integrated logistics organization.

For further information about the C.I.T.T., please visit www.citt.ca or contact:

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Intelligent Transportation Systems Border and Port Systems Technology and Research Funding

By: David Spearin,
President,
Logistic Marketing Services, Inc
Saskatoon, SK

Peggy MacTavish,
Director, Research Programs
Precarn Incorporated
Ottawa, ON

INTRODUCTION

The application and demand for increased applications of Intelligent Transportation Systems (ITS) has been fast tracked since the events of September 11, 2001. Increased security measures due to legislation and US concerns for a Continental systems, has directly increased the demand for new investment. Investments are for new infrastructure and Intelligent Software systems to be installed at Ports and Border Crossings across Canada.

Precarn is an industry lead consortium that provides research funding for new technology developments. Precarn is able to facilitate the growth of the Canadian sector by bringing together technology suppliers and users in collaborative research projects. As an industry led research and development consortium, Precarn has a unique ability and opportunity to enable industry growth. Precarn's mission is to make Canadian firms more globally competitive through the increased development and use of intelligent systems technologies and expertise. Precarn also manages the Institute for Robotics and Intelligent Systems (IRIS), Canada's university-based intelligent system R&D network. Precarn helps Canadian companies bridge the "innovation gap" between university and government research and commercial applications.

Precarn Incorporated provides funding to Canadian companies that can either manufacturer or conduct research in developing new Intelligent Transportation Systems.

Precarn runs a variety of funding programs to address as many respondents as possible, whether they are in Industry, Academia or Government. As well, Precarn aims to address the various layers of each; in Industry we target Small and Medium Enterprise (SME's) through to large companies, in Government we partner with Provincial and Federal departments and in Academia we work with Universities as well as Research Organizations.

Our Regular Program invites proposals at anytime during the year, with deadlines imposed for specific steps in the approval process. All Precarn-funded projects conduct research and development on intelligent systems. The Regional Alliance Program is specifically geared towards SME's. Through

partnerships in six regions of Canada, B.C., Alberta, Saskatchewan, Ontario, Quebec and the Maritimes, Precarn is able to deliver a program that offers an introductory level of project size and duration for SME"s to demonstrate or further develop their expertise in the research and development of intelligent systems.

The Precarn International Program works with existing funding programs in other countries (Intelligent Manufacturing systems, European Sixth Framework, National Center for Manufacturing Sciences). Through this avenue, Precarn encourages the pursuit of IS R&D opportunities in other countries, where a Canadian team works in collaboration with an organization outside of Canada. Proposals for this program are accepted at any time.

Precarn has been providing research funding to several companies currently involved in developing new ITS systems applied to both border and port technology.

Precarn was interested in knowing the market conditions and demand for ITS applications in Canada. Prior to September 2001, Precarn had commissioned a market study regarding ITS applied to the Commercial Trucking sector.

This paper reviews some of the findings of the market study and updates current Port and Border initiatives. The paper also discusses some of the new applications that Precarn is involved with.

ITS Market Demand Commercial Trucking Sector

Before September 11,2001 the demand for Border Crossing applications was due to increased North American trade conditions. ITS demands in North America were lead by legislative changes, the quest for efficiency, and concerns about safety. The importance of the **North American Free Trade Agreement** should not be overlooked as a driver of ITS. Under NAFTA there are two subcommittees that evaluate transportation and technology issues across North America. These committees provide the basis for ensuring that all three nations share the same objectives and goals and develop parallel systems associated with transportation. With the increased use of technology applications in transportation, there is a shared interest to have standards in place between all three countries.

The use of ITS in trucking varies by the commercial application and technology used. ITS applications range from mobile communications, optical sensors, infrared sensors, GPS - Global Positioning Systems, GIS - Geographic Information Systems, Smart cards, transponders, video ramp monitoring to weigh stations. There are seven major functional group applications of ITS: Advanced Traffic Management Systems, Advanced Traveler Information Systems, Advanced Public Transportation Systems, Advanced Rural Transportation Systems, Commercial Vehicle Operations, Advanced Vehicle Control & Safety Systems, and Automated Highway Systems.

The total number of larger trucks in Canada that can employ ITS technology is estimated at 650,000. However, not all operators will adopt this technology. Class 8 operators have the highest probability for adopting new ITS technology. After making this adjustment, 260,000

truck units were used as a baseline to estimate the size of the ITS sales market in Canada.

ITS applications in Canada and the US for the clearance of vehicles; roadside safety inspections; on-board safety monitoring and vehicle safety; vehicle tracking; intermodal freight management; and hazardous material planning were evaluated and companies identified.

The total Canadian market for ITS is estimated to be between $781 and $1,492 million.

The market study identified **173 companies in the global ITS market**, 64 of which were based in Canada. A survey was sent to 26 of the Canadian companies. Almost one half of the respondents had sales between $10 and $50 million. The majority of companies responding developed software or hardware and most companies offer more than one ITS application. Critical issues for the success of the business included government research and development incentives, marketing, software engineers and excellent employees, and greater awareness by users of the benefits of ITS. The most significant barriers to growth were seen as the lack of skilled employees, venture capital, and education and knowledge. The majority of respondents did engage in collaborative research. Universities and/or institutes were the type of institution most often collaborated with.

A patent search of ITS systems found 20 patent trademark applications in Canada and 29 in the US.

A literature review and survey identified **future issues** for the industry. These include wireless communication protocols,

government policy, investment costs, education and knowledge, and inter-operability.

From the survey and review of literature we identified current spending by ITS manufacturers on research and development at $ 11 billion. Some of the expenditures by multinationals includes other technologies not associated with ITS. If this spending is removed, **the estimated spending on research and development for ITS by companies falls to $650 million.** Expenditure on R&D by Canadian SME's was estimated at $438 million while expenditures by US SME's was estimated at $225 million. Canadian MNE expenditures on R&D were estimated at $4.4 billion while US MNE's R & D expenditures were estimated at $4.8 billion.

In 2000-2001 the **Canadian federal government spent $2.7 million** on ITS with Ontario and Quebec receiving most of the funding. In contrast, the **US federal government is spending $351 (US) million** in 2001. California and Wisconsin receive the most federal funding.

Canada has **world-class companies** in Commercial Vehicle Operations, Electronic Payment Services and Public Transportation Operations. However, the **lack of domestic showcases projects impedes the development of exports.** Canada also has companies with strengths in GIS, GPS, sensors, software and system integration. These companies are hampered by the **difficulty in obtaining R&D funding**.

Research opportunities exist in optical research, safety sensors, wireless communication, and GIS-GPS based fleet management systems.

The market for new electronic technology applications using intelligent based systems applied to the Commercial Vehicle Sector has grown significantly over the last decade. In the future, Intelligent Transportation Systems could influence 40% of the US economy. The impact in Canada would be similar. Government spending in the area of intelligent systems is significant with the US, Japanese, and European governments spending between $1.8 billion and $2.7 billion annually. The majority of current expenditures for Intelligent Transportation Systems have been for automobile and public sector applications. There has been some funding applied to the Commercial trucking sector but only to certain regions or areas. For example, border crossing, truck weigh scales and pre-clearance systems are types of truck ITS applications that have received funding.

The Canadian government has been active in the area of intelligent systems. Transport Canada recently completed an intensive examination of the sector in Canada and other countries. The final output was the creation of architecture for Canadian intelligent systems.

In reviewing the current Canadian ITS market demand and opportunities for Precarn we conducted a sector analysis; we identified and surveyed companies as being potential collaborators with Precarn. From this we identified targets and opportunities for Precarn.

Sector/Market Analysis: We examined the current marketplace with particular emphasis on Canadian companies. We identified trends in intelligent system applications, current spending on research and development, and future technological problems and the solutions that will be required. This component was accomplished using primary and

secondary research. Interviews comprised the primary research.[1]

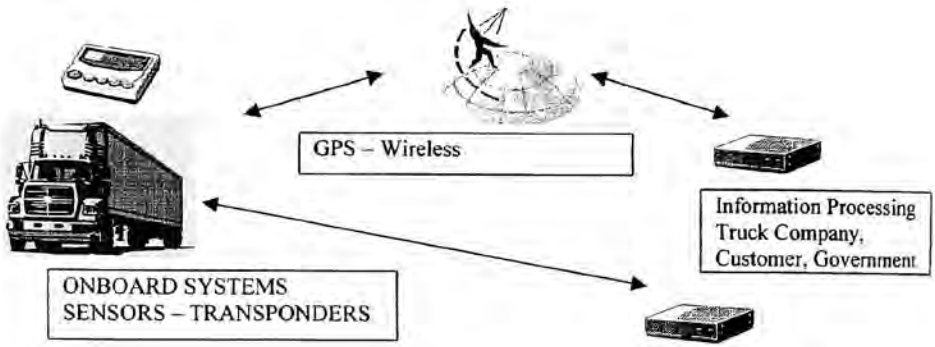
Assessment of Potential Collaborators: Based on the knowledge gained in the first segment of the study, we assessed potential collaborators with PRECARN. The criteria used included: company size, research and development spending, area of expertise, innovation, research potential, past track record on research and development in general, and collaborative research with PRECARN and others

Alignment and Targeting: Drawing upon the insights gained in the first two components, we identified research opportunities that are in alignment with future industry needs and PRECARN. A ranking of research and development alternatives was provided.

Figure 1 shows a schematic of ITS within the trucking industry showing how on board systems are linked to wireless and GPS systems that transmit information concerning the truck to government and interested parties to provide pre-clearances of trucks for weigh scales or at border crossings.

[1] A literature review was conducted to group companies that manufacture components along with the ITS application and location across Canada, the United States and the World. A database was developed to quantify companies to the specific ITS application. From this data we randomly surveyed companies.

Figure 1 : Schematic of ITS within the Trucking Industry



ITS Border Systems:

ITS systems have been applied and tested at various border crossings between Canada and the US prior to September 2001. ITS can provide an effective cross border pre-clearance for commercial trucks.

The US government is leading the development of border crossing systems and the associated technology to implement pre-cleared trucking systems under NAFTA. There have been

test cases and applications between Canada and the US at Detroit, Buffalo and Vancouver, and between Mexico and the US in Texas. Canada is part of the design phase. A review of US data concerning expenditures on border systems between 1997 and 2001 was completed. It is estimated that $19 million has been spent by US state and Federal agencies.

Systems for custom clearance are to automate filing, processing and issuance of documents for import and export of goods being transported by truck. These systems are used to automate transactions, improve control by customs and reduce delays between shippers and receivers. Typically, these systems incorporate transaction-processing software and are communications based.

There are no Canadian Companies participating in this area. US Customs and a few US private companies are the only companies that are developing applications. One of the US companies is Syntra Global Logistic Systems.

The US International Border Clearance Program started to deploy ITS technologies to be tested across seven border crossings in 1991. The two US Canada sites are Buffalo, NY and Detroit, MI. The main thrust is for vehicle identification and information exchange. The US International Clearance Program reached the following conclusions about the two Canada-US crossings:

Buffalo, NY

- Third busiest crossing in North America
- 1.1 million import truck crossings in 1998
- Trade volume has increased by 15% since 1990
- No safety inspection of trucks at the bridge

- Congestion is a problem, plan twinning of bridge
- Commercial Vehicle Processing Center (CPVC) is being developed on the Canadian side
- New York State law allows random truck inspections
- If truck has valid Commercial Vehicle Safety alliance sticker there is no inspection
- New York State transportation department prefers to target high risk carriers with past records of infractions or pattern of delinquency
- With the construction of a new bridge and new IT systems to monitor traffic flows on the bridges, travel time at the crossings should be reduced by 35%.

Detroit, MI

- Busiest crossing in North America
- 1.5 million US import truck crossings in 1998
- 2.7 million truck crossings in 1997
- Trade volume has increased by 50% since 1993
- Michigan Police do not differentiate between Canadian or US trucks when selecting who is to be inspected.
- New Freight Trade Processing System (FPTS) is being tested during 2000-2001 for trucks. The systems allow pre verification of truck registration and safety status prior to the truck crossing the bridge.
- Michigan law does not allow the selection of high risk vehicles using electronic records to target for inspections

The NAFTA Land Transportation Standards Sub-Committee will be meeting later this year to discuss further issues pertaining to border crossing ITS developments.

ITS Port Application

ITS applications at ports include the use of optical video systems to monitor container movements, truck monitoring, use of transponders to identify vessels in or approaching ports

.

Present ITS systems for the monitoring of Intermodal Container traffic include tracing of containers and monitoring containers transferred between vessel, rail or truck at the port or terminal. Future applications of these systems would allow the monitoring of the container from the port to final customer as it passes through various transportation modes. Technology used for this area includes transponders and optical–video surveillance systems to ensure accuracy of data gathering and reporting.

Recent testing of applications in Canada were coordinated by the Transportation Development Centre, Port of Montreal and INO. They just finished testing container optical reading systems to monitor transit at the interface between ships, trains and trucks. The results are not available at this time.

Growth of ITS Border and Port Applications

The following identifies the announcements regarding ITS applications in Canada since 2001.

After the attacks of September 11, a new Interdepartmental Marine Security Working Group was formed. This group has

initiated new projects governing maritime traffic within Canadian waters. These include advance notification, new protocols for ships entering waters and the Great Lakes and other security protocols.

The December 2001 Budget included funding over 5 years of $600 million allocated to improve border infrastructure and the use of technological improvements.

On March 13, 2002, Transport Canada provided funding of $3.7 million, as part of cost sharing for ITS developments. The Port of Vancouver received $200,000 to enhance and expand its Port View software to include the movement of dangerous goods. BC also received $250,000 for deployment of an Advanced Traveler Information Systems at Surrey. This system shows the time delay at the border crossing.

In June 2002 Canada Customs announced new a joint program with the US Customs called "FAST", Free and Secure Trade, which would expedite the processing of low-risk commercial shipments.

On January 22, 2003 the Federal Government, announced a five-year package of new initiatives of up to $172.5 million designed to increase security of Canada's marine and maritime borders. The specific ITS applications include:

- New gamma ray technology to be installed at strategic locations,
- New surveillance and tracking of marine traffic with near real-time identification.

Canada Customs has purchased 11 mobile truck mounted-scanning systems that can scan an image of contents in a marine container.

In the USA recent ITS applications impacting Canada include, development of an E-Seal for containers; The state of Michigan will develop and demonstrate ITS applications at Port Huron and Ambassador Bridge in Detroit to provide weigh-in-motion, truck and operator inspection/processing and customs.
The border crossings at Ft Erie and Niagara Falls are also being considered for ITS projects by the State of New York.

Other ITS projects in Canada are for traffic management and smart card systems and urban transit systems monitoring. Some of the current Canadian companies involved in these ITS programs include:

Delcan, IBI, Fortran Traffic Systems, LEA Consulting, Naztec Inc, EPCOR, Technologies Lynx
Quester Tangent Corporation
NOVAX Industries Corporation
EIS Electronic Integrated Systems Inc.
Power Tech Labs Inc.
Yugo-Tech Conversion Gas Inc.
ECO Fuel Systems Inc.
Alternative Fuel Systems Inc.
Technocarb Ltd.
Dynetek Industries Ltd.

Precarn New Initiatives

Precarn continues to respond to the transportation sector by conducting subsequent phases of Precarn projects. Our first phase II project is "Intelligent Control Systems for Fuel Cells and Natural Gas Vehicles II (ICS II)". The Project involves proponents from across Canada including the Saskatchewan Research Council and the University of Saskatchewan.

Conclusions

Since 2001 the demand for increased security and safety systems at border and ports has increased dramatically. Canada must ensure that they provide the framework in which Canadian companies can develop ITS applications that can be used at borders and ports. Precarn Associates provides both research funding and collaboration with Canadian companies to develop ITS systems that can be used at ports and border crossings.

ELECTRONIC COLLECTION OF AIR TRANSPORTATION STATISTICS PILOT PROJECT

By

Garry Tulipan, Michel Villeneuve, Stephen Ellsworth[1]

Abstract

The Electronic Collection of Air Transportation Statistics [ECATS] Pilot Project was conceived by Transport Canada during the fall of 2001, and the "kick-off" meeting between the ECATS Project Team and stakeholders was held on March 8, 2002. Events leading to the conceptualization and implementation of this project included the "First Report on the Airline Industry" by Debra Ward, Independent transition Observer on Airline Restructuring in February 2001; the Forum on Air Transportation Statistics, held by Transport Canada in Ottawa in June 2001; the recommendations included in the final report of the *Canadian Transportation Act* Review Panel in July 2001; the events of September 11th in the United States; and, the resulting impact on the commercial air industry both in Canada and globally.

Each of the above events highlighted air transportation data issues, in particular the need for more timely data, the need to reduce the reporting burden and associated costs on stakeholders, and to make increasing use of new technology to collect and disseminate information. The objectives of the ECATS Pilot Project have tried to address each of the above considerations.

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[1] Garry Tulipan, Director, Transportation Statistics and Forecasts, Transport Canada
Michel Villeneuve, Chief, Aviation Statistics, Transport Canada
Stephen Ellsworth, Analyst, Air Statistics and Forecasts, Transport Canada

Five air carriers[2], six airports[3], Statistics Canada (SC), the Canadian Transportation Agency (CTA), the Canadian Airports Council (CAC) and the Air Transport Association of Canada (ATAC) participated, on a voluntary basis, with Transport Canada in the pilot project. The implementation phase of the pilot [electronic collection and dissemination of data] started in mid-September 2002 and was completed at the end of January 2003. Participants contributed to the final evaluation of the pilot project.

The following paper describes the objectives, technical considerations, methodological approaches and final results of the ECATS Pilot Project. It also outlines the recommendations leading from the evaluation of the project.

Background

For Transport Canada, the availability and subsequent analysis of data is an important component in policy development and decision-making. A broad range of information is also required for safety and security requirements. For private stakeholders within the air sector and related industries, statistics are used for operational planning and decision-making. The timeliness and quality of the data used is a key factor, leading to analysis that is reliable and logical.

The problems associated with the aviation data presently available to both government and industry make it difficult to perform analysis for current-day conditions. This issue becomes particularly problematic in Canada as the aviation industry has undergone significant restructuring over recent years and continues to evolve today. The need for current, reliable data is crucial for monitoring trends in the marketplace.

Debra Ward highlighted the need for improved air statistics in her first interim report to the Minister in February 2001. She again addressed

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[2] Air Canada, Canadian North, AllCanada Express, Air Transat and Transwest.
[3] Toronto, Vancouver, Calgary, Kelowna, Montreal and Stephenville

data issues in her third interim report, released in March 2002 and in her final report, released in the fall of 2002.

Numerous concerns related to air transportation data were also raised by stakeholders in their submissions to the *Canada Transportation Act* Review Panel, and reflected in the Panel's recommendations. At the same time, the Panel recognized that responding to government data requests can be costly, and recommended that effective and economical solutions, including the use of new technologies, be developed in collaboration with the relevant industry participants.

On June 8th, 2001, Transport Canada (TC) held a one-day Forum on Air Transportation Statistics in Ottawa. The Minister invited over 100 stakeholders from across the aviation industry to discuss and better understand issues associated with air data as well as to brainstorm options for improving the data collection systems. Forum delegates collectively agreed on a number of issues related to air transportation statistics and on the need to resolve them as soon as possible. One of the recommendations was that the Minister consult the air industry and develop an Data Gap Report, along with recommendations on how to best meet the data gaps identified. In the follow-up to the Forum, stakeholders also raised concerns about the burden and associated costs of data reporting and flagged the importance of moving towards electronic collection and dissemination procedures.

The urgency of developing a plan to address Canada's air data inadequacies was amplified by the events of September 11, 2001 in the United States. During the immediate aftermath of the crisis, a broad range of information related to the stoppage of flight operations was required. Security considerations also generated numerous data requests. Over the longer term, monitoring the impact of September 11th on the industry dictated the need for ongoing current information. Transport Canada experienced difficulties in meeting many of the data needs that were generated during this period, further emphasizing the need to develop and implement a data collection and dissemination

system that would be able to provide timely and high quality data on an ongoing basis.

Objectives

The primary objectives of the ECATS Pilot Project were as follows:

- To examine the feasibility of using current technology to collect and disseminate air transportation data electronically;
- To develop and implement a pilot system in close collaboration with other government agencies and industry participants, on a voluntary basis;
- To assess the feasibility of using electronic collection and dissemination procedures to broaden the scope and improve the timeliness of available air transportation data, while at the same time maintaining the high quality of statistics currently available; and
- To reduce the reporting burden and associated costs for stakeholders.

Concept

German System:

The initial concept for the electronic collection of air transportation data in Canada was based on the electronic system in place in Germany. The system was initially developed in the early 1990s for Frankfurt airport, by FIPLAN[4], as a tool for billing purposes. By the mid-1990s, the system had been extended to approximately 30 other major airports, and has since become one of the main sources of aviation data for Germany's Federal Aviation Statistics Program.

[4] FIPLAN Gmbh is a privately owned and operated software and business solution consulting company, based in Frankfurt, Germany.

The data collection process from all domestic and foreign airlines serving the major German airports is completely electronic and automatic. The required information is extracted from carrier electronic messaging systems, better known as SITA messages, and compiled by the German airports. The airports validate the statistics against sources such as flight reports and forward the information to the Federal Statistical Office once data errors are corrected. Operational data collected includes, amongst others, fields showing passenger counts, cargo volumes, baggage, routing and number of seats. Based on FIPLAN's records, approximately 98 per cent of final airline data in Germany is submitted to the Federal Statistical Office within 24 hours of each flight occurrence. At airports, information is available on each flight as soon as the aircraft departs.

Three entities are involved in the data collection process in Germany; airlines, airports and government. Significant benefits accrue to each entity. In the case of the airlines, they now have minimum resource requirements for data reporting, as they are no longer responsible for manual data transcription. Reporting errors are minimized and there are no costs incurred for the development and implementation of data reporting systems. For airports, the system ensures ongoing, consistent information and the validation procedures ensure reliable data for billing and market analysis. For government, the approach provides accurate and timely statistics for industry monitoring and policy decision-making.

Canadian System:

While the initial concept for Canada was loosely based on the German model, the pilot project was modified to meet the following Canadian realities:

- Unlike legislation in place in Germany, the *Canadian Transportation Act* places constraints on both the collection and dissemination of data. As such, the ECATS Pilot was based on the voluntary participation of air carriers, airports, government agencies and industry associations;

- Dissemination of information in Canada requires the signed consent of reporting participants. Therefore the German model which uses the airports to collect and validate the information could not be used;
- The majority of air carriers in Canada do not use SITA messaging systems, thereby requiring another approach to collecting operational data;
- Two of the carriers in the pilot do not manage data in house and as such, use Third Party Information Providers to collect, validate and manage their information requirements, thereby necessitating the involvement of these entities in the data collection process; and
- Based on consultations with the industry, Transport Canada accepted the role of central data collector and repository, with responsibility for validation of the information prior to dissemination to Statistics Canada, the Canadian Transportation Agency, the air carriers and airports. [It must be emphasized that airports were only provided information from those air carriers that gave written consent to Transport Canada for dissemination of their data.]

Participants

Five air carriers and six airports participated voluntarily in the ECATS Pilot Project[5]. The project was also conceived, developed and implemented in close collaboration with Statistics Canada, the Canadian Transportation Agency, the Canadian Airports Council and the Air Transportation Association of Canada.

The carriers that voluntarily participated in the pilot represented the full range of domestic operations in Canada; they included a major national schedule carrier, a major charter carrier that has also started scheduled services, an all cargo airline, a mid-level carrier and a smaller regional

[5] Carriers: Air Canada, Canadian North, All Canada Express, Air Transat and Transwest Air.
Airports: Toronto, Vancouver, Calgary, Kelowna, Montreal and Stephenville

airline. These carriers were also equipped with widely differing technological capabilities.

The airports participating in the pilot also represented a wide range of operations and technical capabilities, including large entities that handled numerous flights and passengers with sophisticated technology, to small airports with limited resources. An effort was also made to include airport representation from across the country.

Prior to implementation of the electronic collection and dissemination process, all participants signed a formal legal Agreement. The ECATS Agreement outlined the roles and responsibilities of each participant, and the confidentiality and other limitations on collection and dissemination procedures throughout the Pilot Project.

At the joint Government / Industry "kick-off" meeting in March 2002, it was agreed that two working groups be established, as a means for all participants to remain informed of progress and discuss issues related to the project. The Policy Working Group convened eight times over the course of the project, addressing such concerns as the role of participants, the ECATS Agreement, collection and dissemination concerns and the evaluation of the project. The Technical Working Group was focused on issues related to the technical collection and dissemination procedures, problems related to accessing specific data, standardizing data definitions and implementation of security measures.

ECATS Data Elements

For the ECATS Pilot, data collected was limited to operational data currently provided to Statistics Canada by participating carriers using the existing survey reporting structure[6]. All operational data elements

[6] Statement 2: Charter On-Flight Origin and Destination Report
Statement 3: Scheduled Revenue Passenger Origin and Destination Report
Statement 4: Coupon Passenger Origin and Destination Report
Statement 6: Daily Airport Activities Report

reported by participating carriers, and therefore collected in ECATS, are included in Appendix I.

Collection of Data

Three of the carriers participating in the pilot [Air Canada, All Canada Express, Canadian North] manage their own information requirements. Conversely, Air Transat and Transwest Air outsource all their data-related activities to Third Party Information Handlers [AIMS and IntelliSys respectively].

As illustrated in Appendix II, data from the three carriers [Air Canada, Canadian North, All Canada Express] that manage their own information needs was transferred directly from each carrier to the Transport Canada FTP Server. IntelliSys, a Third Party Information Handler, forwarded all information on behalf of Transwest Air to Transport Canada using the same transmission process. In the case of Air Transat, AIMS developed the database system that resides at Air Transat's facilities. AIMs collected the required data from the carrier's SITA messages, validated and formatted the information and returned the data to Air Transat. Air Transat then transmitted the information to Transport Canada.

All data was transferred to Transport Canada on a weekly basis, with Wednesday being the agreed date of transfer. From the TC FTP server, the raw data was moved to the ECATS server inside the TC firewall for processing. Once validated, the information was transferred to the SQL server.

The ECATS data was validated in 2 stages. The first step involved testing for data integrity [i.e. fields were checked for errors such as null fields, incorrect data types, situations where the number of passengers exceeded the available number of seats, etc.]. The second stage focussed on comparing movements by aircraft against NAV CANADA

Aircraft Movement Statistics. Problem records in both stages were stored in a table and corrected by manual intervention after follow-up with the carrier.

With the exception of Air Canada, each of the reporting carriers were issued PKI certificates by Transport Canada, to ensure the highest level of security possible during the transfer of data. In accordance with Transport Canada security policy, the entire ECATS system was also subject to a Threat / Risk Assessment (TRA), conducted by Qunara, a private company that specializes in security assessments.

As was expected, the Pilot Project cast light on a number of challenges with the electronic collection process. Initial plans were to have the implementation phase of the project start at the beginning of September 2002. Prolonged negotiations related to the signing of the ECATS Agreement, and completion/implementation of the Threat/Risk Assessment [TRA], delayed the actual start date to mid-September.

Electronic collection of data started immediately from Canadian North and AllCanada Express. Transmission of data from Transwest Air was delayed until the beginning of November, allowing for contract procedures and development work by InteliSys to be completed. The electronic flow of information from Air Canada commenced in early December. The time period between September and December allowed for the completion of system upgrades that were underway as the ECATS project started. Information from Air Transat became available in January 2003, due to system development issues and problems with the data. Because of the late start of data flow from some of the carriers, the Pilot was extended to end-January 2003. Notwithstanding the end of the Pilot project at that time, each of the five carriers continue to transfer information electronically to Transport Canada even after the end of the official Pilot Project.

Dissemination of Data

One of the objectives of the Pilot was to assess the feasibility and benefits of disseminating data electronically to participants after validation by the ECATS Project Team. Electronic dissemination of data has a number of potential benefits: first, all stakeholders, including government partners, would be provided with a consistent set of data; second, stakeholders would receive the validated information within weeks of the actual flight occurrence; and third, costs for validation and follow-up by participants would be minimized as members would only have to deal with Transport Canada.

The procedure followed for disseminating information to participants varied slightly from the proposed approach shown on the ECATS architecture illustrated in Appendix II. Initially, it was proposed that data be accessible to participants via a secure Web-server, however implementation of this technology within TC was not completed during the period that the ECATS Pilot Project was underway. Instead, Transport Canada posted the ECATS information on its FTP server and automatically notified participants by email that the data were available for downloading. Stakeholders could retrieve the information using a FTP application designed and installed by Transport Canada. The transfer of data was protected using Entrust encryption and authentication technology.

In the case of Statistics Canada and the Canadian Transportation Agency, these two agencies were provided, on a biweekly basis, all the information to which they were legally entitled, under the *Statistics Act* and the *Canada Transportation Act*. The majority of air carriers participating in the project were provided information concerning their own operations as a mechanism for validation in ECATS.

Under the confidentiality provisions of Section 51 of the *Canada Transportation Act*, and the provisions of the ECATS Agreement signed by all participants, Transport Canada required written permission from each carrier to provide data to the airports[7] to which

[7] Data was only provided to those airports participating in the ECATS Pilot Project.

they were providing flight services. Transport Canada was also sensitive to the fact that air carriers currently provide information to most airports at which they provide services, and did not want to undermine any existing agreements between these partners.

Two carriers, Air Transat and Canadian North, provided written permission to Transport Canada to disseminate information to those airports they currently served. Air Canada and AllCanada Express did not submit written permission; therefore information collected from these carriers was not disseminated to the airports. Transwest Air did not fly to any of the airports participating in the ECATS project. With the exception of Air Canada Jazz [this carrier withdrew from Stephenville during the course of the Pilot], none of the other carriers participating in the pilot provided services to that airport. In the cases where permission was not granted to provide information to an airport, or where none of the carriers participating in the project provided services, Transport Canada used aggregated historical data to test ECATS transmission capabilities.

Due to technical and data-related difficulties, dissemination of data was not started until late in the project. However, by mid-January 2003, all of the airports had received data via the electronic dissemination process.

Evaluation of the ECATS Project

With respect to the primary objectives of the project, ECATS did establish that *it is feasible to use current technology to collect and disseminate air transportation data electronically.* While the data collection phase of the pilot commenced two weeks behind schedule, most of these delays were due to administrative, rather than technical, reasons. The major shortcomings of the dissemination process were a function of current legislative restrictions.

The project also allowed to successfully *develop and implement a pilot system in close collaboration with other government agencies and*

industry participants, on a voluntary basis. Statistics Canada, the Canadian Transportation Agency and each of the five air carriers and six airports all participated actively in the Pilot on a voluntary basis.

One of the most important objectives of the Pilot was to *assess the feasibility of using electronic collection and dissemination procedures to broaden the scope and improve the timeliness of available air transportation data*. The Pilot focused on collecting the same operational data elements as were being currently reported to SC under Statements 2, 3, 4 and 6. As such, the scope of data collected was not broadened for ECATS. However, one of the five participating air carriers in the pilot was not reporting operational data prior to the implementation of the ECATS project. With this carrier fulfilling its reporting requirements (electronically), the scope of information available has indirectly increased.

Data was transferred from each air carrier to Transport Canada on the Wednesday of each week for the previous week. The raw data was validated and prepared for dissemination within one to two weeks of receipt of the original data. This preliminary data was forwarded by TC to SC, the CTA, select carriers and those airports that were approved to receive carrier specific data. While the information collected and disseminated was in no way considered official or finalized information, the process did verify that the timeliness of collecting, validating and disseminating air transportation statistics could be greatly enhanced using electronic means.

The final objective of the Pilot was to assess the feasibility of *reducing the reporting burden and associated costs* on participating stakeholders. The Pilot did demonstrate that in most cases it was possible to reduce the operating costs attributed to data collection and dissemination for both industry and government stakeholders. In the case of air carriers, operating costs attributable to the ECATS project varied according to the level of technology already in use at the entity and whether the carrier handled its own information needs or outsourced these services to third parties.

Next Steps

Based on the comments received from the participants in the ECATS pilot project, and the satisfactory attainment of the objectives of the project, it was recommended that:

- Transport Canada move ahead with the implementation of an electronic data collection system from the estimated 175 unique air carriers operating scheduled and/or charter passenger and cargo services in Canada;
- The ECATS National Rollout should target the same data elements as were collected and disseminated during the ECATS Pilot;
- Statistics Canada, the Canadian Transportation Agency, ATAC and the CAC should remain as active participants in the ECATS National Rollout. Other foreign associations may also be invited to actively participate in their role as representatives of airlines in other regions of the world;
- The National Rollout should initially focus on dissemination of agreed data to the 43 airports with tower facilities in Canada, and Iqaluit. Inclusion of the remaining 54 airports with Flight Service Stations should be revisited following successful implementation of the National Rollout;
- Transport Canada legal council should explore the requirements for a contractual agreement between all participants in the National Rollout, and the best mechanism for implementing such an agreement;
- Transport Canada Informatics (Security) should identify issues of secure exchange of information, in particular when the exchange involves other countries; and
- Roles and responsibilities, and service levels, of both Economic Analysis and TIMSD staff should be defined and formalized prior to going to full implementation.

Implications for Transport Canada and the Industry

There are a number of positive implications for the Department: with timelier data, a faster, more measured response can be made to issues resulting from events such as September 11th, and the subsequent financial viability and security concerns. With the ongoing evolution of the industry, timely high quality data is required to monitor market trends. The data available for bilateral negotiations should be improved, and there should be more comprehensive and timelier input to the Minister's Report on the State of Transportation in Canada. Over the long term, there should be a reduction in cost to the Department for air transportation data. Many of the above benefits can also be applied to industry; consistent timely data is required for operational decision making through the air sector.

APPENDIX I

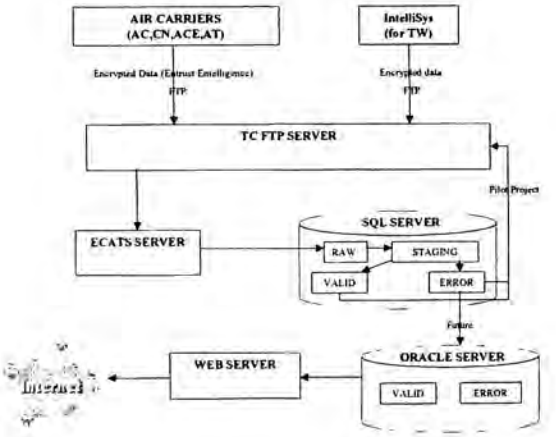
Data Elements Collected during ECATS Pilot Project

- Data Element	Carriers to Report
Carrier Code (OAG)	AC, CNX, TS, 5T, 9T
Year/Month/Day/Time of Record	AC, CNX, TS, 5T, 9T
Flight Number	AC, CNX, TS, 5T
Aircraft Type	AC, CNX, TS, 5T
Type of Flight	AC, TS, 5T
Circle Flight	AC, CNX, TS
Point of Origin	AC, TS, 5T
Final Scheduled Destination	AC, TS, 5T
Charter Type	AC, CNX, TS
Aircraft Available Seats	AC, CNX, TS, 5T
Weight Unit (kg/lbs)	AC, CNX, TS, 5T
Aircraft Capacity – Total Available Weight	AC, TS, 5T
Arriving/Departing Flight Code	AC, TS, 5T
Number of Tons Available for Goods	AC, CNX, TS
Airport of Enplanement – OAG Code	AC, CNX, TS
Airport of Enplanement – Departure Date	AC, CNX, TS
Airport of Deplanement – OAG Code	AC, CNX, TS
Airport of Deplanement – Arrival Date	AC, CNX, TS
Reporting Airport – OAG Code	AC, TS, 5T
Actual Time of Arrival or Departure – Hr, Min	AC, CNX, TS, 5T
Arrived from (Last Airport) or Departed to (Next Airport)	AC, TS, 5T
End of Flight indicator	AC, CNX, TS
Code for Sequence	AC, TS, 5T
Arriving or Departing Passengers	AC, TS, 5T
Arriving or Departing Cargo Weight	AC, TS, 5T
Enplaned or Deplaned Passengers	AC, TS, 5T
Enplaned or Deplaned Cargo Weight	AC, CNX, TS, 5T
Canadian Origin Passengers	AC, CNX, TS
Foreign Origin Passengers	AC, CNX, TS
Origin or Destination Passengers by Airport-Pair	AC, TS, 9T
Carrier Name and Code (ICAO or IATA) by Airport-Pair	AC, TS
Names and Codes (OAG) of Airport-Pairs	AC, TS, 9T
Departing Flights by Airport-Pair	9T

Notes:
AC = Air Canada, 9T = Transwest Air, CNX = All Canada Express, 5T = Canadian North, TS = Air Transat

APPENDIX 2

ECATS ARCHITECTURE - OVERVIEW



200 scm0301d 03/15/2001 03/30/2001 "ITS Data Mining and Archive to Evaluate Nationwide Performance"

Edmond Chin-Ping Chang, Ph.D., P.E.
ITS Program Manager
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6073 USA
TEL: 1-865-574-5003
FAX: 1-202-646-7878
e-Mail: ecc2005@ornl.gov

ABSTRACT

With increasing travel demand, urban traffic congestion and its impact on the environment is one of the major factors that will inhibit future economic growth and social progress. In recent years, a number of large cities have employed Intelligent Transportation System (ITS) methods to reduce traffic congestion. Under the sponsorship of the ITS Joint Program Office (JPO), Oak Ridge National Laboratory (ORNL) has developed a Metropolitan ITS Infrastructure Deployment Tracking system. The purpose of this system is to provide Federal Highway Administration (FHWA) and JPO with an assessment of the level of deployment of the components of the Intelligent Transportation Infrastructure (ITI). Detailed data on deployment of the urban ITI have been gathered for seventy-eight (78) of the largest urban areas, with the population over 50,000 or more.

With an initial support from the U. S. Bureau of Transportation Statistics (BTS), U.S. Department of Transportation (USDOT), ORNL has established a prototype system and proven the practicality and efficiency of the internet-based model for archiving automated traffic data. Data has been continuously collected, processed, and archived for selected freeway networks from the cities of San Diego, Milwaukee, San Antonio and Seattle for more than a year. Indicators of vehicle travel and traffic congestion have been computed for each

metropolitan area. This paper describes a study, using various data mining and data archiving techniques, to examine incident response time statistics before and after the incident management systems were deployed based on the information collected in the Metropolitan ITS Infrastructure Deployment Tracking system. Using data mining techniques, many quantitative statistical measures of the effectiveness of incident management systems with respect to fatal accidents will be estimated to assess the operational benefits of advanced traffic management systems that can take advantages of the ITS system operations and many available ITS infrastructure already in place.

Keywords: Intelligent Transportation Systems, Information Technology, Performance

INTRODUCTION

With increasing travel demand, urban traffic congestion and its impact on the environment is one of the major factors that will inhibit future economic growth and social progress. In recent years, a number of large cities have employed Intelligent Transportation System (ITS) methods to reduce traffic congestion. Under the sponsorship of the ITS Joint Program Office (JPO), Oak Ridge National Laboratory (ORNL) has developed a Metropolitan ITS Infrastructure Deployment Tracking system. The purpose of this system is to provide Federal Highway Administration (FHWA) and JPO with an assessment of the level of deployment of the components of the Intelligent Transportation Infrastructure (ITI). Detailed data on deployment of the urban ITI have been gathered for seventy-six (76) of the largest urban areas.

With an initial support from the U. S. Bureau of Transportation Statistics (BTS), ORNL has established a prototype system and proven the practicality and efficiency of the internet-based model for archiving automated traffic data. Data has been continuously collected, processed, and archived for selected freeway networks from the cities of San Diego, Milwaukee, San Antonio and Seattle for more than a year. Indicators of vehicle travel and traffic congestion have been computed for each metropolitan area. This paper describes a study, using various data mining techniques, to examine incident response time statistics before and after the incident management systems were deployed based on the information collected in the Metropolitan ITS Infrastructure Deployment Tracking system. Using data mining techniques, many quantitative statistical measures of the effectiveness of incident management systems with respect to fatal accidents will be estimated to assess the operational benefits of advanced traffic management systems that can take advantages of the ITS system operations and ITS infrastructure already in place.

STUDY BACKGROUND

The ultimate goal of a central, internet-based National ITS Traffic Information Archive would be to collect and archive ITS real-time information from all metropolitan and rural ITS deployment sites. This would include traffic information (volume, occupancy, and, speed data), real-time incident/accident reports, and time-lapse traffic condition images from traffic surveillance cameras. In addition, information regarding construction, weather conditions, and major events that might have significant impact on traffic conditions could also be added. In particular, ORNL has already demonstrated how safety data such as FARS can be merged in space and time with traffic data to create new information for safety analysis. The Archive would collect and process data, detect errors, impute missing data, calculate mobility/congestion measures, and produce daily, monthly and seasonal mobility/congestion reports. Finally, the Archive will provide data access and retrieval to federal, state, and local transportation agencies, and to the research community.

A central National ITS Traffic Information Archive would produce a consistent set of data that is comparable among metropolitan areas. Available on-line for any desired time-period (i.e., days, months, and years), the data could be used in a wide variety of research studies and evaluations, such as before and after assessments of the impacts of traffic management strategies or deployment of advanced technologies. Non-recurring congestion could be studied through the replay of any particular time and day to review the impact of major incidents or severe weather on traffic flows. The National Archive would produce historical statistics for traffic much the way the Weather Service produces historical data for weather phenomenon. Local news agencies could use these statistics to put daily traffic reports into perspective by reporting on whether traffic congestion is average, or how a particular day related to the worst day on record. The archived traffic and related information will undoubtedly have potential value for commercial applications. For instance, up-to-date time-of-day and day-of-week traffic statistics would allow commercial trucking firms and emergency vehicle operators to route

their vehicles to avoid traffic congestion and better serve their customers. Moreover, a host of unanticipated uses are likely to emerge once the data become readily available.

PRELIMINARY RESULTS

Estimates of monitored-system vehicle travel, delay and speed are now available for each of the four cities for a twelve-month period. These statistics permit some preliminary comparisons of congestion estimates between the automated traffic data and TTI published studies. The comparisons are of considerable interest because the automated traffic data represent an admittedly imperfect measurement of the actual congestion delay of every vehicle traveling on the system. Delay is measured according to the recommended NCHRP definition as the estimated actual travel time for a vehicle on a specific link minus the ideal travel time, represented here by the travel time at posted speed limits. Negative delay (travel faster than posted speed limits) is ignored by assumption. The comparisons must be taken with proper prospect:

1. The monitored network is a subset of the total freeway network as TTI reports.
2. The monitored network is the most thoroughly instrumented and may therefore be the best managed portion.
3. Our congestion delay calculations do not fully capture the effects of stalled traffic, but have yet to implement a solution.
4. Observed differences may well be due to statistical variation.
5. We are comparing data for different years.

Nonetheless, the data shown in Table 1 "Comparisons of Annual Vehicle Travel and Delay" suggest that delay on the monitored systems be considerably lower than the TTI estimates for freeway systems in the same city. In terms of delay per 1000 VKT, measured delay is about one half to one sixth of the TTI estimated levels. This is despite the fact that, except for San Antonio, travel per lane mile is much higher on the monitored systems. One must be a careful

drawing conclusion from these results, for the reasons cited above. However, they are illustrative of the potential usefulness of directly measured congestion and other performance measures in monitoring system performance and evaluating the impacts of measures taken to improve the evaluation of the transportation system operations based on the ITS infrastructure already in place.

ACKNOWLEDGEMENTS

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BIOGRAPHY

Edmond Chin-Ping Chang, Ph.D., P.E. is the ITS Program Manager of the Engineering Science and Technology Division (ESTD) at the Oak Ridge National Laboratory (ORNL). Dr. Chang is stationed in Washington, D.C. and responsible for managing all ORNL ITS related program activities funded by US.DOT. Before joining the Oak Ridge National Laboratory, Dr. Chang was a Research Engineer of the Texas Transportation Institute at the Texas A&M University System. Dr. Chang has over 29 years of practical domestic and international experience on Transportation Engineering, Transportation Management, System Engineering, System Development, and authored over 550 publications. Dr. Chang is a Registered Professional Engineer (P.E.) in Texas, Certified Civil Engineer (C.E.) in Taiwan, R.O.C., Certified National ITS Architecture Integration Professional, and Senior Advisor of United Nations Development Program's (UNDP) STAR and TOKTEN program. Dr. Chang is also members of many active international ITS standards development professional organizations, including ITE, TRB Artificial Intelligence (AI) Committee, Intelligent Transportation Systems (ITS) Committee, and Traffic Flow Theory

and Characteristics (TFT) Committee, ITS America Standards & Protocol (S&P) Committee, ITS America System Architecture (SA) Committee, AASHTO NTCIP Ramp Metering (RMC) Working Group, U.S. Technical Advisory Group (USTAG) to ISO TC204 Committee "Transport Information and Control Systems," and Working Advisory Group (WAG9) and Working Group Expert (WG16) to ISO TC204 Committee "Integrated Transport Information Management and Control."

Dr. Chang's professional research interests include: Intelligent Transportation Systems (ITS), NTCIP, Computerized Transportation Management and Control Systems, Arterial and Network Traffic Signal Timing, Urban Transportation Systems Analysis, Traffic Flow Theory and Real-Time Simulation, Microcomputer Applications in Traffic Engineering, Expert Systems Design, and Artificial Intelligence.

Table 1. Comparisons of Annual Vehicle Travel and Delay.

Annual Statistics based on Real-time data:

Site	VKT (million veh kms)	Delay (thousand hours)	Delay per 1000VKT (person-hours)	Lane-kms	Daily VKT/ln-km (thousands)	Delay per Lane-kms (thousands)
San Diego[1]	6,959	14,858	2.1	500	38.2	29.7
Milwaukee[1]	4,865	4,704	1.0	321	41.5	14.7
San Antonio[2]	2,178	3,705	1.7	498	12.0	7.4
Seattle[3]	8,069	20,428	2.5	606	37.8	33.7

1996 Estimates from TTI report (1998 report)

Site	VKT[4] (million veh kms)	Delay[5] (thousand hours)	Delay per 1000VKT (person-hours)	Lane-kms (1993 data, Freeway)	Daily VKT/ln-km 1996 (thousands)	Delay per Lane-kms (thousands)
San Diego	17,020	73,640	4.3	2,816	16.2	26.2
Milwaukee	4,874	29,140	6.0	981	13.4	29.7
San Antonio	7,796	34,470	4.4	1,512	12.7	22.8
Seattle	12,979	110,090	8.5	2,076	16.9	53.0

[1]San Diego and Milwaukee Lane-kms were estimated as 2 x link-kms
[2]San Antonio data was calculated based on 520 sensors in 1998 and 635 sensors in 1999.
[3]Calculation based on 9/23/98 to 9/22/99 except Seattle that started on 10/06/98
[4]VKT from Table 2 of the 1998 TTI report for freeway/expressway only
[5]Delay from Table 6 of the 1998 TTI report
Assumption on occupancy: 1.25 persons per vehicles, "Urban Roadway Congestion - 1982 to 1993", TTI: 0-1131, p60.

USING TRUCK TRACTOR LOGS TO ESTIMATE TRAVEL TIMES AT CANADA-U.S. BORDER CROSSINGS IN SOUTHERN ONTARIO

Bob Leore, Mireille Trent and Tony Shallow[1]
Policy Group, Transport Canada

1. Background

This paper documents an approach for measuring travel times at Canada-U.S. border crossings using truck tractor logs. The motivation for the study was to develop some empirical evidence to address heightened concerns about border security after the terrorist attacks of September 11, 2001. One of the biggest fears in the months directly after the attacks was whether the vast amount of trade exchanged between Canada and the U.S. would be threatened by potentially increased wait times at the border. Though the effects of border security on transit times are a real concern, unfortunately, no routine data sources exist for measuring crossing times. What we show here is how trip-level tractor logs can be used as a means of filling this important data gap. A distribution of tractor logs can provide information not only on the average time to cross the border but also on the travel time variability, a critical variable in the logistics business.

2. What are truck tractor logs?

Tractor logs provide a summary report of the progress of a trip between origin and destination. Two main technologies exist for collecting a truck's trip data.

1. Currently, the most popular form is **real-time vehicle tracking services** provided either through a satellite-based service such as Cancom/Qualcomm or through Global Positioning System (GPS) units installed on the vehicles (examples of GPS services are AirIQ, PeopleNet, and

Highway Master). Real-time services typically collect information on the geographic coordinates (i.e. latitude and longitude) of the vehicle, date and time stamps, and vehicle speed. A wireless transmitter is normally used to permit remote tracking of the vehicle by the dispatch office.

2. The other approach, less popular now, but historically the dominant mode of vehicle tracking, is a **tachograph** device installed in the vehicle. A tachograph is an instrument that records vehicle speed, time of day, and distance travelled on a circular paper disc. Though geographic coordinates are not collected directly by the tachograph, vehicle positioning can be inferred by assuming a route and aggregating distance along the route. With no geographic positioning, real-time tracking is not possible with tachographs.

Though the technologies are quite different, they both collect data at the trip level and thus can be used to evaluate travel times and speeds over discrete parts of a trip, including borders.

3. Data sources used in the study

With the assistance of the Ontario Trucking Association, Transport Canada obtained tractor log data from two for-hire trucking firms based in Southern Ontario. The two carriers graciously agreed to share copies of their log data on their most frequent runs to the United States. One carrier supplied copies of their GPS-based tractor logs from January 2, 2002 to April 19, 2002, while the other supplied copies of tachograph cards from December 2000 to April 2002. All major border crossings in Southern Ontario were covered, specifically the Ambassador Bridge at Windsor/Detroit, the Peace and Queenston-Lewiston Bridges in the Niagara region and the Blue Water Bridge at Sarnia/Port Huron. Over the spring and summer of 2002, Transport Canada analysed the log data for several thousand trips, tabulating by direction and by time of day. Each source of data will be described in turn starting with the GPS-based logs.

4. GPS-based tractor logs

Transport Canada received over 1,100 GPS-encoded tractor logs from the first participating carrier, broken down by the following crossings:

Ambassador Bridge: 320 round trips
Peace and Queenston-Lewiston Bridges: 342 round trips
Blue Water Bridge: 465 round-trips

Useable data that could be extracted from the GPS logs were a series of checkpoints containing latitude and longitude, date and time stamps to the nearest minute, and descriptions of each checkpoint. On average, a checkpoint was added to the tractor log every fifteen minutes although additional points were recorded every time there was a remote communication between the truck and the dispatch centre.

One complication with the GPS logs was that an accurate estimate of distance was not included for each checkpoint. This was remedied by estimating linear distance travelled using the geographic information system (GIS) TransCAD. TransCAD handles linear referencing, a function that assigns the distance travelled along a trip (i.e. mileposts) to a series of latitude and longitude coordinates located along the trip's route. In this study, all checkpoints in the logs were geo-coded in TransCAD and a linear distance was subsequently attached to each point. Once all points in the log were identified in time and space, a border zone was isolated for each trip and summary statistics on average times and speeds were computed.

4.1. Analysis of Ambassador Bridge using GPS tractor logs

Owing to the relatively infrequent polling interval (i.e. 15 minutes on average) of GPS checkpoints, it was not possible to define precisely the same border zone for each trip; however, after examining all trips, a 5 km section around the Ambassador Bridge was selected for the border zone. Based on the distribution of the checkpoints, out of 320 valid trips, 311 trips could be used to look at crossing times outbound

from Canada to the U.S., and 257 trips could be used to look at crossing times inbound from the U.S. to Canada.

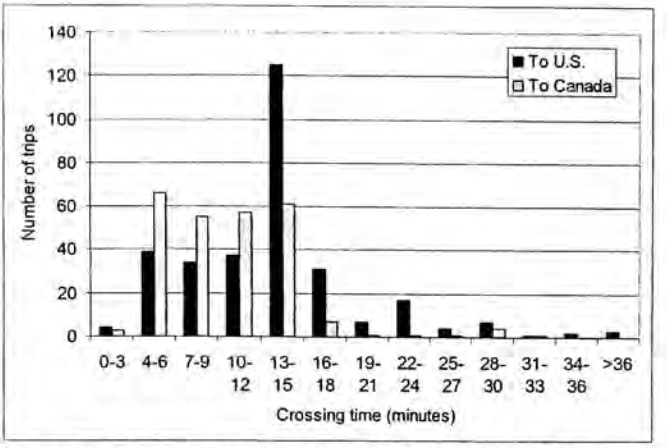


Figure 1: Average crossing time at Ambassador Bridge

The histogram in Figure 1 shows that it took quite a bit longer to travel outbound to the U.S. than inbound to Canada. The average crossing time to the U.S. was 14 minutes with a standard deviation of 6.5 minutes, while the average time to cross into Canada was 10 minutes with a standard deviation of 5 minutes.

One convenient way in which to measure the reliability of travel time, an important performance indicator, is to use a Buffer Time Index (BTI).[2] A buffer time index is calculated as the percentage difference between the 95th percentile crossing time and the average time; it gives a rough indication of the amount of time that needs to be built in to the crossing time to avoid delay at the border. For the Ambassador Bridge, the 95th percentile crossing time to the U.S. was 25 minutes giving a BTI of 81 [(25/14)-1)*100], while the corresponding time for crossings to Canada was 16 minutes giving a BTI of just 57.

4.2 Temporal variation at Ambassador Bridge

One of the real advantages of trip-level logs is that one can analyse the distribution of crossing times by day of the week and by hour. For the carrier treated here, there did not appear to be any strong pattern in the crossing times by month or by day of the week. The distribution by time of day was skewed very much to the hours between midnight and 6 am for trips to the U.S. (40% of the trips) and from 6 am to 9 am for inbound trips to Canada (35% of trips). The average crossing times at these time periods were the lowest for each direction, at under 13 minutes for trips to the U.S. and less than 9 minutes for trips to Canada.

4.3 Importance of border time for the total trip

Another asset of a tractor log is that information for the whole trip is available. This permits one to calculate how much time is spent at the border as a share of total travel time. For the run through Ambassador Bridge, time spent at the border (both directions taken together) accounted for less than 3% of total trip time. This share was very stable over the period showing no tendency to rise or fall with a standard deviation of 1.2 percentage points.

4.4 Analysis of Niagara-area crossings using GPS tractor logs

The route taken on trips to western New York used two bridges in the region: on the U.S.-bound leg trips crossed at Queenston-Lewiston Bridge while on the return leg to Canada trips crossed via the Peace Bridge at Fort Erie/Buffalo. Based on the distribution of the checkpoint data, the border zone was defined to be 5 km long at Queenston-Lewiston and 7.5 km long at Peace Bridge. Out of 342 total trips, 330 trips were used to calculate travel times to the U.S. and 341 trips were used to calculate times back into Canada.

The histogram in Figure 2 shows the distribution of average crossing times in the Niagara region. Average travel time at Queenston-Lewiston Bridge was 13 minutes with quite a bit of rightward skew in the distribution (the mode was 6 minutes and the median was 9 minutes). The standard deviation of the distribution was 11.4

minutes. Average (inbound) crossing time at the Peace Bridge was higher at 18 minutes with a standard deviation of 9.8 minutes. Given the greater skew and more spread in the distribution for Queenston-Lewiston crossing, it is not surprising that the Buffer Time Index (BTI) was much higher at Queenston-Lewiston Bridge than at Peace Bridge. The 95th percentile transit time of the former was 33 minutes giving a BTI of 161, while at Peace Bridge the 95th percentile time was 36 minutes giving a BTI of 100. Thus, while the outbound average crossing time at Queenston-Lewiston was quite a bit lower than at Peace Bridge, the average time was not really an accurate reflection of the entire travel time distribution.

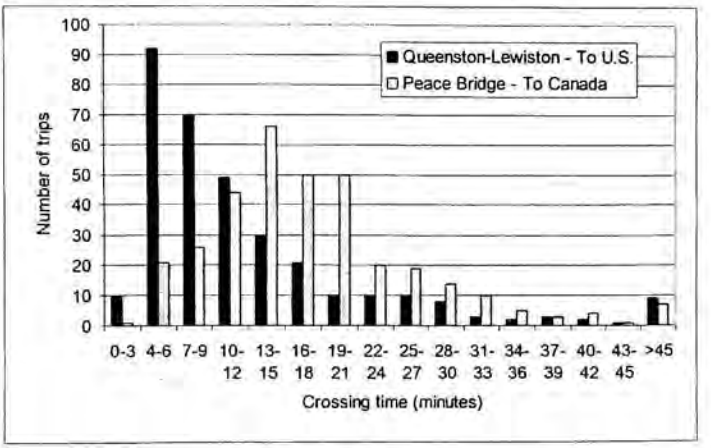


Figure 2: Average transit time at Niagara region crossings

4.5 Temporal variation at Niagara-area crossings

As with the Ambassador Bridge, average travel times at the two Niagara crossings did not display strong monthly or daily patterns. Hourly patterns were similar to Ambassador Bridge with most outbound trips occurring between midnight and 6 am. Average crossing times were lowest during this period at less than 8 minutes. The slowest period was after 6 pm at about 20 minutes. The patterns

were not so clear-cut at the Peace Bridge. Crossing times were more evenly distributed by time of day although there was a small tendency for crossing times to rise after 12 noon. Significant delays during the traditional peak periods from 6 am-9 am and 3 pm-6 pm were not observed.

4.6 Importance of border time for the total trip

Time spent at Niagara-area borders accounted for about 5.5% of total travel time. Most of the trips had border shares clustered tightly around this average figure.

4.7. Analysis of travel times at Sarnia using GPS tractor logs

The third major crossing for which GPS tractor log data were collected was the Blue Water Bridge at Sarnia/Port Huron. Based on the distribution of the checkpoints, a 5 km border zone was defined around the Blue Water Bridge. Out of 465 total trips, 415 trips could be used to analyse outbound movements to the U.S. and 360 trips could be used to analyse return trips to Canada.

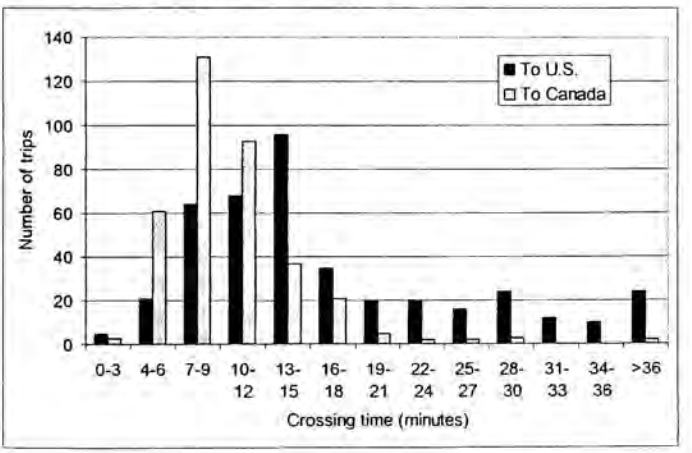


Figure 3: Average transit times at Blue Water Bridge

The histogram in Figure 3 depicts the distribution of average transit times at Blue Water Bridge. As was seen with the Ambassador Bridge, it took longer to cross into the U.S. at Sarnia than it did to return to Canada. The average outbound crossing time was 17 minutes with a standard deviation of 10, while the average inbound times was about 10 minutes with a standard deviation of 5.

Given the wider spread in the outbound distribution, it is not unexpected that the Buffer Time Index was much higher for trips to the U.S. The 95th percentile crossing time was 39 minutes for outbound trips versus only 17 minutes for inbound trips, producing a BTI of 125 for outbound trips and only 68 for inbound trips.

4.8 Temporal variation at Blue Water Bridge

Unlike the other crossings, there was a pretty strong pattern in crossing times by day of the week. Average travel times appeared to be lowest on Monday and Tuesday for both directions, about 16 minutes for trips to the U.S. and 8-10 minutes for trips to Canada. The slowest day of the week for outbound trips was Wednesday while Friday was slowest for inbound trips.

Trips to the U.S. were clustered in the morning with all but 13 reaching the border before noon. Average crossing times between midnight and 6 am were less than 16 minutes, while average times from 6 am to 9 am were slightly less than 19 minutes. Trips to Canada were clustered after 9 am with almost half of the trips reaching the border between 9 am and noon and all but 16 trips arriving at the border between 6 am and 3 pm. Crossing times into Canada showed a tendency to rise during the day from less than 9 minutes between 6 am and 9 am to 10 minutes from 9 am to noon and further to 12 minutes between noon and 3 pm.

4.9 Importance of border time at Sarnia for the total trip

Time spent at borders was not a significant factor for trips using the Blue Water Bridge. Border crossings represented about 3.5% of the total travel time with most trips clustered around this average share.

5. Tachograph-based tractor logs

The tachograph cards supplied by the other participating carrier covered the period from December 2000 to April 2002. Tachographs record trip information on a minute-by-minute basis using a set of styluses much like a heart rate monitor does. The data are documented as continuous lines around a disc-shaped card and are used by trucking firms to track drivers' hours of work and to monitor vehicle speeds. It is a tedious and laborious process to take information off the tachograph cards as the data must be read manually and transcribed by hand.

For this study, data were obtained for the Ambassador, Peace and Queenston-Lewiston Bridges. As was done with the GPS tractor logs, a border zone was identified for each crossing. Then, each trip across the border zone was profiled by transferring information from the tachograph cards into a database. The driver ID, vehicle number, start (end) dates/days of week, and checkpoint times were recorded as were the estimated crossing times for the border zone and other trip segments. The border crossing times for 1,500 one-way trips were documented in this manner.

5.1 Crossing times at Ambassador Bridge using tachograph data

For the Ambassador Bridge, 207 outbound trips to the U.S. and 173 inbound trips to Canada were available for analysis. According to the tachograph data, average transit times at Ambassador Bridge were considerably higher than were seen with the GPS data. The average outbound time was calculated to be about 40 minutes with a standard deviation of 30 minutes. Average inbound time was about 30 minutes with a standard deviation of 25 minutes (See Figure 4).

As the histogram in Table 5 reveals, there were very long tails to the crossing time distribution at Ambassador Bridge. The 95th percentile time for trips to the U.S. was 80 minutes which gives a buffer time index of over 170. For inbound trips, the 95th percentile time was 100 minutes which gives a BTI of 147.

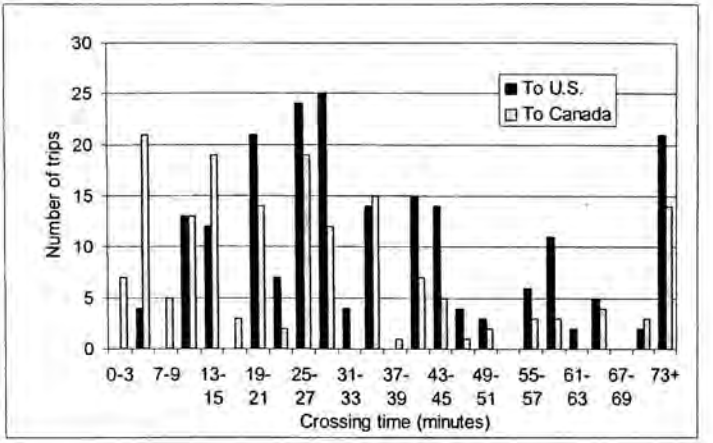


Figure 4: Average transit times at Ambassador Bridge

5.2 Differences in crossing times before and after 9/11/2001

Since the tachograph evidence pre-dates the terrorist attacks of 9/11/2001, it is possible to evaluate any difference in crossing times before and after this date. Surprisingly, average crossing times to the U.S. actually fell at Ambassador Bridge after 9/11/2001. The average crossing time prior to this date was 43 minutes, compared to 36 minutes after. However, the difference was not statistically significant at the 95% level as the computed t-statistic was only 1.6. For trips to Canada, average times before and after the terrorist attacks were virtually identical. These data, although by no means representative of all travel, at least do not show dramatic increases in travel times at Ambassador Bridge, post 9/11.

5.3. Crossing times at Queenston-Lewiston Bridge using tachograph data

As was seen with the GPS logs, the majority of trips to the U.S. through the Niagara gateway used the Queenston-Lewiston Bridge. In the tachograph dataset, there were 521 trips to the U.S. via Queenston-Lewiston and 390 trips to Canada. The average outbound

time was about 16 minutes with a standard deviation of 15 minutes, while the average inbound time was a bit higher at 24 minutes with a standard deviation of 24 minutes (see Figure 5). Once again, the tachograph distribution was skewed to the right. The 95th percentile time for outbound trips to the U.S. was 40 minutes which yields a buffer time index in excess of 150. For return trips to Canada, the 95th percentile time was 80 minutes which generates a BTI of over 230.

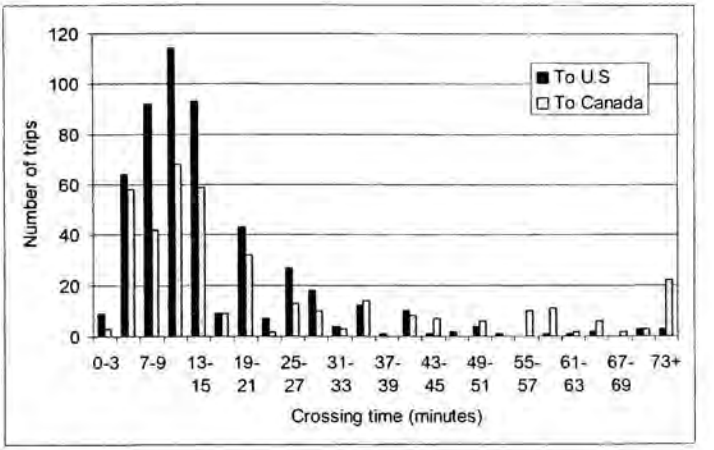


Figure 5: Average crossing times at Queenston-Lewiston Bridge

5.4 Differences in crossing times before and after 9/11/2001

There was no observed difference in crossing times to the U.S. pre- and post-9/11. There was a slight reduction in inbound travel times at Queenston-Lewiston Bridge after 9/11/2001 (26 minutes to 22 minutes) but this difference was also not statistically significant at the 95% level (t-stat only 1.3).

5.5 Crossing times at Peace Bridge using tachograph data

As was also seen with the GPS data, most of the trips in the tachograph dataset used the Peace Bridge to return to Canada. Nearly

180 trips had an inbound leg via Peace Bridge compared to only 29 outbound trips. (See histogram in Figure 6.)

The average outbound transit time at Peace Bridge was 53 minutes with a standard deviation of 24. All but one of these trips was made before 9/11/2001. The average inbound transit time was about 30 minutes with a standard deviation of 28. Given the large degree of variation the buffer time index at Peace Bridge was high. The 95th percentile travel time for inbound trips was over 80 minutes generating a BTI of nearly 170. The BTI for outbound trips was about 80.

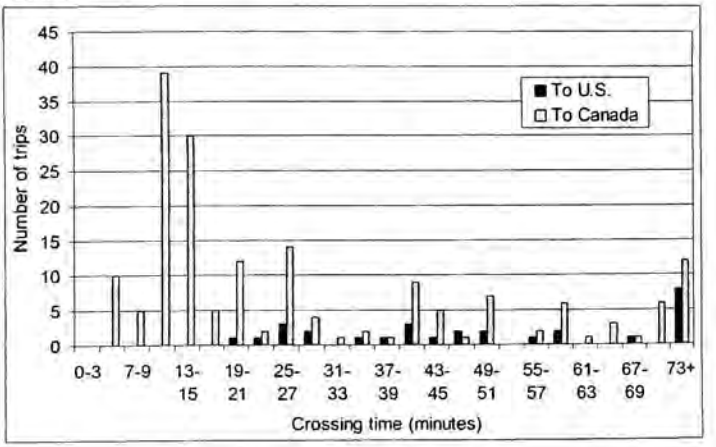


Figure 6: Average crossing times at Peace Bridge

5.6 Differences in crossing times before and after 9/11/2001
For inbound trips to Canada the average transit times fell slightly post-9/11 but were not statistically significant (t-stat was only 0.4).

6. Comparison of results with other studies
Given that the dataset in this study is based on only two carriers, it is interesting to compare our results with other studies. The only recent study for which similar analyses were performed was commissioned

by the U.S. Federal Highway Administration (FHWA)[3] in 2001. This study attempted to measure crossing times at major borders through direct observation at the border facility. Results from the FHWA study are compared against ours in Table 1. As can be seen, the GPS-based tractor log data stacked up fairly well against the FHWA estimates. The average crossing times were not dramatically different and the time distributions, as represented by the buffer time index, also seemed reasonable.

	Average crossing time (min.)			Buffer time index		
Bridge	Tachograph	GPS	FHWA	Tachograph	GPS	FHWA
Ambassador - To U.S.	34	14	20	116	81	66
Ambassador - To Canada	22	10	9	125	57	56
Queenston - To U.S.	14	13	n.a.	156	161	n.a.
Peace - To Canada	34	18	22	108	100	75
Blue Water - to U.S	n.a.	17	34	n.a.	125	135
Blue Water - to Canada	n.a.	10	6	n.a.	68	47

Table 1: Comparison of travel time results with FHWA study

With the exception of the Queenston-Lewiston Bridge, the tachograph data yielded higher average crossing times and consistently larger buffer time indexes than the FHWA numbers. This implies that average times vary depending on the type of carrier and the goods carried. *(Note that the tachograph numbers presented here were restricted to the period January-April 2002 to be more comparable with the GPS data. As a result, the numbers in this table differ from the numbers presented in section 5.)*

7. Summary and next steps

The objective of the study was to test the potential for using tractor logs to estimate travel times at border crossings. As we have shown here, truck tractor logs can yield information on both average travel times as well as travel time variability. Since data on whole trips are summarised in the logs, it is possible to analyse the variation in travel times by a number of factors including time of day, day of the week, share of total travel time, and by individual crossing and geographic location.

Of the two methods, the most promising for future work is more than likely logs obtained through real-time vehicle tracking services. As was mentioned in section 5, tachographs, although a reliable data collection method, require too much manual intervention to be used in large quantities. GPS-based logs, by contrast, do not suffer this limitation as the data are electronic and can be analysed with spreadsheet software. The other huge advantage is the coordinate information contained in the GPS-based logs. Most conventional data sources on trucking movements lack a direct link to the road network over which the trucks move—a fairly critical gap given that location is one of the most important characteristics of road transport. Such was not the case with the GPS-based tractor logs as the checkpoints closely matched the highway network over which the trucks travelled.

Future work will focus on the following areas:

- Obtaining a better cross-section of carriers. A sample of one or two carriers is sufficient to demonstrate the method but is obviously inadequate for making any firm inferences about border crossing times. Crossing times may depend on the type of goods being carried as well as the size and reputation of the carrier and thus will need to be controlled for in any future research.
- More and better coverage by time of day. Although the trips presented here make up a fairly large dataset, significant gaps were detected at various times of day. For example, a large percentage of the observations in the database reached the border before 6 am. For improvement, it would be necessary to collect trips over the entire day to reduce selection bias.
- GPS-based tractor logs need more detail. Checkpoints collected at fifteen-minute intervals are not really sufficient to analyse border issues. As pointed out earlier, it was difficult to identify a proper border zone because the checkpoints never lined up precisely on the border boundaries for each trip; in some cases no points at all fell along the border zone. This created a potentially large source of bias in the tractor log data as most of the border times clustered around the 15-minute level, suspiciously close to

the standard polling interval. To alleviate this problem it will be necessary to have more frequent polling of the truck's location.

- Tractor logs need a good measure of distance travelled. A big flaw in the data TC received was the absence of valid odometer readings for each checkpoint; this necessitated a complicated procedure for estimating distance using linear referencing. If tractor logs are to be analysed on a large scale, a proper measure of distance will be necessary. Should checkpoint data be obtained at much finer intervals, distance measurement could probably be made directly using straight-line calculations.
- Create stable relationships with data providers. This analysis could not have taken place without the generous cooperation of the participating carriers. Any future work will require strong relationships with the data providers to ensure that the information is treated with care and the confidentiality of the carriers is respected.

Reference

Texas Transportation Institute, The Texas A&M University System and Battelle Memorial Institute, *Evaluation of Travel Time Methods to Support Mobility Performance Monitoring*, April 2002.

Endnotes

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[1] The views expressed here are those of the authors and do not represent the views of Transport Canada.

[2] The concept of a Buffer Time Index was presented in the FHWA paper, *Evaluation of Travel Time Methods to Support Mobility Performance Monitoring*.

[3] *Evaluation of Travel Time Methods to Support Mobility Performance Monitoring* [http://ops.fhwa.dot.gov/freight/pmeasure/]

Establishing Benchmarks for International Border Crossing Truck Travel Time

INTRODUCTION

The purpose of this study was to determine a benchmark border crossing performance measure for commercial vehicles. By establishing a benchmark measure, the affects of changes in policy, infrastructure, and traffic volume on travel time and delay can be measured over time. In order to establish these measures, seven ports of entry (POE) were surveyed – four on the U.S./Canada border (Ambassador Bridge [Detroit]; Peace Bridge [Buffalo]; Blue Water Bridge [Port Huron]; and Blaine, WA) and three on the U.S./Mexico border (Otay Mesa, CA; Zaragoza Bridge [El Paso]; and World Trade Bridge [Laredo]). Together, these seven POEs account for a majority of the cross-border traffic between the U.S. and Canada and Mexico.

One of the first steps in developing a performance measure for international border crossings is to understand the system. The border crossing environment and procedures include a variety of operating agencies, each of them "in charge" of a certain portion of the crossing or the infrastructure. While there are differences in the paperwork requirements and operating procedures for freight crossing in each direction on the northern and southern borders of the U.S., the process can be described in a few common steps that are useful for defining the data collection necessary to support a national measure of freight crossing delay.

SELECTING A PERFORMANCE MEASURE

The best measure for the freight transportation system at international roadway border crossings is "travel delay per truck trip" from the initial waiting point in the exporting country through the first (primary) inspection point in the importing country. The term

"delay" is defined relative to operations at relatively low volume. This standard allows the processing time that the inspection agencies need to accomplish their mission to be removed from delay measurements. The processing time will be included in the low-volume condition. As inspections will always occur at the borders, it is not appropriate to use free-flow conditions as the baseline, as is done when analyzing a normal city street or freeway. However, if future treaties or other agreements significantly reduce or eliminate the inspection process, this can be revisited.

Figure 1 illustrates the cumulative travel times for free-flow, low-volume, and normal operating conditions as well as the delay estimate, which is the difference between the low volume and normal operating conditions. The delay estimate was tracked throughout the day and the delay time for each hour was multiplied by the number of trucks experiencing the delay. As a practical matter, the data collection was concentrated in periods when delay typically occurred (based on review of historical monthly, daily, and hourly commercial vehicle traffic volume data).

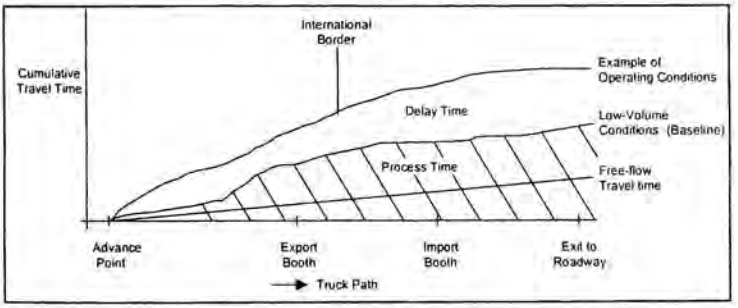


Figure 1. Schematic Display of Free-Flow Time, Process Time, and Delay Time

For this study, the following terms were defined:

- Baseline Travel Time – The time through the system at low-volume conditions. The value used was that of the lowest hourly

travel time in each direction across all study days. This value represents the "no delay" travel time.

- Average Number of Open Booths – The average number of commercial vehicle inspection booths open and available for processing trucks at the importing country's initial checkpoint. This figure is not used to compute delay but is useful to help understand the relationship between open booths, traffic volume, and delay. This analysis was a part of the research but was not included in this paper.
- Average Travel Time – The average travel time through the data collection area from entry to exit for trucks leaving the system each hour.
- Delay per Trip – The difference between the average travel time and the "no delay" time.
- Average Traffic Volume – The average hourly truck volume for the "season" or time of year being analyzed.
- Total Delay – The product of the average hourly truck volume and delay per trip.

DATA COLLECTION METHODOLOGY

For this study, two data collection locations were used in each direction (see Figure 2). The first location was at a point upstream from the first location where trucks might experience delay in approaching the border (Point 1) and the second location was immediately after the primary inspection booths and before detailed, secondary inspection (Point 3). Each data collector used a handheld computer to record license plate information for all commercial vehicles that passed their location. The computer stored the time that each license plate was entered. The data from the two locations in each direction were combined, allowing the travel time between each location to be determined. For each hour, the number of matches was noted for statistical analysis and the average travel time was computed. The travel time for each truck was assigned to the hour when the truck passed through the importing country's primary Customs inspection location as this was the only location that remained consistent throughout the data collection.

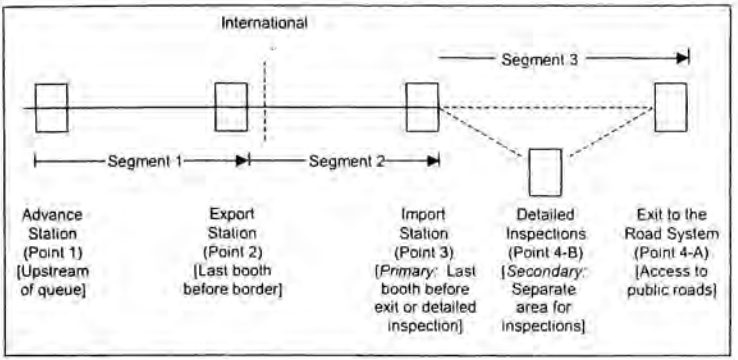


Figure 2. Data Collection Locations and Typical Border Crossing System (Simplified Diagram)

Data were collected at the locations shown in Table 1. "Inbound" refers to movements into the U.S. and "outbound" refers to movements from the U.S.

A Buffer Time and Buffer Index for each POE were also computed. The *Buffer Time* is a measure of travel reliability calculated by ranking crossing times of individual trucks at each POE. A crossing time for the 95th percentile was calculated, i.e., the time within which 95 percent of all trucks would have been processed from the point where they first experience delay through when they exit from primary inspection in the importing country. An average crossing time for all trucks was also calculated. The Buffer Time is the difference between the 95th percentile time and the average time for all trucks. The Buffer Time, then, represented the "extra time" a driver must budget to cross the border at the average time with a 95 percent certainty. This measure is particularly important, since more and more goods move under the stricter time requirements (e.g., just-in-time delivery) where timely, dependable, and consistent goods movement is critical.

Table 1. Data Collection Dates and Times

Port of Entry	Survey Date(s)	Survey Time(s)	Avg. Daily Volume[1]	
			Inbound	Outbound
Otay Mesa, CA	July 17-19, 2001	6:00am-8:00pm	1,886	not avail.
Zaragoza Bridge, TX	June 26-28, 2001	8:00am-8:40pm	1,973	1,080
World Trade Bridge, TX	October 30-November 1, 2001	8:30am-7:00pm	2,956	3,048
Blaine, WA	July 10-12, 2001	7:00am-8:00pm	1,335	not avail.
Blue Water Bridge, MI	June 12-14, 2001 August 14-16, 2001	6:00am-9:30pm 6:00am-9:30pm	2,289	2,030
Ambassador Bridge, MI	May 22-24, 2001 June 19-21, 2001	6:00am-9:00pm 5:30am-9:45pm	4,587	4,969
Peace Bridge, NY	May 22-24, 2001 June 19-21, 2001	6:00am-10:00pm 6:00am-10:00pm	1,990	1,992

The *Buffer Index* is the Buffer Time necessary expressed as a percentage of average time, i.e., the extra percentage of time that must be budgeted to cross the border. This measure serves to standardize the measurement of average delay among the seven crossings by compensating for differences in crossing length as a factor.

RESULTS

Average delay times were calculated for each POE (see Table 2). From these, several significant aggregate findings emerged. Inbound delay times exceed outbound delay times. Southern border delay times exceeded northern border delay times. In total, for all POEs, the average inbound delay time was 16.0 minutes, the average outbound delay time was 8.1 minutes, and the average delay time for all POEs, both inbound and outbound, was 12.4 minutes.

Buffer Time and Buffer Index

The relationship between Buffer Time and Buffer Index is perhaps best illustrated in the comparison of all outbound and all inbound

crossings (see). The Buffer Time for all inbound crossings was almost twice as large as that for outbound traffic. By contrast, the Buffer Index was slightly larger for outbound crossings than for inbound crossings. In other words, the *variability* of the 95th percentile outbound crossing time was larger, but the variability in inbound crossing time leads to a greater overall actual delay for those crossings.

Table 2. Average Delay Time Summary

	Delay Time (minutes)	
Location	**Inbound**	**Outbound**
Ambassador Bridge	7.5	3.1
Blaine	9.2	16.2
Blue Water Bridge	23.1	1.2
Otay Mesa	28.6	9.6
Peace Bridge	13.2	12.7
World Trade Bridge	18.9	15.4
Zaragoza Bridge	29.6	4.2
Northern POEs	12.5	6.2
Southern POEs	24.9	11.6
All POEs	16.0	8.1
Northern POEs (inbound and outbound)	9.8	
Southern POEs (inbound and outbound)	18.0	
All POEs (inbound and outbound)	12.4	

Another point of interest was the difference demonstrated in Table 3 relative to inbound versus outbound Buffer Times. Inbound Buffer Times were significantly larger than outbound Buffer Times in the aggregate (43 minutes versus 23 minutes). The largest single Buffer Time occurs with Peace Bridge inbound traffic (62 minutes), while the shortest Buffer Time was experienced by Blue Water and Ambassador Bridge outbound traffic (5 and 3 minutes, respectively).

There is one final point that further illustrates the potential importance of Buffer Times as a useful measure in assessing crossing times. Among the POEs surveyed, the Peace Bridge showed the most similarity between inbound and outbound average crossing times and,

among these crossings, is at the lower end of spectrum in terms of average time. However, Table 3 shows the Peace Bridge with the highest inbound Buffer Index. The significance of these measures taken together is that while the average crossing time is consistent in both directions, the potential exists for motor carriers to be significantly late in the inbound direction – later, on average, than at any other POE.

From the perspective of the user, the most desirable situation is a consistent, *predictably* low crossing time (i.e., a low Buffer Time), which yields a low Buffer Index.

Table 3. Comparison of Outbound and Inbound Buffer Times (in minutes)

Crossing	Average Time	95th Percentile Time	Buffer Time	Buffer Index
All POEs Outbound	14.2	37.4	23.3	164.1%
All POEs Inbound	26.8	70.1	43.3	161.6%
All Northern POEs Outbound	12.6	34.3	21.7	172.2%
All Northern POEs Inbound	24.1	70.3	46.2	191.7%
All Southern POEs Outbound	17.2	45.2	28.1	163.4%
All Southern POEs Inbound	33.8	64.9	31.1	92.0%
Ambassador Bridge	8.8	13.7	4.9	55.7%
Ambassador Bridge	20.4	33.9	13.4	65.7%
Blaine Outbound	21.5	35.3	14.3	66.5%
Blaine Inbound	17.3	35.6	18.3	105.8%
Blue Water Bridge Outbound	6.2	9.1	2.9	46.8%
Blue Water Bridge Inbound	34.2	80.3	46.1	134.8%
Otay Mesa Outbound	19.1	36.9	17.8	93.2%
Otay Mesa Inbound	35.0	64.3	29.3	83.7%
Peace Bridge Outbound	21.7	38.0	16.2	74.7%
Peace Bridge Inbound	23.3	83.4	61.9	265.7%
World Trade Bridge Outbound	17.2	45.0	27.8	161.6%
World Trade Bridge Inbound	31.2	54.9	23.7	76.0%
Zaragoza Bridge Outbound	13.2	34.0	24.7	187.1%
Zaragoza Bridge Inbound	37.2	77.4	40.2	108.1%

Crossing Volume/Crossing Time Relationships

A scatter plot of each POE (not reproduced in this paper) was produced to compare volume per hour per lane with delay time in minutes. The shape of the scatter plots for each port tells an interesting story. With the exception of the Blaine and Ambassador Bridge crossings, as noted earlier, it took longer to cross the border coming into the U.S. than it did to leave and inbound traffic crossing times showed considerably more variability without regard to volume. In other words, at a given volume, it was just as likely to take 2*x* time when coming into the United States. As a general rule, for outbound traffic, it took less time to cross and there was less variability in the time taken to cross. Even with security enhancements following 9/11, the authors believe this condition continues to exist.

The "ideal" shape of a scatter plot is to have all of the outbound data points groups closely together and all of the inbound traffic data points grouped closely together. Such a distribution would indicate a consistent and reliable crossing time at varying volumes; with distributions grouped more to the left along the horizontal axis indicating more desirable low crossing times.

The scatter plot of the Ambassador Bridge came closest to the "ideal" shape, demonstrating a consistently low crossing time for both inbound and outbound traffic. All POEs, to varying degrees, showed a horizontal distribution of points, meaning there was significant time variability across similar volumes.

Monitoring these time/volume relationships in future years and assessing how the shape of the scatter plots change over time may well prove to be a significant analytical tool in assessing border crossing traffic flows and times and in generating corrective action to facilitate movement. The Buffer Index is a measure that summarize these scatter plots.

IMPLICATIONS

Originally, this research was undertaken to document the development of a baseline border crossing dataset. With the tragic

events of September 11, 2001, and subsequent changes to the international border crossing operation, the comparability of these data may be diminished or eliminated. However, the knowledge gained about data collection procedures, analysis steps, reporting format, and performance measures will be applicable to further research, policy discussions, and POE modifications.

With respect to the implications of what the initial study provided, a few clear lessons could be learned:

- Crossing times at the Ambassador Bridge POE are clearly superior and more consistent than any other POE in the study. While, like other ports, inbound crossing times exceeded outbound crossing times, the margin of difference was significantly narrower and more consistent. Further, lower crossing times were achieved despite (as indicted in Table 1) the bridge having a consistently higher volume of traffic.
- Three of the POEs included in the study (Otay Mesa, Blaine, and the World Trade Bridge) have some form of "truck only" crossing and the Zaragoza Bridge is handles mostly trucks. However, the performance of these crossings, as measured as a function of the time/volume relationship, did not differ significantly from those crossings where auto and truck traffic are intermingled.
- Generally, U.S./Canada POEs (with the exception of the Blue Water POE) processed inbound trucks in less time and with less variability than did U.S./Mexico POEs.

FOLLOW UP STUDY

In October 2002, the Ambassador, Blue Water, and World Trade Bridges were revisited to reassess findings and explore how post-9/11 changes are affecting operations. Key insights from this effort are provided in the following sections.

Ambassador and Blue Water Bridges

Increased Staffing. Sufficient staffing at Customs facilities drove effective operations at both of the Canadian bridges in 2001. Before 9/11, staffing levels would have been insufficient to process traffic under the enhanced security provisions that followed the terrorist

event. Additional full-time U.S. Customs staff were hired. In addition, U.S. Customs staff continue to work longer hours to provide needed coverage of all shifts.

At the Ambassador Bridge, pre-9/11, U.S. Customs had a staff of 37 people on duty per 24 hours. Today, they are operating with the equivalent of 50 people per 24 hours. U.S. Customs at the Blue Water Bridge has augmented their staff with officers on temporary duty from New Orleans and Mississippi.

Addition of Improved Facilities. On the Michigan side of the Ambassador Bridge, the post-9/11 conditions were characterized by extensive delays as security procedures were enhanced. Trucks backed up at the Customs booths. It was clear that there were not enough booths available. U.S. Customs officials desired to build new booths, but were having difficulty gaining official approval.

Consequently, the Bridge Company put up the funds for three additional booths and built them themselves, enabling U.S. Customs to operate up to nine booths at the primary checkpoints. This illustrates that, on certain occasions, a private organization may be able to move more quickly than government agencies to accomplish an objective.

Innovative Methods to Clear Breakdowns and Accidents. The study also examined incidents as a cause of delay. The Ambassador Bridge has developed a very efficient system to clear the bridge of breakdowns and accidents. For cars and small vehicles that are able to roll on their own, Bridge staff turn the vehicles around and use the bridge slope to roll them off the bridge. For small vehicles that cannot roll on their own and for large trucks, contracts are maintained with towing companies to provide rapid response and removal.

New Programs to Provide Enhanced Security. There are a number of programs currently in operation that are likely to enhance security on the borders while working to ensure that delays for trucks crossing the border remain constant or are diminished. These include Canada's Customs Self Assessment (CSA) Program, the U.S. Customs-Trade Partnership Against Terrorism (C-TPAT), the U.S Border Release Advanced Screening and Selectivity (BRASS)

Program, and the joint Fast and Secure Trade (FAST) Program. Details on these programs are available in the follow up report.

World Trade Bridge

Physical and Operational Changes. At the World Trade Bridge, there have been virtually no physical changes (e.g., booths, roadways, secondary inspection areas) since 9/11. There have been no significant staff or scheduling changes or any major changes in operations relative to emphasis on primary versus secondary inspections. Furthermore, based on the on-site interviews, there seems to no significant, if any, increase in bridge crossing times.

According to the Bridge Department Director of the City of Laredo, the heavy emphasis on curtailing trafficking in drugs and illegal aliens preceded 9/11, "we were in September 11 mode long before September 11." This virtually permanent level of increased security at the World Trade Bridge has perhaps made it easier for both U.S. Customs and truckers to adapt to the post-9/11 environment.

Dedicated Truck Crossings. One of the reasons the World Trade Bridge was included for follow-up research was its restricted use by commercial traffic. This should have resulted in faster, less variable travel times. Results of the study indicated otherwise. Theoretically, conflicts among private automobiles, pedestrians, and commercial vehicles should contribute to delay. Yet, research revealed that there may be two reasons why a bridge that is restricted to commercial vehicles does not perform significantly better.

First, even at bridges that handle a mixture of traffic, commercial traffic is at some point segregated by the use of truck-only lanes or other design and/or control measures. Yet, the benefit of vehicle segregation is a function of where the traffic bottleneck takes place. If, for example, a traffic bottleneck occurs prior to the segregation of truck and automobile traffic, such that inspectors are waiting on trucks to arrive for inspection, the mixture of automobile and truck traffic can contribute to increased delay. But, if a bottleneck occurs after the traffic is segregated, or occurs prior to segregation but such that truck queues waiting for inspection still exist after the bottleneck, then there may be no benefit to vehicle segregation. As a result of

these various conditions, the positive benefits of segregating traffic may be less than initially thought.

Second, and more importantly, while data indicate that delay times at the World Trade Bridge may not be less from limiting the bridge to commercial truck use, they do not indicate how much higher the delay times would be if non-commercial vehicles were also allowed. This is particularly the case in Laredo where, as mentioned earlier, more stringent security measures designed to reduce trafficking in drugs and illegal aliens have been in place for a considerable time and may have more influence on delay than does vehicle segregation.

Programs to Enhance Security and Reduce Delay. Five major factors help maintain steady crossing time delays in the face of increased bridge traffic – *all of which were in place prior to the events of 9/11.*

- Increased use of electronic documentation to speed up the inspection process. Use of electronic documentation is expanding as both shippers and Customs officials see the benefit in reducing costs through reducing delay.
- Increased use of x-ray technology to examine cargo. This has helped reduce processing time while simultaneously allowing a more thorough inspection of more vehicles.
- Experienced drayage operators. Almost 90 percent of the traffic at the World Trade Bridge consists of drayage – repeated warehouse-to-warehouse trips between Laredo, Texas and Nuevo Laredo, Mexico. That these drayage companies handle so much of the truck crossing volume and have become familiar with border crossing procedures have been positive factors in helping maintain stable delay times in terms of the pre- and post-9/11 environments.
- Investment in approach infrastructure. From 1993 through 2000, the Texas Department of Transportation spent $388 million on roads and highways in Laredo and is projected to spend another $300 million by 2005. The infrastructure investment has helped keep delay times from increasing significantly in the face of increased truck traffic approaching and leaving the bridge.
- Weigh-in-motion technology and electronic toll collection for southbound traffic. These have helped process more trucks more

quickly as they exit the U.S. At present, almost 95 percent of all bridge tolls are collected electronically via toll tags.

RECOMMENDATIONS

In the post-9/11 environment, ensuring both timely and secure flow of commercial goods at the border will demand a multidimensional effort encompassing staffing, physical facility, bridge operational, and Customs programs. Ensuring that these objectives are achieved will require cooperation among the major participants in both the private and public sector on both sides of the border. For bridges on the northern border, the following recommendations are made:

- Develop a comprehensive management approach incorporating the entire system (including infrastructure, operations, and procedures) affecting both border security and delay.
  - Provide the administrative flexibility to quickly provide additional Customs booths to handle peak traffic without incurring unnecessary delay.
  - Provide adequate staff to operate both primary and secondary Customs facilities for peak traffic and security alert levels.
  - Adopt bridge operations protocols designed to clear incidents quickly from the bridge.
  - Adopt programs designed to prescreen carriers and drivers and move commercial truck traffic more quickly and securely through the primary inspection lanes.
- Employ FAST, in conjunction with C-TPAT, as an effective method for enhancing security at the border, while at the same time reducing delay and speeding up the movement of goods. This program should be adopted at the Mexican as well as Canadian border.

There are three current practices gleaned from the study of World Trade Bridge operations that can be recommended for adoption at all POEs.

- *Integration of infrastructure and Customs operations.* A thorough examination of the surrounding infrastructure in

partnership with all of the entities involved. To achieve the highest level of efficiency while maintaining necessary security levels, local infrastructure and Customs operations must operate as a seamless whole. No matter how efficient bridge crossing operations are, they can only be as efficient as the infrastructure allows them to be. Lane configurations, entrance and exit ramps locations, turn geometries, local road networks, roadway capacity, and a host of other design-related issues associated with the POEs can play a critical role in reducing delay and/or processing times. In most instances, those issues are the responsibility of state, local, or third parties. Adequate investment aimed at alleviating potential problems is a key component of efficient POE performance.

- *Use of weigh-in-motion (WIM) and electronic tolling technologies.* Both WIM and electronic tolling technologies should be applied wherever possible. Both technologies can significantly improve crossing times, particularly for outbound traffic. In Laredo, for example, use of WIM allows the bridge authority to weigh the vehicle as it passes over the weight sensor, record the owner, truck number, license and all pertinent information, calculate the toll, and deduct the toll from the owner's pre-paid account. All of these procedures take place without forcing the truck to come to a stop or requiring a cash transaction to take place.
- *Shifting commercial traffic to non-peak periods.* To the greatest extent possible, POEs should seek to shift more commercial traffic from peak to non-peak hours. Educational efforts should be undertaken, perhaps including financial incentive measures through reduced tolls or other means, to encourage shippers to use weekend and off-peak weekday hours at the POEs.

At the World Trade Bridge, there are two primary measures in place that enhance security and act to reduce (or at least hold steady) delay:

- *Electronic documentation and pre-clearance of goods-in-transit.* This allows Customs officials to anticipate both the volume and type of cargo that will need to be processed, spot any potential issues that deserve further scrutiny, and staff accordingly.

- *X-ray technology.* This technology allows Customs officials to examine cargos without physically unloading them each time to make sure they match manifests. X-rays also serve as another means to readily screen cargos for further examination.

FUTURE WORK

The project team recommends that a three-phased research program be designed and implemented to gain a more in-depth understanding of the characteristics and causes of truck delay as well as insights into the effectiveness of programs designed to enable trucks to move expeditiously and securely across the border. This research program would focus on the following elements:

- An annual or biennial measurement of bridge crossing times, including delay from the initial queue in the exporting country through (a) the primary inspection booths and (b) the secondary inspection facilities in the importing country. Initially the focus should be on collecting these statistics at the major POEs, with refinements and automated data collection facilitating expansion to other ports.
- A survey of shippers who make frequent border crossings in order to obtain direct input about the strengths and weaknesses of the specific POE.
- Annual or biennial interviews with selected Customs and bridge officials to obtain their feedback on existing programs and initiatives aimed at ensuing timely and secure cross border truck shipments.

ACKNOWLEDGEMENT

The authors wish to thank the Office of Freight Management and Operations of the U.S. Department of Transportation's Federal Highway Administration, which sponsored this study. Complete project documentation, including the final and individual site reports, can be found at http://www.fhwa.dot.gov/freight under 'Performance Measures.'

CROSSBORDER TRANSPORTATION SURVEYS: LET'S GET THEM RIGHT!

INTRODUCTION

Canada is an exporting nation that critically depends on the success of its trade and personal crossborder interchange for our country to maintain the standard of living we currently enjoy. The economies of Canada and the U.S. are interlocked and both nations benefit from the close relationships that have developed.

While we collect statistics about the volume of people and goods that flow through each port of entry, we need special purpose surveys to actually understand the nature of crossborder travel and give us a snapshot of the interchanges that are taking place and how they provide linkages between geographic areas. Trade and tourism are particularly dynamic activities that keep shifting. If we don't get a handle on them at selected points in time, we run the risk of making major policy decisions that are out of sync with reality, and making investment decisions that don't take full advantage of the real economic opportunities.

At the present time, for example, decisions about heightened crossborder security measures must be made in reaction to the horrific events of September 11, 2001. These decisions could have substantial economic and social consequences and we don't currently have adequate post- 9/11 survey data on passengers and goods to help national policy-makers with those decisions.

In spite of the fact that border crossing transportation surveys are essential, they are done very infrequently. All too often they are done in an urgent, reactionary mode to some need that has become critical.

This paper reviews some of the experience that the author has had with doing border origin-destination surveys (people and goods). While much of this experience has been gained in the Niagara, Ontario context, an attempt has been made to generalize the findings and the lessons learned. The paper puts forward an approach to help us deal with the border information challenge in a more orderly fashion, hopefully to the benefit of our two nations.

The author is currently employed by Peel Region, a Regional Municipality within the Greater Toronto Area that critically depends on strong trade relationships for its economic well-being. According to MTO surveys, Peel Region is the trucking hub of the GTA, and 12% of the trucks at the Michigan-Ontario border contain goods that were either made in Peel or loaded in Peel.

ORIGIN-DESTINATION SURVEYS ARE DONE FOR MANY REASONS

Some examples are as follows:

1. More bridge/tunnel capacity is needed

Studies in the late 80's led to the decision to add bridge capacity to the Peace Bridge crossing.

2. More freeway feeder capacity is needed

The Niagara Needs Assessment Study (2002) concluded that planning should proceed to secure a Mid-Peninsula Corridor so that Canadian access to the Niagara Gateway isn't so critically dependent on a single facility, the QEW.

3. More system capacity is needed

The current Michigan/Ontario study, led by URS Cole Sherman, is developing a plan to meet the long range border crossing requirements including bridges/tunnels, freeway feeders and border processing facilities (passengers and goods)

4. Understanding Border trade flows

The Eastern Border Transportation Coalition (EBTC) has just completed a major study of Canada/U.S. transborder trucking

5. Understanding the Tourism market

The Ontario government needed better information in the late 80's to develop a tourism strategy and conduct a special purpose survey.

FACTORS TO CONSIDER IN DOING A BORDER SURVEY:

In my experience the following steps will have the greatest impact on the value of the final database:

1. Understand the need for the survey in the broadest possible context

The framing of the survey within the broader context is very important. We must incorporate within the survey program, all of the policy variables that are going to be of interest. This requires a sensitivity to policy issues, both current and future (eg. range of potential future border security measures, introduction of more toll facilities). Figure 1 shows the volatility of auto traffic on the Niagara bridges and some of the reasons for it:

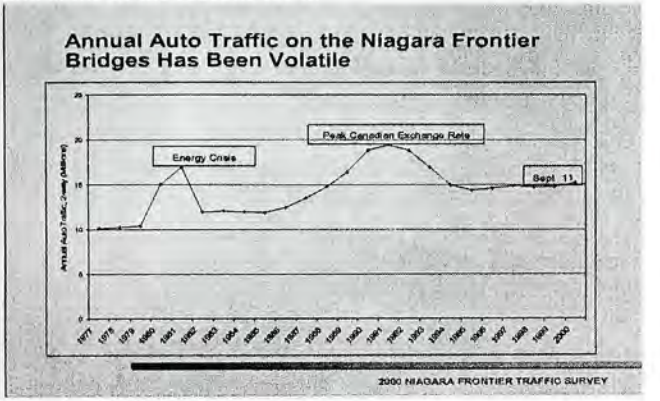
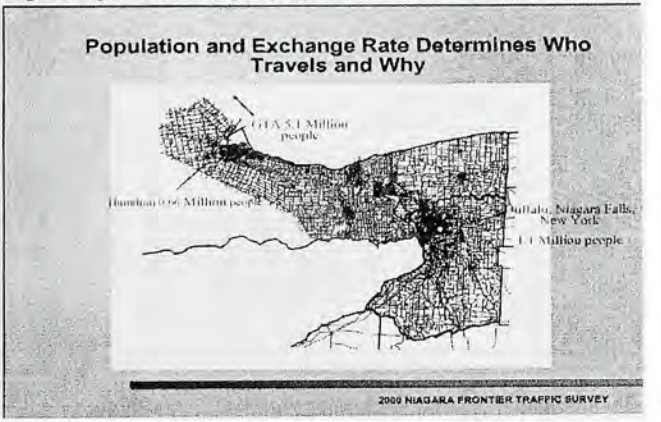
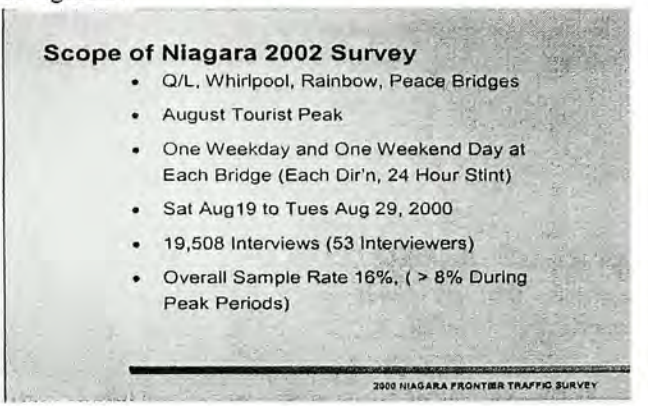


Figure 2 presents the geographic context for bridge traffic:

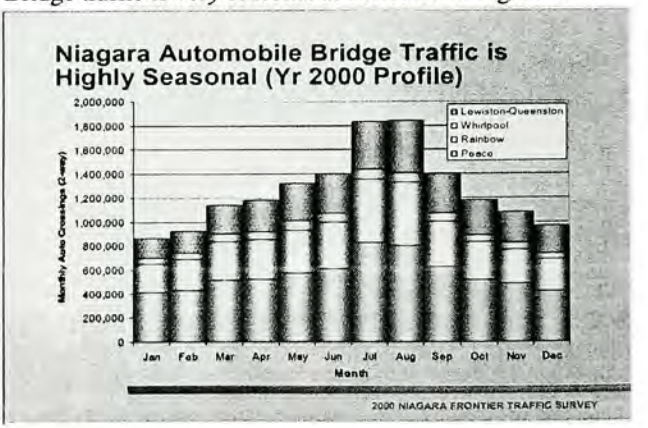


2. Understand the nature of the crossborder travel market before you design the survey

The challenge is to always get better and more accurate information. We need to build on what we know already and improve on previous survey shortcomings in capturing that information. The scope of the Niagara 2000 survey is shown in Figure 3:



Bridge traffic is very seasonal as indicated in Figure 4:



While bridge demand is mostly local, we should not underestimate the importance of the longer trips.

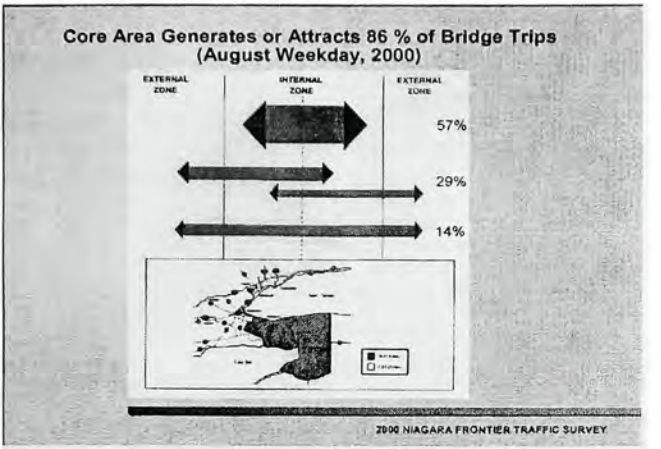


Figure 5

Tourism is the primary market, with the highest growth in tourist traffic from the U.S.

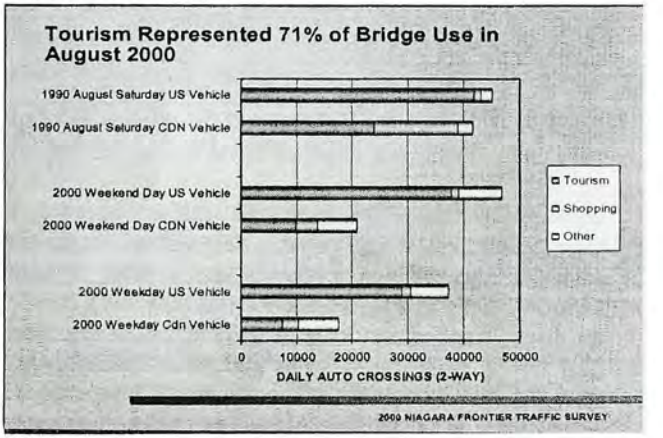


Figure 6

Population geography determines the users for each bridge.

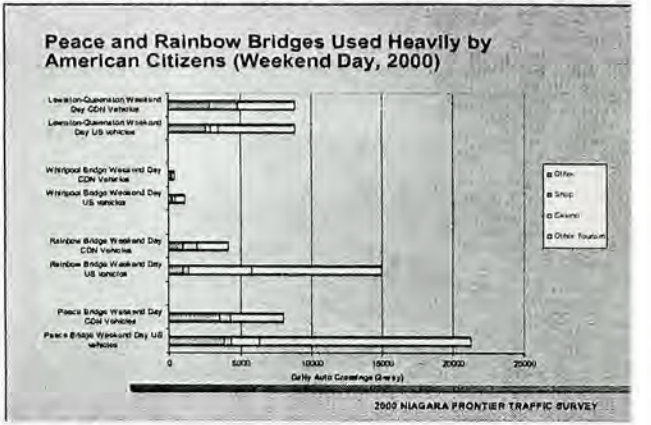


Figure 7

3. Hire the best prime contractor to manage the survey
   The prime contractor must be strongly motivated to deliver a product of the highest quality. He should be an innovator and be prepared to put data quality ahead of profits for the firm.

4. Allow ample lead time to plan and execute the survey
   The agencies sponsoring the survey need to select a good client project manager who can make decisions on behalf of the group. Decisions must be made quickly to deploy the survey.
   Data quality will suffer automatically if the client does not allow sufficient time between award of contract and commencement of the interviewing in the field. (Typically a period of three to four weeks, minimum, should be allowed for this). The contractor needs sufficient time to screen and hire top quality interviewers and train them on critical elements. While the data in the Niagara 2000 survey was of high quality, it could have been improved by having better and more extensive interviewer training on geography and place names on both sides of the border.

5. Field crew selection and operation is critical

In the Niagara 2000 survey, Canadian Facts was hired to plan and execute the fieldwork. They had excellent experience and seasoned supervisory staff that were equal to the challenge. They knew how to draw from a pool of experienced local interviewers. With the tight time frames, the survey would never have happened without this strong base of experience and expertise.

Figure 8 shows how the Niagara 2000 survey was conducted:



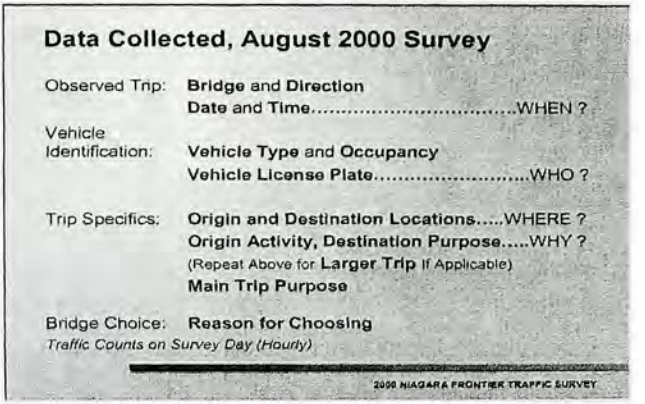
6. Improve the Survey Design and Questionnaire Design

With border surveys being so infrequent, every opportunity must be taken to improve and introduce innovation to the survey process. Eventually an "ideal design" will be achieved.

Paradigm introduced direct data entry to the Michigan-Ontario surveys in 2000. This introduces an opportunity for data quality checks while the interview is in progress. It also facilitates better monitoring of interviewer performance in the early stages of the survey.

Questionnaires must be continually improved to enhance the understanding of the crossborder markets. Any weakness in questionnaire design will show up as weakness in the database itself.

Figure 9 shows the logic for the Niagara 2000 data collection:



A number of new features were introduced to the Niagara 2000 survey as shown in Figure 10:

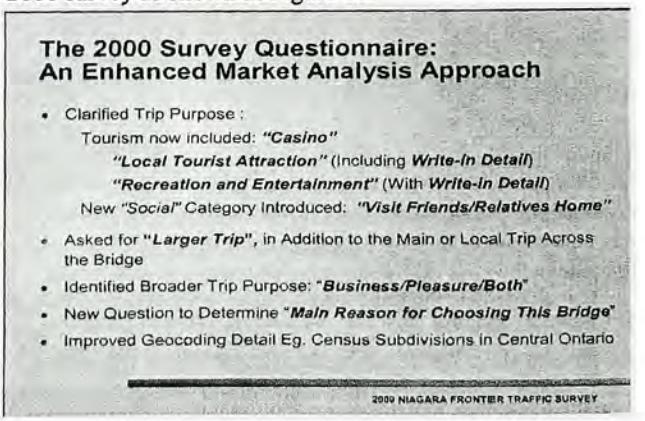
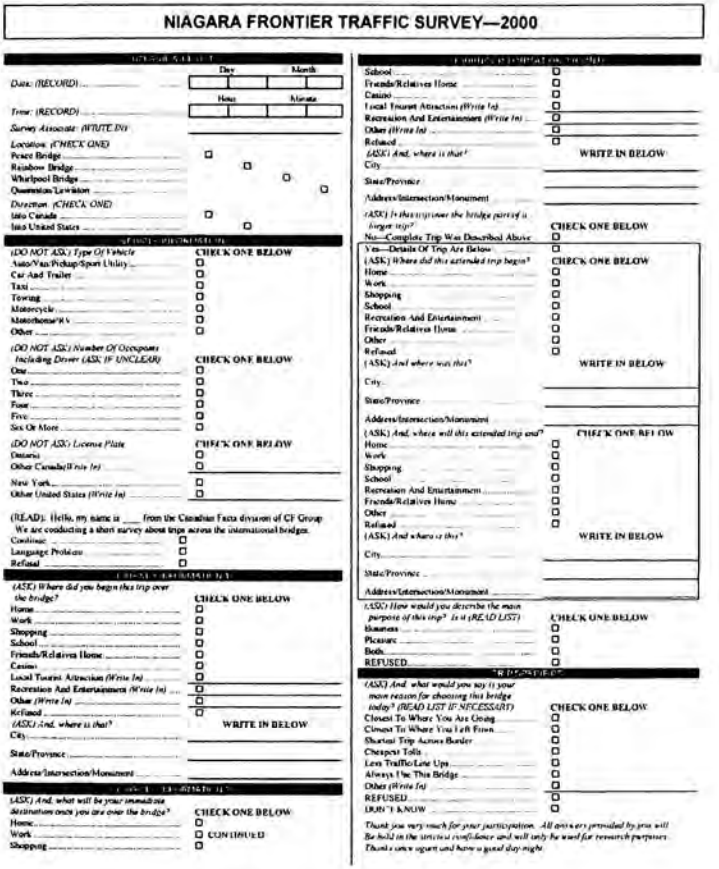


Figure 11 presents the questionnaire used:



NIAGARA FRONTIER TRAFFIC SURVEY—2000

Day / Month

Date: (RECORD)

Hour / Minute

Time: (RECORD)

Survey Associate: (WRITE IN)

Location: (CHECK ONE)
Peace Bridge
Rainbow Bridge
Whirlpool Bridge
Queenston-Lewiston

Direction: (CHECK ONE)
Into Canada
Into United States

(DO NOT ASK:) Type Of Vehicle — CHECK ONE BELOW
Auto/Van/Pickup/Sport Utility
Car And Trailer
Taxi
Towing
Motorcycle
Motorhome/RV
Other

(DO NOT ASK:) Number Of Occupants Including Driver (ASK IF UNCLEAR) — CHECK ONE BELOW
One
Two
Three
Four
Five
Six Or More

(DO NOT ASK:) License Plate — CHECK ONE BELOW
Ontario
Other Canada/(Write In)
New York
Other United States (Write In)

(READ): Hello, my name is ___ from the Canadian Facts division of CF Group. We are conducting a short survey about trips across the international bridges.
Continue
Language Problem
Refusal

(ASK) Where did you begin this trip over the bridge? — CHECK ONE BELOW
Home
Work
Shopping
School
Friends/Relatives Home
Casino
Local Tourist Attraction (Write In)
Recreation And Entertainment (Write In)
Other (Write In)
Refused

(ASK) And, where is that? — WRITE IN BELOW
City
State/Province
Address/Intersection/Monument

(ASK) And, what will be your immediate destination once you are over the bridge? — CHECK ONE BELOW
Home
Work
Shopping
School
Friends/Relatives Home
Casino
Local Tourist Attraction (Write In)
Recreation And Entertainment (Write In)
Other (Write In)
REFUSED
DON'T KNOW

Thank you very much for your participation. All answers provided by you will be held in the strictest confidence and will only be used for research purposes. Thank-you again and have a good day/night.

7. Stratify the Sample
   Crossborder transportation activity occurs in quanta eg. By bridge, day of week, by hour, by direction, by US resident, by Canadian Resident. The variability of these quanta has to be incorporated into the survey design in order to end up with a database that is truly representative. Also, control information for these quanta must be obtained in order to properly expand the data from the sample to the universe. Don't learn the hard way that it is often difficult to get the right survey control information after the fact!
8. Determine Sample Size Requirements
   For O-D surveys, sufficient sample size is always an important determinant of data quality. If the sample is much less than 5%, the O-D patterns captured will not be very reliable. (The O-D pattern is vital to route location studies such as the route for the Niagara Mid-Peninsula Highway Corridor). It is relatively easy to get a good sample for the daily, 24 hour distributions but it is more difficult to get adequate sample size for the peak period. The latter is one of the most important determinants of overall survey size and cost.
9. Arrange for Control Data for the Survey
   Control data are necessary both for data expansion and for relating the data collected in the survey time period to the activity occurring at other parts of the year.
   Ideally, a log should be kept of any unusual events that may have affected the survey data and an assessment made of whether these happenings are representative of events that would normally occur in this period.
10. Data Geocoding is very important
    The process for geocoding the locational data from the questionnaires is a major factor in the quality of the final database. The geocoding operation will go smoothly if the interviewers had a good understanding of the important role of geography in the survey and were well trained on place names. The geocoding process is also founded on having a good traffic zone system and centroids.

Figures 12 and 13 illustrate the auto traffic flow patterns measured in the Niagara 2000 survey and the superzones that were used. While the geocoding of most interview records is straightforward, good supervisor judgement is required to deal with geocoding the more difficult records.

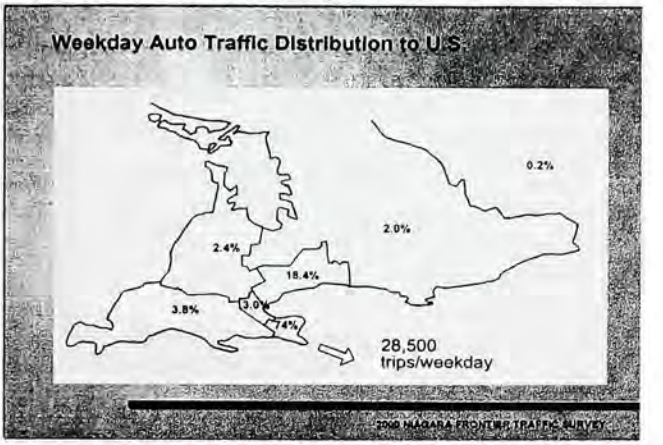


Figure 12

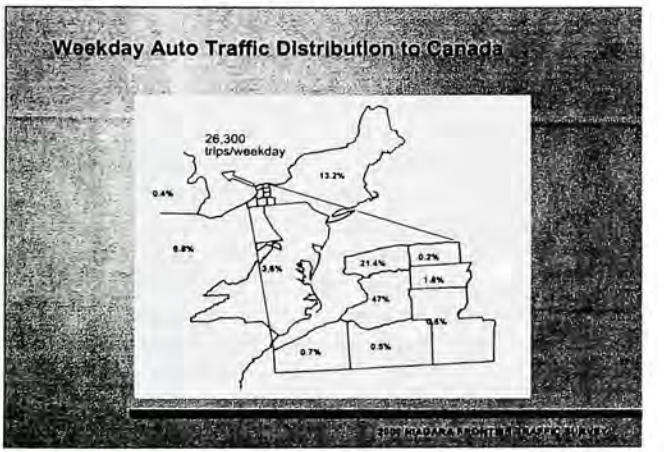


Figure 13

The Niagara 2000 survey had a very detailed traffic zone system and Figure 14 shows the high definition of results available through careful geocoding:



11. Prepare for the added cost of introducing innovation to the survey process

    If we are to move ahead in survey quality and design, the client must be prepared to pay for the introduction of new innovations and improvements to the survey process and for questionnaire design.

12. Followthrough Analysis of the Survey Database

    The consultant is always under extreme time pressure to assemble a clean database (a painstaking and thankless task), to expand the survey database, to develop a user-friendly database, to summarize the results and to present the findings/highlights of the survey. In doing each of these, the consultant progresses up a very long learning curve. But there is never enough time to do a thorough job on the analysis.

    The client would be well advised to hire back the consultant to do an extended job of the analysis while the consultant is

still high on the learning curve. This work would include a comparison of the survey results with those of other surveys. Too often new analysts, unfamiliar with the data, will dive into the data without understanding the right way to apply the control information.

THE RELATIVE COST OF BORDER CROSSING SURVEYS

The following table points out the cost of border surveys in relation to the cost of activities which depend on the surveys:

a) Cost of 1990 Niagara Survey: $120,000Cdn (approx.)
b) Cost of 2000 Niagara Survey: $160,000Cdn (approx.)
c) Cost of Proposed Peace Bridge Twin: $90 Million US (est.)
d) Cost of Bluewater Bridge Twin: $107 Million US (approx.)
e) Cost of Proposed Mid Peninsula Highway $1.2 Billion Cdn (est.)
f) Annual Value of Goods Crossing the Peace Bridge from the QEW at Niagara $50 Billion Cdn (est.)

It should be pointed out that activities c) through e) critically depend on the availability of quality and timely survey data as a foundation for their overall success.

PROPOSED ACTION PLAN FOR IMPROVING BORDER SURVEYS

1) Establish a border survey interest group or coalition

This could be a special federal/provincial/state/municipal group, which could provide oversight for border surveys when they are needed, and offer technical expertise/advice. The group should draw from the best experience and expertise available on both sides of the border. The group could be an extension of an existing organization such as EBTC or TAC, or it could be a special group, hand-picked for the purpose.

2) Approach government interests about supporting/funding border survey activities (passenger and freight)
Providers of study funds on both sides of the border should be approached and briefed on the importance of having an ongoing program of border surveys.
The U.S. government has had a special Borders fund under ISTEA for doing necessary studies and projects. The EBTC has just completed a comprehensive trucking survey and study. In Canada we need to look at better ways to recognize the ongoing need and organize ourselves accordingly.

3) Develop Generic Approaches for doing Cross Border Surveys and prepare written guidelines as suggestions for conducting them
We need to call upon the best collective ideas and experience in conducting transborder surveys. While some border locations may have unique needs, a common approach to conducting surveys would heighten the quality of the product and make real comparisons possible between ports of entry. A collective approach would ensure that innovation is given a high priority to enhance our understanding of changing market conditions and forces. Consideration should also be given to how we could coordinate with surveys and data collection from other modes, such as air and rail.

4) Establish a program for carrying out border surveys at key crossing locations
The program could either be set up on a regular cycle of X years for freight surveys and Y years for passenger surveys (the surveys could be coincident). Or it could be set up with certain trigger conditions that would identify when the surveys should be conducted. The important thing is to put in place a deliberate program to collect more timely, accurate and comprehensive border transportation data.

FINAL COMMENTS

Border surveys are a vital prerequisite to the multimillion dollar investments and policy decisions being made which affect our entire economies on both sides of the border. Border surveys are a small investment relative to the value they add for making the required decisions. They represent a small percentage of the total cost.

We're in an information age - we need to take border crossing surveys much more seriously. At the same time, let's take careful steps to ensure that the border surveys produce data of the highest quality.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the efforts of the following colleagues who have advanced the cause of high quality transborder surveys:

- John Barr, Bob Johnson (Niagara Region)
- Frank Williams, Bill Rhamey, Doug Smith, Julius Gorys, Rob Tardif, Bill Raney, Jin Wang, Fred Leitch, Bruce McCuaig (MTO)
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- Gary Halpenny (Canadian Facts)

It should be noted that the views expressed in this paper are strictly the opinions of the author and may not reflect the policies of the client organizations.

Ultra Large Airlifters (ULAs): A North American Window of Opportunity

Lieutenant Colonel Mike Woodgerd, U.S. Army, Center for Army Analysis

From Kandahar to Korea to Kirkuk, the US military, allies and coalition partners have unceasing demand for strategic deployment capability. Right now, there are two technical limitations—there are not enough lift platforms and what we have is restricted to major ports and airfields throughout the entire pipeline to be fully effective. There are also operational limitations—strategic deployment is "too slow" (as perceived by those at the sharp end engaged in operations), those same ports and airfields are obvious targets, and the actual areas of operations are not always close to good ports and airfields. "Lines of communication—seaports, airfields—cannot be taken for granted. We must be prepared to deal with the environment as it's presented to us, and not assume that a viable infrastructure will be available....We have to be ready to adapt." GEN Paul Kern, Commander, U.S. Army Materiel Command. [1]

One developing technology offers this viable solution to both the technical and operational issues of deployment. The evolving military term for the specific designs we are interested in is Ultra-Large Airlifter (ULA). A ULA is an airship or hybrid air vehicles (a combination of Lighter-Than-Air (LTA) and Heavier-Than-Air (HTA) characteristics) that uses lifting gas (helium) for all or most of

[1] Interviewed by John G. Roos, Armed Forces Journal International, March 2002. Pg 31.

its lift, has a payload far greater than conventional aircraft, range in the thousands of miles, speed significantly greater than surface ships, and does not require significant infrastructure for operations.

This paper describes what they are and why they should work, identifies quantifiable value added to military deployments, and identifies the critical synergy between civilian and military applications. Even during periods of conflict, a great deal of military cargo moves via commercial assets. Also, even a cursory comparison of military deployments with the transportation needs of Canadian mega-projects illustrates the similarities. Both go to remote places and the trips are mostly one way. Military deployments also have surges –a force deploys somewhere to do a mission and deploys back out at some future time. In between, there is a continual sustainment flow, but there are many peaks. This is one place a ULA is needed. To quote the Durand Committee from 1936, "The airship replaces nothing. It augments everything." It is additional airlift, it is additional security, and it is additional platforms.

More ships and planes add little to the equation because of other factors, such as the Maximum On Ground (MOG)—one of various physical limitations on the number of aircraft that can be at an airfield, which limit the overall throughput. This overall throughput is what really matters. Aircraft and surface shipping are near the limits of improvement. Any increase in effectiveness is tinkering at the margins. The only significant way to improve strategic deployment is to develop a platform that can deliver hundreds of tons of cargo to a bare field almost anywhere in the world.

The actual proposed systems that fall into the ULA category are proposed but not yet proven. LTA overall is perceived as a failed technology. Why should the military and commercial investors offer these systems serious consideration? Two reasons: the potential payoff, in both civilian commercial applications and military deployment is too great to simply ignore, and enough historical data exists to form valid conclusions about future viability. The first step is to quantify, as precisely as possible, the value added to military

deployments of a ULA. Secondly, determine how likely these systems are to perform to their design parameters. Put another way, how realistic are their advertised capabilities?

LTA Basics

The term Ultra Large Airlifter is broad by design. It includes airships, hybrid aircraft, and even other technical designs. For simplicity, I will use the word airship throughout most of this presentation although it may apply to various technical designs. For our purposes as "users", the differences are not crucial to basic understanding of the capability.

First, some basic definitions are in order. An airship is a lighter-than-air (LTA) craft with its own motive power. It can stay aloft solely because of "static lift" – the buoyancy of its lifting gas, *which is less dense than air.* The lifting gas, normally helium, inside an airship allows it to float within the ocean of air. In this it is similar to a ship, *which is buoyant due to the air in it,* floating on top of the denser water. An airplane relies on the "dynamic lift" it creates by passing *a wing rapidly* through the atmosphere. Thus, an airplane must move to stay aloft, where an airship, in most circumstances, can stay aloft *with no motive power at all.*

A hybrid aircraft combines the static lift of its gas with the dynamic lift generated by its body shape as it moves through the air. This should allow it to carry more payload than a pure airship, for which it trades off the capability to stay aloft relying only on static lift.

Historical Benchmarks

The closest historical data point to a ULA is a rigid airship, 161 of which were built in the first 4 decades of the 20th Century and performed as passenger liners, mail carriers, strategic bombers, naval scouts, and goodwill ambassadors. Another key source is US Navy experience with both rigid and non-rigid airships, of which it operated over 200 of the latter, especially in WWII and up to 1962.

Two particular comparisons give us an idea. The German airship *Graf Zeppelin* circled the world in 1929 at an average speed of 65 MPH. Flight legs included Germany to Japan and Japan to Los Angeles. US Navy rigid airships USS *Akron* and *Macon*, which were flying aircraft carriers designed for a scouting role, had a maximum speed of 85 MPH, a cruising speed of 65 MPH, and a design range/endurance of 9,000 miles.

Airships also demonstrated consistency in performance. The *Graf Zeppelin* made a total of 144 ocean crossings, including 68 round trips across the South Atlantic during regularly scheduled passenger service between 1934 and 1937, carrying over 13,000 passengers. The punctuality exceeded anything a commercial passenger can, unfortunately, expect today.

During WWII, the US Navy operated over 200 blimps during the period 1941-1945. The overall Operational Readiness Rate and Accident Rates were comparable to HTA. During WWII and during airborne early warning and anti-submarine warfare patrols in the 1950s airships, displayed the ability to remain on station continuously for days during even the most violent winter weather. Navy experiments on the effects of icing found that rime ice, the most dangerous, rarely formed on the airships and minor changes in altitude avoided the effect. In fact, pilots could not even stay in the dangerous areas enough to gather sufficient data. Analysts had to construct mathematical models to complete their estimates.

LTA's heyday was during the two World Wars and during the interwar period. There is a unique symmetry between the time we now live in and those interwar years. Today, the US Army, in particular, and the US Department of Defense as well are devoting a great deal of thought and effort towards transforming themselves for the future. The 1930s were a time of incredible innovation as well, which led to carrier aviation and the use of lighter-than-air, for instance, all developed in fiscally constrained times. Even during the Depression, and with an incredibly small force structure, the military experimented with flying aircraft carriers, and with matching airships

with surface shipping, in what we would now call sea basing. There is always need, and room, for initiative.

The Absence of LTA today

So why don't we see airships in common use today? Airships reached their technological zenith in the early 1930s—coinciding with the worldwide Great Depression. Neither governments nor commercial industry, such as the Goodyear Corporation, had enough money to build many airships. Airships were part of military force structure and so were fighting for a share of a very small defense budget. Spectacular crashes, large capital investment requirements, and the more rapid cycles of HTA development robbed airships of widespread credibility. Successful operations of airships involved very few personnel and took place out of sight over oceans. Aircraft, by contrast, filled the skies during and after WWII and involved hundreds of thousands of people operating them, living near them, or suffering under their attack. The massive infrastructure of airfields, aircraft, pilots and support personnel after WWII made aircraft the most commercially viable systems.

The primary reason that LTA has not re-emerged except for advertising blimps is simply money. Until now, there was simply no significant market for LTA technology. The commercial demand to lift Big, Ugly Freight did not exist, nor did the potential "middle market" for goods between airfreight and sea freight. Those markets now do exist. The technology to build craft large enough to profitably service those markets now exists. The world supply of helium is now large enough to fill those craft. The global economy, despite the current slump, is larger, stronger, and more transparent now and so could support fleets of airships and hybrids in commercial operation.

Freedom from Infrastructure

Figure 1 shows USS *Shenendoah* moored to the airship tender USS *Patoka*, a converted oiler. Airships, like any system, have unique abilities and limitations. Our Navy airships could use the *Patoka* as a

base of operations for extended periods (3 weeks was the record). The airship would moor to the mast on the stern of the ship. The *Patoka* provided all sustainment for both crew and airship and could even steam some distance with the airship moored to the mast. This illustrates that innovative operational thinking will be necessary for proper utilization of any airship or ULA in military operations, but that the possibilities are there.

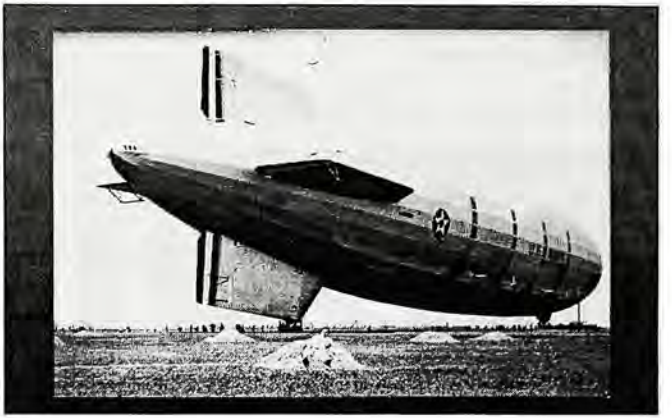
Figure 1: USS Shenendoah Moored to the USS Patoka



Figures 2 highlights a critical point, which is the relative infrastructure independence of an LTA system when compared to traditional lift assets such as aircraft and ships. In general, for an airship, infrastructure is what is called "a stick in a field." Very little infrastructure is actually needed compared to a port or an airfield. Basically, a mast in a field can create an operating base and there are several diverse techniques for ground handling that offer economic and practical means to deliver cargo to remote locations without even the mast. LTA systems offer a small footprint and no demand for additional complex infrastructure with the attendant expense and environmental concerns. This allows delivery of critical payload or some key capability directly from origin to destination or at least bypassing many chokepoints. Reducing "touches" of cargo and

allowing delivery of material outside of the existing limited time frame of ice roads offers significant financial advantage.

Figure 2: USS Akron Moored at an Expeditionary Mast in Florida

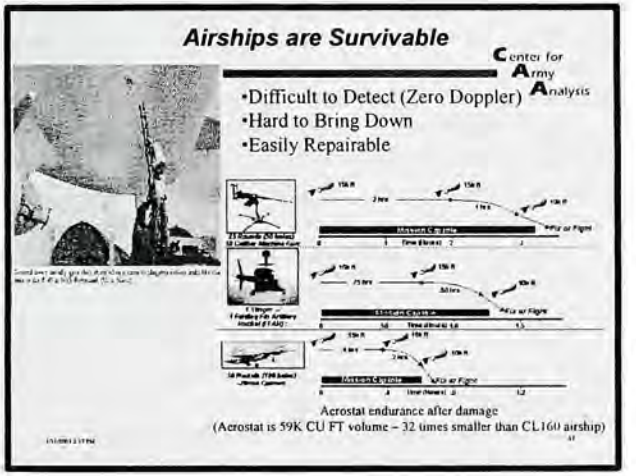


Survivability

Airships are widely believed to be fragile and useless for military purposes. This is a misperception based upon a few tragic accidents and much evidence exists to refute it. During WWII, US Navy blimps performed antisubmarine patrol, convoy escort, and search and rescue missions. The loss rate was 17 percent (29 blimps), and the overall accident rate per flight hour was very close to Navy HTA rates. More recent testing done by the UK Ministry of Defense and the US Army JLENS Program showed that airships are quite rugged. The internal pressure required to keep the envelope (or "bag") tightly inflated is very small and so even with holes blown in the material the gas inside is not under great pressure to rush out. Therefore, unless the damage is a catastrophic rip, airships degrade gracefully and would likely come down under good control. Envelopes do not reflect radar, so finding them is difficult.

Figure 3 demonstrates survivability very well. The charts show deflation times after damage. The picture on the left shows a kid with no T-shirt. A Navy ship came in off patrol with a hole in it and they stuffed a T-shirt in it and will fix it quickly and resume operations. The point to take away is that even with a hole that big in the envelope, the ship did not deflate. They do not pop, the gas does not blow up, and they do not plummet immediately and catastrophically to Earth. The airship deflates slowly and actually it is the bag's loss of rigidity that causes an airship to lose its ability for controlled flight. The ship then comes down and not in a catastrophic manner. So, your payload survives, which is important to me, people are part of that payload.

Figure 3: LTA Survivability Examples



US Military Applications of Lighter-Than-Air Technology

There are four primary areas of interest now within the US Department of Defense utilizing LTA technology. I point these out for information and to point out that such a diversity of interest and missions presents opportunities to synchronize efforts and also ensure that investment in one area pays off across all areas. The four areas are:

- Stratospheric Airship: An airship intended to operate at app. 72,000 feet as a sensor/communications platform for a Wide Area Surveillance Mission. This could be cell phone relay or radar coverage for North American sovereignty and defense. The U.S. Missile Defense Agency (MDA) is the lead on this particular Advanced Concepts Technology Demonstration (ACTD). An ACTD is a method to take a mature technology, stimulate the technological progress and compress development into two to four years. This is a funded program.
- Ultra Large Airlifters for transportation are discussed at length in the rest of this paper. They are also the most germane to the focus of this conference.
- Manned airships for surveillance includes Near Shore patrolling, such as over harbors and coastlines as well as Maritime Domain Awareness (MDA). MDA refers to Navy and Coast Guard desire for an off-shore patrol capability up to 200 miles out, knowing all the ocean around us, understanding it, knowing what is going on with relatively constant surveillance. Neither ULAs nor manned airships are currently funded programs.
- The final area is also a funded program. JLENS stands for Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System. This program uses aerostats (tethered balloons) to lift radar systems for cruise missile defense. Aerostats also support some counter-drug surveillance along our southern border.

The US military wants a capability offered by Ultra Large Airlifters Figure 4 lists the kind of performance ultimately desired. The US never has enough lift. We move more than most people in the world do, so we want something that is pretty massive. Range capability of thousands of miles allows me move from origin to destination without bouncing my fire power a couple of times, and it lets me go around people who do not want me to over fly them. Speed must be greater than the surface ships. These systems must not require a significant infrastructure. The desire is to deliver cargo to a bare open field, roll that cargo off and have the ULA fly away.

Figure 4: ULA Attributes

- Ultra Large Airlifter (ULA)
  - New term for proposed systems either pure airship or hybrid aircraft (combination of LTA and HTA attributes)
  - Payload and Volume far greater than conventional aircraft (100s of tons)
  - Range capability measured in thousands of miles
  - Speed significantly greater than surface ships
  - Does NOT require significant infrastructure for operations
- Additional Airlift: Origin to Destination
  - Volume is perhaps most valuable asset
  - Must bypass ports and airfields
- Seek Asymmetric Advantages
- Not platform specific approach
- Must evaluate overall system contribution and integration into Defense Transportation System.

That is the desired capability. Obviously the reality of ballast issues, ground handling and other aspects will shape the realistic limits. But when you compare it to being limited to an existing airport, if I can land in a field anywhere, even the small infrastructure I have to put in for ground handling still gives me a tremendous advantage. Volume is more important than weight. We cube out before we weigh out. I use up all the space in my lift platform, be it an airplane or a ship, rather than weigh it out. It would be advantageous to fly a helicopter in an operational configuration, and I just have to take the rotor blades off, fold them back, depending upon the particular

helicopter, roll it off, do a quick 30 minute ground check and I have an operational capability. For example, our modeling showed I could notionally move an Apache AH-64 Attack Battalion 10,000 nautical miles and have it up and flying in 12 days versus 33 days by sealift. The airship operates like a ship. It will cruise 24 hours per day nonstop until it needs to refuel. The best way to understand and conceptualize an airship is to remember that it is a ship in every way. The ocean it moves through is an ocean of air. It is crewed and operated like a ship. It operates 24 hours per day and performs best over water.

Strategic Mobility

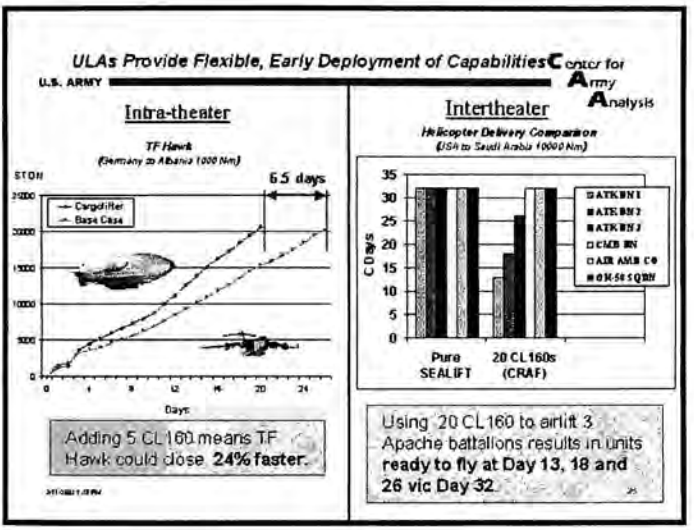
Now, to give you some feel for the significant benefit to the military that this would allow... We use helicopters to fight people, we use helicopters to feed people, rescue them, etc. So that high volume has tremendous military applications

One critical aspect to understand is speed, as measured from origin to destination. Aircraft have great speed, but that is only over certain legs. Look at travel time from actual origin to your destination, in terms of speed and complexity (Figure 5). Average speed of military deployment, from the Motor Pool to ultimate destination moved by surface shipping is 19 KM per hour. With an airship or hybrid aircraft, this may become 90 to even 190 kilometers an hour, a significant speed differential. As a benchmark, existing commercial passenger travel by air averages 68 MPH.

What effective utilization of this technology will ultimately require is a worldwide infrastructure driven by the commercial assets that need it. It is best to have an airship tweaked to its atmospheric conditions and have the pilots used to that area of the world. It is not as effective to move them from different climatological regions. Militarily, we leverage existing commercial assets and we devote time and effort day to day to ensure we have that commercial capability and access to it. Through our Civil Reserve Air Fleet (CRAF) system we provide subsidies to the airlines in return for providing extra strategic lift

when called upon. It is a symbiotic, win-win relationship where by combining the commercial demand and a military demand, we are helping to make sure that lift asset is continually used so it can turn a profit and keep relative cost down.

Figure 5: Deployment Comparisons



We are going to need literally hundreds of these ships *of various types*, because I have never had enough lift to move everything I need to move, and I will have diverse missions, so these future ULAs and other LTA assets can definitely be kept employed. The challenge of course is finding the right combination of people, putting them together and focusing the energies of either existing manufacturers or new players to produce these capabilities. The fact that no military is going to foot the bill on its own pushes us to find an innovative way to partner in some manner to develop this capability. It has been said that, "Airplanes are designed by aeronautical engineers, helicopters

are designed by mechanical engineers, and so far airships are primarily designed by idealists."

Landing Areas/Ground Handling/Ballast/Weather Forecasting

The factors cited above are the main issues relevant to the end user. Different technical approaches address each aspect differently. Many people are now familiar with some of the commercial proposals for heavy lift airships and hybrid aircraft. Which one is most effective will depend upon the exact mission. Landing areas may range between a large soccer field up to flat open areas a few thousand meters long. Ground handling can be addressed several ways and is arguably the biggest challenge to a lighter-than-air craft. Any craft that uses static lift must consider its static condition, for the relative "lightness" and "heaviness" is in constant flux. For the end user this means that ballasting must be factored in to compensate for offloaded cargo. If your location has water, such a small rivers or ponds, then taking on water is a simple solution. Hybrid aircraft designs may allow such ballasting to occur some distance away from the pick-up and/or delivery sites. While it must be considered, ballast is not the major weakness that many believe. Finally, weather forecasting is critical. Investment of research and effort in all these areas will be necessary.

Commercial Role

While military uses of LTA were dominant in the past, and will be critical in the future, the commercial aspect is arguably the more important. Without two men: Paul Litchfield, on the American side, and Alfred Colsman, a name you never hear, on the German side, then airships might not have existed after WWI. They were the businessmen who enabled Goodyear and Zeppelin to exist. Colsman kept the Zeppelin Corporation solvent. Dr. Eckener's airships, though popular and superbly constructed, did not generate profits early on.

Like Goodyear, Zeppelin[2] looked at the long-term financial potential. Litchfield's solid economic focus and solid financial status was what enabled the US to have airship fleets in WWII. Even the military money, which was actually written into the budget by Congress to build the Akron and Macon [two flying aircraft carriers built and operated in the 1930s], could not by itself justify fleets of airships. There has to be a commercial potential for any such capital investment. Litchfield was a visionary; he invested money up front for a long-term economic benefit. He took a long view, and built the infrastructure for airship construction and the two flying aircraft carriers for a monetary loss because he sought a new industry and markets that he would dominate.

Similar challenges exist now, however, as in days past. The up front capital investment will be tremendous, and the time required for design, construction and certification (the latter often overlooked) is measured in years. To justify this tremendous investment, investors must be confident of significant profits, and this suggests hundreds of such craft in operation to achieve economies of scale and return on investment. The military also needs hundreds of airships and hybrids to exist so there would be enough to either operate in an arrangement similar to the Civil Reserve Air Fleet (CRAF) and/or to lease. This means there must be a large LTA industrial base similar to that of aircraft. LTA operations must demonstrate three things to investors and regulators: consistency of operations, complementary capabilities to existing assets, and commercial viability.

A future LTA industry should not be considered solely in terms of the uses of the various airships and hybrid aircraft that will exist to meet diverse needs. The "industry" itself will be a potent force. The following description of the post WWII heavier-than-air aerospace industry in the United States is illustrative.

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[2] The two companies actually partnered as Goodyear-Zeppelin until WWII.

"The development of radar and of very large airframes for bombers made the modern air travel industry possible years before it would otherwise have grown up...The jet engine...revolutionized air travel a decade later...Not only did air travel become one of the driving forces of the postwar American economy, but aircraft construction became a major enterprise and a vital part of America's exports. American planes...continue to dominate this extremely capital-intensive industry."[3]

The tremendous technical challenge of building any such craft, especially the proposed hybrid designs, will demand great resources of engineering brilliance, technical innovation, organizational expertise, time, and money--especially the latter.
The driver to bring these companies/technologies to fruition and maintain their existence must be a business bottom line--satisfying one or more commercial needs at a competitive price. Building, operating, maintaining, and crewing these giants of the air will be an entire industry in itself. Government may play a supporting and even crucial role.

The example of Litchfield and Colsman combined with current commercial and military needs of strategic deployment suggest that now is *the time to combine idealism with the pragmatic business and* military sense. W must identify the key points where commercial, military and government needs overlap to identify the next logical leaps of developing a capability. We can then form the teams to design, build and operate this essential new capability across North America.

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[3] John Steele Gordon, "The Business of America" American Heritage, June 2001, p. 93

Airship Fuel Tankers for Northern Resource Development: A Requirements Analysis

Barry E. Prentice, Director, Transport Institute, University of Manitoba and Jim Thomson CA, Consultant, Mercatus Ventures Inc.

Introduction

Harsh Arctic conditions and the lack of transportation infrastructure frustrate northern development. Without an effective means of getting to market, rich mineral deposits that lay buried beneath the tundra will likely stay there. Ground based transportation in the north, if available, costs ten to 20 times the equivalent of southern transportation. Even at these high prices, the construction of all weather roads for mining may be economically infeasible. While the climate is harsh, the physical environment is fragile. Moreover, aboriginal leaders are apprehensive about the social impacts of connecting their isolated communities to the south by road.

In terms of economic development, the Arctic is similar to the condition of Western Canada at the time of Confederation. Very few people lived on the Prairies, and furs were the only trade good that could justify the cost of transportation to an outside market. Once the railways were extended to Western Canada, the costs of imported goods fell, lower value commodities became profitable to export, and development capital flowed in with the waves of settlers. The Prairies needed a revolution in railway technology to breakout of its frontier economy.

Technological advances are leading to a new generation of cargo airships that could do for the Arctic, what railways did for Western Canada. Airships are a proven technology that was working reliably

when people were still driving Model-A Fords, and nylon stocking were advanced materials[1]. With the advent of ultra lightweight composite materials, modern avionics, vectored engines and computerized design capability, no technical impediments block the development of a new generation of safe and efficient cargo airships.

Airships offer a breakout opportunity to cut the cost of Arctic transportation and stimulate economic development in a manner that is respectful to both the environment and culture of the people. The purpose of this paper is to set forth the economic case for using a new generation of cargo carrying airships to support northern mining operations. The first section provides a brief sketch of the logistical requirements for a cluster of mines located in the North West Territories (NWT). Subsequently, an economic model is presented for an airship that could carry 84 tonnes of fuel or general freight. The model is general, rather than specific to any of the numerous designs that are proposed for cargo airships. The intention is to provide a target for airship builders, and a realistic option for northern mining companies to consider.

The Challenge

Air transport has a long history in mining development. Bush planes, like the Beaver aircraft, were crucial to the early development of gold, silver and nickel mining in northern Quebec, Ontario and Manitoba. Air transport enabled people and equipment for resource exploration to be mobilized in areas that are virtually inaccessible. Even today, Canada has the renown of being the largest single market for helicopter services. Despite their success, bush planes and helicopters have limitations in both payload and flight distance. Development of large-scale mines or energy exploitation was only possible in the southern fringes of the north where rail lines or road links could be built economically.

Many types of cargoes are required for mine development and operations. The main categories include construction materials, fuel, equipment, machinery, cement, explosives, camp supplies, food, etc.

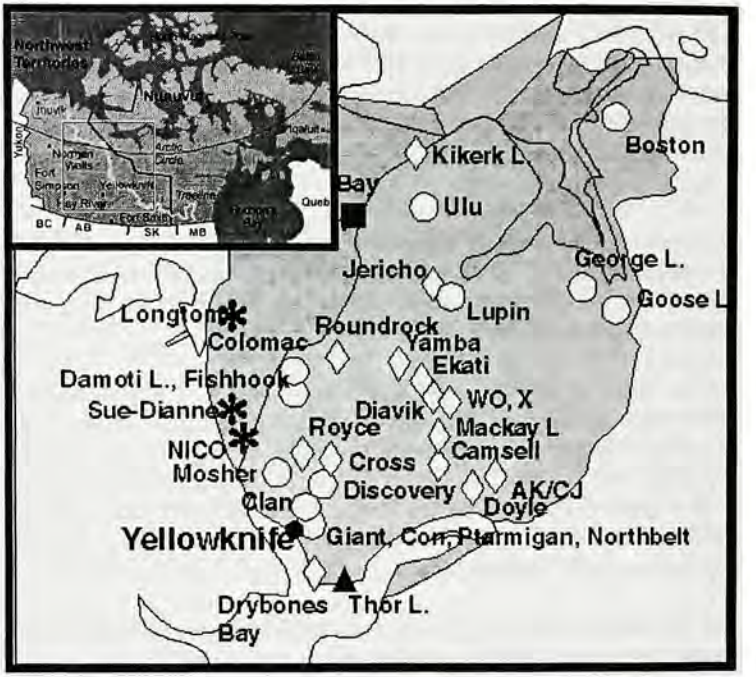
However, fuel is the largest single input requirement that limits northern development. Supply shortages of some mining provisions may be a nuisance, but a fuel shortage can be a catastrophe. A mine that is forced to shutdown the concentrator for lack of fuel may never get re-opened, while the camp can face very significant safety issues without heat and electricity.

Transporting fuel is costly and environmentally risky. Typically fuel is transported in bulk using rail, truck or barges. Mines that have no railway, all weather roads or marine access must operate using ice roads during a short winter season[ii].

Known mineral deposits and operating mines near Yellowknife, NWT are identified on Map 1. A seasonal ice road serves two operating mines and a third mine under construction. Two of the properties are diamond mines (Ekati and Diavik) and the third is a gold property (Lupin). All three mines require one-way hauling with little requirement for back hauls. Combined, these mines require approximately 200 million litres of fuel.

The ice road operates for a 12–16 week period. During this season, a whole year's supply of fuel, grinding balls, explosives, plant supplies, non-perishable camp supplies, etc. must be moved over 400 kilometers on the ice road. The transportation cost for fuel is about $40 million. The total cost for all freight, including building and maintaining the ice road, will be higher.

The existing ice road can manage current requirements for these mines. However, weather variability is always a concern regarding the ice road season. If the season shortens, one of the mines expands (which is a realistic possibility for Lupin), or another property tries to connect to the existing road, capacity could easily reach its upper limit. Additional lanes could be added over the lakes but ultimately, safety concerns impose an upper limit on traffic. Airships could help alleviate this bottleneck and offer regular service year round.



Map 1 Mine Locations outside Yellowknife, NWT

Several other known mineral deposits could be developed in the NWT/Nunavut if a viable transportation option existed. For example, Izok Lake, which is located in central Nunavut, is one of the largest undeveloped zinc-copper deposits in North America. It is estimated that the mine would produce 400,000 tonnes of concentrate annually and employ 250 persons. A pre-feasibility study suggests that the mine would have a minimum life of 13 years based on known reserves. Several major mining companies have considered developing this reserve but all have failed to overcome the transportation challenges associated with economically moving mining supplies, principally fuel, into the mine site and concentrates back out.

Mining companies have examined many creative solutions to the Izok Lake transportation dilemma. Considerable study was made of building a deep-water port on the north shore of the continent at Bathurst Inlet that would be the terminus for a 265-kilometer all-weather road from the mine. The cost of constructing a deep-water port and building the road is estimated to be $250 million. Again, this project proved uneconomic, not to mention the invasiveness that such a road would have to this pristine northern landscape. Part of the study also looked at connecting other properties to this main road/port system. While adding other movements would increase the utility of the road, it would still be an expensive, low traffic volume operation. Further, if metal commodity prices collapse, this road becomes a stranded asset.

The Potential for Cargo Airships

The need for a means of transport that will open up Earth's last remaining frontiers to commercial exploitation are stimulating interest in airship technology. The significant barrier that remains to the production of new generation airships is the investment capital required to finance the research, development and air-worthiness certification. Prior to raising such capital, airship developers have to overcome the skepticism of potential customers. To get the attention of a shipper, the airship must be able to deliver cargo in a way that is safer, more reliable and/or at a cost that is lower than the current system. Northern mining operations are searching for a better means of transport than the ice roads, and could be an inviting market for the first cargo airships to test commercial viability.

The economic model is based on the northern fuel haul from Edmonton to Hay River by truck, and then by airship to the three mines near Yellowknife that now are being served by an ice road. The model assumptions are summarized in Figure 1. Airships enjoy significant economies of size, but the mines are unlikely to risk their fate to an unproven technology. Consequently, the model assumes that a smaller airship of 84 tonnes capacity would be the starting

point. This is equal to two Super B tanker trucks and would provide a convenient unit of transport.

Figure 1 Economic Model Assumptions Annual Basis

Total fuel requirements (litres)	180,000,000
Total landed cost of fuel	$150,000,000
Total transport cost (25 percent)	$ 37,500,000
Airship capital cost	$ 60,400,000
Payload	100,000 litres/84 tonnes
Flying distance	380 kilometers
Average flight speed	161 kph
Loading/Unloading time	1 hour each
Roundtrip travel time	7 hours
Loads per year (260 days operation)	780 loads
Flight crew (3 members, 4 crews)	$ 1,032,000
Maintenance & Administration	$ 704,000
Insurance costs	$ 1,750,000
Fuel burn (2,400 litres per hour)	$ 5,400,000
Depreciation charge	$ 3,655,000
Trucking costs (Edmonton-Hay River)	$ 1,541,000
Return on Invested Capital (10 percent)	$ 6,070,000
Reduced Inventory Carrying Cost	$ 5,010,000

Operating 260 days per year, an 84 tonne airship could carry 78 million litres, or approximately 40 percent of the mines' requirements. The airship is assumed to have a purchase price of $60 million and to be fully depreciated over 20 years, with a skin replacement at 10 years. This is very pessimistic given that the skins would likely last longer, and no salvage value is assumed at the end of 20 years. Also, the insurance at $1.750 million annually might be reduced in later years as more experience is gained.

The model is based on a single vehicle. A fleet of airships would permit the land based infrastructure costs to be amortized over a larger base that would reduce the unit costs. Also, the maintenance

personnel and administration costs per load would decline with a larger fleet.

One of the indirect costs of northern operations is the high cost of holding inventories. Storage tanks are required to be large enough to hold a year's supply, plus some buffer safety stock. Losses due to shrinkage or theft are unlikely, but the carrying cost can be high. Compensation for holding the landed value of a year's supply of fuel is estimated to be $12 million. The savings of using an airship to provide daily deliveries of 40 percent of requirements is assumed to be $5 million.[iii]

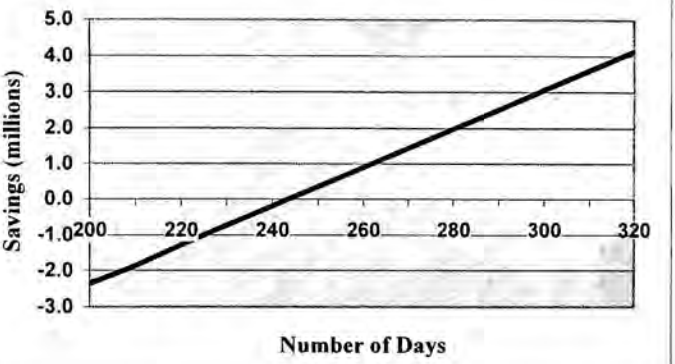
Airships have very interesting trade offs between flight speed, fuel burn, operating distance, capital costs and cargo carriage. At higher speeds, more fuel is burned, and more fuel replaces cargo, but vehicle utilization is higher. For very short legs, the vehicle would likely maximize speed, in order to reduce capital cost. This model assumes a higher speed and greater fuel consumption than might normally be associated with airships. The issue is really a subject of empirical study that is beyond the scope of this paper.

Figure 2 presents the summarized results of the economic model in the form of a breakeven analysis. The airship could satisfy the 10 percent return on investment with approximately 245 days of utilization. As utilization rises the savings to the mine/returns to the airship operator increase. With 320 days of operation the airship would produce $ 4million in extra savings for the mines.

Beyond the Hay River to Ekati scenario many more fuel haul requirements exist today, or could become a requirement if a viable alternative existed. For example, 8-10 known mineral deposits could be developed if the transportation dilemma could be solved. Additionally, there are several millions of litres of fuel oil that must be transported to remote communities that are only accessible by barge or air for short periods during the year. If a base operation serving the Ekati requirements were established, it's likely that other

customers could be added without having to make significant investments in additional ground based infrastructure.

Figure 2 Airship Utilization Breakeven Analysis (3 flights/day)



Another element of reality that needs to be injected into this analysis is the demand for general freight movements over the course of the year. The mines rely on small cargo aircraft to move perishables and equipment that was not included in the ice road re-supply, or whose need (e.g. parts) became apparent later. No doubt this freight would be loaded on the airship first, and the fuel would be used to top off the load. If an airship were viable for a "fuel only" operation, it would be very profitable if general freight were included in its cargo mix.

Why Airships for Arctic Fuel Haul Make Sense

The business case for employing airships to haul fuel must make economic sense. However, several other qualitative reasons make this mode of transportation attractive.

As stated initially, the challenge of northern development is the absence of existing transportation infrastructure. Paradoxically, the greatest potential for the airships is this lack of transportation infrastructure. Airship hauling cannot compete against conventional surface modes of transportation in the south. However in the north, where the costs of transportation are several times greater than conventional southern transportation, airships can compete.

Second, the building of all-weather or ice roads is very invasive to the landscape. There are many possible negative consequences relating to roads. Roads are unnatural structures and create barriers for migratory animals. Roads also provide access to areas that would otherwise be unreachable. Hunters, adventures and the curious would all have access if roads were built. Effectively, roads foster "human contamination" of wilderness environs. Conversely, isolated communities may suffer an exodus of their youth and culture if ready access to the south becomes available. Many aboriginal communities have expressed grave concern over the prospects of the cultural threat roads represent and have been unequivocal in their wish to keep their communities intact at any price. This being said, progress will not be thwarted. The good news about airships is that only small pockets of disruption to the environment need to take place in developing northern mines. Being able to fly cargo into sites negates the need to create fixed road links.

Third, airships are a safe means of transporting fuel. Even if an airship is forced down, it can do so in a controlled fashion thus reducing the risk of a fuel spill in a sensitive and difficult to reach area. By comparison, significant risks are associated with hauling fuel over ice roads. An accident involving a fuel tanker on a frozen lake means a spill on the ice surface, which can be difficult and expensive to clean-up. Worse still, a tanker breaking through the ice and ending up on a lake bottom risks seepage and contamination of the lake, plus the cost of retrieval.

Fourth, airships have a relatively benign impact on the environment. They are not as noisy as a jet so they can fly overhead without

disturbing the local fauna. Airships do not require bridges or other land based disturbances that would negatively impact these fragile northern environs. Further, airships are relatively low producers of air pollution because most of the lift comes from the lighter-than-air gases rather than propulsion.

Airship experts generally agree that hydrogen could be an acceptable fuel to power cargo vehicles. As the fuel cell technology advances, it is a very realistic belief that the airships of the future may be powered by fuel cell. This could be augmented by photoelectric arrays placed on the massive skin of the airship to feed the electrical motors (Prentice and Phillips, 2002).

Fifth, almost all northern destined cargo must be transported in the winter, during relatively hazardous weather conditions. This means that an entire year's supply must be moved to site during a compressed window. There are two financial consequences associated with this required practice; first, the mine cannot avail itself of pricing efficiencies during the course of the year but rather they must buy all their supply at the prevailing prices; and second, a significant inventory carrying cost adds to the operation's overall energy cost. Environmentally, storing a year's supply of fuel increases the risk and consequences should a storage tank fail or some other catastrophe occur.

Call to Action

Recently airship manufacturers, potential customers (mining, energy and northern re-supply companies), government, aboriginal, military, ecotourism, research and business interests gathered at the "Airships to the Arctic Symposium" held in Winnipeg, Manitoba. Over the course of the three-day session, it became clear that the technology and expertise necessary to build large cargo carrying airships was well defined and available (Prentice and Turriff, 2003). Potential customers were keenly interested in what they see as an elegant and effective solution to their transportation concerns. However, the common refrain heard from the manufacturing community was, "Tell

us what you want us build and we will gladly deliver. But we need a customer who will pay money today to finance the building of the first commercial airship". The customers, on the other hand, were saying, "We don't want to own and operate airships. This is not our core business. But we will sign a transportation contract today if the airships can do what they claim to".

Traditionally, carriers fill this void between shippers who want transportation services and manufactures that build transportation equipment. Carriers operate the equipment and contract with the shipper. For example, in the trucking industry, a carrier who successfully bids a transportation contract can then acquire the equipment and drivers to serve the requirement. The financial risk of equipment ownership is underpinned by the transportation contract. The carrier, knowing that there is sufficient cash flow to justify the equipment purchase, is comfortable issuing a purchase order to the equipment manufacturer. The end result of this commercial transaction is that each party's business needs are met and the risks of ownership and operations are properly managed.

Airships face the proverbial "chicken and egg" dichotomy that often limits the implementation of new technologies. Before the airship industry in the north can be birthed, a carrier must step forward to connect the shipper, who has the transportation need, with the manufacturer, who has the ability to provide the equipment to fulfill that need. The carrier who wishes to avail himself of this business opportunity may come from the ranks of carriers in other industries who can adjust their business model to develop that airship industry, or a new class of carrier may be formed from business interests who are prepared to seize this opportunity. Either way, until this role is filled, this fledgling industry will struggle to become a legitimate northern transportation option.

Other potential players could be the catalyst to entice a carrier to come forward. Most commercial interests are accountable to their shareholders and must mange their investments subject to their own perceptions of risk and reward. On the surface, the potential prize for

the carrier who becomes the provider of northern transportation services is great. However, so too are the risks associated with this endeavor. Generally, most of the high-risk areas relate to the operational capabilities of airships that are both unproven and uncertain for the conditions in which the airships will have to operate. Until an airship manufacturer builds and flies an airship in the north, carriers and their investors will likely remain skeptical. Therein lays the impasse.

How then can these operational risks be mitigated so that the carriers can be attached to this opportunity? Here is where other parties who do not necessarily have commercial interests have an important role to play. Incubating such a groundbreaking industry is a legitimate role for government. This is not to say that government needs to get into the airship industry and actually own and operate the first airships. The role of government is to help finance the operations and business research that can answer some of the important questions that create risk. Additionally, given that the Federal and Territorial governments are obligated to their constituents to provide for economic development, it may be worthwhile for these respective governments to provide some of the risk capital. Rather than invest in the $250 million all-weather roads from Bathurst Inlet, perhaps the governments should consider supporting the airship industry.

Other Opportunities

Most people who have taken the time to get an understanding of airships and their potential uses can easily understand why there is such excitement in seeing the first modern cargo airships built. The versatility and applicability of airships, coupled with the capability of building an airship with the technology and materials that actually exist is both compelling and achievable if only the first airship could be built.

The focus of this discussion has been oriented towards bulk fuel hauling. However, there are many other transportations requirements that would be well suited for airships. Airships are a realistic

transportation option and, once established, many more uses for airships will be found. Figure 3 presents a list of commercial and public applications for new generation airships.

Figure 3 Commercial and Public Sector Applications for Airships

		Commercial Uses	Public Uses
Mining and Energy Development		✧	
Hydro-electric and Pipeline Construction		✧	✦
Forestry		✧	
Research:	Environmental Studies		✦
	Resource Exploration	✧	
Emergencies:	Accidents	✧	✦
	Search and Rescue		✦
Defence:	Surveillance		✦
	Heavy lift		✦
Eco-tourism		✧	
Advertising		✧	
Essential Goods and Services Supply			✦
Communications		✧	✦

Hydroelectric projects and pipeline construction represent enormous transportation challenges and opportunities not to mention profit potentials. Over dimensional loads can be more easily accommodated using airships, and for the north, equipment can be re-located with out the cost and damage associated with disassembly. Moving oil drilling rig and supplies (e.g. oil drilling mud) is a similar application. Existing transport is expensive and operations are limited to a very short season that inflates production costs. Small airships could also be used energy and mining exploration.

Airships could have valuable public roles in search and rescue, and in emergency response to pollution spills or other national disasters. The military could also find uses for airships in surveillance and to provide airlift for the armed forces. Forestry, ecotourism and advertising are other commercial markets that have received

attention, while airships have been shown to be ideal platforms for the study of wildlife and to monitor the environment.

Northern re-supply of essential goods and services is an exceptionally costly role for government. The transportation costs of sustaining northern communities is destined to grow ever larger, as their population expands, and demands for equivalent "Southern" services become louder. Airships could lower these costs. Finally, airship technology is being developed for use as a high altitude communications platform. This is a role with both civilian and public applications that has generated a great deal of interest.

Conclusion

Commercial necessity is the usual foundation for developing transportation infrastructure in a frontier region. For example, on the Canadian Prairies, railways were built to connect grain producers to export markets. Communities grew up around the grain elevators, as these centers became re-supply points for surrounding farms. Roads were then needed to move goods and people between communities and the larger centers. Over time a reliable transportation network evolved that served these needs. So what began as a commercial justification for the building of transportation system, gradually migrated to become a societal imperative.

It is unlikely that development of northern transportation infrastructure will follow the same pattern. The harsh climate, aboriginal land claim issues and the fragility of the environment preclude development of the large population centers that exist in the south. Without the social imperative, the justification for transport infrastructure development rests squarely with the commercial needs.

The north has many stakeholders with competing and conflicting needs. For some, like the aboriginal communities, a strong desire exists to leave the land intact and discourage exploitative commercial activities. For others, like the mining companies, the north represents vast mineral reserves that cannot be economically developed because

of prohibitively expensive access costs. Both the Federal and Territorial Governments have land stewardship and social development obligations. Airships represent a transportation option that could potentially align many of these conflicting needs and offer a very credible option to responsible northern development.

This paper has identified a commercial market where a heavy lift airship could be economically viable, based on reasonable performance assumptions. It is by no means the only application for airships, but it is a realistic starting point. The ball is now in the airship manufacturer's court. If they can match or better the cost and performance specifications assumed in this study, the world will beat a path to their door.

References

Prentice, Barry E. and A.J. Phillips. "Airships to the Rescue: Re-supply and Emergency Response in Arctic Resource Development" *Canadian Transportation Research Forum.* Proceedings Issue: 37th Annual Meeting (2002): 371-382.

Prentice, Barry E. and Shelley Turriff. (Eds.) "Applications for Northern Transportation", *1st Annual Airships to the Arctic Symposium*, at Winnipeg, October 23-24, 2002 *(forecoming)*

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[i] In 1929, the Graf Zeppelin completed a 20,500-mile circumnavigation of the world. In total this airship made 144 Atlantic crossings and without any major incidents.

[ii] Airplanes could be used to transport fuel, but they are too expensive for the qualities needed to be transported to be a viable option.

[iii] The inventories cost savings are very complicated. The rate of interest used can vary between the savings rate to the opportunity cost of capital. If a new mine were built, smaller storage tanks could be used. Finally, buying all fuel requirements at one time increases price risk. Being able to spread acquisition out over the course of the year would facilitate hedging and purchasing on dips in the market price.

200 scm0301d 03/15/2001 03/30/2001 "Using Supply Chain Technology to Improve Border Crossing"

Edmond Chin-Ping Chang, Ph.D., P.E.
ITS Program Manager
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6073 USA
TEL: 1-865-574-5003
FAX: 1-202-646-7878
e-Mail: ecc2005@ornl.gov

ABSTRACT

Government agencies in North America are in the process to increase efficiency through the facilitation of international trade. North America Freight Trade Agreement (NAFTA) is a step in the right direction by the elimination of tariffs on goods originating in member countries. The current cross border freight movement has increased drastically that create significantly congestion around and near the North America Border area. There is a eminent need to increase the efficiency of the flows of these goods between the member nations. The major objectives are to eliminate barriers to trade in, and facilitate the cross-border movement of, goods and services between the territories of the Parties, promote fair competition in the free trade area, and Increase substantially investment opportunities in the territories of the Parties.

Supply Chains Management (SCM) has become the businesses lifeline in the global market. The major components include (1) integrated information network, (2) logistic network that connecting all origin of supply/demand, and all trading partners, and (3) integrated inventory control and material flow, that spans multiple organizations and operations. The system must work

together to avoid waste, carry minimum amounts of inventory, and provide customer competitive satisfaction in the shortest cycle time. The impacts of well-organized supply chains can be quite dramatic. For example, the logistics costs as a percentage of GDP in the United States declined from approximately 17% in 1980 to just over 10% in 1993. This decline mirrored the decline in inflation in the United States over the same period. In a similar time frame (1983 to 1997), the value of inventory as a percentage of GDP fell from 24% to less than 17%. To further save the logistic costs, firms are cooperating, improving on logistics activities.

This paper describes the Supply Chain Management (SCM) Analysis being made to improve cross border freight movements among Canada, Mexico, and the United States. The process can save time, reduce distribution cost of freight, and enhance customer services. As demonstrated, this work will result in a "win-win" situation for Customs Service, customs brokers manufacturers, customers, and shippers alike. Increased efficiency in the supply chain and information flows will result in reduced processing time and waiting time for freight movements, foster seamless border crossing freight movements, reduce distribution costs, and lower product costs for end customer at the global scale.

Keywords: Transport Systems, Integrated Supply Chain, Information Technology

INTRODUCTION

Government agencies in North America are in the process to increase efficiency through the facilitation of international trade. North America Freight Trade Agreement (NAFTA) is a step in the right direction by the elimination of tariffs on goods originating in member countries. The current cross border freight movement has increased drastically that create significantly

congestion around and near the North America Border area. There is an eminent need to increase the efficiency of the flows of these goods between the member nations. The major objectives are to eliminate barriers to trade in, and facilitate the cross-border movement of, goods and services between the territories of the Parties, promote fair competition in the free trade area, and Increase substantially investment opportunities in the territories of the Parties.

Supply Chains have become the businesses lifeline in the global market. The major components include the (1) integrated information network, (2) logistic network that connecting all origin of supply/demand, and all trading partners, and (3) integrated inventory control and material flow, that spans multiple organizations and operations. The system must work together to avoid waste, carry minimum amounts of inventory, and provide customer competitive satisfaction in the shortest cycle time. The impacts of well-organized supply chains can be quite dramatic. For example, the logistics costs as a percentage of GDP in the United States declined from approximately 17% in 1980 to just over 10% in 1993. This decline mirrored the decline in inflation in the United States over the same period. In a similar time frame (1983 to 1997), the value of inventory as a percentage of GDP fell from 24% to less than 17%. To further save the logistic costs, firms are cooperating, and gathering information on logistics activities.

This paper describes how the Supply Chain Management Analysis framework can be used to improve in the cross border freight movements among Canada, Mexico, and the United States. The process can save time, reduce distribution cost of freight, and enhance customer services. This work will result in a "win-win" situation for Customs Service, customs brokers, manufacturers, customers, and shippers alike. Increased efficiency in the supply chain and in

formation flows will result in reduced processing time and waiting time for freight movements. As shown in **Figure 1 "Typical Supply Chain Issues,"** the Supply Chain Management (SCM) analysis can successfully increase mobility, foster seamless freight movements, reduce distribution costs, and lower product costs for the end customer at the global scale.

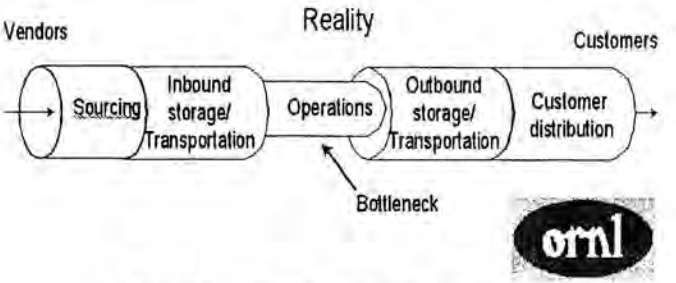


Figure 1. Typical Supply Chain Issues.

STUDY BACKGROUND

Supply chains constitute the life-blood of businesses in the global market. Major components of a supply chain include:

- Integrated information network, consisting of a system of interacting firms spanning multiple organizations that work together to exchange vital information, reduce uncertainty, and establish competitive advantage in order to provide customer satisfaction in the shortest cycle time.
- Logistics (including reverse logistics) consists of a network connecting all of the origins of supply, all of the destinations of demand, and all of the trading partners in between. They all work together to reduce the costs of freight, duty, and warehousing and to establish

competitive advantages to provide customer satisfaction in the shortest time.

- Integrated inventory control and material flow, consisting of a system that spans multiple organizations and operations that work together to avoid waste, carry minimum amounts of inventory, and establish competitive advantages to provide customer satisfaction in the shortest cycle time.

The impacts of well-organized supply chains can be quite dramatic. Logistics costs as a percentage of GDP in the United States declined from approximately 17% in 1980 to just over 10% in 1993. This decline mirrored the decline in inflation in the United States over the same period. In a similar time frame (1983 to 1997), the value of inventory as a percentage of GDP fell from 24% to less than 17%. In order to squeeze even more savings out of the logistics arena, firms are cooperating, studying, and gathering information on logistics activities.

Government must be a participant in this drive to increase supply chain efficiency through the facilitation of international trade. NAFTA is a step in the right direction by the elimination of tariffs on goods originating in member countries, but there is still a need to increase the efficiency of the flows of these goods between the member nations. The major objectives of NAFTA are to:

- Eliminate barriers to trade in, and facilitate the cross-border movement of, goods and services between the territories of the Parties;
- Promote conditions of fair competition in the free trade area;
- Increase substantially investment opportunities in the territories of the Parties;
- Provide adequate and effective protection and enforcement of the intellectual property rights in each Party's territory;

- Create effective procedures for the implementation and application of this Agreement, for its joint administration and for the resolution of disputes;
- Establish a framework for further trilateral, regional and multilateral cooperation to expand and enhance the benefits of this Agreement.

PROPOSED APPROACH

To effectively use the Supply Chain concept to provide the integrated, international border crossing solution, the following 3-step approach is proposed:

Step 1: Characterize the current "as-is" Mexico - United States cross border freight movement logistics and processes through the end-to-end process analysis -
The first step is to work with the Federal Highway Administration, Customs Service, and designated stakeholders to identify a specific commodity sector for the analysis. The NAFTA trade regulations for this commodity will be reviewed. Stakeholders in the cross border movement of freight will be identified and interviewed. These stakeholders will include, but not be limited to the Customs Service, shippers, manufacturers, and customs brokers. The research team will characterize the current Canada - Mexico - United States cross border freight movement logistics and processes through the use of Unified Modeling Language (UML) tool. The UML tool provides a means of logical analysis of information and material flows and business rules. The current components of the cross border operations can be determined. Both the information and distribution flows involved in the cross border trade will be determined. We will find opportunities for improvements in the operations, management, and information flows. This will include descriptions of the operations, procedures, information flows, freight flows, and software support systems. Preliminary suggestions will be made on improvements to the system.

Step 2: Determine cross border operations benchmarking measures -
The NAFTA governments, manufacturers, customs brokers, and shippers all want to make the process of cross border freight movements more efficient. Benchmarking measures for efficiency will be based on the ongoing ITS program performance assessment, the needs of the trading partners, current regulations, management requirements, and best industry practices. Task 2 will provide a means for measuring any improvements that are recommended for implementation. However, it is essential to identify the performance measures for the benchmarking for cross border freight movements and operational evaluation framework.

Step 3: Develop a set of efficiency measures for the cross borders movement of freight and evaluates them based on the benchmarking measures -
Once the "as is" system has been characterized and benchmarking measures have been determined, the cross border freight movement process can be modeled using supply-chain management evaluation tools and freight movement databases to assess a number of alternative efficiency measures. Those measures that result in the greatest efficiencies within a reasonable budget constraint will be reviewed and evaluated in a final report. These operational efficiency measures should also be determined from Figure 2. "Multi-modal Network Routing".

CONCLUSIONS AND RECOMMENDATIONS

This proposed approach would result in a "win-win" situation for Customs Service, customs brokers, manufacturers, customers, and shippers. Increased efficiency in the supply chain and information flows will result in reduced processing time and waiting time for freight movements. This will mean reduced distribution costs and lower product costs for the end customer.

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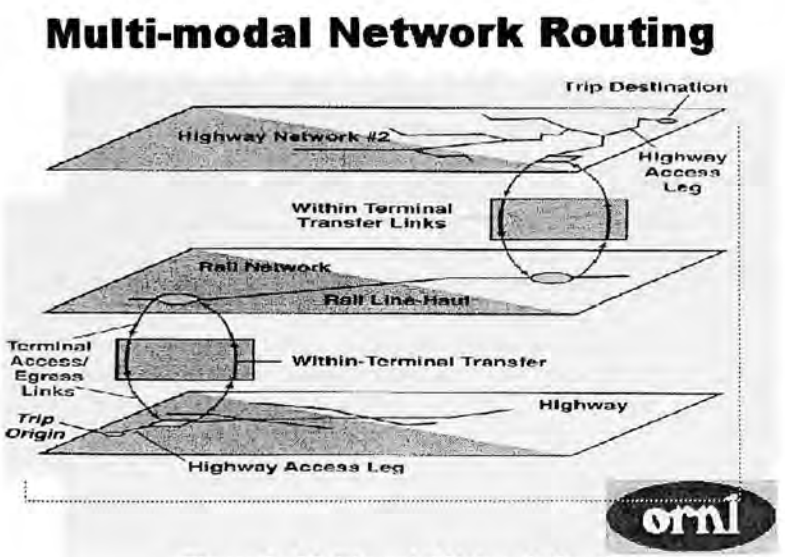


Figure 2. Multi-modal Network Routing.

New Technology Adoption and the Implementation of E-Commerce in the Mid-Continent International Trade Corridor Region

By: Heather Dawn Gibb
PhD Student

North Dakota State University – UGPTI
430 IACC Building
P.O. Box 5074
Fargo, ND 58105

heather.gibb@ndsu.nodak.edu
701.231.6745

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Abstract

The Mid-Continent International Trade Corridor extends from Canada to Mexico, cutting a wide path through the U.S. heartland. This economic region is extremely diverse and the use of E-commerce in this vast region most certainly varies from country to country as well as from state to state. In order to facilitate trade among the different countries and states, it is essential for these separate entities to be able to interact on the same economic platform. The Internet and E-commerce allow these entities to do so in a manner that would benefit all involved.

A detailed survey of trucking companies throughout the corridor provided the information needed to analyze the adoption rate of E-commerce and the potential gains or losses of implementation. A comparison between different geographic zones and sizes of companies within the corridor ensured the clarity of the results. A further breakdown on the size of the company, either small/medium or large, was analyzed. The importance of the breakdown ensured that the results were consistent in different regions due to the diversity of the entire corridor. The use of a stratified sample approach ensured the validity of the survey and allowed inferences from the resulting data using SAS.

Introduction



The Mid-Continent International Trade Corridor, a development of the 1995 North American Free Trade Agreement, is a geographic area that extends from Winnipeg, Canada through to Monterrey, Mexico. The corridor cuts a wide path through the U.S. heartland. This economic region is extremely diverse due to a number of factors.

First, the corridor runs through three separate countries, each with its own laws, regulations, and customs. Second, the mid-continent area in the U.S. involves eleven states, each of which has its own distinct laws as well as varying populations, industries, and economies.

Freight and trade transportation have been a critical factor to the growth and development of the United States, Canada and Mexico. The movement of freight has brought with it a landscape of major urbanized areas, connected to rural areas by multimodal transportation corridors. The concept of a corridor can be broadly defined as providing for the flow of goods and people within a geographic area. It consists of the ground transportation infrastructure and systems that facilitate these flows; and the policies and regulations governing them. In this case it provides for the flow of goods and people domestically and internationally within North America. The benefits of the corridor are widespread. All sectors of the supply chain benefit in some aspect.

The trucking industry makes a significant contribution to economic growth and its activities are a foundation for the effectiveness of hundreds of thousands of businesses, large and small, because of its key horizontal linkages across the economy. The efficient transport of goods has a direct effect on the economy. Due to the important role that the trucking industry plays in connecting the flow of goods from one region to another, it is a vital link in the economies of the three countries involved. For example, there was an estimated 4.982 trillion dollars worth of goods transported by truck in 1999.

The term electronic commerce has evolved from the original definition of electronic shopping to encompass all aspects of business and market processes enabled by the Internet and the World Wide Web technologies. Narrowly defined, electronic commerce means doing business online or selling and buying products and services through Web storefronts. In this analysis electronic commerce is defined as any use of electronic capabilities to run a business. This can be as simple as using a computer for invoices or as complicated as Electronic Data Interchanges.

The use of E-commerce in the vast corridor region is expected to vary from country to country as well as from state to state. In order to facilitate trade among the different countries and states, it is essential for these separate entities to be able to interact on the same economic platform. The Internet and electronic commerce would allow these entities to do so in a manner that would benefit all involved. It is expected that the differences in the stages of implementation of electronic commerce in the trucking industry are wide-ranging throughout the region as well as amongst different company sizes.

Objectives of Study

- Evaluate the current state of electronic commerce throughout the trade corridor
- Analyze the possible reasons for the differences in implementation
- Evaluate the survey results

Methodology and Data

A detailed survey of trucking companies throughout the corridor was completed in order to analyze the adoption rate of electronic commerce. Thirty two questions detailing the company's electronic commerce strategies were defined to provide a glimpse of the trucking industry's electronic commerce capabilities. A stratified sampling approach was used so as to ensure the responses were complete across all of the categories. The sampling strategy considered different states and provinces. Further stratification of the population was implemented to capture the size of the company. For ratio-scale variables, statistical tests were done to analyze variations among categories (e.g., regions, size classes) and confidence intervals were constructed for the mean. Hypothesis tests were performed where applicable.

Implementation Differences and Analysis of Variance

Trucking companies in two Canadian provinces and twelve states were surveyed in detail. The states and provinces were then broken down into four regions for analysis: Canada, Northern plains, Mid-plains and the South. Due to many non responses from the Canadian region, only Manitoba was represented in the final analysis. Mexico was omitted for this study. In addition to a break down by region, the industry was broken down into vehicle classes by the number of vehicles owned and leased. The small, medium and large companies were broken down by the following:

Small	<10
Medium	<50
Large	>= 50

The levels of electronic commerce adoption were defined by a scale of increasing technology. The levels were identified by the following:

1 Company has computer
2 Company has internet access
3 Company has intranet capabilities
4 Company has website
5 Company has interactive forms on website
6 Company has ability to take orders online
7 Company has information sharing programs linked to customers. i.e. electronic data interchange

The previous checklist is in a hierarchical order and the absence of one level would be over looked by the inclusion of the next level. Due to missing values, the total number of observations used in this analysis was 159. The results indicate that there is no significant difference in the implementation status over the entire geographic region. However, there is a significant difference in the implementation status within the size classes. The small and medium

companies are at basically the same level but the large companies are more likely to have an increased level of electronic commerce. The average level for each class is as follows:

Class	Mean	N
>=50	5.9375	32
<50	4.2759	58
<10	4.0145	69

This indicates that the large company's average level of implementation reaches the ability to take orders online. The small and medium company's average level reaches the stage of the establishment of a website.

Additional Significant Survey Responses

Electronic commerce is supposed to decrease costs and increase customer service. It is said that the adoption of electronic commerce can result in such things as improved customer service, reduced costs, and increased market share. In addition it is expected that the main reason for adoption is for cost savings. The following results from the survey questions indicate slightly different answers pertain to a number of the companies.

Do you feel that the computer system has increased your customer service?

		N
Yes	74%	111
No	26%	39

Has the computer system allowed the company to manage its fleet more efficiently?

		N
Yes	62.16%	92
No	37.84%	56

Has the company's market share increased, decreased or remained the same due to the computer system?

		N
Increased	31.96 %	47
Decreased	1.25%	2
Remained the Same	66.79%	98

Has the company's sales volume increased due to the use of the computer system?

		N
Yes	29.73%	44
No	70.27%	104

The decision to adopt the computer system was due to

		N
Potential cost savings	68.15%	92
Pressure from competitors	10.37%	14
Pressure from customers	21.48%	29

Did the computer system result in decreased costs for the company?

		N
Yes	68.67%	103
No	31.33%	47

Did the computer system result in increased costs for the company?

		N
Yes	23.33	35
No	76.67%	115

What was the cost of the computer system?

Small companies	$3700
Medium companies	$6800
Large companies	$36800

(Ranging from $600 – $980,000)

Conclusions

The survey results indicate that there is not a significant variation in the adoption rate of electronic commerce among trucking companies over the corridor region. Both the province of Manitoba and the eleven states involved in the survey are at relatively the same level. One has to look at the size of the companies to find a statistically significant implementation level. It is difficult to identify the reason for the discrepancy but smaller companies have smaller cash flows and less ability to access such flows. Computer systems cost an average of $25,000. This may be the number one reason for the smaller company's shortfall in implementation. Other possibilities include the lack of understanding of the benefits of electronic commerce. Also, a lack of confirmed cases of cost savings and a lack of time for

These results may enable the companies within the corridor region to establish where they are in reference to the rest of the industry. It also may allow these companies to see how far they need to go to keep pace with the rest of the industry. It is important to note that the reason for adoption is not always cost savings. In fact, in some cases the results of implementation are increased costs. It is not possible to predict which companies may experience an increase or why the increase is present. However, it is interesting to note that it is possible. In the end it is up to the manger of the firm to decide about the future of electronic commerce in their company. In the end the implementation of different levels of electronic commerce will have an effect on the company. The results of this survey depict the value of electronic commerce as well as the possible associated pitfalls.

The scope of this study was limited to the trucking industry in Canada and the United States. Further study should include Mexico in order to evaluate their ability to keep pace with their main trading partners. In addition, further study should include the state of electronic commerce in the vertically and horizontally linked industries to establish how they execute business. The effects of electronic commerce on the entire supply chain are dependent on how the flow

of goods is managed. If one sector is behind then the flow is interrupted. Management of the entire supply chain to increase efficiency in all industries is essential. Electronic commerce is the platform to facilitate that increase.

References

1) Casselman, Grace *The New eSupply Chain* ebiz May-June 2000 Vol 2 No 3 page 38.
2) Forsyth, Gordon *Moving Information* American Shipper August 1999 page 24.
3) Helmanczuk, Victor *E-Commerce and its Impact on Logistics* LQ December 1999.
4) Muller, Gerhardt *Intermodal Freight Transportation* 4th Edition 1999.
5) Rascab, John *Managing the Supply Chain* Ivey Business Journal March/April 2000 page 52.
6) U.S. DOT Bureau of Transportation Statistics Transtats Truck Movements in America: Shipments From, To, Within, and Through States May 1997
7) U.S. Department of Commerce, 1997 Commodity Flow Survey, United States, Washington DC 1999.

THE CANADIAN COURIER SERVICES INDUSTRY

Joseph Monteiro*

Introduction

The Canadian courier services industry has been one of the fastest growing segments of the transportation sector. In recognition of this, a recent report states "the Canadian courier industry is a substantial, vibrant and growing component of the supply chain management strategies of many companies and contributes significantly to the success and well-being of the overall Canadian economy."[1] This is hardly surprising, as everyone expects faster service in a world where only the fittest can survive, especially where it involves cost savings.

This paper examines the courier services industry (sometimes referred to as the same day service or overnight or later delivery services industry) in Canada in Part I. In Part II, regulatory changes in the courier industry are reviewed. In Parts III and IV, competition in this industry and the impact of the Internet on this industry will be briefly examined. Finally, a few concluding remarks are made.

I. The Structure of the Canadian Courier Services Industry

a) The Meaning of Courier Services

The meaning of courier services as used here can be described as: same day service or overnight delivery service or later delivery service of letters or *small* parcels by carriers classified under SIC 4842. This corresponds to the statistics collected and published by Statistics Canada. This definition is far from perfect as it excludes small parcels carried by: trucking companies engaged in LTL (i.e., less-than truck load) freight services, bus companies, air cargo companies and rail companies. The definition however includes courier services of Canada Post.

b) The Courier Services Industry

Statistics on the courier services described above are fragmented and until recently (i.e., 1997 onwards) were not available from official government publications. The occasional estimates provided in the table below are an indication of its significance. The courier services

market in 1999 accounted for $3.7b. and the local messenger market accounted for $944m. An alternative source based on a survey by Infobase Marketing Inc. indicates that annual revenues generated by Canadian couriers in 1999 were $4.3b. These services account for

Table 1-Total and Net Operating Revenue in of Courier and Local Messenger Services ('000)

Year	1990	1994	1997	1999
Courier	1,903, 931	2,100, 000	3,129,000*	3,686,208*
Net Operating Revenue	49, 922		233,000	233, 448
Local Messenger	NA	NA	755,000	943,696
Net Operating Revenue	NA	NA	128, 000	134, 012

Source: *Surface and Marine Transport*, Vol. 17, No. 2, Statistics Canada 50-002-XIB and 53-222-XPB * Includes courier services of the Post Office.

about 10% of the annual revenues of the trucking industry. The statistics also reveal that from 1990 to 1999, the operating revenue of couriers increased dramatically by 93.6% (keeping in mind that the 1990 and 1999 surveys are snapshots whose sample size is not strictly comparable) whereas for local messenger service the operating revenue increased by 25% over the period 1997-1999. Generally, local messengers and delivery companies perform same-day delivery services within certain local regions, while overnight or second-day delivery services are usually performed by courier companies. The latter services generally not only include ground transport but also air transport together with the services of custom brokers if the services are to be provided across national borders.

Providing quantitative information on how the various structural components of this industry fit together is complicated by the fact that the components cut across several industries and by the lack of data. Nevertheless, the available data are provided for revenue by nature of service, the mode of transportation through which the revenue is derived followed by revenue derived by origin and destination.

c) Revenue of Couriers by Nature of Service, Mode of Transportation, and by Origin and Destination

Revenue by Nature of Service: Courier revenue by nature of service

is shown in Table 2. Overnight service or later service accounts for 99% of the services provided by courier companies compared to 10% provided by local messenger companies.

Table 2 - Revenue ('000) by Nature of Service 1999 (Carriers over $1m.)

1999	Same-Day	Overnight	Two or More Days	All Services
Courier	30, 089	2, 049, 602	1, 226, 572	3, 306, 263
Local Messengers	437, 272	31, 197	14, 912	483, 351

Source: *Surface and Marine Transport*, Vol. 17, No. 2, Statistics Canada 50-002-XIB.

Revenue by Mode of Transportation: The revenue earned by courier and local messenger companies by mode of transportation is provided in Table 3. For courier companies, surface transport accounts for 52.7% of delivery revenue and air transport accounts for 47.3%. This contrasts with the 96.5% and 3.5% earned by local messenger companies from surface and air transport, respectively. This is not surprising given that most local messenger services occur within a city

Table 3 - Distribution of Delivery Revenue ('000) by Mode 1997 (Carriers over $150,000)

1997	Surface Transportation	Air Transportation	All Modes
Courier	1, 424, 094	1, 277, 318	2, 701, 411
Local Messengers	432, 420	15, 869	448, 289
Total	1, 856, 514	1, 293, 187	3, 149, 700

Source: *Surface and Marine Transport*, Vol. 15, No. 4, Statistics Canada 50-002-XIB.

or region and do not need air transportation. The delivery revenue noted above accounts for 90% of total revenue.

Revenue by Origin and Destination: The total revenue of courier

Table 4 - Courier and Local Messenger Shipments By Origin $('000). Carriers over $1m

1999	Maritimes	Québec	Ontario	Prairies	BC	Total*
Courier /Local Messenger	134, 286	639, 043	2,008,891	557, 306	348, 495	3, 789,614
Percent	4	17	53	15	9	100

Source: *Surface and Marine Transport*, Statistics Canada 50-002-XIB. *=Excludes Territories and outside of Canada.

companies can also be classified by the origin and destination of

shipments. The majority of courier and local messenger shipments originated in Ontario and Quebec as shown in Table 4. Further, these two provinces accounted for 70% of total shipments in 1999. These statistics are not considerably different from statistics obtained form an alternative source which indicates that the two provinces accounted for 68.2% keeping in mind the differences in the two sources.

The destination of shipments is shown in Table 5 for 1990/1999.

Table 5 - Domestic, Transborder and International Courier and Local Messenger Express Shipments $ ('000)

Year	Canada	Transborder	International	Total
1990 Courier	1, 588, 453 (83%)	266, 561 (14%)	48. 916 (3%)	1, 903, 931 (100%)
1999 Courier*	2, 528, 515 (77 %)	573, 265 (17 %)	195, 927 (6%)	3, 297, 707 (100 %)
1999 Local Messengers*	486, 204 (99 %)	5, 294 (1 %)	409 (0%)	491, 907 (100 %)

Source: *Surface and Marine Transport*, Vol. 17, No. 2, Statistics Canada 50-002-XIB. *=Carriers over $1m.

The statistics reveal that in 1999, 77 percent of the courier revenue was derived from services to domestic markets, 17 percent was derived from shipments to transborder markets and 6 percent to international markets. Further, it indicates that revenue from the transborder and international segments have increased in comparison to the domestic segment. These statistics are comparable to statistics from another source Infobase Marketing Inc. which indicates that the domestic, transborder and international revenues accounted for: 84 percent, 11 percent and 5 percent for the year 2000 (their coverage covers all sized couriers).[2] In addition, as can be expected, local messenger express shipments accounted for $492m. of which domestic shipments accounted for 99 percent. The statistics presented above are generated by firms of various sizes in this industry which are examined hereafter.

d) The Firms in the Industry

In 1999, there were 1,629 courier firms and 12,303 local messenger firms (see Table 6). Small firms (i.e., firms with annual revenue of less than $1 million) accounted for 13, 495 of the total, medium firms (i.e., firms with annual revenue $1millon to $25 million) accounted for 219 of the total, and large firms (i.e., firms with annual revenue of $25

million or more) accounted for 218. These large firms comprise 1.6% of all courier and local messenger firms. Most of these firms are located in Ontario and Québec as expected. Overall, the courier market

Table 6 - The Firms in the Industry by Province

1999	Maritimes	Québec	Ontario	Prairies	BC	Total*
Courier	159	307	460	412	289	1, 629
Local Messengers	715	3,540	4, 902	2,008	1, 055	12, 303

Source: *Surface and Marine Transport*, Vol. 17, No. 2, Statistics Canada 50-002-XIB.

is dominated by a few large companies.

II. Regulatory Developments in the Courier Services Industry

In this section, the air, highway, and customs regulations in the pre-deregulation period will be described together with existing regulations that have a bearing on the courier industry. Then, whether any present restrictive regulations should be removed will be briefly noted.

a) Air Carrier Regulations (ACRs) in the Pre-Deregulation Period.

In the pre-deregulation period, the air carrier regulations were extensive. Besides control of entry to operate a carrier and transport acquisitions, the Canadian Transport Commission (CTC) also controlled routes, schedules and class of aircraft that could be flown. The regulations specific to air charters (couriers) were: 1) the filing of tariffs and changes (short term aircargo charter tariff); 2) the type of goods an air charter operator could carry for a courier company (eg. cash, precious metals, negotiable instruments, commercial documents, bank documents, medical supplies, and small machine parts); 3) the size of individual shipments that could be carried for a courier company (max. 50 kg); 4) the requirement for door-to-door transportation; 5) the splitting of domestic and international air charters (prohibited) and sale of space (prohibited for more than one courier company); and 6) the carriage of incidental traffic for domestic and international couriers (prohibited).

b) Air Transport Regulations (*ATRs*) in the Post Deregulation Period.

Domestic Air Express and Courier: In November 1983,[3] the CTC

proposed the following amendments for the air courier industry: the removal of restrictions on the type of goods an air charter operator (domestic or international) can carry for a courier; and, the sale of aircraft space to more than one domestic courier company.[4] However, no changes were made due to ongoing developments. Several months later, the *New Canadian Air Policy* (1984) and the document *Freedom to Move* (1985) proposed numerous reforms (removal of: the public convenience and necessity entry test, licence restrictions and tariff regulations). In addition, the regulation specific to couriers to file rates was removed. To comply with this policy, the *ATRs* (replacing the *Air Carrier Regulations*) in 1988 were passed (SOR/88-58). It removed the requirement to file tariff and tariff changes for air cargo. It also permitted the carriage of incidental traffic on domestic air charters. In 1990, the *ATRs* were amended (SOR/90-740) by allowing domestic charter air services to provide charter aircraft to *more than one* courier company. In addition, the restriction on the *types of goods* that may be carried for air couriers were removed. In 1996, the *ATRs* were amended again (SOR/96-335) removing the requirement on the *size of shipment* and the requirement *for door-to-door transportation.*

Transborder Air Express and Courier: Transborder air services are provided within the context of the Canada-US bilateral Agreement. In 1990, amendment to the *ATRs* (SOR/90-740) removed restrictions on the *types of goods* that may be carried for transborder air couriers. It also permitted tariff filing on one day's notice for tariffs applicable to courier consignments for scheduled air services to enable them to compete with courier services which were not subject to tariff regulation. In 1995, the US Open Skies Agreement permitted Canadian and US airlines to operate unrestricted cross-border cargo services except for the first year of the agreement to Montreal, Vancouver and Toronto by US carriers. Further, all restrictions on aircraft size and package size on US all-cargo service licences were removed. In 1996, the amendment to the *ATRs* (SOR/96-335) permitted split charters, resale of space and freedom for air forwarders to use all-cargo charters. It also removed restrictions on: size of shipment, requirement for door-

to-door transportation, requirements for tariff filing and filing of tariff changes, and the carriage of incidental traffic. However, a courier company is not permitted the use of all cargo services with aircraft exceeding 35,000 lbs. to more than one destination in the other country.

International Air Express and Courier: International services are provided under the framework of bilateral air agreements, international agreements and national policies. In 1990, amendment to the *ATR*s (SOR/90-740) similar to those for transborder were introduced. In 1996, amendment to the *ATR*s (SOR/ 96-335) removed the restrictions on: size of shipment and the requirement for door-to-door transportation. In 1998, the Transport Minister introduced a new policy for international *all-cargo charters*[5] allowing split charters, resale of space and freedom for air forwarders to use all-cargo charters.

Thus by 2000, the regulations identified earlier that restricted transportation for air charters providing courier services were removed.* At present, the regulations applicable to air courier shipments are of a general nature and are contained in: the *Canada Transportation Act* and the *Competition Act*. These are discussed in the air cargo paper.

*** Changes in Regulatory Requirements Since 1980**

Regulatory Requirements 1980	Domestic	Transborder	International
1. Filing of tariffs and changes	Deleted - SOR/88-58	Deleted - SOR/96-335	Deleted - Policy 1998
2. Type of goods	Deleted - SOR/90-740	Deleted - SOR/90-740	Deleted - SOR/90-740
3. Size of shipment	Deleted - SOR/96-335	Deleted - SOR/96-335	Deleted - SOR/96-335
4. Door-to-door transportation	Deleted - SOR/96-335	Deleted - SOR/96-335	Deleted - SOR/96-335
5. No splitting of air charters and sale of space	Deleted - SOR/90-740	Deleted - SOR/96-335	Deleted - Policy 1998
6. No carriage of incidental traffic	Deleted - SOR/88-58	Deleted - SOR/96-335	Deleted - Policy 1998

c) Highway Transport Regulations.

In the 1980s, economic regulation of highway transport was extensive. Economic regulation of highway carriers covered: 1) entry-exit and transfer control; 2) rate regulation; 3) rate filing; and 4) authority restrictions (i.e., restrictions on commodities that can be carried, origin and destination points and routes, etc). Jurisdiction over

highway transport (which includes courier transport) is divided between the federal government and the provincial governments but is exercised by the provinces under the *Motor Vehicle Transport Act*, 1954 and under various provincial motor carrier statutes.

Domestic Highway Transport: The new *Motor Vehicle Transport Act, 1987* (i.e., MVTA) introduced a number of regulatory reforms in *extra-provincial* trucking: 1) easing market entry regulations and discontinuing rate controls; 2) promoting a nationally uniform market entry test, administered by the provinces under delegation of federal authority; and, 3) providing a more effective safety regulation of services under federal jurisdiction. The "public convenience and necessity" test was initially replaced by a "fitness" entry test and a "reverse onus" public interest test. On January 1, 1993, "fitness" became the sole standard for extra-provincial licensing. Existing licences are no longer subject to limitations on specific routes or commodities and "reverse onus" was subject to review to determine if an extension is required. As of January 1, 2000, to meet the objectives of the Agreement on Internal Trade, regulations on extra-provincial trucking were repealed. On the same day, with the repeal of Part III of the MVTA, the last vestiges of provincial economic regulation of *intraprovincial* trucking also expired. As a result, trucking is no longer subject to entry or tariff control regulation in any part of Canada.[6] Since the data for courier services excludes shipments by bus, these regulatory changes are not considered here.[7]

d) Customs Act Regulations.

In 1998, changes were made to the *Customs Act* which could expedite courier services. The major changes include: reduction of tariff for many goods including elimination of all duties under 2%; amalgamation of six coding schedules into one for classification; imposition of duties based on percent rather than fixed dollar amount; and simplification of the refund process due to incomplete original documentation. In addition, transmission of export declaration via the Internet on a pre-arrival basis was introduced together with changes to monitoring compliance from on spot inspection at border crossings to post audit entry through periodic verification audits. The ongoing

customs re-engineering is extensive as a senior officer of a Custom Brokerage House indicated "Governments have changed their direction more in the last three years than they did in the 100 years prior to that."

On October 2001, Royal Assent was given to amendments to the *Customs Act* to implement its five-year Customs Action Plan. It promotes Canadian competitiveness and prosperity in the world marketplace by streamlining the movement of legitimate trade and travel by modernizing Canada's borders and border processing. The Plan creates a comprehensive risk management system that incorporates the principles of self-assessment, advance information and pre-approval, all supported by leading edge technology. Despite the temporary slowdown due to the terrorist crisis, changes are occurring regarding document streamlining and reporting, preclearance, classification, compliance, penalties, etc. all of which could expedite release of shipments including those carried by courier.[8]

e) Present Regulatory Constraints that Deserve Consideration?

A few regulatory restrictions still exist that deserve consideration such as coterminalization which prevents air carriers from serving more than one market across the border; the regulatory constraints on express parcel service of buses (interprovincial and international); and liberalization of air bilaterals with developing countries, particularly, those in China, Hong Kong, Korea and other Asian countries. Finally, new regulatory constraints that emerge deserve careful scrutiny especially those that result from air security, carriage of cargo on regular passenger flights, air navigation fees, air security charges, customs, etc.

III. Competition in the Courier Market Since the Early 1980s

An examination of competition would require a consideration of competitors in the market, a definition of the product, consideration of whether substitutable services exist both from within the industry and from other sources together with the barriers to entry. First, however a brief background of the courier market in the 1980s will be provided.

In 1980, the size of the domestic courier market (i.e., ground transportation) was estimated to be about $700m. The three major competitors, apart from the crown corporations Canada Post and Air

Canada, in the market were: Purolator Courier Ltd.,[9] Gelco Express and Loomis Courier Services Ltd. Purolator was the largest private company with 30-40% of the market, Gelco (formerly Bankers' Dispatch Corp.) the second largest company had 10-15% of the market and Loomis had less than 10-15% of the market. During the mid-1980s, competition in the market began to heat up in response to its growth potential. Air transportation in 1980 was provided by Air Canada for the carriage of most of air express shipments of Canada Post, Gelco and Loomis, etc. Air Canada accounted for 96% of the total air express shipments carried on scheduled flights. Soundair Corp., a charter carrier, provided air express services for Purolator. The major operators in the transborder courier market in the mid 1980s were companies such as FedEx (40% of the market), Emery Air Freight (20%), UPS, Purolator and Airborne Freight Corp. which operated out of their hubs in Louisville, Memphis, Dayton, Indianapolis and Wilmington, respectively. Transborder air transportation (scheduled) was provided by scheduled carriers - Air Canada, American, United, Eastern, Delta, US Air, Federal Express, Torontoair, Brennan and Hargreaves and Airpac; and by charter carriers - Soundair Corporation, First Air, Millardair Ltd. and Pentastar Aviation. Since the 1980s the market has been rapidly expanding and many changes have occurred[10] leading to the present market structure described hereafter.

a) The Courier Services Market

Competitors in the Courier Services Market: In 1997 the nine major competitors in the $3.2b. **total** market were: Purolator, Canada Post, Loomis Courier, United Parcel Service, Federal Express, Canpar, RPS, DHL, and TNT Express Worldwide. These companies accounted for 25.6%, 25.2%, 8.9%, 7.8%, 6.6%, 5.4%, 1.3%, .3% and .1% of the market in terms of volume, the remaining 18.8% was accounted for by others. In terms of revenue, the market share is slightly lower. The HHI for this industry was quite high ranging from 1505 to 2796 (i.e., if Purolator is treated as a subsidiary of Canada Post). For the **domestic** market Purolator's share is marginally higher. Since 1997, the market share of Purolator has declined by a few percentage points.

In the **transborder/international** market, the major competitors are: Federal Express, UPS, TNT Express Worldwide, and DHL. These companies in 1997 accounted for approximately: 29%, 21%, 16%, and 15%, the remaining 19% or less of the volume of shipments was accounted for by others. In terms of revenue, the market share is slightly higher. The HHI for the transborder/international market was more than 1800. Since then the market share of Federal Express has increased by a few percentage points. The high HHIs in both markets indicate that any merger or anti-competitive activity could raise antitrust concerns.

Are there Substitutes for Courier Services?: Before proceeding, it is customary to define courier services. One source describes it as same day service or overnight delivery service or later delivery service of letters or *small* parcels by carriers classified under SIC 4842. Another source, the Canadian Transportation Agency, describes courier service as a service by an enterprise engaged in door-to-door transportation of consignments for overnight or earlier delivery.

In considering whether products in the same market are substitutes among competitors there must be evidence that courier services of the above competitors are responsive to price changes,[11] assuming that other dimensions of this service are the same (i.e., speed of delivery and quality of service which are often considered more important than price). While in general the services of the above competitors are substitutes, careful attention has to be paid to details depending on how narrowly one wishes to define the courier services market, for example: is the service guaranteed or committed (as the difference is in the nature of the refund policy if delivery is not met), does a price discount policy exist (some competitors may offer price discounts and in such cases their guarantee is then void), does a tracking system exist (i.e., is it real time), are their delivery points and fees which affect prices (Federal Express has 8 zones and Purolator has 33), does the service offer online communications technology facilities, etc.

Other sources of substitutable services have also to be considered, for example: a) small parcel courier services carried by LTL trucking companies, parcels carried by bus companies, airport to airport services and rail express services (as these are not included in our statistical data),

and b) e-mail services, fax services, telephone services and general postal services. First, it should be noted that prices of the services listed in a) and b) are considerably lower than courier services and that buyers are unlikely to shift to such services in response to small or moderate price increases. Further, in determining whether these other forms are substitutes, indirect evidence will also have to be considered. Some of these other forms of services may not be interchangeable. First, the services in a) may not be same day or overnight or door-to-door. Second, the services in b) cannot be used for sending packages and general postal services also have the deficiency noted above. Furthermore, industry views and behaviour of purchasers also indicate that these alternatives are not generally substitutable as they lack some of the distinguishing characteristic of courier service. In addition, evidence of demand elasticities and cross-elasticities should be considered if available in determining substitutability. Unfortunately, these elasticities are not available due to the lack of statistical data.

In considering the relevant geographic market, whether alternative routings or alternative modal combinations to the same origin and destination are an effective constraining influence on price of courier services have to be considered. Generally, alternatives to the competitors noted above do not appear to be noteworthy. The industry delineates the geographic market into the domestic market, the transborder market, and the international market based on price differences, carrier regulations, custom regulations, etc. However, this aggregate geographic market definition which is useful for some purposes is not always applicable especially where the market may be a specific origin and destination.

Barriers to Entry: Barriers to entry have also to be considered for example, networks, multiple entry (eg. ground, air, brokerage services, logistics), regulatory requirements, exclusive contracts, economies (scale, scope and networks), etc. These barriers are fairly high especially for new entrants. However, they are not insurmountable for established entrants in other transportation areas as indicated by new services introduced (eg. VIAPAQ of VIA Rail, Epic Express of Canadian Freightways, Time Definite of Yellow Freight, Time Critical of Reimer Express Lines, etc.) or by new entrants who do not provide support and

infrastructure service (eg. goship, smartship, iship, nowdocs, gocargo, and ilinkglobal). These barriers increase as one enters the transborder and international courier markets.

Overall, industry sources believe that the total courier industry is highly competitive and characterized by a wide range of service options and features for shippers. This observation may be true due to the aggressive nature of the existing competitors and because some of them are large international companies. However, given the large market share of Canada Post and its subsidiary Purolator in the domestic courier market, mergers or other anti-competitive practices by these companies are bound to attract attention. Similarly, in the transborder and international markets given the concentration resulting from the market shares (of FedEx, UPS, TNT Express Worldwide, and DHL) and the greater difficulty of entering this market compared to the former market, mergers or alliances between them or other anti-competitive practices are likely to attract attention, particularly if it involved FedEx. Such schemes are likely to raise an issue under the *Competition Act*.

IV. Has the Information Communications Technology (ICT) Affected the Courier Industry?

ICT is having a major impact on the courier industry. This review of ICT will be limited to Internet services and to examine two aspects of its impact: a) How will the Internet affect the volume of courier business?; and b) How will the Internet affect competition in the courier industry?

a) How Will the Internet Affect the Volume of Courier Business?

1. It will have a negative impact on letter or document mailing. The growth in the e-mail has led to a decline in the traditional way of sending mail. Canada Post has indicated that their volumes were down 17 percent in 1999 compared with the previous years. This decline is being facilitated by the fact that electronically signed documents have gained legal acceptance as a result of recent decisions by many governments.
2. It will create the demand for new types of services. Infobase Marketing Inc. indicates that the Internet will create a demand for three types of new services: a) secure document delivery using encryption to send messages; b) electronic bill payment allowing courier companies to

transfer funds and pay bills; and c) eparcel fulfilment allowing retailers and other vendors to integrate their online sales efforts with delivery capabilities of a courier.

3. It will have a positive and significant effect on shipments of small packages. In 2000, twelve percent of all courier industry revenue was generated from Internet based purchases (estimated to be $571million). This percentage is expected to increase by more than 50 percent in 2003. In its 1999 Annual Report, FDX states: "Business-to-business e-commerce is estimated to top $100 billion in sales this year and exceed the trillion dollar sales mark by 2003."[12] These projected sales are for the US when estimated for Canada they are about $200b. In light of its significance, FDX spent over $1.5b in 1998 to strengthen their superior technological capabilities and to attract the brightest people. Similarly, UPS has stated "Over the past fifteen years, UPS has invested US$11 billion on technology improvements. Currently, UPS invests more than US$1 billion every year on information technology."[13]

b) How Will the Internet Affect Competition in the Courier Industry?

1. It will lead to new e-based competitors and lead to emergence of near competitors. A number of new e-based competitors have developed sites which focus on retail purchase by consumers. Examples of such services are goship, smartship, iship, nowdocs, gocargo, and ilinkglobal. While these companies actually do perform physical pick-up and delivery they do not provide support and infrastructure services such as sales force. Courier companies will have to compete with these new e-based competitors or ensure that they are listed as an option for this service. Near competitors whose traditional business was on LTL and larger shipments are attempting to capitalize on increasing purchases through the web by introducing courier type, expedited or express delivery services. Examples, include VIAPAQ by Via Rail Canada, etc.

2. It will lead to mergers and acquisitions. The increase of purchases through the Internet has led to a number of alliances, mergers and acquisitions. Some of these structural changes are to supplement existing weaknesses in the current scope of services, some to broaden the existing scope of services and some to deal with the new forms of competition. The basic reason for these mergers is to achieve network

economies and to exploit scale economies.

There are numerous examples of these developments. Purolator formed an alliance in June 1996 with Dynamic Inc. to provide same day service across Canada. In August 1998, Purolator formed a strategic alliance with DHL Worldwide Express to provide superior delivery to international destinations. In 1999, Purolator formed a strategic alliance with Burnham, a supplier of logistics services. Similarly, Federal Express recently decided to integrate with Roadway Package System provider of business-to-business ground small package delivery. In January 1998, Caliber System, Inc. became a fully owned subsidiary of FDX Corporation. In 1999, FedEx partnered with KPMG and purchased Tower International, a logistics company. Similarly, UPS reports that ending December 31, 2000 the company completed fifteen domestic and international acquisitions valued at $552m. Included in this is the acquisition of Trans-Border Custom Services (specializing in custom brokerage of trade between Canada and US). After this date, it announced three additional acquisitions: Fritz Companies Inc., First International Bancorp, Inc. and Mail Boxes etc. These structural changes could continue into the future as familiarity with the Internet increases and due to the impact of the terrorist crisis on transportation.

3. It will lead to fully integrated logistics, supply-chain solutions. The demand for speed in delivery and better service has caused the larger courier companies to become fully integrated logistic companies providing total solutions or supply chain solutions. For example, UPS states "When you look at the UPS of 2000 - a logistics company, an electronic commerce company, a consulting company, and a financial services company - it's obvious we're not just delivering packages." This development is expected to continue in the supply chain optimization process. Infobase Marketing Inc. states "this trend will surely continue into the future, with the end result being that the use of the term 'courier' may at some point in time only be reserved for local, in-city type deliveries (all others will be fully integrated logistics service providers)."

Concluding Remarks

The courier and local messenger industry has been one of the fastest

growing segments of the transportation sector over the last decade accounting for approximately $4.6b. or ten percent of trucking revenues in 1999. Eighty-five percent of courier revenue is derived from overnight or later services. The revenue derived by surface and air modes is approximately fifty-three and forty-seven percent, respectively. More than two thirds of its revenue originates from Ontario and Québec and nearly seventy-seven percent of it is derived from services to domestic markets. The transborder and international courier markets are dominated by a few companies.

Over the last fifteen years, regulatory restraints applicable to the courier industry have been removed which appear to have had a beneficial impact on competition. Entrants such as FedEx and UPS have been able to capture a part of the domestic market and a larger part of the transborder market from established companies such as Purolator, Gelco and Air Canada. The transborder and international courier market is dominated by international companies such as FedEx, UPS, TNT Express Worldwide and DHL. These companies visualize themselves as having ripened into multi-dimensional single-source providers of full-blown logistics solutions, though they still call themselves couriers. Industry sources believe that the total courier industry is highly competitive and characterized by a wide range of service options. In view of the high concentration in this industry, it would be prudent to check with the Office of the Commissioner of Competition on any schemes (mergers, alliances, anti-competitive acts, etc.) that could raise an issue under the *Competition Act*.

The new information communications technology is having a major impact on the courier industry. This technology is expected to affect competition through possible new e-based competitors and near competitors, acquisitions in the industry and the development of fully integrated logistics with supply-chain solutions. Finally, within the next few years more than fifty percent of courier revenue will be generated through Internet purchases.

Bibliography

1. **Transportation in Canada 2000**, Annual Report, Transport Canada, TP 13012E, pp. 119-121 and pp. 151-153.
2. **Competition in Transportation**, Policy and Legislation in Review, 1993, p. 123.
3. **Transborder air courier services**, CTC, Paget, Douglas, 1980.

4. **Report of the Hearing Panel: regulation of courier air services**, Canadian Transport Commission, 1984.
5. Couriers in Canada: An Industry Profile, A. Mathieson and J. Leduc, **CTRF**, Volume 28, 1993, pp. 12-20.
6. **Courier Industry Size, Structure and Fleet Analysis Study**, Infobase Marketing Inc., Jan. 2001.

* ***The views expressed are those of the authors and not necessarily those of the Competition Bureau.***

Endnotes

1. Transportation in Canada 2000, Annual Report, TP 13198E, p. 121.
2. Courier Industry Size, Structure and Fleet Analysis Study, Infobase Marketing Inc., January 2001.
3. Prior to this period, the two significant changes made to the ACR regarding the air cargo industry were: chartering of aircraft to courier companies without further licensing or regulation; and carriage of mixed traffic, passenger and cargo on charter flights. See The Canada Gazette Part I, 1979, p. 3263 and p. 3040.
4. It also retained the following restrictions: the size of goods carried to 50 kg per single shipment; and, the prohibition of carriage of incidental traffic for both domestic and international courier air services. See *Air Carrier Regulations* ss. 112(12), 112(12.1) and 120.1. Also see *Air Transportation Regulations* ss 11 and 16.
5. The policy: i) allows *several* shippers or charterers to charter space on an *all-cargo* aircraft. Previously, multiple shipper and freight forwarder cargo was reserved for *scheduled* international air services; and, ii) freight forwarders who resell cargo space to other shippers, will be able to act as charterers. Previously, an international all-cargo charterer had to contract the entire capacity of an aircraft on its own and was prohibited from reselling space to other shippers. As a result, if shippers could not fill an entire aircraft it was uneconomical to use it. Further, freight forwarders where prohibited from using international all-cargo charters and had to use scheduled international air services. The above amendments are now part of the *ATRs*.
6. Transportation in Canada 2000, Annual Report, TP 13198E, p. 113.
7. In the pre-deregulation era, for *extra-provincial busing* (Part I of the MVTA) apart from Newfoundland all the other provinces maintain some form of regulation. For *intraprovincial* busing, entry and exit, tariff filing and rate regulation for scheduled services existed for all provinces (Ontario practised limited exit control and Saskatchewan did not require tariff filing). For parcel express bus service rate regulation was practised by all provinces with the exception of Alberta, Québec and PEI.
8. For a more extensive review of the amendments see "Minister Cauchon announces tabling of legislation to implement Customs Action Plan", CCRA News Release, March 2001, and the numerous articles in Canadian Transportation and Logistics on the subject.
9. Purolator started on Dec. 5, 1960 as Trans Canadian Couriers, Ltd. In 1967, Purolator Filter United States acquired control and changed the name to Purolator Courier. On April 29, 1987, Onex Corporation and others purchased Purolator's Canadian operation.
10. In 1987, Purolator formed a strategic alliance with Airborne Express for air express delivery in the US. In 1988, AC became more involved in the fast-growing courier business through its subsidiaries Gelco Express and Northern Messenger. Air Canada also established new regional cargo hubs at Winnipeg and Moncton. It also signed an agreement with Greyhound Canada where the bus line agreed to provide delivery support throughout Canada to its overnight delivery service. In 1989, Air Canada announced its decision to withdraw from the overnight cargo business and sold Gelco Express to Purolator Courier and obtained a 22% interest in the latter with rights to transport Purolator's packages across Canada. A year later, Air Canada designated Dynamex, a wholly-owned subsidiary, to be its pick-up and delivery contractor within Canada. In 1993, Canada Post Corporation purchased 75% interest in Purolator and later increased its ownership to 95.81%. On June 10, 1996, Purolator formed an alliance with Dynamex Inc. In 1989, UPS and Federal Express extended their air express services throughout Canada by chartering aircraft from smaller Canadian operators. Federal Express announced a new hub operation to be established at Moncton and UPS announced similar plans for a hub at Mirabel. In the early 1990s, the scheduled air cargo market share of Air Canada was 64% compared to 36% carried by Canadian (which now included the former CP Air and PWA). Canadian introduced a new overnight all cargo B-737 service during 1993 between Toronto, Winnipeg, Edmonton and Vancouver westbound and between Calgary, Winnipeg and Hamilton eastbound. In 1994, another two all-freighter 737s were added to this service. In 1993, a significant air cargo development was Purolator's decision to use its own air cargo fleet, rather than use Air Canada's fleet of DC-8's. The new Purolator fleet was then the largest such fleet in Canada. On March 31, 1994, Air Canada discontinued its all cargo freighter operations began in 1963 and sold its five DC-8s (three of the eight were sold earlier) to DHL Airways (a subsidiary of DHL Worldwide Express, a major courier company).
11. Based on the *Southam* decision, the Judge indicated that several principles on the matter emerge. " (a) products can be said to be in the same market if they are close substitutes; (b) direct evidence of substitutability includes both statistical evidence of buyer price sensitivity and anecdotal evidence, emanating from buyers on past or hypothetical responses to price changes; (c) indirect evidence of substitutability may be garnered from certain practical indicia, such as functional interchangeability and industry views/behaviour; (d) statistical evidence of high-demand elasticity, if available, will be virtually conclusive that products are in the same market; (e) anecdotal evidence of price sensitivity, while less conclusive, can nevertheless be persuasive in tending to show that products are close substitutes; (f) the complete absence of either statistical or anecdotal evidence of high-demand elasticity does not show conclusively that products are not close substitutes; (g) even in the face of evidence disclosing low-demand elasticity, product substitutability may nevertheless be shown to exist, based upon indirect evidence such as functional interchangeability and industry views/behaviour."
12. FDX Corporation 1999 Annual Report, p. 6.
13. UPS Company History, 2001, p. 3.

THE CANADIAN AIR CARGO BUSINESS

Joseph Monteiro, Melanie Nera and David Krause*

Introduction

In recognition of the importance of the air cargo business, Transport Minister, Mr. Collenette in January 1998 stated "the guidelines ...reflect the growing importance of air cargo and demonstrate the federal government's commitment to foster the growth of Canadian all-cargo carriers."[1]

In this paper, the development of the air cargo business in Canada is examined in Part I. In Part II, regulations that existed in the mid 1980s and 2001 are reviewed. In Part III, the impact of deregulation on competition and measures of performance in this industry will be briefly examined. Finally, a few concluding remarks are made.

I. The Air Cargo Business in Canada

a) The Early Development of Air Cargo Services in Canada

The term air cargo is used here to mean 'all goods carried by air' (i.e., the term goods include all types of non-passenger traffic in other words freight, air express shipments, mail and excess baggage). Air cargo can be transported on scheduled passenger flights, scheduled freight flights, charter flights and occasionally on unscheduled flights.

The carriage of cargo by air in Canada can be traced to the development of flying in the early 1900s. At this stage, the carriage of cargo by air was basically used for transportation of supplies and mail to remote areas. The development of air cargo service as a scheduled unit toll business is of more recent origin.

The early development of the air cargo business can be attributed to a number of factors. The most important were: 1. The need to provide supplies to northern and remote areas; 2. The emergence of the jet engine and the commercialization of air travel; and 3. The need to meet the demands of businesses for increased and new types of services.

b) The Growth of Air Cargo in Canada

The growth of air cargo can be seen in the following discussion.

Air vs Other Transport Modes: The share of goods transported by air has increased in the last decade compared to other modes of transport. This is true both for exports and imports in actual and percentage terms, and in terms of value or volume. This is shown in table 1 and is particularly noticeable in terms of value.

Table 1 - Value and Volume of Total Exports and Imports and Air's Share

United States								
Year	Total Exports				Total Imports			
	$ (B)	Air %	Ton (M)	Air %	$ (B)	Air %	Ton (M)	Air %
1993	150.7	4.5	221.8	.1	113.8	7.5	NA	NA
1999	308.1	5.7	307.5	.2	215.4	9.5	106.2	.9
Non-United States								
1993	36.9	17.1	143.4	.3	56.1	16.6	NA	NA
1999	46.8	20.8	182.3	.3	104.7	23.3	69.6	1.3

Source: *Transportation in Canada 2000*, Transport Canada, 2001, p. 152.

This increase has arisen because of the rising demand for overnight delivery and faster delivery of high value products (i.e., electronic and computer), perishable products (sea and agricultural) and pharmaceuticals.

Air Cargo Loaded and Unloaded at Major Canadian Air Ports: Cargo traffic at the top ten Canadian air ports increased from 538,000 tonnes in 1984 to 820,000 in 1999, an increase of 52%. Toronto, Vancouver and Montreal (Mirabel) are the major ports of international air cargo traffic. Toronto has continued to maintain its pre-eminent position since the 1970s and has increased its share among the ten airports not only in terms of volume (i.e., from 41% to 46%) but also in terms of growth (i.e., 70% compared to 52% for the leading ten airports). The volumes are shown in table 2.

An examination of air cargo in the domestic, transborder and international markets indicates that the composition of air traffic has

Table 2 - Air Cargo Loaded and Unloaded at Major Canadian Air Ports (tonnes) ('000)

	Domestic			Transborder			International			Total		
Airport	1984*	1991*	1999	1984*	1991*	1999	1984*	1991*	1999	1984*	1991*	1999
Toronto	126	138	113	41	70	113	53	103	149	220	312	375
Vancouver	59	71	73	10	18	27	12	34	94	81	124	194
Mirabel	23	9	2	2	11	39	58	65	6	83	85	45
Calgary	29	30	28	3	5	15	3	6	17	35	41	60
Dorval	26	21	20	7	5	4.7	1	-	68.8	35	26	93
Edmonton	26	19	14	.7	1	.3	2	2	1	29	22	15
Winnipeg	21	24	6	1	2	4.3	.5	-	.3	23	25	11
Halifax	17	21	16	.6	-	-	1	4	2	18	26	18
St. Johns	8	4	1.8	-	-	-	-	-	.6	8	5	2
Ottawa	5	6	3.6	.3	.3	2	1	.7	3.6	6	7	7
TOTAL	339	346	276	67	113	203	132	216	342	538	675	820

Source:* *Aviation in Canada*, 51-501E. *Air Carrier Traffic at Canadian Airports*, 51-203 -XPB.

been shifting in favour of transborder and international traffic (i.e., 12% and 24% in 1984 to 25% and 42% in 1999). The decline in the share of domestic traffic (i.e., 63% in 1984 to 34% in 1999) can be attributed to the growth of the overnight transborder delivery service market and later to the changed regulatory environment facing transborder and international air cargo transportation.

Air Cargo Carried by Scheduled and Charter Carriers: Air cargo transported by *scheduled* carriers continued to increase between 1984-1999 rising from 426.8m. kg. to 846m. kg. or by 98%. The fastest growth during this period has come from the international sector (157%) followed by the transborder sector (102%). This is shown in table 3. Air cargo transported by *charter* carriers increased by 84% between 1984 and 1999 most of the increase resulted after 1991. The slow growth in charter traffic was largely a result of the slow growth in domestic charter cargo traffic. This is evident from the statistics in

Table 3-Air Cargo Carried by Canadian Air Carriers Levels I-IV (kg) ('000)

Year	Domestic	Transborder	International	Total
1984*	290, 698	44, 819	91, 316	426, 833
1991*	411, 874	66, 675	150, 936	629, 485
1999**	520, 867	90, 584	234, 547	845, 998

Source:* *Aviation in Canada*, Statistics Canada, 51-501E. ** *Canadian Civil Aviation*, 51-206, Levels I-III (The difference between I-IV and I-III is 2.1% in 1999).

Table 3A-Air Cargo Carried by Charter Services (kg) ('000)

Year	Domestic	Transborder	International	Total
1984*	134, 415	6, 442	3, 884	144, 741
1991*	109, 098	19, 941	19, 706	148, 745
1999**	219, 935	31, 398	15, 330	266, 663

table 3A above which indicates that domestic cargo increased by 64%, transborder by 387% and international by 295%.

Air Cargo by Revenue: Total cargo operating revenue of charter and scheduled services increased between 1984-1999 from $564m. to $1,238m. an increase of 119%. This increase came form charter services rather than scheduled services i.e., an increase of 835% vs. 52% (table 4). Scheduled revenue accounted for 63.4% of the total revenue. In 1999, charter goods revenue accounted for 19.7% of total charter revenue and scheduled goods revenue accounted 7.8% of total scheduled revenue or 9.7% of total passenger and goods revenue.

Table 4 - Air Cargo Operating Statistics 1984-1999 Levels I-IV (00,000)

	1984*	1991	1999
Total Operating Revenue (Charter)	484.0	1, 586.9	4, 525
Total Operating Revenue (Scheduled)	5,156.0	6, 094.0	7, 855
Total Operating Revenue	5, 640.0	7, 680.9	12, 380

Source: *Canadian Civil Aviation*, Catalogue no. 51-206 -XPB. * Provided by Statistics Canada.

c) The Air Express Market in Canada

The air express market is a part of the total air cargo market which generally involves provision of ground transportation services though some times it could involve airport-to-airport service. The air express market was the fastest growing part of the air cargo market. For example, air express cargo in terms of kilograms consisted of 15.8% of cargo in 1965 which grew to 21.1% by 1981. This market has been divided into two components: the overnight transborder delivery services, and the overnight domestic delivery services. An estimate of the size of this market for 1997 was $1.293b.

d) Future Prospects for the Air Cargo Industry

The economic collapse of South Asia late in 1997, the economic slow down in North America and USA, and the terrorist crisis, has resulted in a temporary setback to the growth of the air cargo industry. Nevertheless, the radical changes that have recently occurred at the Toronto, Montreal, Hamilton and other air cargo terminals indicate that prospects for the future look promising. As Claude Morin managing director of cargo for Air Canada stated: "Flying freighters internationally when the economy is strong can be a profitable business..."[2]

In sum, the increase in the carriage of cargo by air can be attributed to several factors: i) the demand from certain new industries (i.e., express delivery, hi-tech, horti-cultural, pharmaceutical and on-line e-mail purchases); ii) the demand from existing industries to reduce cost (due to high interest and inventory costs); iii) the demand made possible due to information communications technology enabling faster communications between suppliers and consumers; iv) the supply of new services arising from combi-aircraft, air freighters and air cargo alliances[3]; v) the supply made possible due to investment in air cargo infrastructure (air cargo hubs, terminals, sorting and tracking technologies, etc,); and vi) the new regulatory environment (i.e., domestic deregulation) and a more liberal international air cargo environment (i.e., Open Skies with the US and more liberal bilaterals).

II. Regulatory Developments in the Air Cargo Business

In this section, regulations affecting air cargo transportation will be examined. Then, whether any regulations should be liberalized will be indicated. First, however the regulations in the pre-deregulation period will be examined followed by changes that occurred thereafter.

a) Air Regulations in the Pre-Deregulation Period

In the pre-deregulation period, regulations affecting air cargo were extensive. Entry to operate a commercial air cargo service required a licence which had to satisfy the present and future public convenience and necessity test. Generally, routes and class of aircraft that could be flown together with other conditions such as schedules were regulated. Further, regulation also extended to cancellation, amendment of licences,[4] tariffs and tolls, Base protection and Class 4 positioning charges. Those specifically relevant to cargo carried by scheduled air services were: 1) the filing of tariffs; 2) the filing of tariff changes; and 3) the review of tariffs (in the event that it is discriminatory, unreasonably preferential, and unreasonably pre-judicial). Those specifically relevant to cargo carried by charters were: 4) the filing of tariffs and changes except for long term charter tariffs; 5) the splitting of air charters was prohibited; 6) the space on a charter could not be sold to more than one firm; 7) the carriage of incidental traffic was prohibited; 8) the carriage of mixed traffic passenger and air cargo on charter flights was not permitted;[5] 9) the entire capacity of the aircraft had to be chartered; and 10) the right to coterminalize did not exist. In addition, regulations applied to couriers (see courier paper).

b) Air Regulations and developments in the Post-Deregulation Period.

Domestic Air Cargo: The *New Canadian Air Policy* (1984) and the document *Freedom to Move* (1985) proposed numerous reforms. The major highlights were: the entry test of public convenience and necessity was to be replaced in favour of a 'fit, willing and able' test for any class of domestic service, and market exit was not to be impeded by a requirement of advance notice; the regulation of domestic tariffs was eliminated (however provision for appeal in case of upward pricing was to exist); the filing of cargo tariff with the CTC was to

continue; a copy of the tariff at the carrier's place of business was to be available; and, the regulation of international rates was to continue. These changes were later partly embodied in the *National Transportation Act* now the *Canada Transportation Act* (i.e., CTA).

On July 5, 2000, amendments to the CTA and the *Competition Act* became law. The Agency was given authority to review cargo rates on monopoly routes (excluding confidential charter rates). This applies to situations (in the event of a complaint) where rate increases are unreasonable; or the range of rates are inadequate; or rates not in tariffs are applied; or unreasonable or unduly discriminatory terms or conditions are applied. The Competition Bureau was given specific powers to deal with airlines in situations of: predatory behaviour; anti-competitive behaviour; and, exclusivity. In addition, airline merger reviews are subject to a three track formal process. Aside from the above, air carriers operating a domestic service must also satisfy regulations which relate to their being Canadian owned and controlled, having liability insurance coverage and having a Canadian aviation document. In addition, carriers are no longer required to file tariffs with the Agency though tariffs have to be established.

Transborder Air Cargo: Transborder air cargo services are provided in accordance with the Canada-US bilateral agreement and the restrictions described for domestic carriers also apply here. In 1995, the Open Skies Agreement between Canada and the United States of America provided for Canadian and US airlines to operate unrestricted cross-border cargo services, with the exception that US service to Montreal, Vancouver and Toronto would be limited for the first year. The Agreement, however did not provide for co-terminalization nor did it provide for cabotage rights in air cargo transportation. To comply with the Agreement, on July 1, 1996 amendments were made to the *Air Transport Regulations*. It permitted more than one charterer to charter aircraft, in other words, freight forwarders and others who obtain payment for transportation are now able to use chartered aircraft.

International Air Cargo: International Air Cargo services (scheduled and charter) are provided under the framework of bilateral air agreements, international agreements and national policies. In

January 1998, the Minister of Transport issued designation guidelines for *scheduled all-cargo* services that allowed for open all-cargo designations in *international markets*. The guidelines indicate that: i) where Canada has open rights, all interested licensed Canadian air carriers will be designated to provide all-cargo service; ii) where Canada lacks open rights, the federal government will enter into negotiations to seek those rights; and, iii) where Canada cannot obtain sufficient additional rights, the rights will be awarded in order of merit based on the quality of service proposals.

A few months later in May 1998, the Minister announced a new policy for international *all-cargo charter* air services. This policy: i) allows *several* shippers or charterers to charter space on an *all-cargo* aircraft. Previously, multiple shipper and freight forwarder cargo was reserved for international *scheduled* air services; and, ii) freight forwarders who resell cargo space to other shippers, will be able to act as charterers. Previously, an international all-cargo charterer had to contract the entire capacity of an aircraft on its own and was prohibited from reselling space to other shippers. As a result, if shippers could not fill an entire aircraft they could not sell unused space. Further, freight forwarders were prohibited from using international all-cargo charters and had to use international scheduled air services. The above policy is now reflected in the *Air Transport Regulations*.

Thus, air carriers operating scheduled international (including transborder) *all-cargo services* must continue to satisfy regulations which require that they are Canadian owned and controlled, have liability insurance coverage and have a Canadian aviation document. Further, international tariffs (excluding charter rates) have to be filed with the Agency, they have to be established and kept available for inspection at its business office. The rates established in a tariff prevail and no rebating will be permitted. These regulations also apply to international *all-cargo charters*. In addition: the *entire* capacity of the aircraft has to be chartered; the Agency has to be notified; the Agency approval is required when operated on a fifth freedom basis, and the carrier has to provide post facto information (see table hereafter).

*** Changes in Cargo** (excluding couriers) **Regulatory Requirements Since 1980**

Regulatory Requirements	Domestic	Transborder	International
Scheduled Carriers			
1. Filing of tariffs	Deleted - SOR/88-58	Required	Required
2. Filing tariffs changes	Deleted - SOR/88-58	Required	Required
3. Tariff review	Deleted - SOR/88-58 Re-introduced - 2002	Exists	Exists
Charter Carriers			
4. Filing of tariffs and changes	Deleted - SOR/88-58	Deleted - SOR/96-335	Deleted - Policy 1998
5. No splitting of air charters	Deleted - SOR/90-740	Deleted - SOR/96-335	Deleted - Policy 1998
6. No resale of space	Deleted - SOR/90-740	Deleted - SOR/96-335	Deleted - Policy 1998
7. No carriage of incidental traffic	Deleted - SOR/88-58	Deleted - SOR/96-335	Deleted - Policy 1998
8. No carriage of mixed traffic	Deleted - 1979	Deleted - 1979	Deleted - 1979
9. Entire capacity chartered	Required	Required	Required
10. No coterminalization	Deleted - SOR/88-58	Exists	Exists

On May 21, 2002 Transport Minister, David Collenette, announced that all Canadian carriers may apply to operate scheduled international air services regardless of the size of the travel market thereby removing the 300, 000 scheduled passenger trips threshold. This will increase the cargo capacity offered on passenger/cargo service. He further indicated that liberalization of Canada's approach to bilateral air negotiations will be considered later.

Liberalization of policies for the air cargo market are also being examined by the OECD. In its May 2002 Report,[6] it examined liberalization principles and alternative liberalization approaches such as a protocol to existing air service agreements and a multilateral air cargo agreement. The principles are categorized into: liberalization of market entry; provision of ancillary services; and trade facilitation.

Practical measures to implement market access arrangements include consistent treatment of scheduled, non-scheduled or charter services. Options include granting on a bilateral or multilateral basis

international fifth and seventh freedom rights, as well as longer term prospect of granting of rights for the operation of domestic air cargo services to designated carriers from other contracting parties. Other desirable liberalization changes include matters such as ownership and control of air carriers. Revised approaches to a number of the cargo-specific regulatory barriers include: additional market access by way of traffic rights for international air cargo transport services, maximum scope to diversify into related business activities, the ability to use surface transportation when necessary to provide the most efficient service to customers; and maximum choice in the arrangement of ground handling services, including self-handling. Furthermore, the provisions include undertakings to implement the best customs practices as recommended by the World Custom Organization and other international bodies.

One part of the report that has attracted attention is the multilateral agreement proposal which provides for a complete set of articles that would facilitate early liberalization of existing market access restrictions including: deregulating pricing and capacity decisions, facilitating multiple designations, calling for fair competition, and ensuring application of laws for transparency in the levying of user charges, and removing the distinction between types of air services.

c) Customs or Other Regulations Affecting Air Cargo Transportation

In early, 2001 certain amendments to the *Excise Tax Act* (Bill C-13) went into effect which would facilitate the growth of air cargo in free trade zones or export distribution centres. First, GST requirements for goods in this zone are changed, previously GST had to be paid on entry of goods into Canada notwithstanding that they were being exported and could be recovered only when the goods left Canada. Second, value is permitted to be added (within limits) to goods in a free trade zone. Third, paper work for goods in this zone is reduced.

The objectives behind these new policies changes were: i) to provide Canadian shippers with a greater range of services and new opportunities to move their cargo; ii) to foster the growth of all cargo Canadian carriers; iii) to reflect the growing importance of the air cargo industry; and, iv) to liberalize further air cargo services and the air

freight forwarder's industry.

On January 1, 1998 sweeping changes to the *Customs Act* were introduced. This would have a major impact on importers and possibly air cargo transportation as it affected: classification, valuation, and determination of origin of goods. The major changes include: reduction in tariffs for many goods including elimination of duties under 2%; amalgamation of six coding schedules into one; imposition of duties in percentages rather than fixed dollar amounts for certain goods; and simplification of the qualifying process for refunds due to incomplete documentation. Changes were also introduced in monitoring compliance from on-spot inspection to post-entry audit and an increase in periodic verification audits. One major customs business noted "Governments have changed their direction more in the last three years than they did in the 100 years prior to that." Further amendments to the *Customs Act* (permitting implementation of the five year Customs Action Plan) received Royal Assent on October 25, 2001. One initiative beneficial to air cargo is Customs Self-Assessment (i.e. quickly releasing low-risk goods at the border when low-risk importers identify themselves).[7]

d) Are There Any Regulations That Need To Be Further Liberalized?

Liberalization of other regulations that could affect air cargo transportation has been advocated. First, co-terminalization of cargo in the US agreement by a carrier should be permitted to achieve certain economies. Second, our present bilaterals are too restrictive compared to the US. Providing 5th freedom rights might prevent diversion of air cargo to the US and may entice large US carriers such as Fedex or UPS to setup international centres in Canada. A two track approach (passenger vs. cargo) for Canada's bilateral agreements could lead to a quicker liberalization of all cargo services. Third, amendments to pre-clearance regulations of Canadian air cargo could also result in benefits in time saving at US borders eg. customs zones at airports. In addition, the rules that apply to the free trade zones could be further liberalized eg. increasing value added to above the 20% threshold. Fourth, a number of related issues require consideration: the need to increase freighter space and capacity, the need to keep navigation fees

comparable to the US, the appropriateness of bonding requirements, the interlining pricing arrangements of Air Canada (i.e., AC) with foreign carriers of cargo which could have an impact on their decision to remain in Canada,[8] the need for better road access to airports and the need for improvements in highway infrastructure at busy border crossings, and the need for improved clearance (eg. through installation of transponders in trucks and pre-clearance of empty trucks).[9]

III. The impact of Domestic Deregulation and the US Open Skies Agreement on the Canadian Air Cargo Industry?

The impact of deregulation, described above, on competition and key measures of performance such as air cargo rates, output, quality of services, etc. is briefly examined.

In the early 1980s, competition in the *domestic air cargo* market (scheduled and charter) was limited. AC and CP Air accounted for approximately 65% and 25% of the market (kilograms or tonne kilometres or operating revenue). The only other scheduled carrier that provided air cargo service of any significance was PWA besides a few non-scheduled charter carriers.[10] The introduction of deregulation in the mid 1980s witnessed major structural changes. By 1994, AC's scheduled air cargo market share had dropped to 58% and the share of Canadian Airlines (which acquired CP Air and PWA) had risen to 42%. In addition, charter carriers of air cargo continued to make inroads, and their market share had increased to 26.7% in 1994 of the total air cargo market from 21.4% in 1990. By 1999, the fight for supremacy in the scheduled air cargo market was over with AC's acquisition of Canadian Airlines. Any remaining competition came from carriers providing scheduled service to major airports (see table 5 - to be read from bottom of column that is origin to destination above) and from the 33 licensed charter cargo operators.

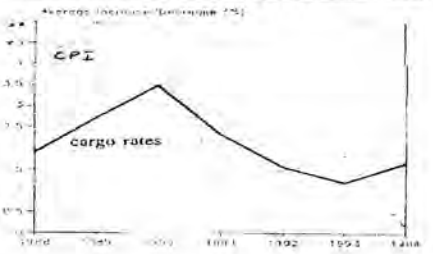
Competition in the *transborder market* for scheduled air cargo in the 1980s was generally limited to two designated scheduled passenger carriers indicated in the bilateral agreement. In the early 1980s, most of the competition to scheduled carriers came from scheduled freight flights of AC, Federal Express, and from small carriers. In the mid

1980s, with the increase in competition from larger couriers AC withdrew from the market. The air services to the courier hubs in the US are usually provided by Canadian air carriers under contract.[11] With the Open Skies Agreement in 1995, competition increased with the increase in scheduled services and capacity. In 1999, Canadian carriers transported 92.6% of transborder *charter* traffic. All Canada Express, Bradley Air Services and Knighthawk Air Express accounted for 70.2%, 24.7% and 5.1% of this charter traffic, respectively.

Competition in the *international air cargo* market is largely determined within the framework of bilateral air agreements. Before 1984, AC was the major Canadian carrier on European, Carribean and South Asian routes and CP Air was the major Canadian carrier on South American and Pacific Rim routes and some European routes. The only competition that arose was from the designated foreign carrier on each specific route or via the US. In 1988, Wardair entered the all cargo Canada-UK market but competition did not last very long due to its demise. As of 2000, five Canadian air carriers were licensed by the CTA to operate international scheduled all-cargo service (none do so at the moment) and 25 Canadian air carriers are licenced to operate non-scheduled all-cargo service. Besides the Canadian carriers, five major international cargo carriers provide scheduled all-cargo air service to and from Canada i.e., Cathay Pacific, Korean Air, Air France, Lufthansa Cargo and Iberia. Thus, the extent of direct competition in this market has so far been limited.

Regarding other measures of performance, air cargo domestic rate changes are available from two sources. The first is the CTA's survey results of shippers between 1988-1994 and the second is data published by Transport Canada from 1986. According to the CTA survey, *average increase in rates* declined over the period 1988-1994 (i.e., the annual average increase in 1988 was approximately 2% compared to the increase of 1.2% in 1993 or 1.7% in 1994). This is also lower than similar increases in the CPI of 2.65% for the period 1988-1994 and is shown in the chart hereafter. The Transport Canada data based on files of Statistics Canada indicates that over the period 1986-1997 air

Changes in Domestic Air Cargo Rates v. C P I Reported by Air Shippers



cargo *rates* declined by 1 percent or about .8 percent for the period 1991-1998. As indicated by Transport Canada, total air cargo rates declined by 5.6 percent over the period 1991and 1998. This is in contrast to the CPI which increased by 10.25 percent for the same period. Thus, both sources of data indicate that users of air cargo services fared better than consumers of a typical basket of goods. Since data on *transborder cargo rates* are not published very little can be said definitely about whether these air cargo rates declined in the first few years after the Open Skies Agreement, other than that rates for *all air cargo freight* (i.e., transborder, domestic and international) increased by .4 percent for the 1994-1999 period which is less than the increase for the CPI during the same period.

In terms of output, total operating goods revenue increased from $564m. in 1984 to $1,156.9m. in 1999 or an increase of 105 percent. Domestic revenues increased by 147 percent and transborder and other international revenue increased by 50 percent. Output measures in real terms (i.e., tonnes) indicates that cargo at the top ten airports [loaded and unloaded] increased from 538, 000 tonnes in 1984 to 820,000 tonnes in 1999 an increase of 52 percent. For the period after the Open Skies Agreement, Transport Canada states "Transborder air cargo was up sharply in 1995 -- to approximately 700 million revenue tonne-kilometres -- an increase of 25 percent over 1994." Between 1994 and 1999 transborder cargo increased by 28% compared to domestic cargo which increased by 13%.

In terms of new domestic air services (and consequently air cargo

space), in 1990 air services in Canada's 25 city-pairs in terms of total flights were 73 percent higher than in 1983 (the year preceding the initial relaxation of economic regulation in 1984). Similarly, after the first year of the US Open Skies Agreement 70 new cross-border services were initiated. After 2000, the new services increased to 132. The Open Skies Agreement also brought about more scheduled passenger services and increased choice of services. Seven major Canadian airports provided services on 59 transborder routes with two or more services as of December 31, 2000 compared to services on 17 transborder routes on February 23, 1995. These seven airports were served with 3 to 13 carriers in 2000 compared to 1 to 8 in 1995.[12]

Overall, the data on domestic air cargo indicates that shippers were better off due to a decline in air cargo rates, increases in output, new services and more choices after domestic deregulation of air cargo. This is also true for air cargo on transborder services, however, due to lack of data no conclusion can be drawn with regard to rates.

Concluding Remarks

The air cargo business has been an important sub-group of the air business that has been growing since the mid-1980s. This is true for the domestic, transborder and international air cargo segments and particularly so for the air express market.

This growth has resulted not only because of demand and supply factors but also because of regulatory changes such as: the domestic deregulation introduced in the 1980s, the US Open Skies Agreement, the US Free Trade Agreement, the introduction of international liberalization through designation guidelines, the new all cargo international policy, the new cargo transhipment policy, and the broader regulations pertaining to free trade zones and customs.

These regulatory changes have resulted in significant benefits. There has been an increase in competition from existing carriers and new entrants. This has resulted in benefits such as increased output, new services, improved services, and lower prices.

This suggests that further and faster liberalization in the international subsector along the lines described earlier could lead to

further benefits. As one observers noted, policy overall is moving too slowly - "it's like watching snails trying to mate." This observation is an exaggeration with the new developments and expected changes to Canada's approach in dealing with bilaterals. The recent terrorist crisis has retarded this process, nevertheless, it should provide Canada a breathing space to catch up to the US as the air cargo market turns up.

Bibliography

1. **Transportation in Canada 2000**, Annual Report, Transport Canada, TP 13012E, pp. 119-121 and pp. 151-153.
2. **Competition in Transportation**, Policy and Legislation in Review, Volume 11, 1993, p.123.
3. **Transborder air courier services**, Canadian Transport Commission, Paget Douglas, 1980.
4. **Report of the Hearing Panel: regulation of courier air services**, Canadian Transport Commission, 1984.
5. Air Cargo - The Canadian Content, Ron Ashley, **CTRF**, Vol. 20, 1985, pp. 555-590.
6. **Liberalisation of Air Cargo Transport**, OECD, DSTI/DOT (2002)1/Rev1, May 2, 2002.

Table 5 - Scheduled Carriers Serving the Major Domestic Airports (December 15, 1999)

Toronto	A*2Q	A*2Q	A*2Q	A*2	A*2Q	A*2Q	A*2Q	A*2	A*Q	A*	A	A*	A	A*	
Vancouver		A*2Q	A*2	A*2W	A*2W	A*2QW	A*2		A*2	A*W2B 8H	A*W	A*F	A*W	W	A*W
Montreal			A*2Q	A*	A*	A*2Q	A*Q	A*	A*7	A*		A*FR			
Calgary				A*2W	A*W	A*W	A*2	A	A*	A*W	A*W	A*	A*W	W	A*W
Edmonton					A*2QW	A*W	A*W		A*	A*W	A*W9	A*	*W9	WJ	AW
Winnipeg						A*2QW	A*		A*	A*W	A*9	A	A*W9	A*	AW
Halifax							A*2QW	A*2	A*	A	A	A			
St. John's								A*2	A*						
Ottawa									A*2 Q7	A*		A*F7R		A*J	
Victoria										A*W2J8	W		W		W
Regina											A*W9		97		W
Quebec												A*F7R		*	
Saskatoon													A*W 97		AW
ThunderBay														A*WJ	A
Kelowna															A*W

Air Canada=A Canadian=*; WestJet=W Canada 3000=2 Royal Aviation=Q First Air=7 West Coast Air 8 Athabaska Airways Ltd.=9 Regionaair Inc.=R Bearskin Airlines=J Harbour Air Ltd.=H Helijet Airways=J Source: *Official Airline Guide*,Dec 15, 1999

* ***The views expressed are those of the authors and not necessarily those of the Competition Bureau or the CTA.***

Endnotes

1. See Designation Guidelines adopted for all-cargo air services, News Release, No. H004/98, Transport Canada, January 12, 1998.
2. However he indicated that if you asked me today, 'Is it possible to make money flying freighters? I would tell you that I doubt it because of the meltdown in Asia." Whither Canada? American Shipper, March 1999, pp. 70-71.
3. The first air cargo alliance was formed in 1990 but had limited success. The emergence of two new alliances in 2002 is likely to give this development new vitality. The three major air cargo alliances to date are: SkyTeam Cargo; New Global Cargo; and Oneworld.
4. See sections 16(1), (3), (6) and (8) of the *Aeronautics Act*.
5. See ss. 112(1), 117(4); 112(12), 112(12.1), 44(12); 112(12), 112(12.1), 44(12); 112(12.1); 112(12) and 112(12.1) of the *Air Carrier Regulations*. In addition, other relevant regulations were: notice period required for tariff changes of unit toll scheduled carriers (s. 120.1), suspension or disallowance of any tariff (ss. 112-114), appeal of freight rates (s. 23 NTA) and acquisitions (s. 27 NTA and s. 22.1 ACRs).
6. Liberalisation of Air Cargo Transport, OECD, DSTI/DOT (2002)1/Rev1, May 2, 2002.
7. Following the Sept. 11, 2001 crisis in the US, new temporary or permanent security regulations are also expected to have an effect on air cargo flows and handling procedures. Despite delays in implementing some of the previous plans, new plans have emerged such as an agreement between Canada and the US to introduce a program called Free and Secure Trade (FAST).
8. With the takeover of Canadian Airlines by AC, British Airways, Air France and Cathay Pacific accused AC of abusing its monopoly position by charging higher airfreight rates than existed under their agreement with Canadian Airlines. Some observers claim that this may cause the three carriers to shift to US centres. AC indicates that the increase in rates occurred after their contracts expired with Canadian Airlines and that the new rates were in line with their other rates.
9. See Putzger, Ian,"Opening the door to new air cargo opportunities," Canadian Transportation and Logistics (i.e., CT & L), April 2002; "The Waiting Game," CT & L, October 2000; "Global Gateways," CT & L, April 2000; "Cargo Questions," CT & L, June 2000; "Canada's Air Cargo Challenge," CT & L, Sept. 1999; and Pethick, P.C., "Fast and Furious," CT & L, September 1999.
10. Other non-scheduled air charter carriers that transported cargo were for example: Conair Aviation, Torontair, Austin Airways Ltd., Kenn Borek Air Ltd., Soundair Corp., Millardair Ltd., North Coast Air Services Ltd., Air Niagara, Kelowna Flightcraft A.C.L. Ltd., Northwest Territorial Airways.
11. Knighthawk Air Express, Air Canada Express, CanAir Cargo, Bradley Air Services, Kelowna Flightcraft Air Charter Ltd., Western Express Airline, Perimeter Airlines, etc.
12. Monteiro, Joseph, David Krause and André Downs, The open skies agreement between the United States of America and Canada - the results. Does it suggest the need for a wider pact and a more liberal air pact?" Canadian Transportation Research Forum Proceedings of the 2001 Annual Conference, St. John's, Newfoundland, May 11 - May 15th, 2002, pp. 319-337.

The Case of Nav Canada Revisited

Michel Boucher
École nationale d'administration publique
Université du Québec

1. Introduction

Until beginning of the nineties, the federal government was the only provider of transportation infrastructures in Canada. But, hard economic conditions as successive deficits, a steady rate of growth of the ratio of the national debt on the gross domestic product, insufficient investments to maintain existing infrastructures, long delays in making new investments when required and a recession finally induce the federal government to transfer those public assets to new organisations. Our main interest is to focus on the process leading to a newly commercialized infrastructure provider in charge of the Canadian air navigation system (ANS), Nav Canada. Until 1996, the civil air navigation system is an integral part of Transport Canada that benefits from the support of the different Department's services. This new entity is now a not-for-profit corporation owned by its members.

The purpose of this article is to throw some light on some particular characteristics that influence its operations and ultimately its performance. Nav Canada is a legal monopoly and the sole supplier of air navigation services needed by air carriers and aircrafts crossing Canada sovereign and Canadian-controlled international airspaces. Its main components of the production function are composed of capital and labour. Section 2 describes the actual status, the general context of the sale by Transport

Canada and the financial structure put in place by the new private firm to acquire it. These elements are used later to assess the delegation process from Transport Canada, the principal, to a not-for-profit monopoly, the agent. Section 3 presents the various components of its user charges and the main constraints imposed by the financial market and bonds holders. Section 4 considers the main governance issue faced presently by the private organisation, the major role played by trade unions, specially, the air traffic controllers' trade union. In other words, the pattern previously observed when a public department provided the air navigation system always persists even in a new context. Finally, Section 5 offers some remarks on the efficiency of the delegation process and its performance.

2. Considerations on the privatisation of the air navigation services

In 1996, the federal government enacts the *Civil Air Navigation Services Commercialization Act* that authorises the sale of all relevant air navigation assets to Nav Canada for a lump sum payment. The new commercial firm is a not-for-profit, non-share capital corporation pursuant to Part II of the *Canada Corporations Act*. The corporation has two categories of members, voting members and non-voting associate members. Of the voting members, one is appointed by the government, one by trade unions as representative of Nav Canada's employees and two members are user groups representing commercial carriers and business aircraft carriers. They are the only one entitled to vote at meetings of the members. There are 126 no-voting associate members who are appointed by the board of directors because they are « interested in furthering the objects of the Company »[1]. The board of directors comprises 15 directors; voting members appoint 10 of them, four unrelated independent directors are by the directors themselves and the president and the chief executive officer, appointed by the board, is the ex officio member. Finally, for every committee, the by-laws require that directors be appointed by the three different classes of voting members and

independent directors. This particular model of corporate governance « is intended to promote a balance among the interests of the various classes of members »[2]. They ease thus the costs of the collective decision-making that result from the heterogeneity of interests among the members.

A short account of the main provisions contained in the ANS Act describes the rights given to Nav Canada to become a legal or statutory monopoly. Subsection 10(1) grants a de facto monopoly by prohibiting possible competitors to enter. Subsection 32(1) sets out that « the Corporation may impose charges on a user for... air navigation services...»[3] and subsection 35(1) states the charging principles for user fees. Charges must be risk neutral; no discrimination between the types of flights and carriers is allowed; a charge must be linked to the cost of providing the services; the value of services may be recognised as a charging principle and charges must be related to the firm's current and financial requirements. In addition, Nav Canada may seize and detain an aircraft « for the collection of an unpaid and overdue charge »[4]. Finally, subsection 35(5) sets out the public financial requirements of the corporation those allow lenders and stakeholders to get an easy access to its financial health.

The major difficulty of the privatization process is that the Canadian civil air navigation system is not a stand-alone entity, but a service supported by various integrated systems and blended into the operations of Transport Canada. There is no actual financial statement per se of the air navigation system. Then, the nature and the extent of land holdings, their environmental conditions; large numbers of leases and assets across the country are inaccurate and incomplete. More investigations are also needed and required because the government does not have an integrated picture of the system it sells, nor does it have a solid idea of the entity's value. In this unknown and uncertain context, the buyer's due diligence review is therefore far more difficult than expected. The problem becomes complicated because Nav Canada has very few staff. In the end, the financial advisors hired

by Transport Canada estimate in 1995 that the value of the 30-year (perpetual) monopoly is $2.4 billion. For the Auditor General, « this estimate incorporated both going-concern and financeability considerations »[5]. In other words, this conservative estimate is the fair market value that Transport Canada has to seek when negotiating with Nav Canada.

Nav Canada purchases the operating rights and the assets of the air navigation system for $1.5 billion. The transfer price, which is less than the going-concern value, represents according to the Auditor General « a substantial indirect subsidy to the aviation industry »[6]. Canadian taxpayers are denied revenues generated by past investments. The subsidy, measured by the difference between the fair market value and the final price paid by the purchaser, reduces the level of risk faced by future bond holders and puts Nav Canada bonds in a higher class than similar bonds.

The Auditor General adds significant costs coming from the transfer of the air navigation system to the not-for-profit organisation. The most important among them is directly related to the labour force. Transport Canada needs the trade unions' consent to support the new commercial entity. Government employees require some incentives to give it the green light and also to transfer voluntarily. According to the Auditor General, additional severance costs are estimated to $31.5 million and higher pensions negotiated with the government for public employees transferring to Nav Canada are estimated to $275 million. If some minor additional costs are considered such as negotiation costs estimated to $26 million and contingent environmental liabilities, the overall deadweight loss assumed by Canadian taxpayers from this transfer is estimated between $1.145 to $1.276 billion[7]

Nav Canada also makes commitments to its new labour force by entering into two memoranda of understanding (MOUs) relating to employee matters. They provide a « framework for the smooth transfer of the ANS wok force from the public to the private

sector »[8]. It means that Nav Canada makes offers of employment to all employees so designated. In addition, a wage increase upon the signature of the sale contract is also paid to compensate the pay freeze borne by its new employees during the last five years as civil servants. Finally, the new commercialized entity agrees not to undertake layoffs for a three-to-five-year period after acquiring the air navigation service. If a work force reduction is necessary, employees who will leave will be entitled to new severance packages.

The financing plan is realised in two steps, a $3 billion bank debt from an international banking system to cover its initial operating requirements and its revenue shortfalls during the transition period and a subsequent initial public offering (IPO) of $750 million in non-tradable revenues bonds. Debt holders (principal) require bonding expenditures from the Nav Canada managers (agent) so that they will fulfil their initial obligations as anticipated. A summary of the three main covenants and protective measures follows. First, a rate covenant stipulates that user charges are revised annually so that operating revenues in each fiscal year are not less than the sum of (1) operating and maintenance expenses for the year, and (2) 1.25 times the net interest expense and principal amortization for the year, plus (3) required deposits to the firm's Debt Service Reserve Fund and the Operations and Maintenance Reserve Fund, less than (4) the balance in the Revenue Account on the last day of the immediately preceding year. The second covenant requires that budgeted capital expenditures are not to be made unless Nav Canada has made its contribution to Reserve Funds and has made necessary interest and principal payment on its debts. The third one compels the firm « to maintain insurance in commercially reasonable amounts having regard to the services it provides...and to maintain insurance related to any liability that may result to the Company...»[9]. Nav Canada holds such comprehensive aviation liability coverage of US$2. Billion. In short, the flow of charges is assigned primarily to the debt holders and the remaining revenues go to operating and maintenance expenditures. So, bonding

expenditures constraint the discretionary power of the Nav Canada's managers.

The initial public offering is massively oversubscribed and Transport Canada agreed later on « that financeability alone suggested that the market would have been prepared to support much higher values »[10]. The important rents received by Nav Canada from this transfer are capitalised into the value of the bonds. In other words, the real discounted value of the revenue flows is higher than Nav Canada acquisition value. John Crichton's statement that « Nav Canada has the lowest cost of capital of any major corporation in North America with four AA or better ratings »[11] only confirms a well-known fact. A statutory monopoly, combined to implicit subsidies integrated into a low sale price paid by Nav Canada and existing covenants put in place by institutional investors, considerably mitigates the level of risk in owning its bonds.

3. The User Charges

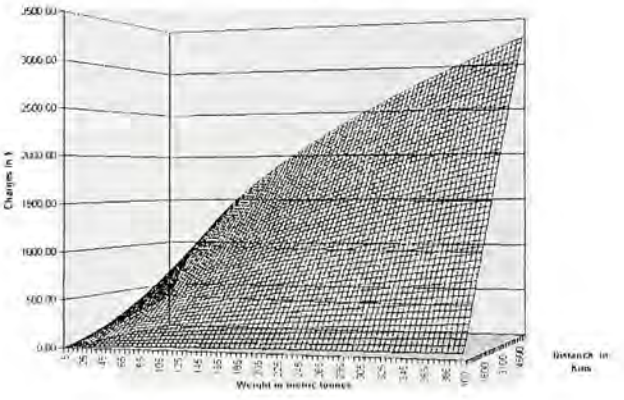
In November 1, 1998, at the end of the 24-month transition period, Nav Canada introduces a set of charges reflecting the services rendered. These include air traffic control, flight information, weather briefings, airport advisory services and electronic aids to navigation. In its financial prospectus of 1996, Nav Canada admits that the firm's most significant revenue contributors will be commercial air carriers and that business aircraft, general aviation and state/military aircraft will not contribute a significant portion of total revenue.

The charging system is divided into three broad categories as sets out below[12]. The first type of charges refers to annual charges to Canadian aircrafts and quarterly charges for foreign-registered aircrafts less than three metric tonnes. Nav Canada collects annual lump sums that are determined by the maximum permissible take-off weight and their respective weight group. The second form of charges applies to propeller aircrafts over

three metric tonnes and small jet aircrafts weighing 7.5 metric tonnes or less. They are subject to a daily charge for terminal and enroute air navigation services. Their respective charge depends on the maximum permissible take-off weight and their respective weight group. The daily charge for helicopters is a fixed amount.

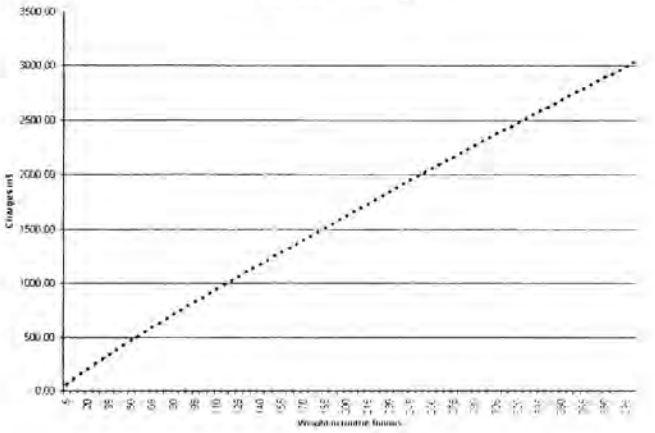
The third category consists of movement-based charges for terminal and enroute services for aircraft over three metric tonnes. The enroute charge takes into account the distance flown and less than proportionately, the aircraft weight. The charge, applied on a per flight basis, is equal to the product of the unit rate (R), fixed by Nav Canada, the weight factor (W) in metric tonnes, defined as the square root of the maximum permissible take-off weight of the aircraft, and the distance (D) measured by the great circle distances in Canadian-controlled airspace in the case of overflights and international fights landing or taking off in Canada. So the calculation is $C=R*W^{0.5}*D$. Figure 1 shows the evolution of charges according to the weight in metric tonnes and the distance flown in kilometres.

Figure 1
Enroute charges



The terminal services charge is applied to departing flights from aerodromes. The charge takes into account, less than proportionately, the aircraft weight. It is applied on a per flight basis and is equal to the product of the unit rate (R), fixed by Nav Canada, and the weight factor (W) in metric tonnes is obtained by taking the 0.9 power of the maximum permissible take-off weight of the aircraft. The calculation of the charge is $C=R*W^{0.9}$. Figure 2 presents the terminal services charge as the weight of the aircraft increases.

Figure 2
Terminal Services Charges



Finally, there are two oceanic charges collected by Nav Canada, the North Atlantic Enroute Facilities and Services Charge (NAT) and the international Communication Services Charge (Int'l Comm). It is a flat fee per flight and it is less and less important as time goes on.

Table 1 contains an overview of these charges since the beginning of its activities as a private provider of air navigation

services. The main comment refers to the relative importance of the enroute charges as a major source of revenues: It fulfils management expectations. As Nav Canada is legally bound to set rates to achieve full cost recovery; any surplus must be used, either to increase capital expenditures or to reduce user charges. Nav Canada postpones a fee increase in 1998 and in 1999, implements a base rate reduction, plus a temporary reduction extended to 28 months, until the beginning 2002. In 2002, the temporary reduction is abolished and in 2003, Nav Canada proposes to increase customer service charges by three percent, after customer consultation.

Table1
The Evolution of Customer Charges, in million of dollars, 1998-2002

Charges/Year	2002	2001	2000	1999	1998
Enroute	456	479	472	474	302
Terminal	333	349	345	331	117
Daily/Annual	35	42	45	29	-
Nat&Int'lComm	34	38	38	41	38
Total	858	908	900	876	385

Source: Nav Canada Annual Reports

The foundation of the Nav Canada's customer charges system is called two-part tariffs. As a matter of fact, this pricing scheme involves a fixed fee that all carriers must pay to fly into or over Canada's sovereign airspace or Canadian-controlled international airspace and then a variable fee based on usage of air navigation services. Our interest concerns the enroute charges paid by aircrafts using the Canadian airspace when transiting from their origin to their destination. Because of Canada strategic location in North America, foreign airline firms routing through Canada can greatly reduce their distance flown, thereby saving their passengers time and minimizing their production costs. The « great circle » distance advantage means that Nav Canada, a not-for-profit firm, is able to charge user fees according to the Ramsay's rule, the inverse price elasticity of the demand for

enroute flights. Subsection 35(2) of the ANS Act defines clearly this charging methodology as « the value of services ». The demand is inelastic because there is no alternate routes. In fact, any other route that does not use the great circle distance, therefore avoiding the Canadian airspace under control, incurs higher operating costs and, in particular, a much longer flying time for passengers.

The technique used by Nav Canada to set price discrimination on enroute flights is to include a weight factor (W) defined as the square root of the maximum permissible take-off weight of the aircraft. However, as a not-for-profit organization, Nav Canada has a limited power to collect a greater share of the economic rent coming from the Canadian geographic location. Subsection 35.(1)i stipulates that «charges must not be set at a level that ...would generate revenues exceeding the Corporation's current and future financial requirements. »[13].

On the other hand, the fact that small propeller aircrafts and small jet aircrafts weighing less than 7.5 metric tonnes pay a flat fee rather than daily charges reveals the presence of cross-subsidies. This observation comes from an exchange of letters between Lovink and Nav Canada's President and CEO. Lovink proposes that the weight factor for the terminal services charge be reduced from $W^{0.9}$ to $W^{0.7}$ and applied to all aircrafts, small and large. The Nav Canada representative's reply is that this suggestion « gives me great concern as it would aggravate the problems for the regional and other operators of small aircraft »[14].

Finally, an international comparison with the enroute flight charges of other countries shows that Canadian fees are lower, by varying degrees, than those required by Australia, New Zealand, France, Germany, Great Britain and Italy for three specific types of aircraft. However, terminal services fees are higher in Canada than those collected by the six countries mentioned. Nav Canada's authorities are clearly aware that they can « do more to

increase our customer's competitiveness, particularly in respect of terminal charges where we have more work to do »[15].

4. The Labour force in a not-for-profit statutory monopoly organisation

To date, the conduct of Nav Canada, holder of a monopoly power, complies very well with the initial expectations because of the internal and external system of checks and balances that helps and sustains its development. However, a potential problem that everyone thought would be solved by the privatization is raising again. It is a sensitive issue because its affects, not only day-to-day operations, but also has possible ramifications on safety. In short, the trade unions, especially the Canadian Air Traffic Control Association, does not change their conduct even if they have a voting member in the board of directors. The not-for profit organisation has tried and tries to co-opt the most important union in terms of memberships, but in vain.

In a competitive environment, a trade union seeks to increase the wages of its members, to defend their working conditions, especially those of the median voter. Thus, the union sees that employees who are have invested or are investing in firm-specific human capital, such as special skills or more extensive knowledge related to the internal workings of the firm, do not lose their quasi-rents to employers. It ensures that the shareholders of a firm do not gain from their relative immobility by not paying them to their marginal productivity.

In contrast, the air traffic controllers work always for a public monopoly, either when it was an integrated activity produced by Transport Canada or as a statutory monopoly managed by a not-for-profit organisation. In this particular context, their first goal is not to obtain their traditional measures of promoting the welfare of their members, whose firm-specific human capital makes them vulnerable to some form of expropriation by their employers, but rather to improve their particular situation to the

detriment of the firm itself in the long run. They demand wage conditions that are far higher than their marginal productivity and obtain too non-monetary (fringe) benefits that have no relation at all with their job. They have many means to reach their goals. Besides strikes that paralyse the air transportation industry and their passengers that require generally intervention from the federal government through special legislation, it happened many times over the years under the former regime, they can carry out slowdown and rotating strikes, threaten to strike and resort to hard-diagnose claims, stress-related injuries being the most common and most difficult to identify[16]. These dubious practices, which increase the level of uncertainty in the industry, occur often in industrialised countries. In short, Nav Canada, although a not-for-profit organisation is not immune from this recurring moral hazard problem, which is part of the history of the air navigation services industry.

The union members take thus advantage of their power by taking the users of the air navigation services hostage, insofar as Nav Canada is the only authorized provider of services. Nav Canada has significant investments and various facilities, like area control centres, terminal control units, control towers and flight services stations that extend from coast to coast. Trade unionized members can acquire by different methods some part of the quasi-rent of this non-human capital, namely the cash flow generated by this fixed, sunk and non-transferable capital. This form of appropriation, commonly called hold-up in the literature, is mitigated by the strict covenants imposed by financial institutions that induce managers to focus on repaying the debt before investing in technological expenditures. In other words, resorting to debt financing rather than equity financing is a type of countermeasure to the hold-up problem.[17]

Table 2
The Relative Importance of Wages in Nav Canada Expenses, in million $, 1998-2002

Year	2002	2001	2000	1999	1998
Wages	524.4	510.8	470.1	500.8	500.6
Total Expenses	971.2	915.5	907.3	926.2	886.5
Wages/expenses	54.0%	55.8%	51.8%	54.1%	56.5%

Source: Nav Canada Annual Reports

As written previously, Nav Canada works hard during the transfer of Transport Canada employees by entering into two memoranda of understanding (MOU's) and by minimizing the transaction costs of the transition. However, this win-win strategy does not prevent the air traffic controller's union from nearly going on strike in 1999 and wanting again to launch a strike in early fall of 2001. Of course, both parties reach a new collective agreement, but under an open threat of a special federal government legislation. In 2002, as all collective agreements between Nav Canada and its employees expire and as an agreement cannot be reached consensually, the matter is referred to the Canada Industrial Relations Board (CIRB) to establish the scope of the agreement[18]. The CIRB decision contains two elements, the first being that nearly all operations be continued and secondly that an aeronautical study of the safety implications of further service withdrawals be undertaken.

Over the years, Nav Canada tries to increase the performance of its workers. So in 1999, Nav Canada tells that thanks to this new collective agreement, it would be able « to improve productivity levels, increase the number of air traffic controllers, and reduce the amount of overtime »[19]. In addition, in the Business Plan 1999-2002, the firm «will be developing a gain sharing proposal to tie some portion of the employee compensation to individual, group or corporate contributions in the delivery of safe ANS services »[20]. This proposal raises major issues, the first being that this incentive-based compensation implies that the observed marginal productivity of employees would be lower than that set

out in the contract, hence the need to turn to gain sharing to ensure that unionized workers fulfill the terms of the collective agreement. This solution does exist only because of the not-for-profit status that also happens to be a statutory monopoly. By the way, the new Nav Canada Business Plan 2002-2005 does not mention at all incentives, or new means to increase performance. In a recent news release, Nav Canada favours even a proposed wage freeze for unionized employees as their contribution as stakeholders to stabilise its operating costs.

The second issue concerns the actual status of Nav Canada, a not-for-profit institution. Its incorporating act prevents it from distributing the net cash flow (profits) among its members, in this case the unionized workers. On can argue that some stakeholders like the airlines firms benefit from rate reductions and workers shall also be entitled to their fair share. This argument is misleading because, sine 1997, the trade union employees have received higher pay than their counterparts in the private sector and employees working in the transportation, communications and public utilities[21]. Is Nav Canada attempting to do indirectly that it cannot do directly?

We can conclude that the governance structure built in the not-for-profit organization alleviates many problems that the civil air navigation services was facing when managed by Transport Canada, a political institution. Nevertheless, the predatory behaviour of some trade unions still exists, but it is reduced. Certainly, Nav Canada is being better monitored and controlled than it was under the former organization, a department that does not have property rights. But, Nav Canada must incur bonding expenditures to comply with the user expectations, a safe environment, which is based on a trade-off between marginal benefits and marginal costs.

5. Concluding Remarks

This positive analysis of Nav Canada performance shows that the delegation process of transferring the civil air navigation services to a not-for-profit organisation is efficient. Bonding expenditures imposed by external forces, namely the financial market and bondholders, play an important role. These *ex ante* moral hazard measures induce the Canadian not-for-profit organisation to make credible commitments to behave as anticipated by its creditors. Various covenants, that constraint a possible discretionary power owned by managers, are such that the financial plan assigns them a priority on the flow of user charges. In other words, bonding expenditures encourage Nav Canada to align its own interests with those of the debt holders. The only flaw that can jeopardise this efficient delegation process is the trade unions actual behaviour, particularly the Air Traffic Control Association. Its relative important among trade unions in the production function allows it to hold the users of Nav Canada hostage and to claim the quasi-rent of the overall physical capital composed of the fixed, sunk, non-transferable investments. This possible expropriation problem is still unsolved by Nav Canada. The sole solution is to oblige this particular trade union to incur bonding expenditures to ensure that it will align its interest with those of the firm. By committing itself in such a way, it demonstrates its good faith and reduces any uncertainty likely to arise from its actions.

The second part of the assessment relates to its operational performance. Until now, Nav Canada does not appear to be encountering any significant difficulties. It price structure, some of them being of the Ramsay type, guarantees that it can generate funds and meet its investment need. In 2003, Nav Canada increased customer service charges by three percent and intended to reduce its operating costs. All the stakeholders, including trade unions, are invited to participate to this new effort, caused by the decrease in aviation activities following the September 11, 2001 tragic event.

Notes and References

[1] Nav Canada, *Initial Public Offering*, 1996, p. 31.
[2] Nav Canada, *Initial Public Offering*, 1996, p. 32.
[3] Bill C-20, *An Act Respecting the Commercialization of Civil Air Navigation Services*, 2d sess, 35 Th. Parl., 1996, p. 16, [hereinafter ANS Act].
[4] *ANS Act*, op. cit., subsection 56 (1) p. 28.
[5] Auditor General of Canada, *Report on Divestitures of Government Operations*, 1997,Ch. 19, p. 14.
[6] Auditor General of Canada, *Report on Divestitures of Government Operations*, 1997, Ch. 19, p. 17.
[7] Theses general estimates come from the different estimates computed by the Auditor General of Canada.
[8] Nav Canada, *Initial Public Offering*, 1996, p. 20.
[9] Nav Canada, *Initial Public Offering*, 1996, p. 23.
[10] Auditor General of Canada, *Report on Divestitures of Government Operations*, 1997, Ch. 19, p. 15
[11] John Crichton, *Panel on Transportation Commercialisation*, Canadian Transportation Research Forum, Charlottetown, Forumation, July 2000, p.1.
[12] Nav Canada, *Customer Guide to Charges*, 2000 and 2003, [on line].
[13] ANS Act, op. cit., p. 18.
[14] J. A. A. Lovink, *Choosing the right autonomy for operators of privatized government services: the case of Nav Canada*. Canadian Public Administration, fall, 1999, vol. 42, no .3 p. 385.
[15] Nav Canada, *Nav Canada Business Plan 1999-2002*, p. 34 [line]. When announcing the year end financial results for 2002, Nav Canada writes « that Company is continuing to pursue opportunities to increase non aeronautical revenues ». Nav Canada, October, 22, *News release*, [line].
[16] For examples of the many practices used by air traffic controller's unions in the United States, see M.E. Staten and J. Umbeck,

Information Costs And Incentives to Shirk: Disability Compensation of Air Traffic Controllers, American Economic Review, vol. 72, no 5 1982, p.1023-1037 and M.E. Staten and J. Umbeck, *A Study of Signalling Behavior in Occupational Disease Claims*, Journal of Law and Economics, vol.29, no 2, 1986, p.263-286.

[17] A. A. Alchian and S. Woodward, *Review of the Williamson's The Economic Institutions of Capitalism*, Journal of Economic Literature, vol. 26, no1 1988, p. 73.

[18] Canadian Industrial Relations Board, *Nav Canada vs. Canadian Air Traffic Air control Association et al.*, dec. 186, 2002

[19] Nav Canada *Business Plan, Supplement 2000-2003*, 1999, p. 20 [in line].

[20] Nav Canada *Business Plan 1999-2002*, 1999, p. 68 [in line].

[21] Nav Canada *Business Plan, Supplement, 2000-2003*, p. 8 figure 8, [on line].

Air Security Fees and Highway Safety

by
W.G.Waters II and Chunyan Yu*
Centre for Transportation Studies
Faculty of Commerce and Business Administration
The University of British Columbia
Vancouver, B.C.
Bill.waters@commerce.ubc.ca
Chunyan.yu@commerce.ubc.ca

ABSTRACT

The current practice of uniform airport security fees implies a disproportionately higher percentage increase in the total price of short haul air travel compared to long distance flights. Much short haul air travel has a potential substitute via surface trips, most likely by automobile but possibly by intercity bus or rail. Therefore, it is likely that the airport security fees on short haul air travel will cause some diversion of trips to the automobile. Because the crash and fatality records of road transport are higher than for commercial air travel, the current Canadian aviation security fees will lead to an increase in transport injuries and deaths. This paper provides some initial estimates of the magnitude of these road safety impacts resulting from aviation security fees. The calculations are rough, but about 250,000 air travelers per year divert to car trips due to the air security fee. This will be associated with about one to two car crash fatalities, and about 75 to 140 injuries and many more minor incidents. This does not include travelers diverted due to "hassle" or fears about security.

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Safety and Security

Safety and security are top priorities in air transportation. There has long been a substantial emphasis on safety in aviation, i.e., policies and procedures to minimise the risks of failures in the design and operation of commercial airlines. Security is concerned with deliberate sabotage or other acts to cause harm to air operations and the travelling public. Security measures had gradually increased over the years, e.g., inspection of hand luggage, questioning passengers about their baggage, restrictions on access to aircraft by airport workers. But the tragic and despicable acts on September 11, 2001 ("9-11") demonstrated that existing security measures were woefully inadequate to defend against planned terrorist attacks.

Led by the United States, governments around the world have strengthened aviation security measures and authorities. This has been very costly to all parties concerned: the airlines, the travelling public who face long lines, and the airports and security personnel. Literally billions of dollars are being spent by governments and airport authorities. In addition, according to IATA, airlines paid US$3 billion in added security measures in 2002. Plus, passengers have to endure the extra security checks and delays. This "hassle factor", as it is called in the U.S., is now one of the main reasons why people are reluctant to fly. The US airlines estimated that loss of business resulting from the "hassle factor" amount to over US$2.5 billion in 2002.

How to finance the dramatically enhanced security measures is a subject of debate in Canada, the United States, and many other countries. Increasing fees of any kind further discourage air travel in an already depressed market.

Aviation Security Fees in Relation to Trip Price

There has been substantial controversy about the Canadian Air Traveller Security Charge since its inception. The Federal Budget of December 2001 announced a total of $7.7 billion to be spent on national security over five years, including $2.2 on air security (ATAC and Lazar, 2002, p.23). The $2.2 billion air security is to be

financed directly by the Air Traveller Security Charge (ATSC), and the monies are to be dedicated to air security expenditures. Separate from other taxes on aviation, the Federal Government introduced a flat fee of $12 per passenger per flight within Canada or abroad, or $24 for a round trip ticket. (At the time of writing, the ATSC was reduced to $14 on domestic flights; the calculations below are made using the $24 round trip fee). The trans-border (to/from U.S.) fee is $12 per trip. The Canadian security fee is the highest in the world (see Table 1). Perhaps even more controversial is that it is a flat fee, the same security charge for the shortest or lowest cost flight to the most expensive journey. One might rationalise this as reflecting a relatively constant per unit cost of supplying equal security for all to access the air system, although it is more complicated than this. Regardless, the impact on different members of the travelling public and the air carriers is very unequal. The air security fee represents a much higher proportion of the total trip price for short-haul and/or discount travellers. Table 2 presents some illustrative fare calculations compiled by ATAC and Lazar (2002). For long distance, full fare flights the security fee is only one or two percent of the base fare. But for discount flights and/or short-haul routes, the security fee can be as high as 25 percent of the base air fare. (There are further issues about the cumulative effect of other fees and taxes relative to air fares, e.g., ATAC and Lazar, 2002, but we limit our discussion to the security fee).

Table 1

Average Security Charges, Various Countries ($CDN)

Canada	$22.43
Germany	16.34
Israel	12.42
France	10.64
Australia	8.02
U.S.	7.65
Netherlands	6.39
Russia	3.16
Italy	2.89
UK	0

Source: ATAC and Lazar (2002), p.38, citing IATA

Table 2
Air Fares Compared to Percent of Security Charges, Selected Domestic Flights and Fares, November 2002

Air Canada	Air fare	% security
Toronto-Vancouver	$3074	0.7
Toronto-Halifax	1438	1.6
Halifax-St.John's	1058	2.1
Toronto-Ottawa	664	3.4
Vancouver-Toronto	438	5.1
Halifax-St.John's	299	7.5
Toronto-Halifax	288	7.8
Tango		
Toronto-Vancouver	593	3.8
Montreal-Calgary	533	4.2
Toronto-Halifax	313	7.2
Toronto-Ottawa	173	13.0
Halifax-St.John's	98	23.0
Toronto-Quebec City	88	25.6
Zip		
Winnipeg-Calgary	671	3.3
Vancouver-Winnipeg	435	5.2
Westjet		
Toronto-Kelowna	523	4.3
Calgary-Toronto	298	7.4
Hamilton-Moncton	267	8.4
Calgary-Regina	239	9.4
Prince George - Calgary	213	10.5
Abbotsford-Calgary	148	15.2
Kelowna-Vancouver	90	24.9
Jetsgo		
Toronto-Vancouver	328	6.8
Montreal-Halifax	313	7.2
Toronto-Winnipeg	178	12.6

Source: ATAC and Lazar (2002), pp. 27-28

Many have raised concerns about the impact of air security fees on air travel, particularly the burden on consumers and loss of business to airlines, along with related impacts on the travel industry. Issues have also been raised about whether or not the level of air

security fees is commensurate with the level of safety being provided. Still another question is whether or not air travellers should bear all the costs of air security, or is safe air travel an issue of national and economy-wide interest and hence at least should be partly funded by the tax-payers generally? We do not address any of these issues that have been addressed by others. We are interested in another dimension of safety: the prospect that the air security fees could be diverting travellers from relatively safe air travel to less-safe auto travel. If so, there is a counter-productive aspect of high aviation security fees, particularly on short-haul air travel, that may actually be reducing rather than enhancing public safety.

Transportation Safety

It is widely publicised that commercial air travel is among the safest ways to travel. In contrast, auto travel is recognised as being much less safe by practically any measure. Ceteris paribus, a shift in travel from air to auto will be accompanied by an increase in injuries and fatalities. The increase may not be obvious since injuries and fatalities are relatively low probability events in either mode.

Table 3 Motor Vehicle and Air Carrier Fatality Rates

Motor Vehicle Fatality Rates (U.S.)
(per 100 million vehicle miles)

	1980	1985	1990	1995	2000
All rural roads	4.40	3.35	2.97	2.57	2.18
Interstate	1.68	1.39	1.35	1.20	1.19
Other arterial	4.67	3.51	2.99	2.70	2.12
Collector	5.28	3.97	3.68	3.13	2.67
Local	5.91	4.84	4.45	3.76	3.43

Air Carrier Fatality Rates (U.S.)

0.127 fatalities per billion passenger miles (1997-2001)
0.047 fatal accidents per 100,000 flight segments (1990-1996)
0.02 fatal accidents per 100,000 hours (CFR 121)
0.04 fatal accidents per 100,000 hours (CFR 135) (commuter)

Sources: www.bts.gov/publications/nts/htm/table_02_18.html
NTSB statistics; North American Transportation in Figures, p.39;

Table 3 contrasts the fatality rate for the two modes. Keep in mind that there are a number of different measures of safety, e.g., fatalities per passenger kilometre, per vehicle kilometre, per trip, etc. Also, crash statistics are influenced by travel conditions, particularly for automobiles. There is a two to four hundred percent difference in safety between divided limited-access freeways and regular rural highways. Further, due to the inherent differences in operating conditions between these two modes, injury and/or property damage caused by crashes for automobiles are several times higher than fatality rates (about 80 injuries for every fatality in road crashes, *North American Transportation in Figures*, p.37).

Anecdotal Evidence about Air-Auto Substitution

Before turning to empirical evidence about demand elasticities, we first review some anecdotal evidence about substitution between air and auto travel.

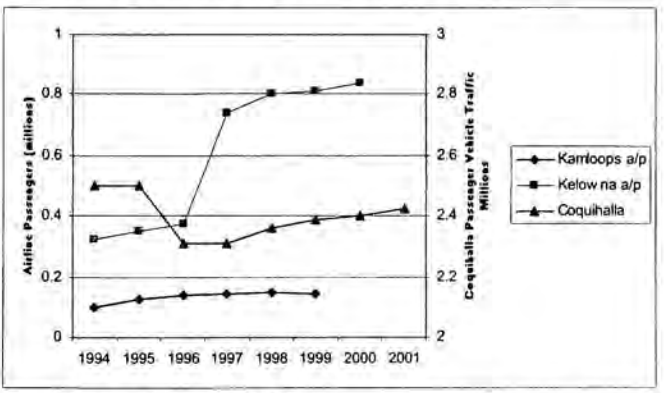
While many probably can cite an experience where they have chosen between car versus air for a specific trip, there are a couple of broad examples that indicate significant shifts of traffic between the two modes. The first example is the extensive growth of air travel that accompanied the air deregulation movement in the 1970s through 1980s.

> "Between 1975 and 1985, domestic passenger enplanements for the largest U.S. carriers grew at a rate of 6.6 percent per year and domestic revenue passenger-miles grew at 7.7 percent per year.... Some of the increase represents a shift from other modes of travel such as automobile, rail or bus."..... "Two studies have used annual time series data to estimate the decline in auto travel that resulted from airline deregulation.... The more plausible of these estimated declines in annual intercity passenger car miles of 2.2 percent, an average of 9.5 billion vehicle miles per year over 1978-88... This implies an increase of 9.5 billion air

passenger-miles if each car carried only a driver, or 19 billion air passenger-miles if two people occupied each car. These imply that 7 to 14 percent of the 140 billion increase in airline passenger-miles between 1975 and 1985 came from displaced auto travel ..... These rates imply average reductions of 100 to 145 auto fatalities per year over 1978-1988. This contrasts with 5 to 10 expected fatalities in 9.5 to 19 billion passenger-miles of domestic air travel. Even with conservative estimates of the extent of modal shift and highway fatality rates, the overall number of lives saved by switching travel to the air is substantial: on the order of 90 to 140 or more lives per year." (Rose, 1992, p.80-1).

An interesting anecdotal account about air-road substitution concerns British Columbia's Coquihalla (toll) Highway. It is a substitute for a portion of the Trans-Canada Highway between Calgary and Vancouver, and more important, it is the most convenient route to Vancouver from the Kelowna, B.C. region. A B.C. Ministry of Transportation and Highways report noted the decline of Coquihalla traffic in 1996 when WestJet started to fly.

Figure 1 Shift in Highway and Airline Travel

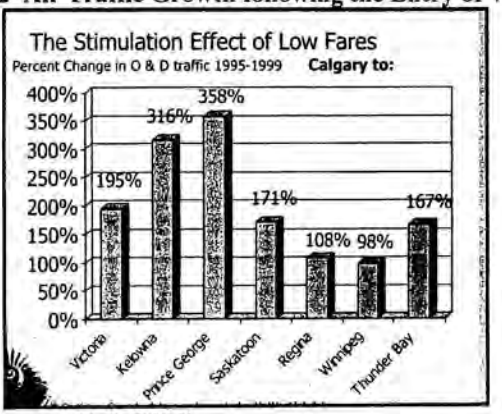


Source: Actran (2002)

"the 1996 drop in Coquihalla traffic coincided with the start-up of Westjet's operation. ..... Passenger volumes at Kelowna Airport increased by about 500,000 people between 1994 and 1999 while the number of vehicles on the Coquihalla fell by 125,000. If half of the increased airline traffic was destined for Vancouver and the Island and the average passenger vehicle on the Coquihalla carries two people, the increase in airline travel is roughly equivalent to the traffic that was lost from the Coquihalla." (Figure 1) (Actran, 2002).

Statistics Canada (1997) also reported similar dramatic air traffic growth in other markets WestJet was operating in as shown in Figure 2. Although we do not have the information on the changes in automobile travel for those routes, we can safely assume that much of the air traffic growth were diverted from automobiles.

Figure 2 Air Traffic Growth following the Entry of Westjet



Source: Bell (2003)

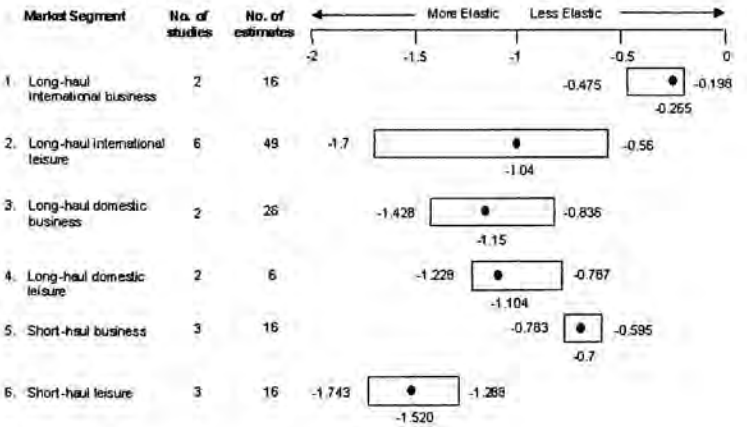
The Empirical Evidence on Air Demand Elasticities

There are a number of empirical studies about the sensitivity of air travel to the price charged. Two recent studies are Brons, et al. (2002) and Gillen, Morrison and Stewart (2002). They both conduct

extensive literature surveys to review the range of empirical results as well as factors influencing specific elasticity results. Brons, et al. identify elasticities that range from highly inelastic (-0.2) to highly elastic (-3.2). The distribution of results is bi-modal, essentially reflecting the differences between studies that focussed on business travel and those of leisure and/or short-distance travellers. The latter elasticities are predominately in the range of -1.4 to -1.6.

Gillen, Morrison and Steward (GMS) (2002) also review a large number of air transport demand studies in connection with the recent investigation into the impact of Canada's ATSC on air travel. They eliminate some studies from consideration but still find a substantial range of elasticity values, not quite as wide as those in Brons et al. (2002). Figure 3 shows GMS' summary of elasticity results. Short-haul leisure travel elasticities are quite elastic, about -1.3 to -1.7 with a modal value of -1.52. Interestingly, they show a modal elasticity about -1.1 for both long-haul domestic and leisure travel. Their results indicate elastic short-haul air travel demand.

Figure 3 Own-Price Elasticities of Demand



Source: Gillen, Morrison and Steward (2002)

Both of the above reviews point to a short-haul demand elasticity around -1.5, and the prospect of even long-haul elastic demands. Business travel is likely to be inelastic but it is still fairly sensitive to price in short-haul markets. We use an elasticity of –0.7 for our calculations.

The vast majority of demand elasticity studies focus on the overall or own-price elasticity of demand. Most studies do not explicitly estimate the cross-price elasticity between air and auto travel. They might note that the estimated elasticity will tend to be higher for routes where auto travel is an attractive alternative, hence the price elasticity estimate will be more elastic in those markets. But most studies do not explicitly estimate the own- and cross-price elasticity of demand. There are only a few such studies and estimates of cross-price elasticities are even more volatile than own-price elasticity estimates. The cross-price elasticity between air fares and auto travel tends to be a very low number depending on the size of air and car traffic volumes already on the road (if an auto route already has a large number of vehicles travelling, even a substantial absolute number of air travellers diverting to road would still constitute a small percentage increase in road traffic, hence the cross-price elasticity of air price and road traffic volume would be very low). For our calculations we make explicit assumptions about the number of travellers priced out of air markets who divert to auto travel.

The Size of Short-Haul Air Markets in Canada

Data about travel volumes on specific routes are very difficult to obtain. Fortunately, Sypher-Mueller International (2002) prepared a recent report for the Department of Finance that examined the impacts of the ATSC on low-cost and regional airlines.

> "Low Cost air carriers accounted for approximately 31% of ASKs on domestic scheduled flights in Canada in September 2002....
>
> Low Cost air carriers provide service for roughly 175 city pairs... carrying about 160,000 OD passengers per week in September 2002....

> Routes less than 500 km account for almost 15% of the passengers, with the ATSC ranging from 10.6% to 12.6% of the fare for most passengers....
> Routes between 500 and 1000 km account for just over 45% of passengers, with the ATSC ranging from 6.8% to 10.8% of the fare...
> Regional air carriers account for approximately 16% of ASKs on domestic flights in Canada....
> About 250 of the city pairs served by the Regional carriers are between ATSC listed airports.... Passengers on these routes totalled almost 50,000 per week in September, 2002 (excluding connecting passengers)....
> Routes less than 500 km account for just over 50% of passengers paying the ATSC, with the ATSC ranging from 5.9% to 10.9% of the fare for most passengers....
> Routes between 500 and 1000 kms account for almost 35% of passengers paying the ATSC, with the ATSC ranging from 3.0% to 7.1% of the fare for most passengers."
>
> (Sypher:Mueller International Inc, 2002)

We are able to work with these statistics to explore the likely diversion of air traffic to automobile, and the implications for safety. Their estimated weekly traffic for September is extrapolated to annual figures using the ratio of total annual Canadian air travel relative to September for the year 2000. We also scaled traffic volumes to year 2000 figures. Regional air traffic is limited to service between airports where the ATSC is levied. The two busy routes of Toronto-Montreal and Toronto-Ottawa are high-volume routes served primarily by Air Canada and hence are not included in statistics for low-cost and regional carriers. So we compile statistics for these two routes separately. We use the average percentage ATSC relative to fares for each category.

Appendix A lists our calculation assumptions about elasticities, split between business and leisure travel, diversion rates between air and auto, etc. For these initial calculations, we assume that 50% of short-haul low-cost air carrier traffic priced out of the market due to the ATSC will divert to the automobile, while 25 % are assumed to switch modes for the longer distance (500-1000 km)

travel. According to Transport Canada, overall Canadian air traffic is estimated to be 66% business travel, and 34% pleasure. However, we assume 50/50 for passengers on the low-cost carriers. This is consistent with other low-cost carrier experience. We apply the average 66/34 figures to the regional carriers. The specific routes of Toronto-Montreal and Toronto-Ottawa are assumed to have an above-average percentage of business travel; we assumed this to be 75 percent. (It appears that most Montreal-Ottawa traffic is included in regional air carrier calculations). As noted earlier, we assume elasticities of –1.5 for leisure travellers and –0.7 for business travel.

Safety Implications

We calculate the implied number of travellers diverting from air travel to auto in response to the ATSC fee. The primary impact is on the low-cost air carrier traffic. Approximately 175 thousand low-cost travellers divert to the automobile over a year. There is also a sizeable impact on regional carriers: approximately 66 thousand divert to auto travel. The calculated number diverting on the Toronto-Montreal and Toronto-Ottawa routes are relatively small (approximately 9900 and 11,600 respectively).

Table 4 summarises the estimated traffic diversions and the expected net impact on safety. The fatality rate for auto trips is calculated between 12 and 22 per billion vehicle miles; compared with air travel fatalities of 0.127 per billion passenger miles. There is a net expected fatality rate of about one to two persons per year for the calculated diversion of about 253 thousand trips by motor car instead of by plane. There are about 80 injuries for every road fatality. Then there are a much larger number of property-damage-only car crashes that could be estimated as well. If one assumes that air travellers have above-average driving records, the estimated loss of life would be reduced somewhat from these figures (Evans, Frick and Schwing, 1990, estimate that driving records of air travellers are 24 percent better than average). Higher vehicle occupancy would reduce the number of vehicle miles hence estimated fatalities; on the other hand, assuming only 50 percent diversion to road from short-haul low-cost carriers may be an underestimate.

Table 4 Summary Estimates of Air to Auto Trips and Safety Implications.

	Per year, 2000 traffic base	
	<500 km	500-1000 km
Low-cost carriers		
Leisure travellers	55,690	63,922
Business travellers	25,989	29,831
Regional carriers		
Leisure travellers	28,814	6,003
Business travellers	26,102	5,438
Toronto-Montreal		
Leisure travellers		4,107
Business travellers		5,750
Toronto-Ottawa		
Leisure travellers	4,817	
Business travellers	6,743	
Total trips diverting to auto		253.396
Expected net auto fatalities		0.97 to 1.78
Expected auto injuries		~75 to 140

These figures refer only to the diversion of air travellers to road travel because of the ATSC. They are primarily from the price-sensitive travellers on low-cost carriers, and short-haul regional flights. The "hassle factor" will be diverting some air travellers to road as well, but this is a separate matter. If the ATSC were reduced by half, this would reduce the road safety implications by half as well. Note that a proportional ATSC could be levied that would collect the same revenue but with a much smaller impact on the number of air travellers diverting to less safe road transport.

BIBLIOGRAPHY

Actran Consultants (2002), *Coquihalla Highway Backgrounder*, a report prepared for Business Partnerships Division, B.C. Ministry of Finance, Victoria

ATAC (Air Transport Association of Canada) and Fred Lazar (2002) "A Crisis in Costs: The Canadian Government and Airline Passengers," Ottawa, November 2002.

Bell, D. (2003), Presentation at the Air Transport Association of Canada Annual General Meeting 2002, January 28, 2003.

Brons, M., E. Pels, P. Nijkamp and P.Rietveld (2001) "Price Elasticities of Demand for Passenger Air Travel: a Meta-Analysis," *Journal of Air Transport Management* 8 (2002)165 – 175

Bylow, L.F, and I.Savage (1991) "The Effect of Airline Deregulation on Automobile Fatalities," *Accident Analysis and Prevention* 23, May, pp.443-52.

Evans, L, M.Frick, and R.C.Schwing (1990) "Is It Safer to Fly or Drive?" *Risk Analysis* 10, June, 239-46.

Gillen, D.W., W.G.Morrison and C. Stewart (2002) "Air Travel Demand Elasticities: Concepts, Issues and Measurement," Report for the Department of Finance, Ottawa, Canada.

Rose, N.L. (1992) "Fear of Flying? Economic Analyses of Airline Safety," *J. of Economic Perspectives* 6:2, Spring, pp.75-94.

Savage, I. (1999) "Aviation Deregulation and Safety in the United States: the Evidence after Twenty Years," in M. Gaudry and R.R.Mayes, eds., *Taking Stock of Air Liberalisation*, Kluwer Academic Publishers, Boston, pp. 93-114.

Statistics Canada (1997), "Air Travel Costs", *The Daily*, Friday, June 6, 1997

Sypher:Muller International, Inc. (2002) "Air Travellers' Security Charge (ATSC) and Low Cost and Regional Air Carriers," report prepared for the Department of Finance, Canada www.fin.gc.ca/consultresp/airtravel/ATSCcrac_e.html.

U.S.Department of Transportation, Bureau of Transportation Statistics, U.S. Department of Commerce, Census Bureau; Statistics Canada;Transport Canada; Instituto Mexicano del Transporte; Instituto Nacional de Estadística,Geografiae Informática;and Secretaría de Comunicaciones y Transportes, *North American Transportation in Figures*, BTS00-05,Washington,DC: 2000

APPENDIX A: Calculation Assumptions

	<500 km.	500-1000km
Low-cost carriers	15% of traffic	45% of traffic
	50% pleasure	50% pleasure
	50% business	50% business
	11.5% ATSC	8.8% ATSC
	-1.5 elasticity – pleasure	
	-0.7 elasticity – business	
divert to car	50% pleasure	25% pleasure
	50% business	25% business
avg trip length	300 km	750 km
Regional Carriers	50% of traffic	35% of traffic
	34% pleasure	34% pleasure
	66% business	66% business
	8.4% ATSC	5.0% ATSC
	-1.5 elasticity – pleasure	
	-0.7 elasticity – business	
divert to car	50% pleasure	25% pleasure
	50% business	25% business
avg trip length	300 km	750 km
Toronto-Montreal	n.a.	25% pleasure
	n.a.	75% business
	n.a.	3.0% ATSC
		-1.5 elasticity – pleasure
		-0.7 elasticity – business
divert to car		25% pleasure
		25% business
avg trip length		550 km
Toronto-Ottawa	25% pleasure	n.a.
	75% business	n.a.
	3.4% ATSC	
	-1.5 elasticity – pleasure	
	-0.7 elasticity – business	
divert to car	50% pleasure	
	50% business	
avg trip length	400 km	

An Exploratory Benefit-Cost Analysis of Motor Carrier Safety Fitness Ratings in Canada

Fred P. Nix
Consultant
RR #1 Orangeville, Ont
L9W 2Y8

frednix@auracom.com

W. G. Waters II
University of British Columbia
100 - 1924 West Mall
Vancouver, British Columbia
V6T 1Z2

Bill.waters@commerce.ubc.ca

Introduction: This paper develops estimates of benefits and costs associated with a motor carrier safety fitness rating regime as described in the proposed *Motor Carrier Safety Fitness Certificate Regulations,* specifically the *National Safety Code Standard #14, Safety Rating* (NSC#14). NSC #14 sets out factors that have to be taken into account in giving motor carriers a rating on safety performance. Under amendments to the Motor Vehicle Transport Act, every province and territory will be required to implement such a regime. The difficulty is that there is no empirical evidence in Canada to measure the relationships between a regulatory action (implementation of safety-ratings) and a consequence (fewer crashes). While a few provinces have used safety-ratings for several years, it is too early to find data on changes that result from these initiatives. Therefore we draw on studies from the United States for ideas on the experience with the costs and benefits of safety-rating regimes. But even in the US there are only a couple of studies that directly address this question. We borrow from these and explore the applicability of their assumptions and calculations to Canada.

Safety Ratings: Safety ratings are a means of ranking motor carriers according to the relative risk they represent for highway safety. The intent is to change the safety-management practices of the carrier.

Canadian jurisdictions agreed to 16 standards in the NSC in 1987; the original NSC #14 was subsequently deleted. In 1992, it was re-introduced, only this time it was to be an on-going rating system. A standard was approved in 1997 and, since then, provinces and territories have been struggling with implementation.

Highway Safety: In 2000, there were 45,539 trucks (registered weight of 4,500 kg or more) involved in collisions. This is a drop of 2.2% from 1991. At the same time, the number of trucks involved in fatal collisions fell by 3.8%.[1] Good information on exposure, say vehicle kilometres of travel, is not available so these numbers cannot easily be converted into collision rates. However, it is known that the level of activity during the 1990s increased rapidly. For example, the number of trucks crossing the Canada-United States border increased by 89% between 1990 and 2000[2] and total tonne-kilometres of freight moved by the larger for-hire carriers increased by 112% between these same years.[3] It is reasonably certain, therefore, that the collision rate dropped dramatically over the past decade. Unfortunately, nobody can say with certainty what factors caused this drop.

One possible explanation is the introduction of the NSC and, in particular, NSC #14. There are problems, however, with this hypothesis. There is no empirical evidence to link a truck safety regulation—particularly one among a large interrelated set of such regulations—to collision rates. There is also no way to measure the level of enforcement with current information. That is, while safety regulations may exist "on the books," there are large differences in how actively they are enforced. Finally, a major difficulty with the hypothesis is that the last decade has been one, long and gradual process of implementation of safety ratings. The pace of implementation varies considerably and several jurisdictions do not yet have their rating systems in place. So, from a measurement perspective, there is no simple "before and after" time period.

For these reasons, the attempt to measure benefits and costs in this paper is preliminary. These reasons also explain why it is necessary to draw on US research in making this measurement—it provides the

evidence to make assumptions about impacts. But to properly borrow from the results of research in the United States, the differences in the rating mechanisms have to be explained.

Canada's system: The NSC (standard #7) requires that records be kept (carrier profiles) on collisions, convictions and roadside inspections. The exact list of things recorded on profiles varies from jurisdiction-to-jurisdiction as does the sequence and nature of enforcement interventions. Points for various categories of collisions, convictions and inspections build up to critical threshold levels that, in turn, trigger interventions. These may include warning letters, requirements to file safety plans, carrier safety audits or a downgraded rating—to Conditional, and ultimately to Unsatisfactory. Because of the many differences among jurisdictions, there is no common methodology that can be used in assessing impact of NSC #14. In this analysis, however, this is overlooked and safety ratings are treated as a homogeneous tool with a common impact across the country.

United States: Under the Motor Carrier Act of 1984, the US Department of Transportation was required to audit all interstate carriers. These were done in two stages. The first, a Safety Review (SR), involved a visit to a carrier more for the purpose of education than enforcement (no charges resulted). But, during the course of the SR, information was collected on knowledge about safety regulations and violations that had occurred. Based on this, plus information on collisions, roadside inspections, past convictions, and other matters, inspectors rated the carrier Satisfactory, Conditional or Unsatisfactory. The Unsatisfactory were subjected to a follow-up audit known as a Compliance Review (CR).

US procedures have changed since 1984 and the focus now is on a number of tools used to identify high-risk carriers and then using the CR to get the carrier to change safety-management practices. One tool, SafeStat, evaluates the relative status of individual carriers with respect to the rest of the population in four areas—collisions, driver performance (moving violations or OOS events), vehicles (OOS events or violations detected during a CR), and safety management

(factors determined during a CR or other enforcement action). An OOS or out-of-service event is a condition agreed to by all US states and Canadian jurisdictions that puts a vehicle or driver off the road until the condition is fixed.

SafeStat uses up to 30 months of data to develop measures and indicators in the four areas. These are then combined into an overall score. Time markers are used to weight more recent events more heavily than older events and weights are also used to give more importance to collisions than other areas. SafeStat scores are used to identify carriers in need of an audit (CR).

There are large differences in the details between the ratings systems in Canada and the United States, and there are even larger differences between individual Canadian jurisdictions. These details are ignored here as, in broad outline, all rating systems use a number of indicators (compliance with regulations, performance measures such as OOS events, convictions and collisions) to produce a rating (or a threshold level or a SafeStat score) that triggers some intervention. In most cases, these interventions ultimately can lead to what amounts to a finding of a carrier being unfit and, therefore, having its right to operate a commercial vehicle revoked. In what follows, it is the costs and benefits of the broad outlines of a safety-rating regime that are being estimated, not the particular costs and benefits of the system in place in any one jurisdiction.

Research from the United States: The first research into the effectiveness of ratings (audits and ratings) was in the early 1990s by Moses and Savage.[4] They calculate benefits and costs associated with the US audit program (SRs, ratings and subsequent CRs). To do this, they take records on the 85,000 carriers audited up to 1992. Of these, 6% had been rated Unsatisfactory after a SR and, subsequently, received a CR. The key finding is that 91% of Unsatisfactory carriers reduce collision rates by an average of 43% between the time of the SR and the CR. That is, the impact of an auditor showing up at the door and the subsequent Unsatisfactory rating is enough to spur these

carriers into implementing appropriate safety-management procedures. And this results in a decrease in the collision rate.

In a 1998 analysis, Madsen and Wright develop a model of the impact of CRs.[5] During a CR, an auditor records all reportable crashes during the previous 12 months and the total distance travelled (vmt). From this, a crash rate can be calculated. They then select all carriers with two or more CRs from April 1993 to June 1997. From this group, they select the 1,738 with CRs from one to two years apart (ie, so crash rates do not overlap). The analysis shows that, at the time of the initial CR, carriers had a crash rate of 0.750 (0.75 crashes per million vmt). At the time of the second CR, carriers had a crash rate of 0.661, a 12% improvement.

Although this analysis is quite different than the one by Moses and Savage, the magnitude of the difference in the findings (43% versus 12%) is still surprising. One possible explanation is that carriers examined by Moses and Savage had extremely poor safety performance. The enforcement effort first concentrated on the worst actors and, therefore, the change in collision rates was very dramatic with these early interventions.

Madsen and Wright also assess the effectiveness of SafeStat which is used to target carriers most in need of a CR.[6] The analysis can be summarized as follows: assuming SafeStat is, in fact, a measure of on-going safety performance, there ought to be a correlation between a SafeStat score and a carrier's collision rate. Indeed, this is found to be the case. Carriers with the worst score have a collision rate 169% of the rate for carriers with the best score. This may seem a tautology as the SafeStat score itself is heavily influenced by the collision rate. But, in the analysis, it is the SafeStat score at one point (April 1, 1996) that is compared to the collision rate for the 18 months after that date. These results reinforce the assumption that information collected in the profiles, and used for ratings in Canada, is capable of identifying high risk (high collision rate) carriers.

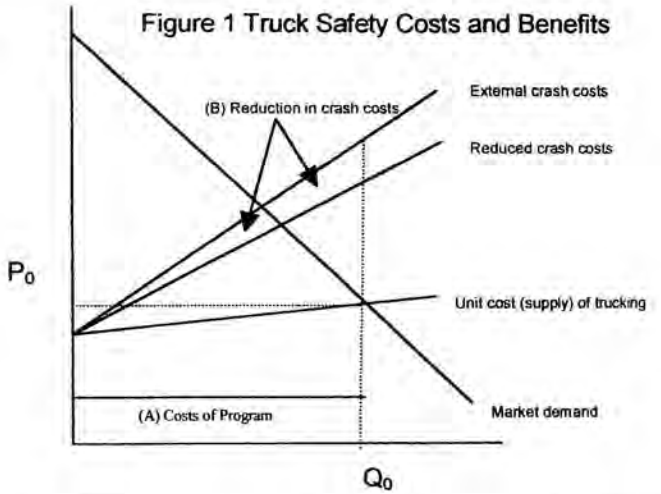
The third research by the Volpe Center attempts to improve the figures developed in the original Madsen-Wright work (12% reduction in collision rates).[7] The original analysis was forced to use carriers that had had two CRs (because it is during a CR that inspectors collect the information on collisions and vmt in the prior 12 months). This gave the analysis a "before" and "after" collision rate. However, one problem is that it focuses on the worst carriers—those who do not improve performance after the first CR. In the latest work, the analysts use the results of all carriers receiving a CR in 1998 and then use a follow-up survey to determine the change in performance. The reduction in the collision rate is 10.3% not much less than Madsen and Wright's finding of 12%.

To summarize, US research indicates that carriers scoring poorly on measure of compliance with regulations or measures of performance are, in fact, a greater risk to road safety than other carriers. In this context, "score poorly" could mean the Unsatisfactory rating in Moses and Savage's work, a poor SafeSat score or a threshold level in a Canadian rating. All use similar measures to identify high-risk carriers. US research also suggests that the process of rating a carrier (a US CR, a rating, a SafeStat) and the possible interventions that accompany such a process do lead to improved performance—safety-management practices that have the result of lowering collision rates.

A Benefit-Cost Framework: We illustrate the benefit cost framework by first assuming that a safety regime improves the safety of all carriers. Our illustration of benefit and cost categories is in Figure 1. It shows a market demand for trucking along with a unit cost or supply function. Trucking is a competitive industry so the price of trucking is equal to the cost, price Po and quantity Qo. There are external social costs of truck collisions indicated by the external cost line above the industry unit cost. A safety program produces a benefit (B) representing the reduction in crash costs. The government costs associated with running the program are item (A) (e.g., salaries for inspectors, auditors and related costs). The present value of benefits would be compared to the present value of costs to determine the net benefits and benefit-cost ratio.

Moses and Savage further assumed that the safety program would increase the costs of trucking. This is not shown in Figure 1, but it would entail shifting the unit cost (supply curve) upwards (they assume 6%). Truckers must pass on these increased costs of doing business. This rise in price would cause a decline in output. Moses and Savage assume an elasticity of demand of –1.3, hence a 6% price increase results in about an 8% reduction in output. The resulting reduction in truck travel further reduces truck collisions and costs.

Figure 1 Truck Safety Costs and Benefits



They identify two additional items. One is that the increased price and reduced output brings a deadweight loss to customers who were shipping their goods before but are priced out of the market by the 6% increase in unit costs. This is a relatively small cost. Second, they suggest a partial offset to the rise in safety costs. If customers regard safety as an increase in the quality of service, this would be indicated as an outward shift in the demand function and hence some increased revenue from customers. (This is not shown in Figure 1.)

We have two difficulties with the Moses and Savage approach. First, we question the assumed 6% increase in truck operating costs. This figure came from a study comparing the costs of high-quality versus low-quality carriers. But service quality and safety are not identical. Further, at least part of a cost increase to improve safety could be offset by reduced insurance and lost time due to crashes, as well as by the possibility that carriers recognised that increased safety could be valued by customers. Second, the benefits of reduced crashes are assumed to only come from carriers subject to intervention, and not all carriers. While costs might increase for intervened carriers, any traffic lost would likely divert to other carriers who did not improve safety. Moses and Savage acknowledged this possibility but did not take it into account in their calculations. In sum, we question the size of an increase in truck operating costs in connection with improved safety, and hence we do not expect significant safety improvements from reduced trucking activity brought about by a higher cost/price of trucking.

In our calculations below we follow the approach of assuming that only carriers subject to intervention increase safety and we test the sensitivity of the calculations to assumed cost increases to carriers due to increased safety requirements.

Exploring Benefits and Costs for Canada: We are hampered by lack of data and must make assumptions (for example, we do not have a measure of total output as illustrated in Figure 1). Nonetheless, we explore the benefit and cost categories discussed above, and make use of the US research to develop estimates for Canada.

Government costs are difficult to identify because there is no isolated agency administering NSC #14. Rather, there are NSC staff administering safety ratings as well as other truck safety regulations. In addition to annual operating costs, there may be significant set-up costs for a safety-rating system. For here, and based on earlier research and discussions with six provinces,[8] we estimate that there is one agency employee for every 1,547 carriers and that these employees have an annual cost of $100,000 each. This rather high

figure accounts for the fact that some employees are auditors who spend time travelling from one carrier's premise to another. These assumptions produce annual government costs of $64.65 per carrier. While we have no information on set-up costs, we test an assumption that an appropriate amortization of these expenditures is 10% of the annual operating cost. Government costs are adjusted for the shadow value of public funds (also called the marginal excess burden of taxation). This assumes that any program financed through income taxes has disincentive effects on economic activity. True opportunity costs of lost private production/ consumption are greater than the revenue derived from an incremental imposition of taxes. Moses and Savage assume a deadweight loss of $0.21 per dollar of tax revenue. Expressed another way, any public project must show a benefit-cost ratio greater than 1.21 before there is a net positive benefit. We inflate the government costs by this factor.

In terms of carrier costs, although large tractor-trailers on the highway have operating costs in the range of $1-to-$2 per kilometre, these vehicles are a minority within the trucking fleet. Seventy-two per cent of all trucks with a registered of 4,500 kg or more are straight trucks and one-quarter of these are heavy pickups and vans.[9] So, for here, we assume a lower fleet average operating cost of $0.75/km for our calculations. As for the impact of safety measures on carrier costs, no information is available except the figures used by Moses and Savage: US $875 in carrier staff time for a CR and an increase of 6% in operating costs for carriers implementing better safety-management practices. In their calculation, these are summed from year one to infinity at a discount rate of 7% and are assumed to suffer from a decay rate (carriers gradually lapse from the safety practices over time). In the calculations here, we bound the analysis by alternatively assuming that operating costs increase by 6% or operating costs do not change at all.

In sum, carrier costs are assumed to be CDN $1,800 per audit (875*1.5*a decade of inflation at roughly 3%) plus either (a) a 6% increase in an average operating cost of $0.75 or (b) no increase in operating costs. The audit cost is essentially staff time required to be

available to handle the audit (produce files, respond to letters, make equipment available, downtime, etc) although in some cases it could also be the cost of a third-party audit. This estimate of $1,800 may be high as the average size of an interstate carrier in the United States is larger than the average size of a carrier audited in Canada. From anecdotal information, many carriers facing interventions in Canada tend to be small, one or two-truck fleets. The increase in operating costs, if it occurs, is assumed to continue into the future so the calculated cost is the present value of this future stream of costs assuming a certain decay rate (following from Moses and Savage).

As for benefits, there are two choices: (1) assume that 91% of carriers rated Unsatisfactory reduce collision rates by 43%, or (2) assume that every audited carrier reduces its collision rate by one of the Volpe Center numbers (12% or 10.3%). Since procedures in the United States are not the same as in Canada, neither assumption is quite what is needed. For one thing, an Unsatisfactory rating in Canada is almost the same as a finding that a carrier is unfit and, therefore, is almost the same as a carrier having its operating privileges revoked. For another, the auditing policies of each jurisdiction in Canada—that is, what threshold triggers an audit—differ.

The questions for this analysis are: (1) at what point of an intervention does a carrier start to change its safety-management practices? (2) when a carrier changes its safety-management practices, what is the reduction in the collision rate? And (3) is there an industry-wide deterrent impact independent of any carrier-specific intervention?

In terms of the first question, and given the absence of empirical evidence, we assume that a carrier changes its safety-management practices when it first comes to the attention of enforcement staff—in other words, the first intervention within each province or territory (whatever that intervention is). Since we know the provinces and territories have a goal of intervening with 5% of the carrier population annually, this gives us an initial figure to analyse.

In terms of the second question, a figure of 15% is used for the reduction in collision rates. This is slightly higher than the Volpe Center numbers of 10% to 12% in recognition of the higher figures from Moses and Savage.

Because benefits of rating occur over time, the same assumptions as those used by Moses and Savage are used to estimate benefits into the future. Rating will result in a reduction in the number of collisions in the first year after the intervention but this reduction will decay in future years both because some carriers (5%/year) will disappear and because remaining carriers (0.7%/year) will lose some of their vigilance. For here, a discount rate of 10% is used.[10] The equation

$\Sigma((0.943^n)*\text{collisions avoided})/(1.1^n))$

represents the benefits of safety-rating as measured by the physical count of the reduced number of trucks involved in collisions from year one to infinity. Estimating the full count of these reduced collisions between now and infinity and using a discount rate to do this is the same as calculating the present value of this benefit. (This same calculation is used to estimate the present value of the 6% increase in operating costs discussed above).

To translate this reduction in the number of collisions to a monetary value, the most recent (1999 dollars) FMCSA estimate of the average cost of a truck collision (US $75,637) is used.[11] This includes estimates for the costs of medically-related activity, emergency services, property damage, lost productivity and the "monetized quality-adjusted life years." This number is converted to Canadian funds as $113,456 (1.5*75,637).[12]

In terms of the third question, the calculations assume there is no deterrent effect on other carriers. This is a conservative assumption that results in lower estimates of safety benefits.

Activity Assumptions: Table 1 shows information needed for the analysis. There are critical assumptions in these numbers. The

number of carriers (profiles) is based on earlier research[13] with adjustments to account for a large number of carriers (123,000) not included within the safety-rating system, up-dates from a few provinces, and an adjustment for two provinces that do not rate carriers on a base-plate basis. Assuming 5% of these will face some intervention every year, the "target" population is 10,175. This earlier research also showed that the average carrier only has 2.2 trucks and this is the source of the estimated regulated fleet size on line 2. Statistics Canada's new CVS actually shows 661,446 trucks on registration lists in 2000.[14] There are reasons to believe that the CVS underestimates the fleet in Québec so the actual fleet size here is estimated as 671,446 (ie, 10,000 higher). This fleet size times the average vkt (of the "in scope" trucks) from the CVS suggests a total of 31.2 billion kilometres of travel in 2000. Transport Canada's TRAID data shows 45,539 trucks involved in collisions in 2000 which results in the collision rate of 146.36 (per 100 million km) shown on the table.

Table 1: Scope of Activity and Performance

1	# carriers	203,493	Provincial/territorial information
2	# trucks	447,992	# trucks/profile * line 1
3	# target carriers	10,175	5% of line 1
4	Annual audits	2,035	1% of line 1
5	Annual distance per carrier (vkt)	102,020	CVS 2000 average (46,341) * # trucks/profile
6	Collisions rate/ 100 million km	146.36	TRAID data (2000)/ CVS (adjusted) vkt

Results: With information from Table 1, it is possible to calculate benefits and costs (Table 2). The Base Case assumes government costs of $64.65 per carrier times 1.21, plus carrier costs of $1,800 per audited carrier. Benefits are the 15% reduction in the collision rate for the targeted carrier population times the cost of a collision all calculated as the present value of a future stream of benefits using a 10% discount rate and the decay rate from Moses and Savage. As shown in line 1, benefits exceed costs by a wide margin.

Table 2: Benefit-Cost Ratios

1. Base Case	9.25
2. Targeted carriers are small and have high collision rates	8.41
3. Base Case, plus safety-management increases carrier operating costs by 6%	0.60
4. Combining #2 & #3	0.98

Line 2 of Table 2 shows a variation on the base case assuming (reasonably) that the 5% of carriers targeted for interventions every year will actually have a collision rate higher than the industry average and that these targeted carriers will tend to be small (even though it is difficult to be much smaller than the 2.2 trucks/fleet shown in Table 1). The B/C ratio is still very large. In addition, assuming there are set-up costs for safety ratings, an amortization factor (10% of operating costs) was added to government costs but it does not change the B/C ratios significantly.

In line 3 of Table 2, a safety-rating system begins to look like a poor expenditure of government funds if the effect is to increase operating costs by any significant amount. If the assumptions in lines 2 and 3 are combined (line 4), a safety-rating regime may be just worth it (given the quality of the data used here, a B/C ratio of 0.98 is too close to unity to conclude whether net benefits are positive or negative).

In our view, the assumption that safety-management practices increase operating costs by as much as 6% is difficult to justify (even though we have no data to contradict this). Therefore, we are reasonably certain that the true B/C ratio lies somewhere between the very high ratios on the first two lines and the somewhat lower ratios on the last two lines. If this is the case, then, government expenditures on safety-rating regimes seems to be justified.

This is a very tentative conclusion given the weaknesses in the activity statistics (Table 1) and the assumptions used. We also know that the calculation of the collision rate is tenuous. While the numerator (Transport Canada's TRAID) is reliable, the denominator

(Statistics Canada's CVS with adjustments) could be questioned. Further, this rate is assumed to apply to the targeted carriers. If US research is any guide, targeted carriers probably have a higher collision rate than the industry average.

Finally, the analysis makes no allowance for the possibility that there will be a reduction in collision rates for carriers other than the targeted carriers, i.e., no deterrent impact is assumed. This is a very conservative assumption, suggesting that the benefit-cost ratios could be much higher than what we have calculated.

Summary: This analysis is preliminary. But, and this aside, the figures seem to suggest that the benefits of a safety-rating regime outweigh the costs unless there is a very high cost to carriers of implementing safety-management practices.

This finding that the benefit-cost ratio is positive is encouraging as a great deal of effort over the past decade has gone into the development safety-rating regulations and procedures. But a point made earlier in the paper has to be repeated: the actual benefits and costs of safety rating have to be judged within the context of the programs in place in each jurisdiction. This analysis has only shown (in a preliminary way) that there is a strong presumption that the benefits of such programs outweigh the costs.

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1 Transport Canada, TRAID.

2 Statistics Canada, International Travel data (unpublished)

3 Statistics Canada, *Trucking in Canada*, cat #53-222.

4 Moses, L.N. & I. Savage, 1997, "A cost-benefit analysis of United States Motor Carrier safety programs," *Journal of Transport Economics and Policy*, 31(1), pp 51-67. The version used in this research is labelled "working paper version, July 1994."

5 Office of Motor Carriers, 1998, "Compliance Review (CR) Impact Assessment Model, Version 1.0," *MCSAFE*, Vol 3, no iii, March 1998

6 Madsen, David G & Donald G. Wright, 1998, "An Effectiveness Analysis of SafeStat" TRB paper 990448, Washington DC.

7 John A. Volpe National Transportation Systems Center Economic Analysis Division, DTS-42, 2002, FMCSA Safety Program Performance Measures Compliance Review Impact Assessment Model, Revision 1, prepared for FMCSA, Washington, DC

8 Earlier research is: Nix, F.P., 1998. *Commercial Vehicle Program Thresholds*, prepared for Road Safety & Motor Vehicle Regulations, Transport Canada. The 6 provinces consulted are: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario and Québec.

9 Statistics Canada, *Canadian Vehicle Survey 2001*, Cat # 53-223-XIE.

10 The Treasury Board Secretariat uses a 10% real discount rate.

11 US DoT, FMCSA, 2001. "Cost of Large Truck-and-Bus-Involved Crashes," *Analysis Brief*, Publication # FMCSA-MCRT-01-005.

12 The numbers suggested by Moses and Savage (US $188.211 in 1992 values) and an expansion factor of 4.94 between reportable collisions and all collisions were also investigated. The results, however, were not credible. Accounting for inflation and a conversion to Canadian funds, the average cost of a truck in a collision would be about $200,000. Inflating the TRAID number of collisions by 4.94, however, produces an unlikely number of collisions. The reason, it is thought, is because the threshold for reporting a collision in the Canadian data is $1,000 whereas in Moses and Savage's work it was $4,400 (US funds in 1992) which is something like ten times as high.

13 op cit, Nix (1998)

14 Statistics Canada, *Canadian Vehicle Survey 2000*, Cat # 53-223-XIE.

VALIDATION AND ANALYSIS OF COMPUTATIONAL RESULTS FROM A REGIONAL ASSIGNMENT-SIMULATION MODEL TO EVALUATE TRANSIT SIGNAL PRIORITY IN CHICAGO

Elaine Chang
Athanasios Ziliaskopoulos

Department of Civil Engineering
Northwestern University
2145 Sheridan Road
Evanston, IL 60208-3109
Phone: (847) 491-7612
Fax: (847) 491-4011
Email: ejchang@northwestern.edu

INTRODUCTION

Public transit has the potential to alleviate ever-worsening transportation network capacity problems, including congestion, emissions and energy consumption. As such, recent years have seen growing research attention turned toward methods of improving transit service. One strategy that has been implemented in many European cities and tested in several North American cities is that of providing priority to transit vehicles at traffic signals. Traffic signals cause significant delays for buses and increase operating costs for on-street transit service, so the potential of transit signal priority (TSP) to improve transit operations and service quality is significant. By reducing bus intersection delays TSP may contribute to decreases in transit travel times, improved schedule adherence, and more efficient

utilization of labor and capital equipment. However, enthusiasm for TSP in North America has been tempered with concerns that overall traffic performance may be unduly compromised when signal timing plans intended to optimize traffic flow are overridden to provide a travel advantage to transit vehicles. These concerns highlight the need to balance enthusiasm for TSP's potential with consideration of increasing delays to cross-traffic.

With various cities in Europe and North America testing and running TSP, the body of TSP experience is growing; however there remains significant uncertainty regarding the impacts and level of benefits that will result from a particular combination of traffic conditions and TSP strategy. Since no generally accepted standards or guide to TSP implementation have been developed, planning decisions regarding TSP implementation generally begin with reviews of other cities' experiences; however, since every city differs in geography, traffic conditions and general travel behavior, results and conclusions from one city are not fully transferable to other cities, so evaluations specific to the city in question must be performed. This is typically done through computer simulations, which are more flexible and lower in cost than field tests. Further, the results of computer simulations can be used to guide later costly field tests.

The most common approach to computer simulation of TSP is simulation of a short corridor of intersections, with traffic generated based on intersection turning movement counts. An alternative approach is to simulate a large area including not only the TSP corridor, but the whole trip-making region, with traffic generated based on assignment of OD trips. Using this approach, impacts and effects that are regional in nature and scale, such as vehicle route changing behavior, interaction of parallel and intersecting TSP corridors, geographic distribution of travel time benefits, can be captured. The turning movement-based approach and the OD assignment-based approach each have strengths and weaknesses. This paper explores the differences between the two approaches with the goal of providing TSP decision-makers with an understanding of the tradeoffs between the two in terms of data and calibration requirements and outputs provided.

The next section explains TSP implementation and impacts and discusses how these should be effectively represented in simulation for evaluation purposes. Differences between turning movement- and OD assignment-based modeling approaches are then described in detail. Next, computational results are presented to illustrate the OD assignment-based approach applied to the Chicago region. The paper then closes with conclusions and plans for future research.

BACKGROUND: TRANSIT SIGNAL PRIORITY

This evaluation project focuses on active transit signal priority strategies, where buses are detected at an intersection and depending on the current signal phase and elapsed phase time, the phase is extended or truncated, or a phase is injected or suppressed. Such priority strategies have been found to improve both transit travel time and reliability; however, they risk degrading the level of service for the rest of the traffic stream by reducing the amount of green time available to cross-traffic, and by reducing the effectiveness of coordinated signal systems. This section discusses the potential impacts of TSP to provide a basis for understanding the simulation needs for the TSP evaluation project.

Signal priority for transit is typically used to shorten transit travel times by adjusting timing plans to benefit transit movements, or by having signal phases switch when a transit vehicle approaches; however, beyond simply reducing intersection delay, in a more general sense TSP provides an added element of control over transit travel times. For example, TSP can be invoked to increase stop time for buses that are running early, and decrease stop time for buses that are running late. In this way, travel time variability can be reduced and schedule adherence can be improved. Reduction of travel times and travel time variability and improvements in schedule and headway adherence constitute important service improvements that have the potential to attract new riders to transit. This not only represents increased operational revenues, but also improved efficiency of the existing transportation infrastructure, which can be translated to lower congestion, emissions and fuel consumption.

Reductions in travel time variability and improvements in schedule adherence also provide potential operational cost savings. More specifically, if a bus runs late, it may complete its run after its scheduled departure for the next run; therefore, an extra bus must be sent out in order to begin the next run on time. However, if all buses run on time and return in time to begin the following runs, fewer buses will be needed to provide the same level of service, thus maximizing the efficiency of the use of labor and capital equipment. In other words, TSP provides the ability to reduce travel time variability and improve schedule adherence, so that operational costs can be reduced.

In addition to operational cost savings and increases in ridership, potential negative consequences must also be taken into consideration. Specifically, if priority is given to transit approaches, cross-street traffic will suffer a reduction of green time. The resulting delays are further increased when the cross-street is part of a coordinated signal system. The effects of TSP on general traffic must be considered since popular support will be diminished as the delays to the general traffic stream increase.

Another effect of TSP is that due to the shift in the signal timing advantage, automobile users may reconsider their route choices. For some travelers, it may be beneficial to choose routes that avoid non-priority approaches at TSP intersections, while for others it may be beneficial to choose routes that include many priority approaches at TSP intersections. One potential impact of this route-changing behavior is that congestion levels on residential side streets may increase as drivers seek to avoid TSP intersections, and this may affect neighborhood safety. Driver route-changing behavior was demonstrated by Agrawal et al. (1) in their TSP simulation study performed using VISTA with OD assignment restricted to a subsection of south Chicago.

Also, the travel time impacts resulting from TSP will benefit travelers between different origins and destinations differently, and it would be important to be aware of the geographic and socio-economic distributions of these benefits. Further, examination of these distributions may add insight into significant transit markets following TSP implementation.

Interaction of intersecting and parallel TSP corridors must also be considered. At intersecting corridors TSP preemption requests may conflict with each other and thus reduce the benefits to one or both corridors. Along parallel TSP corridors travel time changes related to TSP may cause vehicle routing changes thus affecting the congestion along nearby streets, which in turn will affect the congestion on other nearby streets, resulting in a ripple effect throughout the network. Also, parallel TSP corridors that cross an arterial with coordinated signals may cause undue delays to the cross street and cause further routing changes. Routing changes cannot be considered for only a small area, but must be considered over travelers' entire trips from origin to destination, and for all travelers, including those who are not directly affected by signal priority, but by changes in congestion as others switch paths.

Planning decisions regarding TSP implementation generally begin with reviews of other cities' experiences; however, since every city differs in geography, traffic conditions and general travel behavior, results and conclusions from one city are not fully transferable to other cities, so evaluations specific to the city in question must be performed, and this is typically done through computer simulations and/or field tests. Computer simulations, like all models, lack the realism of field tests, but are more flexible and lower in cost than field tests. Further, the results of computer simulations can be used to guide later costly field tests.

Effective simulation requires that a model realistically captures the effects of TSP, and also reports relevant measures of effectiveness. Simulation models should be able capture the full length of TSP corridors, the interaction of TSP corridors, the interference of TSP with coordinated signal corridors, and path and mode choices of network users in reaction to TSP implementation. The simulation model should also provide output measures on automobile and transit travel times along the corridor, delays to cross-traffic, and variability in transit travel times. In addition, measures should be considered on a regional level, so that distribution of travel time benefits to travelers between various origin-destination (OD) pairs can be observed, changes in flows on residential and side streets can be studied, and effects on full bus routes can be directly related to

schedule adherence, efficiency in use of labor and capital equipment, and transit operational costs. Ideally, the simulation would also give insight into ridership effects and resulting impacts on congestion, emissions and fuel consumption.

MODELING APPROACHES FOR EVALUATION OF TRANSIT SIGNAL PRIORITY

Traffic simulation is used to model and evaluate the impacts of transit signal priority schemes. Currently, the most common approach involves simulation of small networks (individual TSP corridors) with traffic generated based on intersection turning movements counts. An alternate approach is to simulate an entire region with traffic generated based on assignment of OD trips. This section provides a description and practical comparison of these two approaches.

The turning movement-based simulation approach is generally associated with microscopic simulation. Microscopic simulation models treat vehicles as individual entities according to car-following and gap-acceptance principles. Traffic signal operation, randomly assigned driver characteristics and stochastic traffic events allow these models to reflect real world traffic processes. Microscopic models are extremely detailed, but also computationally intensive and thus limit the size of networks that can be simulated. More specifically, computer simulation studies of TSP scenarios are most commonly carried out using various commercially available microscopic simulation packages, such as VISSIM, WATSIM and NETSIM, which are all PC Windows-based, and are thus limited to the computational power available on standard PCs. This memory constraint combined with the high computational requirements of microscopic simulation results in test scenarios that are typically limited to small networks of around 15 intersections. Complete trips cannot be modeled on networks of this size, so generation of traffic is left to intersection turning movement counts.

This turning movement-based approach ignores vehicle route changing behavior that results in reaction to the change in traffic conditions. Specifically, it is reasonable to assume that TSP will shift the signal timing advantage thus changing travel times not

only priority transit vehicles, but also of regular vehicles traveling both along and across the priority approach. As a result, non-priority vehicles may choose to use or not to use TSP intersections depending on whether or not their approach is given the advantage, and may therefore change their travel route. However, the turning movement-based approach takes intersection traffic volumes and splits as an input parameter, thus assuming that the flows and turning movements on the corridor remain unchanged regardless of any shift in travel time advantage.

To avoid having to make this assumption, a large area including not only the TSP corridor, but the whole trip-making region should be simulated with traffic generated based on assignment of OD trips. Using this OD assignment-based simulation approach vehicle route choice behavior can be captured while accounting for TSP effects on travel time. Further, on a large network the interaction of parallel and intersecting TSP corridors can be modeled, and impacts of TSP on different OD pairs can be compared. These effects are regional in nature and can only be captured by a simulation that is regional in scale, and not by individual simulation of short corridors.

The OD-assignment approach is the approach used in DTA models, which iterate between assignment of vehicles to shortest paths and simulation of vehicle flow along those paths to determine link travel times. Examples of DTA models include TRANSIMS, INTEGRATION, DYNAMIT, DYNASMART as well as VISTA, which is the model being used in the Chicago regional TSP study. A review of DTA models is provided in Peeta and Ziliaskopoulos (2).

VISTA's DTA procedure requires that the network, OD demand, bus routes and schedules, signals and signal priority data be inputted into the model. Next, in the first iteration the ROUTESIM simulator is run with vehicles assigned to the free flow shortest paths. The link travel times resulting from that assignment pattern are then used to calculate a new set of shortest paths and the simulation is repeated with vehicles assigned to a combination of the previously calculated path sets. VISTA continues iterating between the mesoscopic simulation and vehicle assignment until the link flows converge. This procedure accounts for vehicle path choice with changes in traffic conditions.

VISTA's ROUTESIM simulator propagates vehicles mesoscopically, according to Daganzo's cell transmission model (3), such that link conditions are simulated by evaluating flow at a finite number of intermediate points along each link. The principles of the cell transmission model are consistent with the hydrodynamic theory of traffic flow, but can also capture microscopic effects, such as queuing. ROUTESIM computes the cell location of each vehicle at every time step. This information is less detailed than the output provided by microscopic simulation (exact vehicle position, speed and acceleration at each time step) but is much more computationally efficient and allows mesoscopic simulators to solve large networks. The VISTA software takes advantage of this, and further is designed to run on Linux machines, which have much higher computational power than PCs, especially when run in parallel.

The VISTA software can model regional networks, and phenomena that are regional in nature, such as the interaction of TSP corridors, the interference of TSP with coordinated signal corridors, and path choices of network users in reaction to TSP implementation. VISTA provides output on automobile and transit travel times along the corridor, delays to cross-traffic, and variability in transit travel times, but also allows observation of regional impacts such as changes in distribution of travel time benefits to travelers between various OD pairs, changes in flows on residential and side streets can be studied, and effects on full bus routes such that conclusions can be drawn regarding schedule adherence, efficiency in use of labor and capital equipment, and transit operational costs. Since VISTA models vehicles but not people, the simulation does not give direct insight about ridership effects; however, VISTA's travel time outputs can be used in a mode split model to gain insight into the mode shift and resulting ridership, congestion, emission and fuel consumption effects of TSP.

In short, the memory limits of commonly available PC-based microscopic simulation packages make simulation of large regional networks infeasible. Using these packages, simulation is restricted to short individual corridors with vehicles generated based on the turning movement counts, such that route choice behavior is ignored. By contrast, DTA models with less computationally intensive

mesoscopic simulators have been developed, such that large-scale networks can be modeled to capture impacts that are regional in scale, such as the interactions between multiple TSP corridors and the route choice behavior of drivers.

COMPUTATIONAL RESULTS

This section shows computational results for the OD assignment-based simulation approach using the VISTA software. The project did not include resources for data collection. Instead, planning data were obtained from secondary sources, and adapted to the task of simulation. The network, transit, demand and signal data are briefly described below; further details about the data-related assumptions and challenges are discussed in (4).

The regional network includes 13,566 nodes and 40,163 links. The region is divided into 1778 zones with 2.1 million automobile departures between 7am and 8am. The network also includes over 200 city and suburban bus routes and 12,000 bus stops. 6,165 signal were defined; however, timing plans were not available for the majority of the signals, so most were assigned simple two-phase timing plans with 30-second green times for each phase. These timing plans will eventually be assigned optimized based on flows generated by the simulation.

The VISTA software was run on a Linux server with a dual P3 1GHz processor and 3GB RAM. The model requires 90 minutes for simulation, and 5 days for calculation of shortest paths. Typically, six iterations of the DTA procedure (including simulation and calculation of shortest paths) are performed in order to reach convergence, so a full DTA run takes approximately 30 days. However, once a path set has been calculated those paths can be re-used, thus precluding the time-consuming calculation of shortest paths at each iteration. As such, a full run of DTA (six iterations) can be completed in approximately 9 hours (time required for 6 simulation runs). Preliminary DTA results for the Chicago model are shown in this section.

Preliminary Model Validation

Expressway vehicle counts were compared to the simulation results, and the results for 411 detector locations throughout the region are shown in Figure 1. The figure plots the simulation model's vehicle count output against observed vehicle counts. The diagonal line is a reference line showing where the model counts match the observed counts exactly. Points that lie below the reference line correspond to links where the model's vehicle count was lower than the observed count, and points that lie above the reference line correspond to links where the model's vehicle count was higher than the observed count. The plot shows that most of the model's counts were lower than the observed values, while a few were higher.

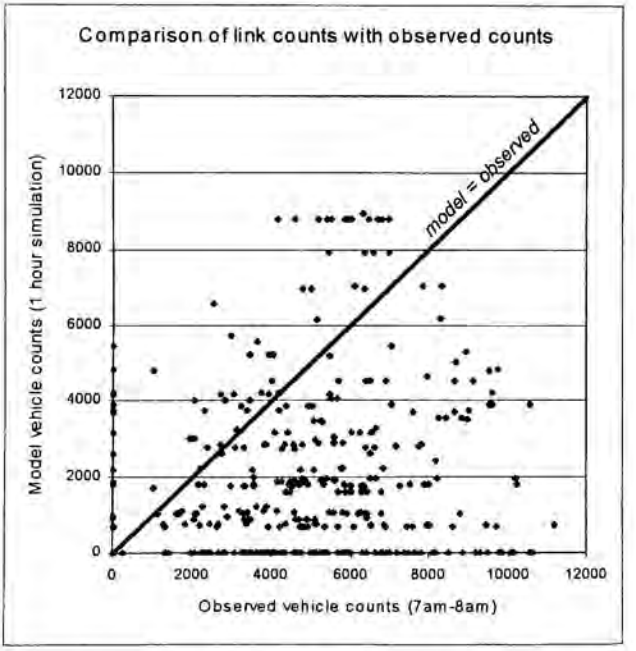


Figure 1: Comparison of model's link counts with observed counts

The discrepancy between the model and observed results highlights the difficulty in matching planning data (automobile OD counts) with detailed operational output (link counts). Whereas the OD trip tables are estimated, the expressway vehicle counts consist of observed data, so the results suggest that the OD trip tables may be incorrect. As such, development of the model will continue with use of the expressway vehicle counts for calibration of OD demands. Validation of model results will rely on travel time studies rather than link counts.

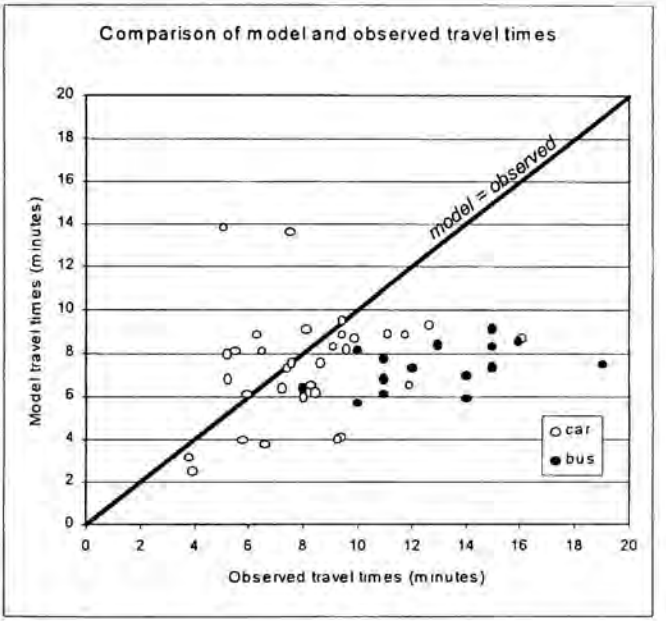


Figure 2: Comparison of model travel times with observed values

A comparison of the model's travel times with observed travel times is shown in Figure 2. The plot examines the automobile and bus travel times for selected corridors around the Chicago area, where each corridor is between 0.8 and 5.0 miles long. As in Figure 1,

a diagonal reference line shows where simulation results match observed results. The plot shows that most of the automobile travel times are reasonably close to the observed values with points scattered both above and below the reference line. By contrast, the simulation computed bus travel times that are consistently faster than the observed values. It is expected that the results will be improved with continued model development and calibration efforts.

Preliminary Analysis of TSP Impacts

When the model has been calibrated and validated, it will be used to estimate the impacts of TSP. An example of the use of the simulation output to evaluate TSP impacts is shown in Table 1.

Table 1: Model estimated travel time impacts of TSP by corridor

Corridor		Distance (miles)	Average transit travel time without TSP (min)	Average transit travel time with TSP (min)	Change in average transit travel time (min)	Change in average transit travel time
Dempster	Crawford to Oak (EB)	2.0	7.8	5.7	-2.1	-27%
	Oak to Crawford (WB)	2.0	7.0	5.2	-1.8	-26%
Dempster	Lehigh to Bronx (EB)	1.9	6.1	6.1	0	0%
	Bronx to Lehigh (WB)	1.9	5.9	4.6	-1.2	-21%
Grand	Green Bay to County	2.7	8.3	7.8	-0.5	-6%
	County to Green Bay	2.7	7.3	6.3	-1.0	-14%
Irving Park	Western to Marine	2.2	7.2	5.5	-1.7	-24%
	Marine to Western	2.2	6.8	5.0	-1.8	-26%
Cermak	Central to Keeler	1.8	5.7	5.4	-0.3	-5%
	Keeler to Central	1.8	6.4	6.6	0.2	3%
Cicero	I-55 to 63rd	1.4	7.5	6.5	-1.0	-13%
	63rd to I-55	1.4	7.4	7.4	0	0%
87th	Cicero to Ashland	4.0	9.2	7.8	-1.4	-15%
	Ashland to Cicero	4.0	8.6	5.9	-2.6	-31%
Halsted	147th to 123rd	3.3	8.4	7.3	-1.1	-13%
	123rd to 147th	3.3	8.2	7.5	-0.7	-8%

The table compares bus travel times along selected corridors under a base scenario (no TSP) and with simple TSP implemented (phase extension and truncation upon detection of a bus). The

preliminary results show that TSP reduced bus travel times by up to a quarter or a third along some corridors; however, in some cases, there was no improvement and along one corridor the bus travel time actually was increased. The reasons for the increase in travel time merits further study.

Further, bus travel times can be examined for complete routes, as shown in Table 2. For example, Table 2 shows the travel time change for bus route 250 along Dempster. The total travel time change for the complete route is less than the total savings along the two WB Dempster St. corridors. The difference results because the corridor averages include other bus routes, but also because changes in the timing plans may affect driver route choices and thus congestion in other parts of the network. As such, it is valuable to evaluate TSP impacts for complete routes, rather than examining only the TSP corridor. Travel time insights for complete routes can be used to determine the efficiency of the use of transit equipment and labor as an impact of TSP.

Table 2: Model estimated travel time impacts of TSP by route (route 250, Dempster WB)

	Travel time without TSP (min)	Travel time with TSP (min)	Change in travel time (min)	Change in travel time
Run A	26.6	25.4	1.2	5%
Run B	24.5	23.3	1.2	5%
Run C	26.2	24.6	1.6	6%
Average	25.8	24.4	1.3	5%

In addition, transit travel time variability can also be considered for both corridors and complete routes. Since the simulation model tracks the location of each vehicle at each time step, the simulation output may also be used to evaluate schedule adherence. Travel time variability and schedule adherence are important measures of both transit service and operational efficiency. These outputs will be illustrated in future research following full calibration and development of the Chicago regional model. TSP

impacts on the general traffic stream will also be examined in further detail. These analyses will show the travel time impacts of TSP and spatial distribution of travel time benefits.

CONCLUSIONS AND FUTURE RESEARCH

Transit signal priority refers to the policy of adjusting signal timing to the benefit of buses. TSP can improve transit service by reducing travel time and travel time variability, which may in turn increase ridership and improve operational efficiency. However, the change in signal timing will also affect the intersection delays experienced by the general stream. As such, route choices of automobile drivers may also change as a result of TSP implementation.

Computer simulation can be used to evaluate the impacts of TSP. Traditionally, TSP is modeled on a corridor-by-corridor basis using microscopic simulation; however this approach fails to capture driver route-choice behavior that results as signal advantages shift. This paper describes an OD assignment-based approach that iterates between mesoscopic simulation and path calculations. The mesoscopic simulation is less detailed in its output than is microscopic simulation, but it is more computationally efficient, making it possible to solve large-scale regional networks. The regional network captures complete bus routes, so that operational efficiency can be more directly observed, as well as complete automobile trips, so that OD path choice behavior can be observed.

An assignment-simulation model is currently being developed to evaluate the regional impacts of TSP in Chicago, and preliminary computational results were presented. Comparisons of simulation vehicle counts and travel times with observed values yielded reasonable results; however, further refinement of the model will be necessary. Further, preliminary analysis of the travel time impacts of TSP were presented; however, a full examination of TSP impacts will be delayed until the model is calibrated and validated.

This study of the regional impacts of TSP in Chicago will continue with further calibration and validation of the model. The validated model will then be used to simulate various TSP scenarios, so that trends in TSP impacts can be observed.

Future development of the VISTA software includes refinement of a hybrid mesoscopic-microscopic model. A hybrid model would allow the majority of the network to be modeled using the less detailed mesoscopic simulation, with areas of interest, such as TSP corridors, modeled at the more detailed microscopic level. This hybrid mesoscopic-microscopic approach would remain a regional OD assignment-based approach, able to capture effects of vehicle routing changes and interactions of TSP corridors. A microscopic simulator has already been coded in VISTA; however, this microscopic model will require significant calibration before realistic results can be expected.

ACKNOWLEDGEMENTS

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REFERENCES

1. Agrawal, B. B., S. T. Waller and A. K. Ziliaskopoulos. A Modeling Approach for Transit Signal Preemption. On the *81st Annual Meeting of the Transportation Research Board, 2002*, Pre-print CD ROM.

2. Peeta, S. and A.K. Ziliaskopoulos. 2001. Foundations of dynamic traffic assignment: The past, the present and the future. *Networks and Spatial Economics* 1 (3/4): 233-65.

3. Daganzo, C.F. 1994. The cell transmission model : a dynamic representation of highway traffic consistent with the hydrodynamic theory. *Transportation Research* 28B (4): 269-287.

4. Chang, E. and A. K. Ziliaskopoulos. Data Challenges in the Development of a Regional Assignment-Simulation Model to Evaluate Transit Signal Priority in Chicago. On the *82nd Annual Meeting of the Transportation Research Board, 2003*, Pre-print CD ROM.

Evaluating Accessibility to Employment by Public Transit from the Commuter's Perspective

Christopher Fullerton
Ph.D. Candidate, University of Saskatchewan and
Lecturer, Brock University

Introduction

In this paper I argue that efforts to promote more frequent commuting by public transit will require better understanding of the infrastructure, facilities and services required by public transit users. Furthermore, I propose that this also necessitates greater attention to contemporary journey-to-work patterns, in terms of both spatio-temporal travel flows and socio-demographic characteristics of the labour force. Finally, I present the preliminary results of a research endeavour in which I am attempting to develop a framework for evaluating employment accessibility by public transit *from the commuter's perspective.*

Background

It is now widely recognized that the "predict and provide" philosophy that has prevailed since the end of World War II can no longer serve as the guiding paradigm for urban transportation planning in Canada and other industrialized nations. This approach, which has generally involved a process whereby "demands [for automobile transportation] are projected, equated with need and met by infrastructure provision at least as far as the public purse will allow"[1], has brought with it numerous environmental, economic and social consequences. To name only a few, these include wasteful levels of resource consumption, air, water and noise pollution, the inefficient use of public funds, and accessibility constraints for individuals who do not

have the use of an automobile to access required facilities and services.

It is with problems such as these in mind that municipalities throughout Canada have embraced the notion of "sustainable transportation" in recent years as a potential alternative to the automobile-oriented "predict and provide" approach. One of the best known and widely accepted definitions of sustainable transportation is that developed by the Toronto-based Centre for Sustainable Transportation, which states:

> "A sustainable transportation system is one that:
> - allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations;
> - is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy;
> - limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, reuses and recycles its components, and minimizes the use of land and the production of noise."[2]

The CST's definition of sustainable transportation is significant for at least two reasons. First, it recognizes the notion of *access needs* and the often-overlooked fact that automobile transportation is only one potential means of serving those needs. Secondly, the CST has advocated a holistic approach to transportation planning in which attention is simultaneously devoted to meeting environmental, economic and social objectives. Thus, a transportation system that is deficient in one or more of these three areas – that is, if it is not environmentally benign, economically efficient *and* socially equitable – cannot be considered *sustainable*.

The notion of sustainable transportation has been incorporated – either explicitly or implicitly – in numerous land use and transportation plans since the early 1990s. Among these are: the City

of Calgary's *Transportation Plan*; the City of Winnipeg's *Plan Winnipeg*; the City of Edmonton's *Plan Edmonton* and *Transportation Master Plan*; the Greater Vancouver Regional District's *Livable Region Strategic Plan* and *Transport 2021* plan; and, the recently amalgamated City of Ottawa's *Draft Official Plan.*

As part of their larger efforts to promote the development of sustainable transportation systems and ultimately to reduce automobile dependency, municipalities have adopted a wide range of policies that give higher priority to public transit planning and investment. Furthermore, many such policies aim specifically to encourage more frequent use of public transit for the journey to work. For example, Calgary's Transportation Plan (or "GoPlan") envisions the following long-term scenario:

> "We live closer to where we work, relying less on our cars for the shorter work trip and more on transit, walking and cycling. While the car remains the dominant choice of travel for Calgarians, investment in transit has resulted in a higher level of service and usage: shorter walk times to transit and LRT [light rail transit] stops and preferential "transit treatment" make the transit trip more attractive and convenient..."[3]

Table 1
Mode of Travel to Work, Canadian CMAs, 1996

Census Metropolitan Area	Primary Mode of Travel to Work (%)				
	Car Driver	Car Passenger	Public Transit	Walk	Other*
Trois-Rivieres	84.1	4.7	2.3	7.0	1.9
Chicoutimi - Jonquiere	83.3	6.5	2.2	6.5	1.5
St. Catharines - Niagara	83.0	7.8	2.0	5.4	1.7
Windsor	82.5	7.2	3.4	5.1	1.9
Oshawa	81.2	8.1	5.6	4.1	1.1
Thunder Bay	81.0	7.8	3.4	5.8	1.9
Sherbrooke	80.2	5.7	5.3	7.5	1.2
Kitchener	79.8	8.8	3.9	5.7	1.8
Regina	79.2	8.0	5.0	5.8	1.9
Hamilton	78.1	7.2	8.0	5.2	1.4
Saskatoon	77.8	7.3	5.1	6.4	3.4
Sudbury	77.8	9.3	5.0	6.4	1.5
London	77.3	7.8	6.1	6.6	2.2
Edmonton	76.9	6.9	9.0	5.0	2.1
St. John's	76.5	12.7	2.4	6.7	1.7
Quebec City	76.2	5.8	9.3	7.2	1.5
Saint John	75.4	11.3	4.6	6.8	1.9
Calgary	72.8	7.2	12.6	5.4	2.0
Vancouver	70.6	6.6	14.3	5.8	2.6
Winnipeg	68.1	9.0	14.4	6.2	2.3
Victoria	67.1	6.8	9.9	9.8	6.4
Montreal	66.6	5.5	20.3	5.9	1.7
Halifax	66.6	10.4	10.9	9.9	2.2
Toronto	65.3	6.7	22.0	4.6	1.5
Ottawa – Hull	64.3	8.8	17.1	7.0	2.8

*** Includes bicycle, motorcycle, taxicab, and all other modes of transportation.**

Source: Statistics Canada. 1999a. *Place of Work*. Ottawa: Minister of Industry. Catalogue number 94F0007XCB.

Contemporary Commuters and their Journey to Work Patterns

If efforts to promote public transit commuting in these or other jurisdictions are to succeed, it is of paramount importance that planners and policy-makers acquire a better understanding of the needs of public transit users. Indeed, the lack of consideration for the infrastructure, facilities, services required by public transit users has been cited on numerous occasions as a primary reason for the automobile's extremely high share of the journey-to-work modal split in Canada (Table 1), complete with its environmental and economic consequences. Furthermore, the lack of attention to public transit user needs has been identified as having social consequences related primarily to the spatio-temporal constraints experienced by individuals who rely on public transit in making their journeys-to-work.

It has been argued that public transit today generally represents a viable mode of commuting for only one subgroup of the metropolitan labour force, namely suburban residents who travel directly to a workplace in the Central Business District during the weekday morning peak period and return directly home during the weekday afternoon peak period[4]. Although still comprising a large share of the total commuter population, commuters with these spatio-temporal travel patterns have become *less* prevalent over the past several decades in light of numerous geographical, economic and social employment trends. These trends and their implications for commuting patterns are discussed below:

1. Geographical trends relate primarily to the continued suburbanization and exurbanization of households and employment. As urban dwellers and jobs have relocated to the urban periphery, reverse commuting and cross-commuting have come to make up a larger proportion of journey-to-work flows. As a result, a smaller proportion of commuters makes the traditional trip between a suburban residence and downtown work location.

2. Economic trends include the increasing prevalence of part-time employment, the rise in moonlighting (in which workers hold two or more jobs), and changes in hours of business operation (e.g. retail operations that remain open until the late evening and on Sundays). The impact of these trends has been an increase in commuting activity during non-peak hours; indeed, commuting has become a 24-hour a day, seven-day-per-week phenomenon.

3. Social trends include the "feminization" of the labour force and the increasing prevalence of dual-earner and lone-parent families. These have had a substantial impact on patterns of commuting in that employed individuals more frequently engage in trip-chaining, whereby the journey to work is combined with travel to other destinations, such as daycare facilities and grocery stores.

As these trends have unfolded, it has become increasingly difficult for many commuters to address their access needs by public transit. A growing proportion of commuter trips now begin and/or end within suburban areas, yet it is within these areas that the infrastructure, facilities and services required by public transit users are most inadequate, if even available[5]. For example, commuters wishing to stop at required facilities and services between home and work face the problem of travelling between locations that are often located far apart from one another, thus reducing the ease with which they can be reached in a timely fashion without the use of a car. Individuals working part-time are also frequently unwilling or unable to commute by public transit as, in many cities, service during off-peak hours (midday, evenings and weekends) and when part-time workers often commute, is often infrequent or altogether unavailable.

These problems are further compounded for individuals who *do not have* access to an automobile for commuting purposes. In their cases, the lack of infrastructure, facilities and services required by public transit users has been found to impose a variety of employment constraints[6]. For example, a reliance on inadequate public transit services in many cases limits the number of areas in which

employment can be obtained and/or the hours in which individuals are able to travel to and from workplaces.

Given the current deterrents to public transit-based commuting, the pursuit of related sustainable transportation objectives therefore presents planners and policy-makers with two key challenges. First, in the case of commuters who have the option of travelling instead by private automobile, public transit is frequently viewed as an inferior mode of travel that does not adequately serve their access needs and is therefore not used[7]. It is therefore necessary to improve the attractiveness of public transit vis-à-vis the automobile, in order that persons who have become accustomed to commuting by car can be encouraged to change their mode of travel to work. Secondly, it is also necessary to eliminate the public transit constraints affecting persons without automobile access to places of employment.

It is only by first identifying constraints to public transit commuting that any weaknesses or deficiencies may be identified and corrected. As a result, planners and policy-makers require a tool for evaluating the conditions under which public transit commuters must currently travel. However, such a tool does not yet exist. The purpose of this research has therefore been to address this gap by developing a framework for evaluating accessibility to employment by public transit that incorporates infrastructure, facility and service considerations. While this is a work in progress, some preliminary findings and ongoing challenges are discussed below.

The Concept of Public Transit Commuter Needs

The evaluation of employment accessibility by public transit amounts essentially to an analysis of public transit commuter needs. Analyses of needs generally entail two steps: defining needs and measuring the servicing of needs. As a result, the first step in this research was to conduct an extensive literature review in which previous studies related to four thematic areas were examined:

1) studies which have explored the needs of *public transit users in general*;

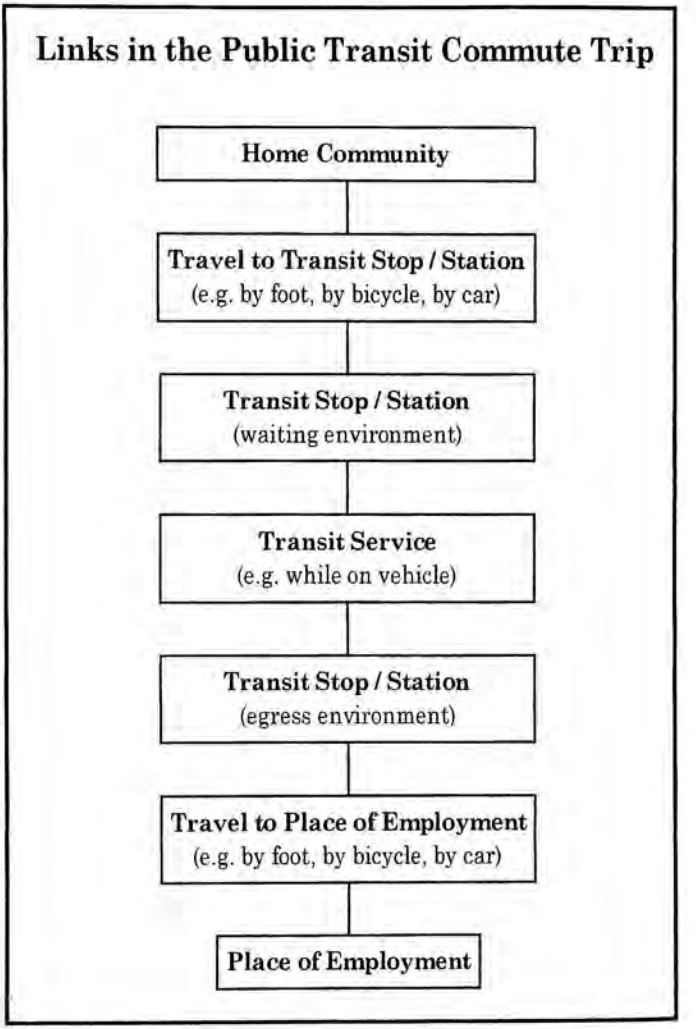
2) studies which have explored the needs of *public transit commuters*, including those of particular commuter subgroups (such as, for example, women and low income earners);
3) studies which have sought to identify factors that encourage, or increase the viability of, travel by public transit;
4) because it is also important to consider modes of access to and egress from public transit, studies that have explored the needs of pedestrians, cyclists and persons who access transit by automobile.

The objective at this stage was to combine considerations for various subgroups of the commuter population – e.g. men, women, persons with disabilities, low-income earners, moonlighters, etc. in order to develop a comprehensive definition of "public transit commuter needs". The studies examined were conducted in three countries where the decline of public transit has become an important matter of concern: Canada, the USA and the UK. Information was generated using a variety of quantitative and qualitative methods, ranging from statistical analyses to focus groups and depth interviews.

Definition of Public Transit Commuter Needs

It was decided that the best way to define public transit commuter needs was by examining their requirements as they relate to each link in the public transit commute trip (Figure 1). Indeed, the journey-to-work by public transit is much more complex than simply riding on a transit vehicle – for example, commuters must also travel to and from stops or stations, and may also need to stop at other destinations. The proposed definition of public transit commuter needs therefore encompasses the wide range of factors that determine the viability of commuting by public transit. Based on the literature review, the needs of public transit commuters were found to include numerous infrastructure, facility and service dimensions. These were synthesized to created a comprehensive definition of "Public Transit Commuter Needs", as outlined below.

Figure 1


Links in the Public Transit Commute Trip
Home Community
Travel to Transit Stop / Station
(e.g. by foot, by bicycle, by car)
Transit Stop / Station
(waiting environment)
Transit Service
(e.g. while on vehicle)
Transit Stop / Station
(egress environment)
Travel to Place of Employment
(e.g. by foot, by bicycle, by car)
Place of Employment

A Comprehensive Definition of Public Transit Commuter Needs

Within the vicinity of their homes, public transit commuters need...

- frequent public transit service that is available when they commute and travels where they commute, or that provides the opportunity to transfer efficiently to another route that travels where they commute
- a variety of shops and services

When travelling between their homes and public transit stops/stations *on foot*, public transit commuters need...

- direct access along aesthetically-pleasant and well-lit walking routes that are highly visible by passing traffic and from adjacent buildings
- wide, properly maintained, obstacle-free and wheelchair-accessible sidewalks that are separated from busy roadways by buffers and cleared of snow and ice during winter months
- road crossing opportunities that include audible, pedestrian-controlled signals

When travelling between their homes and public transit stops/stations *by bicycle*, public transit commuters need...

- direct access along aesthetically-pleasant and well-lit bicycle routes that are highly visible by passing traffic and from adjacent buildings
- wide, clearly demarcated and obstacle-free bicycle lanes

When travelling between their homes and public transit stops/stations *by automobile*, public transit commuters need...

- easily accessible, well-lighted, highly visible, and security-monitored park-and-ride facilities that provide ample free parking and direct access to a transit stop/station

A Comprehensive Definition of Public Transit Commuter Needs (continued)

When waiting at a public transit stop/station, public transit commuters need...

- a clean, well-lighted, highly-visible and paved boarding area
- shelter from the elements
- information, including scheduled arrival times, impending service changes, route maps and system maps
- trash receptacles and newspaper boxes
- [in the case of stations] convenience stores/vending machines, public and emergency telephones, public washrooms
- [in the case of commuters accessing public transit by bicycle] bicycle racks or storage facilities

When travelling on public transit vehicles, public transit commuters need...

- safe, friendly and reliable service from drivers who announce upcoming stops
- clean, universally accessible, uncrowded public transit vehicles
- [in the case of commuters who combine bicycle and public transit travel] bicycle racks on public transit vehicles

When alighting at a public transit stop/station, public transit commuters need...

- a clean, well-lighted, highly-visible and paved alighting area
- shelter from the elements
- [in the case of stations] convenience stores/vending machines, public and emergency telephones, public washrooms

A Comprehensive Definition of Public Transit Commuter Needs (continued)

When travelling from public transit stops/stations to their place of employment *by foot*, public transit commuters need...

- direct access along aesthetically-pleasant walking routes that are highly visible by passing traffic and from adjacent buildings
- wide, properly maintained, obstacle-free and wheelchair-accessible sidewalks that are separated from busy roadways by buffers and cleared of snow and ice during winter months
- road crossing opportunities that include audible, pedestrian-controlled signals

When travelling from public transit stops/stations to their place of employment *by bicycle*, public transit commuters need...

- direct access along aesthetically-pleasant bicycle routes that are highly visible by passing traffic and from adjacent buildings
- wide, clearly demarcated and obstacle-free bicycle lanes

Within the vicinity of their place of employment, public transit commuters need...

- a variety of shops and services
- [in the case of commuters who combine bicycle and public transit travel] bicycle racks or storage facilities

Measuring the Servicing of Public Transit Commuter Needs

The second and ensuing objective of this research endeavour is to develop a tool that can be used to evaluate accessibility to employment by public transit – in other words, to determine whether public transit commuter needs are being adequately served. Perhaps the most significant challenge in this regard is to develop an evaluation tool that combines: 1) a satisfactory degree of academic rigour, in order to ensure its acceptability as a legitimate research mechanism; 2) an appropriate level of user-friendliness, in order to ensure that it does not intimidate potential users by its complexity; and 3) a reporting format that is both understandable and useful to the readers of the final results.

In working towards this objective, while also taking into consideration the concerns noted above, the methodological foundation utilized for this endeavour will be the "need analysis" process. Need analysis is a tool for identifying and evaluating needs that has been widely used in community planning and development for several decades - in the areas of housing and education, for example. The general purpose of a need analysis is to objectively measure existing conditions as they relate to a particular need, to compare these with prescribed standards (or minimum acceptable levels of service) and, ultimately, to identify areas where needs are not adequately served. The proposal here is therefore to create a framework for conducting a "Public Transit Commuter Need Analysis" (hereinafter referred to as "PTCNA") (Box 1).

BOX 1
STEPS IN PUBLIC TRANSIT COMMUTER NEEDS ANALYSIS (PTCNA)

1. Select place of employment (POE) for which the PTCNA will be conducted.
2. Identify temporal commuting patterns for POE.
3. Select the community from which accessibility to the POE by public transit will be analysed.
4. Collect information related to each link in the public transit trip, beginning in the selected community and ending at place of employment.
5. Compare results with prescribed standards.
6. Evaluate how well public transit commuter needs are being served.
7. Prepare report and submit to target audience.

Conclusion

This ongoing project is currently at the stage of identifying and selecting appropriate indicators that can be utilized in conducting the PTCNA. Once again, the approach deemed to be most logical has been to evaluate the conditions under which commuters must currently travel by public transit by examining the availability of required infrastructure, facilities and services as they relate to each link in the public transit commute trip. Once the framework has been established, a trial application will be conducted in the City of Ottawa.

Endnotes

[1] Owens 1995: 44

[2] Centre for Sustainable Transportation. 1998. *Definition and Vision of Sustainable Transportation*. Toronto: Centre for Sustainable Transportation.

[3] City of Calgary. 1995. *Calgary Transportation Plan*.

[4] Hanson, S. and Pratt, G. 1988. "Reconceptualizing the Links between Home and Work in Urban Geography," *Economic Geography* 64, no. 4, pp. 299-321.

[5] Perl, A., and Pucher, J. 1995. "Transit in Trouble? The Policy Challenge Posed by Canada's Changing Urban Mobility," *Canadian Public Policy* 21, no. 3, pp. 261-283.

[6] Mensah, J. and Ironside, R. G. 1993. "Employment Opportunities of the Urban Poor: An Assessment of Spatial Constraints and the Mismatch Hypothesis." In *Public Issues: A Geographical Perspective*, J. Andrey and J. G. Nelson, eds. Waterloo, Ontario: University of Waterloo, Faculty of Environmental Studies, Department of Geography, pp. 111-131; Rutherford, B.M. and Wekerle, G.R. 1988. "Captive Rider, Captive Labor: Spatial Constraints and Women's Employment," *Urban Geography* 9, no. 2, pp. 116-137.

[7] Pucher, J. 1998. "Back on Track: Eight steps to rejuvenate public transport in Canada," *Alternatives Journal* 24, no. 1, pp. 26-35; Rosenbloom, S. and Burns, E. 1994. "Why Working Women Drive Alone: Implications for Travel Reduction Programs," *Transportation Research Record* 1459, pp. 39-45.

BUS TRANSPORTATION -TOWARDS REGULATORY REFORM IN INTERCITY BUSING?

Joseph Monteiro*

Introduction

Busing is an important form of urban, intercity and school transportation in Canada, particularly to segments of the population with modest means. Parts of it are heavily subsidized, parts of it have been historically declining, and most of it has a fragmented regulatory framework across Canada. The need for regulatory reform has been suggested by the Royal Commission on the National Passenger Transportation, the Canadian Intercity Bus Task Force, Transport Canada, and the Canada Transportation Act Review Panel. However, little has yet been accomplished in Canada. This is not because of a lack of desire to introduce reform but rather due to a failure to achieve consensus among the Provinces.

In this paper, Part I examines the structure of bus transportation in Canada. Part II reviews the regulations that existed in the 1980s, and the regulatory developments thereafter. Part III describes the activities of the Competition Bureau in busing. Part IV reviews the experience of bus deregulation in the US, UK and Canada. Part V examines the need for deregulation of intercity busing in Canada.

I. Bus Transportation in Canada

This section describes the significance, the structure, the types of services and sources of revenue, the firms and the concentration in the bus industry.

a) The Significance of Bus Transportation in Canada

Bus transportation plays an important role in the movement of people both within a city and between cities. This role has become more important especially at a time when attempts are being made to control road congestion, environmental pollution and energy consumption. In 2000, bus transportation services accounted for $6.2

billion in revenues and provided full-time employment for more than 65,982 individuals. Its importance is also suggested in its share of the intercity passenger market in terms of passengers shown in Table 1.

Table 1 - The Intercity Bus Passenger Market Share by Modes (1987-1998)

Transportation Sectors	1987	1998
Bus	44%	32%
Air	43%	58%
Rail	13%	10%

Source: The Canadian Intercity Bus Industry Orientation Document, Minister of Transport, March 2001.

In 1987 it was 44% compared to 32% in 1998. Today, the passenger market share by air exceeds that by bus.

b) The Structure of Bus Transportation in Canada

The structure of bus transportation services is presented in Table 2 along the lines of government published data: urban transit; intercity busing; school busing; and charter. The statistics over the period

Table 2 - The Bus Industry by Segments (1986-2000) - Revenue/Establishments

Bus Industry	1986	1995	2000
Urban Transit	2,283/2,923.2*	3,579.7/3,435.4*	4,265.7/3,758.3*
Intercity Bus	336/430.2*	367.9/353.1*	127.6/112.4*
School Bus	640/819.5*	1,052.6/1,010.2*	1,459.6/1,286*
Charter Bus	154/197.2*	243.2/233.4*	378.4/333.4*
Total Revenue	3,413/4,370*	5, 243.4/5,032*	6,231.4/5,490.2*
Total Establishments**	960	878	968

Source: Passenger Bus and Urban Transit Statistics, Statistics Canada, 53-215-XIB. * Converted to 1992 dollars. ** Revenues $2000000+

1986-2000 reveal that the revenue of the intercity bus sector has been declining in relative and absolute terms. This decline is quite pronounced. In contrast, the revenue of school bus and the charter bus sectors have increased.

c) Types of Bus Services and Revenue From These Services

The types of services provided by buses are: urban and suburban; scheduled intercity; school bus; bus charters, sightseeing and shuttle; express parcel; and other passenger services. Their major sources of revenue (excluding subsidies) appear along the diagonal in the first half of Table 3. A significant portion of the revenue from express parcel is derived from the school bus industry, this contrasts with the past when there was a major shift in 1998 from intercity busing (statistic not shown). Subsidies are one of the most noticeable components of urban transit revenue.

Table 3 - Types of Bus Services and Revenue From Services 2000

Bus Industry	Urban	Scheduled	School	Charters	X Parcel	Other	Subsidies	Total
Urban Transit	**1888.5**	0	1.8	4.8	0	**105.1**	**2,265.6**	4,265.7
Intercity Bus	5.4	**72.8**	2.5	14.8	16.7	10.9	4.4	127.6
School Bus	46.9	163.7	**939.2**	178.0	**76.8**	54.7	0.3	1,459.6
Charter Bus	15.4	34.0	21.0	**251.4**	2.2	54.1	0.3	378.4

Source: Passenger Bus and Urban Transit Statistics, Statistics Canada, Cat. No. 53-215-XIB.

d) Bus Services by Province of Operation

Bus services by province of operation are shown in Table 4. Not

Table 4 - Bus Services by Province of Operation (Revenue and Establishments) 2000

Bus Industry	Ont	Que	B.C.	Alberta	Manitoba	Atlantic	Canada
Urban#	2,056	1,081.6	569.6	384.2	124.4	49.8	4,265.7
School	918.4	382.5	12.7	130.3*		15.8	1, 460
Charter	119.0	83.5	66.6	47.7*		5.4	322

Source: Passenger Bus and Urban Transit Statistics, Canada, 53-215-XIB. * Alberta, Manitoba and Saskatchewan . # Includes subsidies

unexpectedly, the provinces of Ontario and Québec account for a significant proportion (51.1% and 25.6%) of the above noted operating revenues.

e) The Firms in the Bus Transportation Industry

Urban transit in each province is generally provided by one

company because of the licensing practice of awarding monopoly on routes. There were 67 operators in the transit segment in 2000 with annual revenues of more than $200,000. Examples of such companies are: TTC in Toronto, STM in Montreal, OC Transpo in Ottawa, Outaouais in Hull, BC Transit, etc. Most of these transit systems receive very large subsidies.

In intercity bus transportation, there is one national network operated by Laidlaw Inc. the largest busing company (which owns Greyhound Lines of Canada, Laidlaw Motor Coach, Grey Goose Bus Lines, Voyageur Colonial, Chatham Coach, Penetang Midland Coach Lines, etc.). It operates more than 490 coaches. The other operators are regional intercity 'scheduled' carriers. The largest of the 27 operators in 2000 (with annual revenues of more than $200,000) were: Pacific Western Transportation Inc. (i.e., Red Arrow); Saskatchewan Transportation; Ontario Northland; Trentway-Wagar and Erie Coach (Stagecoach PLC); Orleans Express; Les Autobus Maheux; Autocar National; Intercar; SMT/Acadian, and DRL. The above noted national and regional carriers operate more than **70%** of all coaches. Laidlaw, the largest, has a market share of more than 45% both in terms of coaches and passengers.

The school bus industry in Canada consisted of 718 operators in 2000 (with annual revenues of more than $200,000). Laidlaw Inc. entered the school transportation business in 1979 through acquisition of Travelways Ltd. in Ontario. After several acquisitions - Mayflower Contract Services, National School Bus Service, Charterways Transportation and Cancom Transportation, etc. - it became the largest school bus operator in Canada in 1994.

The charter bus industry in Canada consisted of 156 operators in 2000. The largest in the preceding year were: Autocar Connaisseur Inc; Kunkel Bus Lines; Brewster Transportation and Tours; Autocars La Capitale Inc.; Gray Line of Victoria (Laidlaw); Charter Bus Lines of BC; Vancouver Island Coach Lines (Laidlaw); Canamera Tours Ltd. (International Coach Tours); and International Stage Lines. These companies accounted for approximately 40% of all coaches. Five of the these companies, the last five noted above, are located in

British Columbia, and account for approximately 20% of all coaches in Canada.

f) Concentration in the Bus Industry

A special tabulation was made by Statistics Canada in 1995-6 to study concentration trends over the period 1982-1992 in the scheduled intercity bus industry and in the charter bus industry. The statistics reveal that for the largest 5 and largest 10 intercity carriers concentration rose from 1980 to 1986 and fell thereafter till 1992. For the largest 5 carriers, the proportion of revenues accounted by them for the above three years were: 73.4, 83.5 and 72.7; and for the largest 10 carriers, it was 89.3, 94.8 and 88.3. For charter carriers, for both the largest 5 and the largest 10, the proportion of revenues accounted by them have declined from 1982 to 1992. In the case of the former from 41.6 to 31and in the case of the latter from 55.8 to 49.1. Concentration has likely increased in the intercity bus industry in light of the acquisitions since 1992.

It should be noted that the overall concentration statistic can be misleading as to the extent of competition since each specific route has to be examined. Further, it has been pointed out by economists that as long as there are no specific barriers to entry and the industry is contestable, concentration per se in any sector should not be a matter of concern. Finally, the extent of competition from other substitutable modes of transportation (automobile, rail, and air) should be considered before arriving at any conclusion as to the significance of concentration.

In sum, the structure of the bus industry (intercity) has been changing dramatically over the last few years with the recent acquisitions. "Direct competition ... is currently limited to the Edmonton-Calgary-Fort McMurray corridor (Greyhound and Red Arrow) and routes in Southern Ontario, particularly around Toronto and on the Toronto-Niagara corridor (Greyhound, Trentway, PMCL, Ontario Northland)"[1]. Laidlaw is the only carrier with a national network and on a number of routes it has a monopoly.

II. Regulations in the Bus Industry

Extra provincial bus transportation in Canada is regulated pursuant to the *Motor Vehicle Transportation Act* (i.e., MVTA) which was enacted in 1954. This includes not only extraprovincial operations but also intraprovincial operations by extraprovincial carriers and operations to international locations. The MVTA delegates the federal powers of regulation to the Provinces. As a result, regulation varies from province to province[2]. Intra provincial busing is regulated under the motor carrier laws of each province[3]. The MVTA and provincial acts are administered by various motor carrier transport boards or commissions in each province with names that may not be identical[4] and these boards act as federal boards when dealing with extraprovincial matters.

a) A Brief Review of Regulations in the 1980s

In the 1980s, bus regulation in Canada was extensive and busing

Table 5 - Regulatory Framework of Busing by Provinces in the 1980s

		R A T E			
Province	Entry-Exit Control	Intra/Extra-Provincial Scheduled Service	Charter	Parcel Express	Tariff Filing
British Columbia	Yes	Yes/No	Yes	Yes	Yes
Alberta	Yes	Yes/Yes	Yes	No	Yes
Saskatchewan	Yes	Yes/No	Yes	Yes	No
Manitoba	Yes	Yes/No	Yes	Yes	Yes
Ontario	Yes*	Yes/Yes	Yes	Yes	Yes
Quebec	Yes	Yes/Yes	Yes	No	Yes
New Brunswick	Yes	Yes/Yes	No	Yes	Yes
PEI	Yes	Yes/No	No	No	Yes
Nova Scotia	Yes	Yes/NAP	No	Yes	Yes
Newfoundland	Yes	Yes	Yes	Yes	Yes

* Limited Exit control. NAP=Not Applicable.

was tightly regulated. To indicate the regulatory process, one

province is used as an example. In British Columbia, the BC Motor Commission regulates extra-provincial bus services as if they were intraprovincial services which are subject to their *Motor Carrier Act*[5]. In considering a licence application in B.C., the criteria considered in applying the public convenience and necessity test are: objections of other transport operators in the same market; the effect of the proposed service on other transportation services and the public interest; and the quality and permanence of the proposed service and the fitness and ability of the applicant to provide a proper service. There are two types of licences: one for scheduled service with a prescribed fare; and the other for charter, tour and other non-scheduled service. The criteria are much more strictly applied for scheduled service. The number of vehicles to be operated under a licence is also specified by the Commission. A carrier must also seek authorization from the Commission to modify, extend or discontinue a service. Further, the legislation provides for fare regulation (intra-provincial). When tariffs are filed, the Commission examines these fares in comparison to those filed by other carriers. Once the fares are approved, the Commission uses them as a base to evaluate further fare applications.

The extent of economic regulation in the provinces in the 1980s is summarized in Table 5. This regulatory framework for busing was left unaffected by the reforms introduced in 1987 which deregulated extra-provincial trucking by requiring a reverse onus test until 1992 and a fitness test thereafter.

b) Regulatory Developments in the 1990s and the Current Status

The matter of regulatory reform arose in the mid 1990s in the context of the federal-provincial internal trade negotiations[6] regarding economic regulation of the intercity bus industry but no consensus was reached.

In addition, a number of reviews were undertaken on busing in the 1990s which will be briefly summarized. First, in 1992 the Royal Commission on National Passenger Transportation undertook a review. It recommended deregulating the extra-provincial bus industry. Second, in 1996 the Canadian Intercity Bus Task Force

recommended deregulation of the charter bus industry and recommended the streamlining of regulatory requirements for scheduled bus service to eliminate or minimize most forms of economic regulation, other than entry control.

The discussions and the developments in the above context provided the impetus for further review, and in 1996 Transport Canada after consultation with the provinces and industry released a MVTA Review Discussion Paper in April 1997. The Discussion Paper "proposed deregulating charter bus services and streamlining the regulatory requirements for scheduled bus service through amendments to the *Act*, followed by full deregulation after a two-year interval[7]." In Feb. 1998, Transport Canada published its Position Paper "Review of the Motor Vehicle Transport Act" outlining proposed amendments to the *Motor Vehicle Transport Act*[8].

In light of the above, amendments to this *Act* (Bill C-77) were introduced by the Transport Minister in the House of Commons on March 25, 1999. The reason provided for the amendments was because the current regulatory regime in which extra provincial bus carriers operate is becoming increasingly inconsistent and fragmented. Further, a number of provinces and territories are prepared to abandon economic regulations as deregulation would ensure that extra provincial carriers are treated consistently. This deregulation by increasing competition will help the bus industry operate in a more efficient and productive manner. The amendments were also designed to improve safety in the Canadian motor carrier industry. The amendments would over the two-year period, deregulate extra provincial and international bus service, while leaving the provinces and territories discretion as to whether to continue to regulate intra provincial bus service during this transition period[9]. The amendments did not complete the legislative process prior to prorogation in September 1999.

"In September 1999, the Minister of Transport announced that, in the absence of consensus on the future of extra-provincial bus regulation in Canada, he would not proceed with proposed amendments to deregulate the bus industry"[10]. Instead, he would

refer the issue of bus regulation in Canada to a Parliamentary Committee for examination and prepared a document entitled *The Canadian Intercity Bus Industry Orientation Document* (March 2001). In June 2001, the Canada Transport Act Review Panel released its report. It did not address the question of bus deregulation as the matter was referred to the above Committee but realizing the problems recommended that 'the Minister of Transport continue the process already initiated to address regulatory fragmentation in the bus industry'[11]. In March 2002, the Standing Senate Committee on Transport and Communications began hearings on intercity bus.

Thus at the time of the hearings: Nova Scotia, Québec, Manitoba, Saskatchewan, and BC maintained significant economic regulation; N.B., Yukon, Ontario and Alberta maintained lighter economic regulation; and PEI, Newfoundland, NWT and Nunavut were deregulated. Over the last few years, changes have gradually occurred to the regulatory status of extra-provincial busing.

III. The Competition Bureau's Activities Related to Busing

The Competition Bureau has a long standing interest in busing as indicated by its activities in advocacy, enforcement and mergers. These are summarized in the tables below.

Advocacy: On the advocacy front, it made a few interventions in busing. The interventions to various regulatory bodies or Commissions either supported licence applications or proposed deregulation in intercity busing. These are shown in Table 6.

Enforcement - Criminal: On the enforcement front, the Bureau examined complaints in busing under various sections of the *Competition Act*. Those that resulted in a conviction or a guilty plea together with the fines and/or prohibition order are shown in Table 8. Most of the complaints involved false representation or bid-rigging.

Of the above cases, the only noteworthy case involved four busing companies, i.e., case 3 in Table 7. New jurisprudence was established with regard to bid-rigging. The Judge indicated that in the case of identical bids, to avoid violation of the bid-rigging section, affirmative notification by the parties is required making the bids.

Table 6 - Interventions in Busing

Name of Intervention and Nature of Intervention	Outcome
1. The Legan Bus Lines (1982). The Commissioner supported Legan's application for extra-provincial bus operating authority.	The Alberta Motor Board did not grant the licence.
2. The Alberta - Review of Intercity Bus and Trucking Regulation (1983). The Commissioner proposed relaxing entry into some intercity bus and trucking markets.	The Govt. deregulated intra-provincial charter busing.
3. The Populaire Express Inc. (1986). The Commissioner supported Populaire's application for extra-provincial operating authority.	Application withdrawn.
4. NTA - Hearing on VIA Rail (1988). Voyageur Colonial Limited challenged VIA's proposed tariff. The Commissioner elaborated on predatory pricing.	The proposed tariffs were found prejudicial by the NTA.
5. The Royal Commission on National Passenger Transportation (1990-1). The representation emphasized an integrated approach to inter-city passenger transportation, economic efficiency, greater reliance on competition and targeted financial assistance rather than cross-subsidization of unprofitable routes.	The Commission proposed user pay costs and reliance on competition.
6. Submission to the National Transportation Act Review Commission (1992). The submission proposed extending the transportation reform initiative introduced in 1987, and proposed open entry and pricing freedom.	The Commission made no recommendation on intercity busing.
7. The Submission to the Canada Transportation Act Review Panel (2000). The submission advocated deregulating extra-provincial and international busing (i.e., scheduled passenger, charter passenger and express parcel service) as it could lead to lower fares, increased services, etc.	The Panel recommended that the Minister continue the process to address fragmentation.
8. The Submission and appearance before the Senate Committee (2002). Same as 7.	The Panel recommended a reverse onus entry test.

Table 7 - Criminal Cases in Busing

Company Convicted or Charged	Section*	Fine
1. Voyageur Colonial Limited (1978)	s. 36(1)(a) 2 counts	$1, 500 on each count
2. Voyageur Colonial Limited (1978)	s. 37.1	$200
3. Four Bus Companies (1978)	s. 32.2 (2)	$52, 000
4. Music Mann Tours Limited (1983)	s. 36(1)(a)	$3,000
5. Travelways Tours Limited (1984)	s. 36(1)(a)	$3,500
6. Wainwright Transportation (1984)	s. 47(2) 2 counts	$3,000 and $5,000
7. Gray Line of Vancouver Inc. (1985)	s. 33	Prohibition Order
8. Association du Transport Écolier du Québec (1988)	s. 47	$23, 000 and Prohibition Order

* Section 36 - false or misleading representation; s. 37.1- sale above advertised prices; s. 33 - monopoly; and s. 32.2(2) or s. 47(2) - bid-rigging.

The notification of identical bids prior to the opening of the bids should be made to the caller of bids.

Civil (Mergers): A few mergers in intercity busing have also been reviewed by the Competition Bureau under section 93 of the *Competition Act*, however, none have been taken to the Competition Tribunal so far.

IV. A Brief Review of the Studies on Bus Deregulation in the US, the UK and Canada

In this section, a few studies [12] on the impact of deregulation in the US, the UK and Canada will be briefly noted.

a) A Brief Review of the Experience in the US

C.V. Oster and C.K Zorn (1985): The authors noted a steady decline for at least 9 years in the number of communities (the smallest) receiving intercity bus service and in the amount of bus service provided. However, these trends were also observed before deregulation. Franchising to low cost carriers was able to halt some of the service reductions. Further, the rapid growth in post-deregulation charter service could compensate for losses on regular routes and service impact on small communities.

R.J. Button (1987): This study found that there was an increase in licence applications to supply intercity services. As a result, new services emerged (especially airport express and casino). A number of services were discontinued but this change also occurred before deregulation. In addition, the main carriers became more efficient by focusing on profitable routes and improving internal efficiency.

E.A. Pinkston (1986): This study indicated that deregulation was highly successful in stimulating competition (including competition from new entrants). However, the impact on interstate fares was minimal and only .5% of the US population were slated to lose service. There were some cutbacks in service and also a decline in wages. While the industry languished under regulation, deregulation enabled the industry to respond to the demands for new service.

D. B. Vellenga, D.L. Shrock and R.A. Peterson (1986): The authors found that operating and marketing strategies were revised and were

aimed at developing charter, airport and affinity markets. Further, the structure of the industry was modified by new entrants. Finally, the industry used the freedom granted under regulatory reform to enhance its position in transportation.

James H. Miller (1990): This study indicated that abandonment of unprofitable services by scheduled carriers, rate increases for intrastate routes, and an explosion in the number of new charter and special operations authority applications were expected with the bus reforms in the 1982 Act. However, the first two negative consequences noted above were not as severe as early studies suggested. Pennsylvania, the state given special consideration, experienced only minor losses of service, and retained most of its intercity service. When service was abandoned, publicly funded rural transit systems were able to meet the needs of those who had no alternative. Finally, the reforms resulted in an industry structure that offers promise for preservation and improvement of service.

Transport Canada (2001): The impact of deregulation on busing in the US was summarized by Transport Canada as "Deregulation occasioned a major re-structuring of the American industry. Generally, the industry shifted away from network-oriented intercity service towards regional, charter and niche services. While charter was the clear beneficiary of deregulation, and while there was small community service loss, the American industry has not shrunk in recent years, in contrast to the situation in Canada"[13].

b) A Brief Review of the Experience in the UK

D.M. Cape (1985): The author reported a change in the structure of the industry (mergers, bankruptcy and one successful new entrant), and a flurry of new services (especially on major trunk routes). There was also a decline of service on some routes, however by 1983, the industry as whole succeeded in reversing its decline over 1975-80. Further, there was an improvement in service quality and strong price competition on trunk routes led to very low fares.

W.K. Tally and R.P. Kilvington (1985): The authors found that deregulation significantly increased charter, tour and excursion service. New scheduled intercity bus service also increased. Consolidation

occurred along trunk lines and attempts were made to establish one major express coach firm. Both quality of coach service and quality of coaches to larger population centres increased. In contrast, service to smaller population centres deteriorated. Finally, fares for express coach services declined.

A.K. Cross and R.P. Kilvington (1985): The authors reported that in the first three years of deregulation, coach users benefited from competition. Reduced fares, improved quality and greater choice occurred on major trunk routes. However, there was a decline in service on some secondary routes. Free competition reinforced specialization between large and small operators. Further, more long-term competition took place within the seasonal express market.

c) A Brief Review of the Experience in Canada

The experience of limited deregulation in Canada can be summarized as follows "Several provinces which have deregulated or liberalized regulation (Alberta, Ontario, New Brunswick, Newfoundland) have not reported significant service abandonment. For example, New Brunswick reported in 1995 that scheduled bus service had "remained stable" during the first seven years after the relaxation of economic controls in 1988. In contrast, Québec, which maintains full economic regulation, reported 43 instances of service abandonment in the province between 1986 and 1995. Economic regulation thus does not always ensure the continuation of low density service, or prevent service abandonment. Nor does deregulation necessarily mean its abandonment"[14].

In sum, the studies and experiences in the US and UK indicate that deregulation of intercity busing has had some beneficial effects though one has to be cautious when extrapolating from other experiences.

V. Towards Regulatory Reform in Intercity Busing?

More than a decade has passed since the Royal Commission on National Passenger Transportation (i.e., RCNPT) called for regulatory reform but little progress has been achieved to date. The rationale for regulation of intercity busing has been based on the following arguments: the natural monopoly characteristics of the industry; the

need to ensure service to small communities; and the possibility of redistribution to those less fortunate in our society. We shall briefly examine these arguments.

First, for a natural monopoly (decreasing long run cost) situation to occur, it must be shown that: a. Fixed costs must be equal to a large percentage of total costs, b. Fixed capital assets must have a very long life and be highly indivisible, and c. The production process must give rise to very large economies of scale. The evidence indicates that the industry does not exhibit economies of scale, since a greater proportion of costs are variable. Vehicles can be easily moved to different routes or sold in the same location or other locations. Terminals can also be sold and it does not appear that the sunk cost associated with terminals in this industry are very significant. In light of the above, most academics have agreed that the industry does not display characteristics of a natural monopoly.

Second, the need to ensure service to small communities is based on the ability to cross-subsidize which requires regulation to control entry. One, the ability to cross-subsidize does not guarantee provision of services to small communities. Examples are service abandonments in Saskatchewan and Québec on routes with low density. Two, cross-subsidization has hidden costs associated with it. Cross-subsidization prevents some services from being competitive with alternative modes of transportation. Three, it prevents other viable services from developing eg., mini-vans, etc. Four, there may be alternative ways to achieve the intended objectives of cross-subsidization.

Third, the argument to provide services to individuals of modest means (or redistribution) also appears to be questionable. A large proportion of bus users on all routes are the elderly, students or low income users. Subsidizing the less fortunate users of low density routes by charging higher fares to the less fortunate of high density routes is redistribution that is questionable. Therefore, the above three arguments on which the rationale for regulation in intercity busing is based does not appear to be valid.

Deregulation could lead to numerous benefits which has been convincingly stated by the RCNPT in 1992 "Regulation has its

drawbacks. Our analysis suggests that average intercity bus transportation costs are higher than they would be in a more open market, in part because of lower efficiency." Further, it states "Our research indicates that there would be advantages to travellers if the Canadian bus industry faced more competition. In a more open market, carriers would rationalize service and trim costs or lose market share on profitable routes to lower-cost competitors. Easier market entry would invite innovative services that could reverse, or at least slow down the current decline in bus ridership. Competition or potential competition on higher-volume routes should lead to lower fares. ... Relaxed economic regulation would encourage innovation and entry of new operators in some markets, and more carriers in a market should increase service choice. Intermodal connections and innovative management techniques would be encouraged by a more competitive environment. Mini-bus operations and a variety of part-time ventures offering scheduled service would replace inefficient full-sized coach services to some smaller communities"[15]. Other national reviews or reports also favour deregulation[16].

In early 2002, the Senate Standing Committee on Transport and Communications held hearings on Intercity Busing and released its Report in December 2002. The majority of the Committee members concluded that governments should gradually pull out of regulating fares and should allow competition to govern service standards and prices. Given the divisive nature of the testimony and the fact that some areas would be left without service, the Committee recommended that the economic regulatory regime for extra-provincial bus transportation be amended to require at most a reverse-onus test for entry into service, and that after five years a formal review be conducted to determine whether further deregulatory steps might be appropriate. In addition, the Committee recommended that the federal government re-evaluate the need for consensus among all the jurisdictions and players before initiating action on intecity bus policy[17].

In sum, the rationale for economic regulation of intercity bus is not convincing and deregulation is likely to lead to benefits.

Concluding Remarks

The basic reason for not proceeding with reforms in the intercity bus industry to date in Canada is because of lack of consensus among the provinces and not on the merits of whether the reforms will be beneficial to 'all of Canada'. Making policy recommendations are usually not easy when varied individual interests have to be satisfied. Yet decisions that transcend individual interests have to be made.

Based on the merits of the economic arguments, it is difficult for economists not to avoid falling back on the belief that freedom of entry is more likely to improve efficiency than not, unless there are some significant externalities which point in some other direction. Fortunately, the latter does not apply in the intercity busing industry. This was acknowledged by the Senate Committee in its statement "the academic observers argued vigorously for a shift to a deregulated regime. To them the economic advantages of deregulation are clear, and the purported benefits of a regulated system are illusory, with the real effects being poor service and a lethargic industry."[18]

The recommendation of the Standing Committee to introduce partial deregulation instead of complete deregulation, due to social and political considerations as a result of the divisive nature of the testimony, means that we are only half way there. It is my opinion that complete deregulation of extra-provincial and international bus services (i.e., scheduled passenger, charter passenger and express parcel service) with the $30m. per annum subsidy (recommended by the Committee) equal to extent of the cross-subsidy on non-profitable routes would have been a fair resolution to this problem. Consensus is not a viable solution when it is generally not feasible. We have been trying to get consensus for fifteen years and we do not seem to be getting anywhere. Public policy should strive to prevent the existing market structure from being frozen. Keeping the way open to change will ensure that a structure emerges that is most suitable to meet the needs of all society.

* *The views expressed are those of the author and not necessarily those of the Competition Bureau.*

Endnotes

1. Transportation in Canada, Annual Report 2000, 2001, p. 122.
2. The MVTA was a direct result of a Supreme Court decision in 1954, prior to this period intercity busing was regulated by the provinces as a result of regulation introduced in the 1930s.

3. *The Motor Carrier Act* in B.C.;*The Motor Transport Act* in Alberta; *The Vehicles Act* in Saskatchewan; *The Highway Traffic Act* in Manitoba; *The Public Commercial Vehicles* and *The Highway Transport Board Acts* in Ontario; *The Transport Act* in Québec; *The Motor Carrier Act* in New Brunswick; *The Motor Carrier Act* in PEI; *The Motor Carrier Act* in Nova Scotia; and *The Motor Carrier Act* in Newfoundland.

4. The Motor Carrier Commission, Motor Transport Board, the Highway Traffic Board, the Highway Transport Board, the Transport Commission, the Motor Carrier Board, the Public Utilities Commission, and the Board of Commissioners of Public Utilities.

5. The objectives in the legislation are "to promote adequate and efficient service and reasonable and just charges, and to promote safety on the public highways, and to foster sound economic conditions in the transportation business of the Province."

6. This led to the Agreement on Internal Trade through which all provinces agreed to deregulate intra-provincial trucking and the federal government agreed to repeal Part III of the MVTA through the Agreement on Internal Trade Implementation Act.

7. Transportation in Canada, 1999, Annual Report 1999, p. 176.

8. The recommendations in this paper proposes January 1, 2000 as the date for the coming into force of the MVTA motor carrier safety performance assessment regime, and for bus deregulation. All extra-provincial motor carriers would then require a MVTA safety fitness certificate issued in a manner consistent with the provisions of the Act. The amendments would allow extra-provincial bus licences to continue in those provinces which retain them in addition to the MVTA safety fitness certificate. It would also provide for comprehensive review of the effect of the provisions in the fourth year.

9. Proposed Amendments to the *Motor Vehicle Transport Act*, News Release, Transport Canada, H027/99 March 25, 1999.

10. Vision and Balance, Canada Transportation Act Review, June 2001, p. 204.

11. News Release, Transport Minister Announces Intentions for Amendments to *Motor Vehicle Transport Act*, Transport Canada, September 28 , 1999.

12. Oster, C.V., and C. K. Zorn, "Franchising as a Response to Increased Competition in the Intercity Bus Industry," Transportation Research Forum, 1985, pp. 59-65; Button, K.J., "The Effects of Reform on the U.S. Intercity Bus Industry," Transport Reviews, Volume 7, Number 2, 1987, pp. 145-166, Pinkston, E.A.,"The Rise and Fall of Bus Regulation," Regulation, September/December 1986, pp. 45-52; Vellenga, D.B., Shrock, D.L., Peterson, R.A.,"The New Intercity Bus Industry: Innovative Operating and Marketing Strategies," Transportation Research Forum, 1986, pp. 282-286; Miller, James, H., "The Effect of Intercity Bus Deregulation on Regional Operators and the Pennsylvania Experience," Journal of the Transportation Research Forum, Vol. XXX, No. 2, 1990, pp. 332-341; Minister of Transport, The Canadian Intercity Bus Industry Orientation Document, March 2001; Cape, David M., "Intercity Motor Coach Deregulation in the United Kingdom - 1980, Its Effects on Public Passenger Services (200-400 Mile Travel)," Transportation Research Forum, 1985, pp. 66-71; Tally, W.K. and Kilvington, R.P., "Deregulation of Intercity Bus Service: A U.S. and U.K. Comparison," Transportation Research Forum, 1985, pp. 327-332; Cross, A.K. and Kilvington, "Deregulation of Intercity Coach Services in Britain," Transport Reviews, Volume 5, No. 3, 1985, pp. 225-245.

13. The Canadian Intercity Bus Industry Orientation Document, Minister of Transport, March 2001, p. 14.

14. Id.

15. Directions: Report of the Royal Commission on National Passenger Transportation, November 1992, pp. 294, 296-97.

16. In 1996, the Canadian Intercity Bus Task Force "reported its majority position to the Council of Transportation Ministers in October 1996. Most jurisdictions agree on streamlining the rules for scheduled bus service and deregulating charter bus services and bus parcel express by January 1, 1998, but differences of opinion remain on both the recommendations and the question of whether to ultimately deregulate scheduled bus service. The federal position is in favour of bus deregulation, while provincial and industry opinion remains divided." [MVTA Review discussion paper, April 1997, p. 15]

In 2001, the Canada Transportation Act Review Panel did not make any specific recommendation as to whether to remove or ease regulatory constraints on intercity bus market entry as the matter was referred to the Senate Committee on Transport and Communications. However, since the regulatory fragmentation facing the bus industry is a clear cause for concern the Panel recommended "that the Minister of Transport continue the process already initiated to address regulatory fragmentation in the bus industry."

17. In addition it made recommendations with regard to: safety, service to disabled, service to small communities and the environment. Intercity Bus Service in Canada, Report of the Standing Senate committee on Transport and Communications, December 2002.

18. *Id.* p. 24.

Participation in the Hydrogen Economy: A Transportation Perspective

Doug Duncan, Connie Van Rosmalen
Transport Institute, University of Manitoba
John Spacek, Terry Zdan
Manitoba Transportation Policy Branch

1.0 Introduction

This research paper is a result of an assessment of hydrogen opportunities commissioned by Policy Branch, Manitoba Transportation. The evolution of the hydrogen economy is a moving target, because the technology is still in its infancy and it is difficult, to predict the outcome. This paper examines steps taken by various jurisdictions in North America to protect either the State or Provincial industrial base or to capitalize on the impending paradigm shift from oil to a hydrogen based economy.

The ultimate movement away from conventional petroleum-based transportation is inevitable. However, experts are continually changing the timelines for the commercial implementation of hydrogen and fuel cell technologies. A recent progress report by the U.S. Department of Energy (DoE) has put a more conservative face on this outlook. This is important in that the U.S. DoE drives U.S. government investment in fuel cell technology. In addition, the vehicle manufacturers, energy companies and fuel cell developers have all pushed back their estimates of hydrogen and fuel cell technology commercialization. Some have suggested commercialization of the fuel cell vehicle within the next five to ten years, while others put commercialization at fifteen to twenty years from now. The only certainty is that the application of hydrogen to transportation will be fluid and non predictable in the near future. Bush's recent Freedom Fuel program was launched to complement

the Freedom Car Program to speedup implementation of a U.S. hydrogen economy.

As of August 2002, the majority of vehicles on the road are prototype or near production vehicles that have been built for product introduction and demonstration projects, eg. Toyota FCHV. The number of fuel cell powered automobiles at a pre-production and demonstration development stage is under 100 worldwide but increasing. Once the European bus demonstration project has its buses on the road, the total fuel cell buses in demonstration projects worldwide will be under 50.

Plant infrastructure is being built to meet near term market demand in close proximity to the technology developers. As technology improves, new plants will be built and old plants will be modified accordingly. As the technology is refined, costs of production will drop to competitive levels. With competitive prices and a strengthened market demand for zero emission vehicles, opportunities will rapidly develop across all market sectors for hydrogen-fueled vehicles.

2.0 The North American Competitive Environment

The "Hydrogen Economy" can be considered as development of technologies and infrastructure associated with the use of hydrogen as an energy carrier for industrial and consumer applications. Internationally identified benefits have included addressing resource limitations of conventional petroleum, improving air quality through reduced emissions, addressing climate change through reduced greenhouse gases, and enhancing security of energy supply and energy infrastructure. The priority drivers are also recognized to vary from country to country.

In the United States, the hydrogen economy has been identified as a long-term goal for achieving a more emissions free environment and making the U.S. less dependent upon other regimes for energy supply. Fuel cells have been under intense development for over a decade and are still a long way from commercialization.

Implementation has had to wait for the market drivers needed to generate the investment for research and development and then for technological breakthroughs to develop technologies that work and can be produced at a low cost in a manufacturing environment.
Consequently, the current focus on emissions reduction is improvement to existing technologies, particularly for transport vehicles. A total of 24 states in the U.S. have established and developed financial incentive programs to promote cleaner transportation technologies, over and above what the federal law requires. These incentives primarily focus on alternative fueled vehicles but in some cases provide for fuel cell vehicle development. In most cases the incentives for fuel cell implementation are in the power supply market for the installation of stationary fuel cell power plants for commercial use.

In several jurisdictions, the base economy of the state is driven by the design, development and production of automobiles and other transport related activities. These states have taken specific measures to ensure that their companies participate in the new economy. To not do so could spell economic disaster for the state.

Both Michigan and Ohio have made their evaluations of their capability to participate in the "Hydrogen Economy" public which enables us to review how they have developed action plans to ensure that their states are players in the future.

2.1 Michigan
In August 2001 the state of Michigan issued a report titled "Positioning the State of Michigan as a Leading Candidate for Fuel Cell and Alternative Powertrain Manufacturing"[1]. The report was written in hopes of identifying "key market trends in new powertrain technologies (including fuel cell) and hybrid electric vehicles – a critical enabler for automotive fuel cell application – and assist the State in identifying critical actions to position itself as a strong candidate for potential automotive fuel cell manufacturing investment."

The following quote is taken from the executive summary to this report. "Many industry participants believe that fuel cell technology has the potential to replace the Internal Combustion Engine as the primary source of propulsion for automotive applications. Although there are significant hurdles yet to be overcome in the development of a cost-effective automotive fuel cell and a viable infrastructure, the implications for the automotive industry and the State of Michigan could be truly profound. There are 10 engine plants and 5 transmission plants in Michigan with nearly 27,000 people employed in these facilities. The development of a cost-competitive automotive fuel cell would likely make many of those powertrain facilities obsolete."

In developing its strategy for the future, Michigan has analyzed the new processes for developing and manufacturing hydrogen fuel cell vehicles in relation to the existing technologies available in Michigan. In April 2002, Governor John Engler unveiled NextEnergy – a comprehensive economic development plan to make Michigan a world leader in the research, development, and commercialization of alternative technologies such as hydrogen fuel cells. These technologies include mobile applications to power cars and trucks, stationary uses for homes and factories and portable needs such as laptop computers, cell phones and PDAs.

Highlights of Engler's energy blueprint are as follows:

- **NextEnergy Center** – a state-of-the-art facility affiliated with the University of Michigan will serve as a comprehensive clearinghouse and information resource on alternative industry-university collaborative research and commercialization projects.
- **Michigan NextEnergyZone** – a 700-acre state owned site that will become the focus of the alternative energy cluster of innovation. In addition to being designated a tax-free Renaissance Zone, companies that locate there will receive a tax rebate based on the jobs they create in the zone.
- **National alternative Energy Program** – Designed to complement the work of the NextEnergy Center, the national

program could act as a type of Underwriters Laboratory for the development of industry standards, certification systems and to identify research gaps and needs.

- **NextEnergy Tax Incentives** – Exemptions from the SBT and personal property tax for companies, or activities within companies, whose primary focus is alternative energy research, development of manufacturing.
- **Spurring NextEnergy Demand** – Steps include an exemption from the sales and use tax of any purchase of stationary and vehicular devices using alternative energy technologies.
- **NextEnergy Leadership Council** – Governor Engler will appoint national experts to this panel to provide critical advice on the implementation of our NextEnergy agenda and on issues ranging from research investments to questions about intellectual property.

2.2 Ohio

A report written in November 2001 by the Weatherhead School of Management called "Opportunities for Creating a Fuel Cell Industry in Ohio"[2], observes that a realignment brought about by emerging fuel cell technology will be profound, not only for consumers but equally so for industry and regions where these new industry activities will eventually cluster. Change inevitably brings with it opportunities for the quick and agile. States will need to be nimble if they wish to capture the job growth and new wealth that business activities are going to create. Because of its research presence in electrochemistry and its manufacturing expertise in specialty materials, components and control instruments, Ohio is well suited to become a national leader in fuel cells. However, the report suggests that although Ohio is populated with several world-class materials and component suppliers, it currently lacks a fuel cell manufacturing facility. This void constitutes an important leak in the commercialization system. As a result, fuel cell technology engineered at Ohio R&D labs is likely to flow out of the state and enrich firms and workers in other communities.

To participate in this growth this report recommends five policy strategies:

- Growing the R & D base.
- Creating a fuel cell institute.
- Workforce training.
- Fostering a more supportive regulatory environment.
- Increasing the visibility of Ohio's competitive assets.

Several states have initiated monetary programs designed to advance fuel cell development and implementation.

2.3 Connecticut

The Connecticut Clean Energy Fund solicited and received 31 proposals in response to its Fuel Cell Initiative Request. In its first year the fund is expected to pay out $ 6 million to support these applications. The Clean Energy Fund invests in enterprises and other initiatives that promote and develop sustainable markets for energy from renewables and fuel cells that will benefit ratepayers. This program is targeted at electrical generation projects as the funding comes entirely from electrical ratepayers in Connecticut.

2.4 Texas

In 2001 the State of Texas enacted a bill to create the Texas Fuel Cell Commercialization Initiative. The original concept called for the allocation of $ 95 million to competitively promote and facilitate the accelerated commercialization of clean small-scale fuel cell power generation and small combined heat and power fuel cell systems. This bill was not implemented as planned. The funding has not been allocated and the program has been reduced to undertaking a study. We were advised that Texas is leaving all activity related to transportation vehicles to projects already in existence such as the California Fuel Cell Partnership and other federal projects to progress the development of the fuel cell vehicle.

2.5 State Incentives for Cleaner Transportation Technologies

Many states are more focused on cleaner transportation technologies than fuel cell implementation and have developed a broad range of

programs to stimulate investment in and conversion to cleaner transportation technologies. A report titled "State Incentives for Cleaner Transportation Technologies, September 2001"[3], prepared for the U.S. Environmental Protection Agency assessed these incentives as follows:

The majority of the state incentive programs rely on monetary reward to promote cleaner transportation technologies. These types of programs generally seek to offset the higher cost associated with purchasing or operating an energy efficient or low emission vehicle with programs such as:

- Alternative Fueled Vehicle (AFV) purchase incentives,
- Emission-reduction (non-AFV) incentives,
- Fuel purchase incentives, and
- Infrastructure development incentives.

2.6 Canada

Due to the success of Ballard Power Systems Inc. in B.C. and significant research in hydrogen technologies, Canada has positioned itself as a leading nation in fuel cells and hydrogen technologies. More specific to the development of fuel cells for transportation, the Canadian Transportation Fuel Cell Alliance has been created as part of the Government of Canada's Action Plan 2000 on Climate Change. The alliance is a five-year (2001-2006), $ 23 million initiative geared towards encouraging advancements in hydrogen and fuel cell technologies, and GHG reductions by developing fueling infrastructure for fuel cell vehicles.

Most of the fuel cell industry in Canada is clustered in five provinces with activities as follows

Region	Activities
BC	Focused on PEMFC technology
	Ballard Power Systems R & D
	Service companies and organizations (e.g., venture capital) specific to the fuel cell industry becoming established

Alberta	Currently at an embryonic stage
	High interest in fueling infrastructure
Manitoba	Kraus Global is a world leader in fueling systems
	New Flyer is a partner in the hydrogen fuel cell hybrid bus initiative which is building a bus for a Winnipeg demonstration project
Ontario	Companies developing PEMFC and SOFC technology
	Clustering being led by Fuel Cell Technologies, Hydrogenics and DuPont Canada
	Centre of Canadian Automotive manufacturing area
	Close proximity to US automotive manufacturers
Quebec	Has attracted subsidiary of US fuel cell company H Power

Most jurisdictions in North America have recognized the opportunities that will flow through the growth of the fuel cell industry. Jurisdictions that will be affected by a powertrain shift to fuel cells are taking steps to ensure that they participate in the future development of the industry. As identified above, the growth will likely take place around the geographic clusters that are now developing. For any jurisdiction to participate seriously in future fuel cell development, it is essential to firstly undertake a strategy development and secondly to maintain focused investments to ensure that opportunities are not lost to foreign competitors. This later aspect of continued investment was recently emphasized for Canada in a major report conducted by PriceWaterhouse Coopers for Fuel Cells Canada.

3.0 Readiness to Compete

In assessing their States ability to compete in the emerging hydrogen economy, Michigan has completed an assessment of the components that contribute to the design, development and manufacture of fuel cell powered vehicles. Ohio has assessed its strengths and weaknesses by industrial sector.

The report "Opportunities for Creating a Fuel Cell Industry in Ohio"[4] summarized the skill requirements and Manufacturing characteristics for the four fuel system components for the fuel cell powertrain:

System components	Manufacturing Characteristics
Fuel Cell Stack	Will likely be produced by specialist companies who have developed the technology. Requires knowledge in electrochemistry and materials sciences.
Fuel Cell System	Automotive component suppliers will need to shift production skills to accommodate designs that incorporate fuel reformers. Some retraining will be required.
Balance of Plant system	Components are similar to those currently produced by automobile manufacturers and its supplier industries.
Electric Drivetrain	Automobile manufacturers can produce the electric drivetrain and transaxle components, however, power electronics require skills that are not traditionally found in the auto industry.

Ohio also created a "Fuel Cell Industry Scorecard" to assess its **Readiness to Compete**.

Component	Assessment
Research & Development	Strong
Material Suppliers	Strong
Component Suppliers	Strong
Fuel Cell Manufacturers	Weak
System Developers	Average
System Installation	Average
Application Market:	
• Transportation Market	Weak
• Portable Devices	Weak
• Stationary Power Generation	Average

The ability of any province in Canada to participate in the transportation driven hydrogen economy necessitates an assessment of the developing "clusters" in Canada and an evaluation of that provinces strengths and weaknesses as in the Ohio model. Success will depend on a well researched strategy and targeted investment by the province.

4.0 Commercialization Opportunities in Canada

4.1 Light Duty Applications

Automobiles

It is clearly evident that a vast amount of research has taken place in the development of fuel cell technology for application to the automotive market around the world. Review of the steps being undertaken by U.S. States to protect their position in the development and manufacture of the future automobile suggests that R&D, component manufacture and OEM assembly plants will not likely relocate to jurisdictions where it does not already exist. The primary capabilities, technologies and facilities will locate in natural clusters as the auto industry is structured today.

The June 2002 draft report "Fuel Cells: The Opportunity for Canada"[5] clearly identifies BC and Southern Ontario and to some degree, Quebec as the only locations where industry clusters have developed sufficiently to participate in development and manufacturing. The ability of other provinces to participate in this market would be entirely dependent upon the development of critical niche technologies and significant investment in the exploitation of those technologies.

Bicycles and Scooters

The market for bicycles and scooters is extremely large and will likely see significant growth of fuel cell powered vehicles. However, the market lies in Asia and India. The market drivers for the purchase and use of these vehicles in North America are vastly different from Asia and India. They will not likely become a prime mover of people

in our economy. It is highly unlikely that Canada could participate in this market.

4.2 Medium/Heavy Duty Applications

Bus

The bus industry is the one significant transport sector where Canada has the technology and the manufacturing capability to participate in the manufacture of fuel cell powered buses. The prime R&D and component manufacture of critical components such as the powertrain system will take place as part of the automotive industry. However, Canada has a number of centres that specialize in bus vehicle design and manufacture. Winnipeg is a prominent example of a bus manufacturing centre, which was the recent focus of a new multi-partner project to develop an advanced hybrid fuel cell bus.[7]

Railways

Development of fuel cell propulsion for the rail industry is not foreseeable in the near future.

Marine

Marine applications can be subdivided into several categories; ship propulsion power, specialized applications such as submarines, small boat applications and auxiliary power unit applications. Our research indicates that the marine industry will follow the automotive industry in the development of hydrogen fuel cell systems. The only opportunity seen for the near future is the potential market for auxiliary power units on board vessels.

Off Road/Farm Equipment

To date there has been no significant research done in off-road (farm equipment) applications of hydrogen. The transportation sector has presented more challenges than other applications due to its complexity. Most experts agree that once adoption of fuel cell technologies occur in buses and passenger vehicles, other applications such as off-road will follow.

7.3 Specialized Applications

Airplanes

The aviation market is only on the drawing boards at this time for propulsion systems and do not present any near term opportunities. As with the marine industry, the nearer term opportunities lie in the development of auxiliary power units.

Industrial Fuel Cell Vehicles

The application of fuel cell technology to the light industrial vehicle is still in its infancy. Several organizations have developed concept vehicles such as the Gator 1 & 2 and unveiled fuel cell powered golf carts. Largely these applications involve marrying existing fuel cells to existing vehicles. We have not been able to identify any manufacturing and distribution operations involving light industrial vehicles. Logic suggests that this application will not become fully commercialized until the production and operating costs are completely competitive with existing technology. The market is now adequately served by existing technology.

The application of fuel cell technology to industrial vehicles could present an opportunity for Canadian manufacturers in specialized niche markets. Capitalizing on these opportunities would require the development of technical expertise and support to our manufacturing companies to explore these opportunities.

Mining

The most promising application of fuel cell technology in the near term is in mining. The market driver for developing this technology is profit. Although the vehicles themselves will be more expensive than existing technology, the ability to eliminate fuel emissions from the mine or tunnels will eliminate a major capital and operating cost of mine operation, the ventilation system. The first prototype locomotive is in test phase and the first mine loader is in a 4-year design and build phase.

Hydrogen Fuel Trailers

Another opportunity might be in the manufacturing of trailers to transport high-pressured, carbon-fiber hydrogen storage cylinders. Currently hydrogen is transported in steel tube trailers, however there are several drawbacks to this mode. As the hydrogen market grows, the need to transport substantially larger amounts of hydrogen will also grow, meaning transporting at higher volumes, and transitively, higher pressures. Transporting hydrogen in the steel tube trailer is not cost effective, as steel tubes need increasingly thick walls to hold higher pressured hydrogen. The thicker the steel tubes are, the heavier they become until they are too heavy to be pulled by trailers.

Dynetek is developing lightweight carbon-fiber tubes to store hydrogen. They have worked jointly with Powertech labs to build a lightweight trailer to carry these tubes and are currently investigating trailer manufacturers they can team with to build more of these trailers. As the R&D in the hydrogen infrastructure progresses there will be more and more of a need for these lightweight trailers

7.4 Auxiliary Power Unit Applications

We have identified future opportunities in both the marine and air industries for auxiliary power unit applications. The automotive industry has already developed auxiliary power units for demonstration vehicles. The fuel cell developers have been developing power units for small applications and portable power generation for decades. It is our expectation that the auxiliary power unit will be the first fuel cell application that will achieve commercial application in vehicles in the near future.

Once again, fuel cell developers around the world have been focused on creating these small power units. Any Canadian opportunity would likely be focused on a licensed manufacturing operation.

Conclusion

As suggested in Michigan's report entitled, "Positioning the State of Michigan as a Leading Candidate for Fuel Cell and Alternative Powertrain Manufacturing", many industry leaders and experts are certain that fuel cell technology has the potential to replace the Internal Combustion Engine as the primary source of propulsion for transportation applications.

The opportunity also exists for any Canadian province to participate in the developing hydrogen economy. However, participation requires being prepared for the challenges. Based on our review of the current status of developments with respect to transport vehicles, we identified a number of key generic initiatives that need to be considered:

- Growing a University based research technology capability for fuel cell applications.
- Promoting information sharing and form a collaborative effort and partnership among industry stakeholders.
- Promoting the creation of demonstration projects.
- Assessing capability to participate in the Hydrogen Economy with a view towards identifying the strengths and weaknesses of the industrial and technology base.
- Exploring opportunities in the areas of strength, based on results of capabilities assessment.
- Investigating opportunities in spin off and integration technologies.
- Developing tax or other incentives to attract interest from domestic and foreign companies.
- Creating fuel cell associated educational technology tax incentives.

Bibliography

[1] Center for Automotive Research, *Positioning Michigan as Leading Candidate for Fuel Cell and Alternative Powertrain Manufacturing*. Detroit, MI, Aug. 2001

[2] Gregory M. Stoup, *Opportunities for Creating a Fuel Cell Industry in Ohio*. Center for Regional Economics Issues, Weatherhead School of Management, Cleveland, OH. November 2001

[3] *State Incentives for Cleaner Transportation Technologies*. Prepared for U.S. Environmental Protection Agency, Washington, DC. 2001

[4] Gregory M. Stoup, *Opportunities for Creating a Fuel Cell Industry in Ohio*. Weatherhead School of Management, Cleveland, OH, 2001

[6] PriceWaterhouse Coopers, *Fuel Cells: The Opportunity for Canada*. Prepared for Fuel Cells Canada, June 2002

7 http://www.gov.mb.ca/chc/press/top/2002/12/2002-12-06-01.html

Hydrogen Fuel Cell Vehicles and Demonstration Projects: Where They Are At

Doug Duncan, Connie Van Rosmalen
Transport Institute, University of Manitoba

This research paper is a result of an assessment of hydrogen opportunities commissioned by the Policy Branch, Manitoba Transportation and Government Services.

1.0 Introduction

The evolution of the hydrogen economy is a moving target, as the technology is still in its infancy. As a result it is difficult, if not impossible, to predict the outcome and market adaptation of hydrogen based vehicles. Experts have, in the past, presented continually changing timelines for the commercial implementation of hydrogen and fuel cell technologies. Some estimates have suggested commercialization of the fuel cell vehicle within the next five to ten years, while other, more conservative estimates put commercialization at fifteen to twenty years from now. The only certainty is that the application of hydrogen in transportation will be fluid and non-predictable in the near future.

The objective of this paper is to assess and synthesize the market commercialization status of transportation related applications of hydrogen technologies.

2.0 Technical Assessment/Commercialization Status in the Transport Industry

This paper reviews our assessment of the technology development in terms of its "Technology Status" and its "Market Adoption Status". The assessment has been based on standard definitions for the current state of the technological development and market adoption as follows:

Technology Status Definitions (Five Stages):

- T1 – Idea Concept Formulation Stage
- T2 – Research Stage (Technical R&D undertaken)
- T3 – Development Stage (Product is refined to reach cost and performance goals)
- T4 – Pre-production and Demonstration Stage (Test units in demonstration)
- T5 – Matured Product Stage (Product is available)

Market Adoption Status Definitions (Six Stages):

- M1 – Innovators/Technology Enthusiasts: Commitment to new technology
- M2 – Early Adopters/Visionaries
- M3 – Critical Niches (Technology begins to prove itself)
- M4 – Early Majority/Pragmatists (Adoption of technology)
- M5 – Late Majority/Conservatives (Risk-adverse segment adopts new technology)
- M6 – Lagging market/Tradition Bound

2.1 Light Duty Vehicles/Cars

Through extensive research, a few things have become evident; every major automotive manufacturer has formed alliances and partnerships with other manufacturers, fuel cell developers and government agencies. Each of these alliances has made significant headway in fuel cell vehicle development. While not one of these groups has a fuel cell vehicle available on the commercial market and market adoption status is at the M1 to M2 stage (Innovators – Early Adopters), each has at least one vehicle in the T3 to T4 stage

(Development / Pre-production and demonstration) of technical development.

2.1.1 DaimlerChrysler

DaimlerChrysler has been a key player in moving fuel cell vehicles to the point they are at today. To date they have spent hundreds of millions of dollars on fuel cell vehicle R&D, and in the next four years will invest more than $1.4 billion to develop fuel cell technology. With Ford, they are part owners of Ballard Power Systems Inc. and are leaders in the race for developing and commercializing the next generation of fuel cell vehicles.

DaimlerChrysler has been the leading force behind the NECAR Development Project. Launched in 1994, NECAR 1, a fuel cell mini-bus was the first of a series of FCV prototypes. The project has progressed through a 5th prototype, NECAR 5, released in November 2000. NECAR 5, uses a Mercedes-Benz A-Class platform and is the technological successor of the NECAR 3. It reaches peak velocities of over 150 kms/hr, and the car's complete drive system, including a methanol reformer, is located on the under-side. As a further step in the direction of commercialization, DaimlerChrysler is now concentrating on the use of cost-effective materials.

2.1.2 Ford Motor Co.

TH!NK Technologies is the engineering arm of Ford Motor Company that concentrates on advanced electric drive vehicles. In November of 2000, the group introduced the world's first production-prototype, direct hydrogen fuel cell vehicle, based on the Focus platform. The group has also developed prototypes of other popular Ford models that use hydrogen fuel cells, methanol fuel cells, and battery electric drives.

In 2002 Ford launched the TH!NK Road Show, touring North America, attending and hosting large-scale media events, and visiting universities and schools to promote and build awareness of hydrogen fuel cell technologies.

2.1.3 General Motors

GM introduced the world's first operating fuel cell vehicle, the GM Electrovan in 1968. Although the technology worked it was not practical for that time period. In the mid 80's Opel and GM reopened their fuel cell investigation and developed the Zafira in 1998. In 1998 GM also formed the Global Alternative Propulsion Center, GM's internal organization for advanced fuel cell technology.
In 2000 GM introduced the Precept, a concept fuel cell sedan, featuring a fuel cell system with a metal hydride hydrogen storage system, as well as, the HydroGen1, an Opel Zafira based fuel cell vehicle operating on liquid hydrogen. At the 2002 Detroit Motor Show, GM unveiled AUTOnomy, a new concept vehicle that reinvents the automobile based on fuel cell technology and a futuristic drive-train model.

In pursuing the development of hydrogen technologies, GM partnered with Toyota and with QUANTUM in 1999 to collaborate on improving the range of GM fuel cell vehicles through the development of hydrogen storage, handling and electronic control technologies for fuel cell applications.

2.1.4 Honda

Honda has been developing its FCX-V fuel cell vehicles since 1999. It has since modified and improved upon its first prototype, and in April 2002, Honda confirmed that it plans to make roughly 20 FCX-V4 hydrogen fuel cell cars available in Japan by 2003.

2.1.5 Nissan

Nissan has completed initial development and has begun test-driving its fuel cell vehicle equipped with a methanol reformer. Nissan FCVs have adopted technology that enables them to achieve optimum electric power by switching between a fuel cell-powered driving mode and a battery-powered driving mode.

2.1.6 Toyota

In 1996, Toyota developed the world's first working FCV prototype to carry fuel in a hydrogen-absorbing alloy. The following year,

Toyota revealed a second prototype that generated its own hydrogen with an on-board methanol reformer – another world first. Success with these prototypes convinced Toyota to complete its R&D phase and advance into its product development phase. Toyota engineers have made great strides in improving individual components vital for viable fuel cell vehicles

Building on the success of its 1996 hydrogen absorbing alloy technology, Toyota unveiled its second-generation alloy tank at the 1999 Tokyo Motor Show. It can store 2.2 kg of gas in 100 kg of metal – a 10 % improvement over the initial design. On the vehicle development side, Toyota has developed the FCHV-5, which is based on the Highlander body and incorporates a gasoline reformer to generate the hydrogen for the fuel cell.

2.1.7 Volkswagen

In April 2002, Volkswagen and the Paul Scherrer Institute released information on their joint efforts to produce a low-cost hydrogen fuel cell. The fuel cell incorporates new membrane, which is cheaper to manufacture and is integrated with the Jetta platform. Volkswagen is also doing work developing ultra capacitors.

Assessment

Technology Status = T3–T4; Market Adoption Status = M1–M2

2.2 Scooters & Bicycles

The market potential for pollution free, two wheeled vehicles is enormous with an estimated 100 million motorized two-wheeled vehicles in use worldwide - the greatest concentrations being in Asia. Worldwide scooter production is estimated to be over 17 million a year and use is expanding globally.

2.2.1 Bicycles

In the fall of 2001, Italian bike makers, Aprilia unveiled its prototype fuel cell bicycle. The bike is powered by a fuel cell produced by Manhattan Scientifics, Inc of Germany, and stores compressed hydrogen in a two-liter canister housed in the frame. The bike has a

top speed of 20 mph, weighs 20 % less than regular electrics and travels twice as far, about 43 miles before it needs re-fueling. The bike is estimated to be available in 2003 for approximately $ 2,300.

2.2.2 Scooters

In November 2001 **Manhattan Scientifics Inc.** unveiled a fuel cell powered electric scooter, powered by the company's own unique and proprietary fuel cell technology developed by its German unit NovArs Gmbh. Production models of the scooter are expected to have a range of 120 miles and attain a top speed of 35 mph.

In January 2002, India's state owned **Scooters India Ltd.**, announced that it is working on a fuel cell scooter. The scooter is slated to be launched in 2003 and development is being financed by the Ministry of Non-conventional Energy Sources.

On April 17,2002, **Palcan Fuel Cells**, out of Vancouver, entered into an agreement with Italy's Celco Profil S.R.E. to jointly develop fuel cell power systems for its scooters.

Assessment

Technology Status = T3; Market Adoption Status = M2

2.3 Medium/Heavy Duty Applications

2.3.1 Buses

Although automotive manufacturers have been the leaders in developing fuel cell technology for transportation related applications, the majority of the demonstration projects have occurred in bus technology. There are several bus manufacturers, fuel cell developers, electric powertrain specialists and government agencies forming alliances in efforts to develop viable fuel cell buses for real life use. These demonstrations have allowed manufacturers and developers to improve the technology significantly

Assessment

Technology Status = T3-T4; Market Adoption Status = M1-M2

2.3.2 Railways

In April 2001, the Transport Institute prepared a report for Environment Canada on the "Feasibility of Fuel Cell Railway Locomotives: A Study of Energy Alternatives" [1]. The following comment summarizes developments in the rail industry:

Our survey of the North American rail industry that included rail system operators, locomotive engine manufacturers, the Canadian and American railway associations and the leading fuel cell developer in Canada, indicated that they are not pursuing the application of fuel cells in locomotives. The industry generally believes that with time and money the engineering hurdles could be surmounted and a fuel cell locomotive could be built. However, the practical limitations of fuel cell locomotive implementation will preclude significant activity in the short and medium term.

Assessment

Technology Status = T1; Market Adoption Status = 0

2.4 Marine

2.4.1 Vessels

A study was prepared by the U.S. Coast Guard Research and Development Center[2] in September 1999 titled, **"Marine Fuel Cell Market Analysis – September 1999"**. The study argues that marine applications will proceed as a "fast-follower" shortly behind land applications of fuel cells. Marine market penetration of FC technology will depend on the rate at which land applications of fuel cells can be made technologically and economically competitive to primarily diesel engines as prime movers for propulsion and ship service generators. Most importantly for early adopters, market penetration will depend on emerging environmental requirements (e.g., emissions credits, regions with local air quality problems, etc.).

Assessment

Technological Status = T2; Market Adoption Status = 0

2.4.2 Submarines

In March 2002, Kowaldtswerke-Deutsche Werft AG (HDW) christened U31, the first of four 212A Class submarines. Destined for the German Navy, U31 is scheduled to be commissioned on March 30, 2004. HDW in Kiel and Thyssen Nordseewerke in Emden are currently constructing the four boats. The new class 212 submarine developed by HDW has an air-independent propulsion system using a hydrogen fuel cell. HDW is reported to be the first shipyard in the world to offer a fuel cell propulsion system ready for series production. The Italian Navy has followed the lead of the German Navy and is building two class 212 boats at the Fincantieri shipyard in Italy.

Assessment
Technological Status = T4; Market Adoption Status = M3

2.4.3 Ferries

In March 2002, the San Francisco Water Transit Authority (WTA) announced it was awarded a $100,000 Federal grant to design the first fuel cell powered commuter ferry in the world. The vessel links Treasure Island with San Francisco and the East Bay. This project is a big step in extending fuel cell technology from cars to buses to boats.

Assessment
Technological Status = T3; Market Adoption Status = M2

2.4.4 Small Boats

Several companies have initiated demonstration projects involving the installation of fuel cell propulsion systems in small boats. One example is the Hydra, a 12 m wooden passenger launch built in Germany. The fuel cell is built by ZeTek and is their "Europ 21" alkaline cell stack of 5 kW that drives an Ocosachs electric motor. Top speed is about 6 knots with a range of 50 miles on a single charge.

Assessment
Technological Status = T3; Market Adoption Status = M2

2.5 Mining

2.5.1 Fuel Cell Propulsion Institute

The mission of the Fuel Cell Propulsion Institute, an international consortium of 32 universities, national laboratories and corporations is development and evaluation of fuel cell vehicles and fuel infrastructure for applications with high commercialization potential. Because mining and tunneling have the highest near-term potential, the Institute is focusing on underground applications. The consortium has built the world's first fuel cell underground vehicle, a mining and tunneling locomotive, which was displayed at MINExpo 2000. In January 2001 the consortium commenced a transnational project of the U.S., Canada and Mexico that will develop and evaluate the largest fuel cell vehicle yet built. A fuel cell battery hybrid is an underground mine loader, weighing 26 thousand kilos, developing 300 kW of peak power and storing 30 kg of hydrogen onboard as a metal hydride.

Locomotive Assessment

Technological Status = T2; Market Adoption Status = M1

Loader Assessment

Technological Status = T1; Market Adoption Status = M1

2.6 Major Demonstration Projects

In addition to partnerships and alliances formed by individual companies to pursue product development, there are several demonstration projects that are either on-the-go or have been recently completed in North America, Europe and Japan. These demonstrations have been instrumental in the advancement of fuel cell applications for vehicles. Larger-scale fleet demonstration projects will be necessary before commercialization takes place.

California Fuel Cell Partnership – Sacramento, CA

The California Fuel Cell Partnership (CaFCP) represents one of the most significant collaborative efforts to advance new vehicle technology. The Partnership has provided an opportunity for automobile companies and fuel suppliers to join together to demonstrate fuel cell vehicles under real day-to-day driving

conditions. The CaFCP has plans to place up to 60 fuel cell passenger cars and fuel cell buses on the road between 2000 and 2003. In addition to testing the vehicles, the Partnership is examining fuel infrastructure issues and beginning to prepare the California market for this new technology. The Partnership aims to achieve four main goals:

- Demonstrate FCV technology by operating and testing under real-world conditions in California;
- Demonstrate the viability of alternative fuel infrastructure technology;
- Explore paths to commercialization; and
- Increase and enhance public awareness and opinion of FCVs.

SunLine Transit Agency[3], a California Fuel Cell Partner, is leading a complex integrated hydrogen demonstration project. Both renewable and fossil-based hydrogen production technologies are being evaluated, along with compressed gas storage. The ongoing testing will pave the way for the complete transition of California's Coachella Valley transit system to hydrogen fuel cell vehicles.

In April 2000, SunLine opened the world's first hydrogen generation /storage/fueling facility built by a public transit agency. The facility boasts two Hythane buses (80 % CNG/20 % hydrogen), the XCELLIS ZE-bus, the nation's first street legal hydrogen fuel cell mini-car (SunBug), three hydrogen fuel cell powered golf carts and a hydrogen powered internal combustion engine pickup.

SunLine expects to begin conversion of its CNG bus fleet to hydrogen fuel cell buses in 2003. If all goes according to plan, SunLine and AC Transit in Northern California will each receive 10 fuel cell buses as part of the California Fuel Cell Partnership Bus Demonstration Project. For the moment the two transit companies have been given permission to purchase four fuel cell buses. At least three will come from ISE Research-ThunderVolt Inc. of San Diego. The buses are equipped with fuel cells from UTC Fuel Cells, based in Connecticut. Delivery of the buses is expected in 2004.

P3 Bus Program

In addition to the collaborative efforts of the CaFCP, Ballard Power Systems carried out earlier work on fuel cell buses. The P3 Bus Program that was conducted from 1996 to 2000. In 1996, an agreement was reached between Ballard, the BC Government and BC Transit, in which the government provided $8.6 million in funding for a project that used fuel cell buses in real-life, passenger-carrying, revenue transit services. The funding was used to build, operate, and evaluate 3 fuel cell powered buses in actual transit operations over a two-year period. A similar agreement was reached between Ballard and the Chicago Transit Authority and the entire project was named the P3 Bus Program.

A New Flyer Industries 40-foot low floor bus chassis was chosen for the project and after the fuel cell integration and testing the 3 buses began the 2-year demo phase in June of 1998.

Bavarian ICE LH2 Bus & Bavarian CGH2 PEMFC Bus

In 1991 the Erlangen and Munich Governments, in cooperation with MAN bus and Linde, commenced the Bavarian Liquid Hydrogen Bus Demonstration. Hardware development and manufacturing of the buses and refueling stations took place from 1991 to 1996, followed by the demonstration of the MAN ICE LH2 bus and refueling station from 1996 – 1998. The LH2 Bus project was soon followed by the Bavarian Fuel Cell Bus Project that commenced in 1996 and continued until 2000.

Munich Airport H2 Project

The opening of the new international airport of Munich, Bavaria, in 1992, presented an ideal opportunity to convert the entire airfield services; catering vehicles, aircraft tractors, waste removal trucks and passenger transport vehicles (minivans, buses, passenger cars) to hydrogen propulsion in a step-by-step process, gradually replacing existing vehicles. Planning and hardware development for the endeavor began in 1995 and the actual installation of vehicles occurred from 1997 to 2000. All the vehicles were centrally refueled from one of two parallel refueling stations; one for refueling a pron

vehicles with gaseous H2; and the other for refueling passenger vehicles at the terminal. Vehicles used included a PEMFC fork lift, a MAN low-floor bus – H2-ICE, 3 articulated buses with advanced H2 ICE, 2 PEMFC buses, and 15 VIP cars – BMW LH2-ICE.

NECAR and NEBUS Development
In 1992 the NECAR (mentioned earlier) and NEBUS Development project was initiated as a joint effort between DaimlerChrysler, Ford Motor Co., Ballard Power Systems and the German Government. Since its commencement, the project partners have poured over 900 million German Deutsche Marks (approximately $450,000,000 USD) in funding and have developed and demonstrated the five prototype cars as well as two buses, with plans for project completion in 2004.

European Fuel Cell Bus Demonstration Project
The most current demonstration project was announced in Europe in 2001, making Europe a hot spot for fuel cell bus development. Three demonstration projects fall under the main European Fuel Cell Bus Demonstration Project and are being supported by the European Union. The three projects will include 33 fuel cell buses operating in 13 cities and 9 countries throughout Europe by 2003.

The first project, **The Fuel Cell Bus for Berlin, Copenhagen, and Lisbon II**, is being realized in co-operation with several European manufacturers and public transport operators. The project will demonstrate, for the first time, the operation of three fuel cell buses powered by liquid hydrogen in regular urban public transit. The project will demonstrate the long-term advantages of urban application through introduction to a wide market. A MAN N L223 low floor bus platform equipped with DE NORA 150 kW fuel cell is being used.

Under the **Clean Urban Transport Europe (CUTE)** project the European Commission has awarded 18.5 million euros to nine European cities for the introduction of 27 hydrogen fuel cell buses. This project will be the first test of this scale for fuel cell buses,

conducted anywhere in the world. The bus platform is an EvoBus – Citaro (LH2).

The **Ecological City Transport System (ECTOS-project)** is a combined demonstration and research project of hydrogen infrastructure and the operation of hydrogen fuel cell buses in Reykjavik, Iceland. The project's 4-year goal is to build a filling station in Iceland, with on-site production of hydrogen by electrolysis using renewable power. In addition three fuel cell buses will be operated in normal service by the Reykjavik Municipal Bus Corporation.

3.0 Conclusion

To date, the FCVs on the road are prototype vehicles that have been built for product introduction and demonstration projects. The number of fuel cell powered automobiles at a T4 development stage (pre-production and demonstration) is under 100 worldwide. Once the European Bus Demonstration Project is implemented within the next year, the total FC buses in demonstration worldwide will still be under 50.

Our review of the status of technological development and market commercialization suggests that commercialization will not take place in the next five to ten years. We are clearly in the development, pre-production and demonstration phase of hydrogen fuel cell transportation vehicles.

The 14th World Hydrogen Energy Conference (WHEC) held in Montreal from June 9 – June 13, 2002, confirmed the views and assessments presented in this report. A significant observation made relating to the market development of fuel cell vehicles was as follows: There are still several key factors prohibiting the adoption of fuel cell technology for mass production such as cost, performance, infrastructure, and fuel sources. Major breakthroughs in each of these prohibitive areas must occur in order for there to be any considerable advance in technology development and adoption. Only then will the commercialization of fuel cell vehicles occur.

THEORETICAL DERIVATION FOR CBR MATHEMATICAL EXPRESSION

Xingyi.Wang Susan.Tighe
Department of Civil Engineering
University of Waterloo, Waterloo, ON. Canada

SUMMARY

The traditional CBR equation below was first mathematically deduced from empirical tests in 1956.

$$t = \sqrt{\frac{P}{8.1CBR} - \frac{A}{\pi}}$$

Because this traditional CBR equation works well with experiments in the ranges of CBR value not higher then 12 (or CBR/P ≤ 0.22), it becomes one of the main design methods in road and airport industry. But the traditional CBR equation cannot explain the relationship of load-intensive in CBR values above 12. This problem has perplexed pavement researchers and engineers for a long time since the traditional CBR equation was developed. The inherent deficiency of the traditional CBR equation limits its usage for new pavement materials.

In this paper, based on Mohr-Coulumb Criterion and Boussinesq's solutions, the new CBR equation was theoretically derived as:

$$t(s, \xi, m) = \sqrt{\frac{P}{sCBR} - m\xi\frac{A}{\pi}}$$

Three parameters were introduced into traditional CBR expression. The new CBR equation was well confirmed with historical test data by varying parameter Poison' ratio in $m = \mu / (1-\mu)$ while the other two parameters were fixed as $s = 8.1$ and $\xi = 1$. The new CBR equation provides a solution to the above problem.

INTRODUCTION

Since California highway department presented California Bearing Ratio (CBR) design curves in 1928, the efforts in contribution to theoretical formulisation of CBR design curves continue. The major results can be reviewed in references of M.W.J.Turnbull, C.R.Foster, R.G.Ahlvin 1956[1]; A.Taboze 1977[2]; ZH. Zu, ZH.Xu 1987 [3].

Based on the assumption that most typical pavement structure damages result from failure in material shear stress resistance under loading, the traditional CBR equation was first mathematically deduced from empirical tests [1] in 1956. Then in 1977, its modifications [2] were extended and applied to airport flexible pavement structure design in cases of multi-wheel loads and bearing capacity more than 5000 coverage. Because this traditional CBR equation works well with experiments carried out in both laboratories and fields in the ranges of CBR value below 12 (or CBR/P $\leq$ 0.22), its validation and simplicity allow it to be widely used as one of the main flexible pavement structure design methods in road and airport industry in ICAO, FAA, Japan, Canada et al[4]. The CBR design procedure is still one of the main parts of the academic textbook that addresses flexible pavement structure design theories for the 3rd and 4th year under-graduate students in transportation discipline over the world [5, Per. Ullidtz, 1987; 6, E.J.Yoder, M.W.Witczak, 1975, etc.].

The traditional CBR equation cannot be used to explain the relationship of load-intensive in CBR values above 12 [1]. This problem has perplexed pavement researchers and engineers who try to extend the traditional CBR equation to higher CBR area since it was developed. This inherent deficiency of the traditional CBR equation precludes its usage for new pavement materials, thus there is a need for a theoretical explanation for CBR design procedure for the reasons on research and application.

This paper includes the theoretical derivation and several tests for the new CBR equation, which was derived from the Mohr-Coulomb Failure Criterion and Boussinesq's solutions. The derivation process

provides an insight into traditional CBR design methods. The material parameter Poisson's ratio is naturally appearing in the new CBR equation that provides not only a solution to the above problem in load-intensive in higher CBR values, but an approach to improve the existing CBR design procedure.

HISTORICAL RESULTS

As early as in 1928, California Highway Department presented CBR design curves, which was widely spread over the world shortly after World War Two for it has following advantages that are (1) with comparison of multi-layered elastic design procedure, its simplicity in fewer design parameters and less cost in the procedures for testing the soil subgrade and the pavement components, (2) A record of satisfactory experience, and (3) Adaptation to the airport problem until now [4],[7],[8].

During the period from 1950 to1956, based upon numerous empirical experiments of the prototype-pavement structure carried out by the Corp of Engineers, M.W.J. Turnbull et al got the constant $D\times\overline{CBR}=0.1236$ when CBR≤12 [1] , then

$$D=\frac{0.1236}{\overline{CBR}}=\frac{1}{8.1\overline{CBR}}\frac{in.^2}{lb}=\frac{t^2}{P}+\frac{1}{p\pi}$$

Then the CBR design curves were formulised and given out a following well-known CBR mathematical expression:

$$t=\sqrt{\frac{P}{8.1CBR}-\frac{A}{\pi}} \qquad \textbf{(e.1)}$$

The general CBR-Depth t relationship for flexible pavement structure is exhibited by this formula, **behind which** the physical model of pavement is a thin asphalt concrete toper layer with a thick underlying well-graded crushed-stone base on the prepared

subgrade[shown in figure1]. It reflects the static-equilibrium relationship among the subgrade bearing capacity (the repetition number less than 5000 coverage), single load ***P*** and total thickness ***t*** of pavement structure. In 1977, to extend the equation (**e.1**) to the cases of multi-loads and more than 5000 coverage, two new concepts of the pavement performance parameter α and the equivalent single wheel load (ESWL) were introduced to modify (**e.1**) as

$$t = \alpha\sqrt{\frac{ESWL}{8.1CBR} - \frac{A_c}{\pi}}$$

$$\alpha = 0.231 \log N_c + 0.144 \qquad \textbf{(e.2)}$$

The limitation of (e.2) is that it is still only valid in CBR value below 12 (exactly CBR/P $\leq$0.22)[shown in figure 2]& [2]. Using the regression technique, the further modification was statistically deduced regarding to heavy wheel load performance [2], [6].

$$t = \alpha\{\sqrt{A}\,[-0.0481 - 1.1562(\log\frac{CBR}{p_c}) - 0.6414\,(\log\frac{CBR}{p_c})^2 - 0.4730\,(\log\frac{CBR}{p_c})^3]\} \qquad \textbf{(e.3)}$$

Where the variables are used in functions (e.1) to (e.3):
t = the total thickness(in) of pavement structure; P=single wheel load(Pound); A=the tire contact area or imprint area (in^2); A_c= the ESWL contact area or imprint area (in^2). CBR=the bearing capacity on the surface of soil ground, from CBR test (%)
ESWL=the equivalent single-wheel loads (pound); α = the coefficient of repetitive number; N_c= the cumulative repetitive number of ESWL of the standard design load. p_c =corresponding tire pressure of ESWL (psi).

The modification (e.3) is sometimes called the cubic or regression equation to equations of (e.1), (e.2) in some paper, which can be applied for all ranges of CBR [shown in figure 2]. The CBR equation (**e.1**) and its modifications (e.2), (e.3) are traditionally addressed in all the academic textbooks for undergraduate students in transportation discipline over the world. They have been widely used in engineering practice as well, especially in airport industry [4], [7]. However, they

cannot be directly used to work out the thickness of component layers above subgrade rather than do other pavement design theories like layered elastic system theory, as the pavement structure becomes more multi-layered. Usually in CBR design procedure, the equivalent conversion factors based on the empirical tests are employed to find out the thickness of the component layers.

THEORETICAL DERIVATION FOR TRADITIONAL CBR EQUATION

(1) Background. Usually the pavement structure for CBR procedure are assumed to consist of an asphalt concrete top layer and a granular base layer above soil subgrade, and the most road structure damages under the traffic loads are assumed resulting from the soil shear strength failure. Based on these assumptions, the equation **(e.1)** is used to determine the total thickness t of pavement structure, which spreads loads into the soil subgrade so widely in this way that the amount of the interior stresses (shear stress) produced by loads will be less than the capacity of soil in the designated point at the depth z = t. That is, the pavement layers and soil subgrade are assumed acting together as integrate one with the same modulus E to figure out the depth t firstly, then equivalent factors are used to convert this depth t into corresponding thickness t_i of each component layer. The general thickness t from (e.1) complies with test results well at the soil depth with CBR values below 12[shown in figure 2]. One of the advantages of this method is the simplicity with which the designated test can be performed. But a disadvantage of this procedure is that the test is empirical therefore, the design is based upon correlation of CBR test [6]. If this design equation (e.1) can be derived from known theories, it could be understood deeply and used wisely in engineering sense. In order to derive the equation (e.1), two assumptions are made: one is static equilibrium in Boussinesq's space for soil subgrade. Another is that the shear stresses caused by the load equal to or less than soil subgrade allowable shear strength while the body weight (gravity) of pavement structure is neglected. Thus the equation (e.1) can be directly derived from the Mohr-Coulomb Failure Criterion and Boussinesq' solutions: the maximum shear

stress τ_{max}, and normal stresses σ_2, σ_1. The following steps will be shown the entire derivation process of CBR equation.

(2) In Boussinesq' space, Hooke's law works in linear range of stress and strain:

$$\sigma_1=E\,\varepsilon_1,\ \sigma_3=E\varepsilon_3,\ \ \sigma_1/\sigma_3 = \varepsilon_1/\varepsilon_3 = 1/\mu;\ \mu\,\sigma_1=\sigma_3 \qquad \textbf{(e.4)}$$

(3) Here, the Coulomb equation of the shear stress $\tau = c + \sigma \tan\varphi$ is used to represent the inherent stability of a material, then the principal stresses relationship from Mohr' diagram can be expressed as

$$\sigma_{1,2,3}=\frac{\sigma_z+\sigma_r \pm\sqrt{(\sigma_z-\sigma_r)^2+(2\tau_{rz})^2}}{2} \qquad (e.5)$$

Then from static equilibrium of Mohr' diagram, we have

$$\tau_{max}=\frac{\sigma_1-\sigma_3}{2}=\frac{1}{2}\sqrt{(\sigma_z-\sigma_r)^2+(2\tau_{rz})^2} \qquad \textbf{(e.6)}$$

To avoid the shear failure of soil ground under the load, the following constrain should be met:

τ_{max} <= the allowable shear strength of soil = C* CBR **(e.7)**

Here the CBR value represents the relative shear strength of a soil.

$$\frac{\tau_{max}}{CBR} = C\ (\text{constant}) \qquad \textbf{(e.8)}$$

(4) In figure 1, the stresses, which locate at any depth z along the centreline of the load P, will be considered. That is to let $\theta = 0$, then $\cos\theta = 1$, $\sin\theta = 0$, $R = z$, Thus the Boussinesq's solutions in a cylinder co-ordinates **[5]** are reduced to simple ones that are listed at table 1.

Table 1 Boussinesq's Solutions in a Cylinder Co-ordinate [see figure 1]

Normal Stress	$\sigma_z = 3P/(2\pi R^2) \times \cos^3\theta = 3P/(2\pi z^2)$ $\sigma_r = P/(2\pi R^2) \times [3\cos\theta \sin^2\theta - (1-2\mu)/(1+\cos\theta)] = -(1-2\mu)P/(4\pi z^2)$
Shear stress	$\tau_{rz} = 0$

From Table1, $\tau_{rz} = 0$, (**e.6**) becomes,

$$\tau_{max} \frac{\sigma_z - \sigma_r}{2} \qquad \textbf{(e.9)}$$

Substituted by σ_z, σ_r from table1, (**e.9**) is further transformed to,

$$\tau_{max} = \frac{1}{2}\left[\frac{3P}{2\pi z^2} - (-1)\frac{(1-2\mu)P}{4\pi z^2}\right] = \frac{7P}{8\pi z^2} - \frac{\mu P}{4\pi z^2} \qquad \textbf{(e.10)}$$

Divide both sides of (**e.10**) by CBR, then we have

$$\frac{\tau_{max}}{CBR} = \left[\frac{7P}{8\pi CBR} - \frac{P\mu}{4\pi CBR}\right]\frac{1}{z^2} = C \qquad \textbf{(e.11)}$$

$$z = \sqrt{\frac{7P}{8\pi C \times CBR} - \frac{P\mu}{4\pi C \times CBR}} = t \qquad \textbf{(e.12)}$$

This formula means that at the depth z or at the bottom of the pavement with the equivalent soil thickness t, the shear stresses caused by the load P is less than soil allowable shear strength which is equal to C×CBR.

(5) Set P as a circular uniformly distributed load $P = p_0 \times A$, from (**e.4**) and (**e.7**), we have $C \times CBR = \tau_{max}$ and $2\tau_{max} = \sigma_1 - \sigma_3 = (1-\mu)\sigma_1$, respectively, and replace the denominator of the second term in (**e.12**) with these relationships to get,

$$t = \sqrt{\frac{7P}{8\pi C \times CBR} - \frac{\mu A p_0}{2\pi(1-\mu)\sigma_1}} \qquad \textbf{(e.13)}$$

When to let $8\pi C/7 = 8.1$[1], $\sigma_1 = \frac{1}{2}p_0$, $\mu = 0.5$, the traditional CBR equation can be got, $t = \sqrt{\frac{P}{8.1CBR} - \frac{A}{\pi}}$ **(e.1)**

Where: the units in above formula: t = in , P = pound, A = in^2, p_0 = psi, CBR = %.

When looking back into the whole derivation process, we can take an insight into the structure of the traditional CBR equation.

VERIFICATIONS UTILISING HISTORICAL DATA

The theoretical derivation of new CBR expression (**e.13**) can help us clearly understand the structure of the traditional CBR equation (**e.1**), its condition, origination and limitations on its validation. Based on preceding derivation, several newly inferences can be drawn. For clarity and convenience in discussion, three parameters will be introduced into the new CBR equation:

Strength factor: $s = \frac{8\pi C}{7}$, $C = \frac{\tau_{max}}{CBR}$. (For soil, s = 8.1).

Vertical stress ratio factor: $\xi = \frac{p_0}{2\sigma_z}$, $\xi \geq 0.5$.

Material factor: $m = \frac{\mu}{1-\mu}$, μ = 0.2~0.5, thus m = 0.25~1.00.

The vertical stress ratio ξ is one that the vertical stress at the top of the component layer is over the vertical stress at the bottom of the same layer. The new CBR equation (e.13) becomes,

$$t(s,\xi,m) = \sqrt{\frac{P}{sCBR} - m\xi\frac{A}{\pi}} \qquad \textbf{(e.15)}$$

Then we can see that the tradition CBR equation (e.1) is the special case of (e.15), that is, t (8.1,1,1). Some discussions can be made based on this equation.

The Corp of Engineers carried out the experiments of prototype pavement model and documented test data, on which the figures 2 to 4 are based. The figure 2 shows the most explicit evidence in that the traditional CBR equation (e.1) has a good agreement with the test results in the ranges of CBR below 12, and also shows its modification (e.3) from statistical regression has fitted the test results well in entire CBR test ranges. From figure 3, under the condition of fixed s = 8.1 and ξ = 1, a bunch (cluster) of curves from new CBR equation (e.15) with different Poisson's ratio match the different

ranges of CBR tests very well. And all of them offset a little right to the traditional curve of (e.1), which means a little safer in thickness design than later.

From figure 4, the curve of (e.15) with varying Poisson's ratio perfectly matches the whole ranges of CBR test results and much better than does the modification (e.3). In the table 2 are listed the detail calculations for the curve of (e.15) in figure 4 with different μ.

INTERPRETATION FOR CBR DESIGN METHOD

The tradition CBR equation (e.1) and its modifications (e.2), (e.3) are conservative formulae because the vertical stress ratio of p_0 / σ_z is usually larger than 2 beneath the bottom of the pavement structure with the thickness determined by (e.1),and CBR test method is simulating the worst condition of subgrade during the life cycle of pavement. This is the reason why the CBR equation always works well in practice for it is an approximate conservative one of design methods for AC pavement because in most cases the vertical compressive stress σ_z is less than $p_0/2$.

From the preceding step (5), the **(e.1)** is validated under the conditions of the stress ratio $p_0 / \sigma_z = 2$. The reason why the mathematical derivation of (e.1) in 1956 had not revealed this mechanical constrain is because of the limitations of empirical experiments itself other than mechanics. There are two parameters CBR (or Young's Modulus E) and Poisson's ratio μ that are usually used to indicate elasticity of a material. For material with higher CBR value usually has lower Poisson's ratio. The derivation of the tradition equation (e.1) neglected the effect of Poisson's ratio variation and fixed it as 0.5, the variable of which actually exerted an unexpected influence upon the test results. The (e.1) does not contain the explicit Poisson's ratio so it has perplexed pavement engineers for a long time since it was developed in that it fails to interpret the test results with higher CBR then 12. The (e.1) partially explains the test results while its regression modification (e.3) can be applied for the entire CBR range [see figure 2], but the design results from these equations are

still ambiguous and cannot be explained clearly in engineering sense other than does the new equation (e.15) give out a complete explanation with three parameters (s,ξ, m). As Poisson's ratio varies, the new one (e.15) fits the test results very well in the whole ranges of CBR [see figure 3, 4].The upper layers above subgrade usually bear stress ratio higher than 0.5. The hidden precluding constrains of Poisson's ratio of 0.5 and the fixed stress ratio of $p_0 / \sigma_z = 2$ cramped the equation (e.1), which in fact have the equation (e.1) unable be extended to work out the thickness of upper layers with the material CBR above 12.

Usually μ is thought no significant effect on the pavement structure calculation, so it is fixed and its effect is hardly considered in pavement design while the traditional CBR equation is applied. But from the new CBR expression, it can be seen that the Poisson's ratio μ has significant affect on the pavement thickness calculation (when μ varies from 0.5 to 0.25, the total thickness is increasing around 22%). Different material has different Poisson's ratio μ, the new theoretical expression (**e.15**) can be applied for any the stress ratio at any value of μ, which varies from 0.25~0.5.

Only when the load acts directly on the surface, the $\sigma_1 = \sigma_z - \sigma_r = \sigma_z = p_0$, otherwise the $\sigma_1 < p_0$ at any depth. So in light of new equation (e15), the minimum thickness of surface layer can be decided based on the shear strength (or CBR), Poisson's ratio μ of underlying materials and the vertical stress ratio. From here, the newly design strategy for flexible pavement structure may be expected to be developed.

For the case of multi-wheel load, with the help of the concept of ESWL, the equation of (e.15) is still valid and worked through the procedure suggested in [2] or FEM method. So, set P =ESWL. The (**e.15**) become:

$$t(s,\xi, m) = \sqrt{\frac{ESWL}{sCBR} - m\xi\frac{A}{\pi}} \qquad \textbf{(e.15')}$$

CONCLUSIONS AND RECOMMENDATIONS

- The new expression of CBR design is
-

$$t(\alpha, s, \xi, m) = \alpha \sqrt{\frac{P}{sCBR} - m\xi\frac{A}{\pi}} \quad \text{for single wheel load}$$

$$t(\alpha, s, \xi, m) = \alpha \sqrt{\frac{ESWL}{sCBR} - m\xi\frac{A_i}{\pi}} \quad \text{for multi-wheel axial loads}$$

Where:

Strength factor: $s = \frac{8\pi C}{7}$, $C = \frac{\tau_{max}}{CBR}$. (For soil s = 8.1).

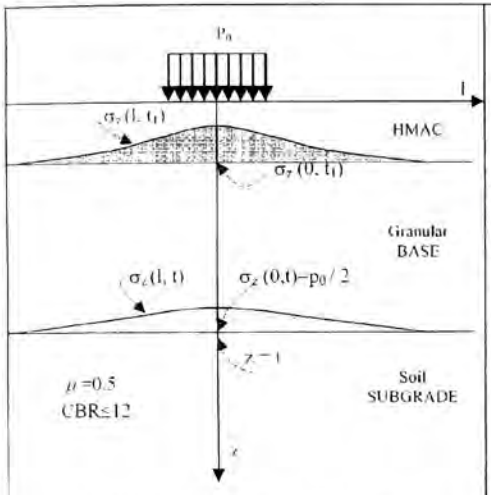
Vertical stress ratio factor: $\xi = \frac{p_0}{2\sigma_z}$, $\xi \geq 0.5$

Material factor: $m = \frac{\mu}{1-\mu}$, μ = 0.2~0.5, thus m = 0.25~1.00

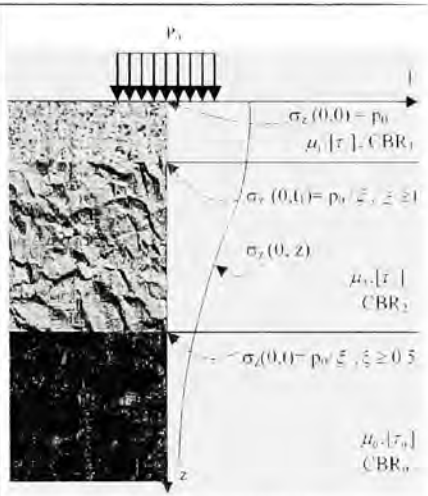
Pavement performance factor: $\alpha = 0.231 \log N_e + 0.144$

- The Poisson's ratio μ has a significant affect on the flexible pavement structure design.
- The three parameters and their relationships in new CBR equation need be explored further for different pavement materials and the new design strategy for flexible pavement.

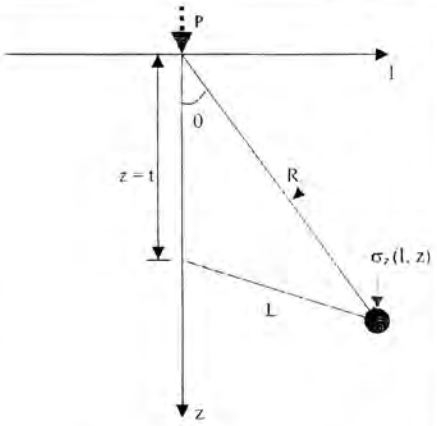
Figure 1 CBR Models & Boussinesq's Point Load Model



The Model of Traditional CBR Equation



The Model of New CBR Equation



Boussinesq's Point Load Model
in A Cylinder Co-ordinate.

Legend:

p_0 = tire pressure of a single wheel load (psi)

P = a single wheel load of a point load model (pound)

σ_z = a vertical compressive stress at a point

$\sigma_z(l, z)$ = a vertical compressive stress function

$\mu_i, [\tau_i]$, CBR_i parameters of material(i)

ξ_i = ratio of vertical compressive stresses

z = the depth

t = the total thickness of pavement

l = radial distance

$R = \sqrt{z^2 + L^2}$

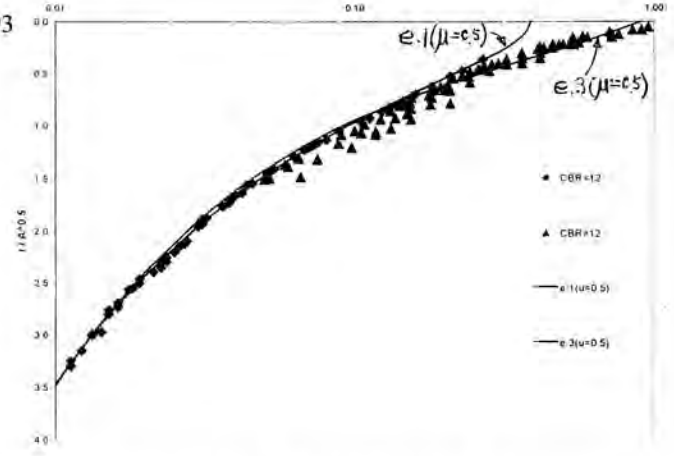


Figure.2 Consolidated CBR design criteria (Waterways Experiment Station, Corps of Engineers)[7]

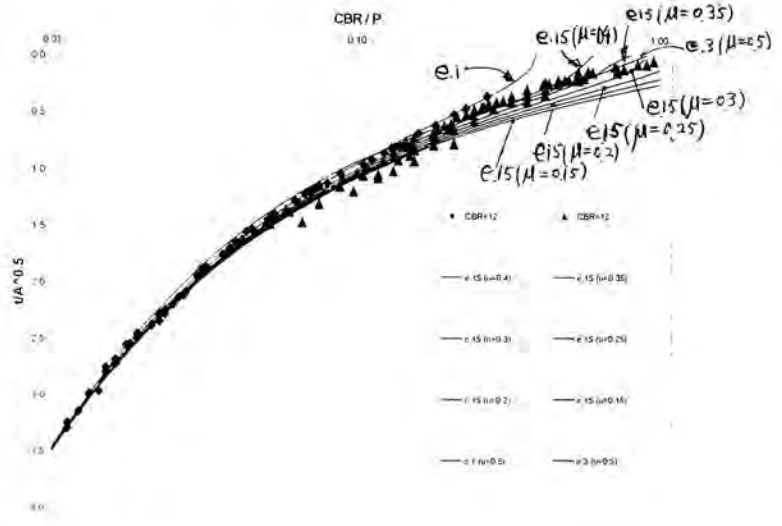


Figure.3 A bunch of curves from new CBR equation (e.15) with fixed respective Poisson's ratio (μ)

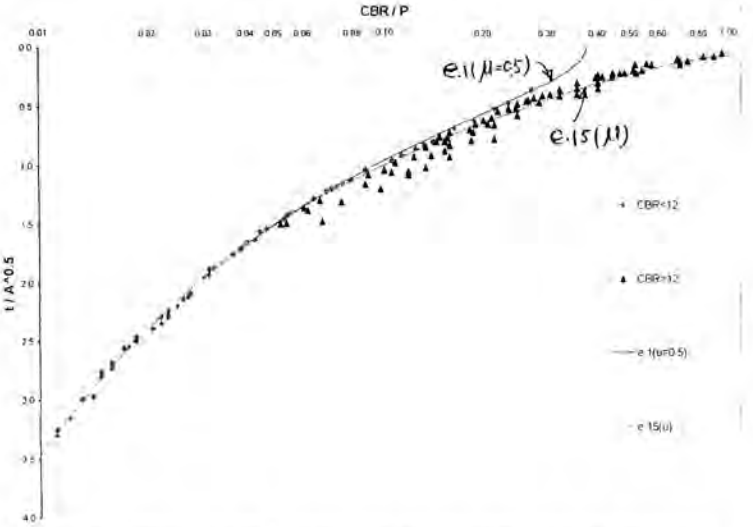


Figure 4 the new CBR equation (e.15) with varying Poisson's ration (μ)

Legend :

◆ Points for CBR values below 12

Points for CBR values above 12

Note:

$s = 8.1, \xi = 1$

REFERENCES

[1] M.W.J.Turnbull, C.R.Foster, R.G.Ahlvin "Mathematical Expression of the CBR Relations" Technical Report No.3-441, Waterways Experiment Station, Corps of Engineers, U.S.Army Vicksburg, Mississippi, November 1956

[2] A. Taboze Pereira "Procedures for Development of CBR Design Curves" Final report, U.S.Army Engineer Waterway Experiment Station P.O.Box 631, Vicksburg, Miss.39180, June 1977

[3] Z.h. Zu , Z.h. Xu "Design Theories and Methods for Flexible Pavement", Tongji University, Tongji Press, 1987.

[4] FAA, AC150/5320-6D, "Airport Pavement Design and Evaluation", 1996
ICAO Annex 14 "Pavement Design Manual" Japan Airport Authority" Airport Asphalt Pavement Design Guide, 1994"
" Canadian Standards and Recommended Practices----Airport Engineering", 1996
" Pavement Structural Design Training Manual" , 1995

[5] Per Ullidtz "Pavement Analysis", Denmark, 1987

[6] E.J.Yoder, M.W.Witczak " Principles of Pavement Design" Pudue University and University of Maryland 1975

[7] R.Horonjeff, F.X.Mckelvey "Planning and design of Airports" University of California, Michigan State university

[8] M.Sargious "Pavement and Surfacing for Highways and Airports" The university of Calgary, Alberta, Canada, 1975

Effects of Highway Traffic Diversion on Roadside Businesses from Long's Creek to Fredericton, NB

Abstract

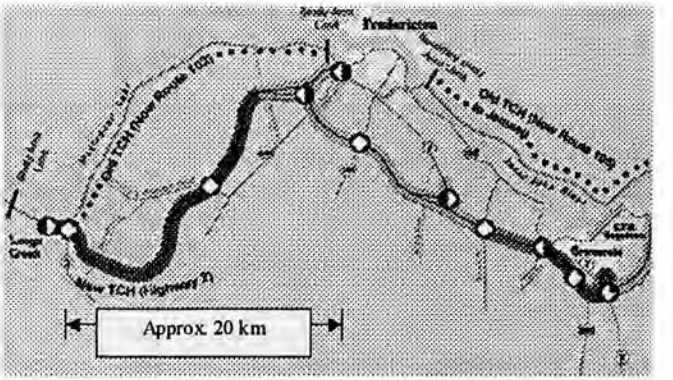
"The construction and operation of a new limited access highway that replaces one where businesses have direct access to roadway and the traffic on it will have an impact on those businesses." (Fiander Good, 1996b). This statement, written in the Environmental Impact Assessment for the Trans Canada Highway (TCH) upgrade from Fredericton to Moncton, leads to the question: "How much impact do businesses actually experience a few years after the diversion of traffic?"

Because the new TCH replaces a two-lane highway that was in operation for decades, there is the issue of what happens to businesses that have developed along the original two lane sections. This study looks specifically at one of the first sections to be bypassed by the new TCH. This section runs from Long's Creek to Fredericton, NB, resulting in the bypass of over 20 roadside businesses in 1999, 13 of which were identified as possibly being traffic dependent. Data collected for this report has been compared to the general estimates in the Environmental Impact Assessment (EIA) or component reports, as well as two additional study areas.

Scope

The effects studied were limited to traffic dependent businesses; however a sample of traffic independent businesses was obtained to help determine overall effects of traffic diversion. Mitgitative measures for surviving businesses were also investigated. Because the Long's Creek to Fredericton section has been bypassed for approximately three years, data obtained should be reflective of a stabilized economy. Two other areas along the TCH, both west and east of the study area (Figure 1) were surveyed to provide comparison.

Figure 1: Map of study area (Source: MRDC)



Methodology

Including the main study area and the two comparison study areas, a total of 41 surveys were hand-delivered to businesses: 13 from Long's Creek to Fredericton; 28 in the comparative study areas (1 west of Long's Creek; 27 east, from Fredericton to Jemseg)

Rationale

The project consisted of a Long's Creek to Fredericton study, with comparisons made to Fredericton to Jemseg businesses being bypassed. The Fredericton to Jemseg section was bypassed one week prior to the location observation, in late November 2001. West of Long's Creek was studied because the area is still located along the existing TCH, therefore it can act as a benchmark for other businesses in the study area.

Data Collection

The first stage involved driving the study area from Long's Creek to Jemseg and cataloguing all the visible businesses, their locations relative to one another, visible signage, and relevant information such as proximity of housing and distance from urban center. This collected data was then transcribed onto a spreadsheet.

The number of businesses in each study zone was counted and the appropriate number of surveys photocopied.

The second stage involved the distribution of surveys to the businesses. Surveys were distributed to businesses that were visibly traffic related, such as gas stations and motels, as well as businesses that may have been moderately related to traffic. Businesses that were obviously not dependent on highway traffic for part of their business (such as construction companies or contractors) were also sampled.

Analysis Methodology

The main indicator of a shift in traffic dependency was recording what each business had in terms of long distance, local, and non-highway traffic based business, before and after the bypass. Each business identified this traffic-based business in terms of a percentage of their business from each type of traffic.

Parametric and non-parametric statistical tests were attempted in order to test for a shift in data. The paired t-test and the Wilcoxon Signed Rank Test were both chosen to compare the before and after data. The null hypothesis in this case was that there was no significant change in the amount of long distance traffic based business for the area of Long's Creek to Fredericton. In the case where statistical analysis was either unwarranted or not useful, graphic analysis was used.

Data

Of the 41 surveys delivered to businesses located along the old Trans Canada Highway (TCH) from Long's Creek to Jemseg, the 27 surveys delivered from Fredericton to Jemseg resulted in nine returned. There were 13 surveys delivered from Long's Creek to Fredericton with seven returned, and one survey delivered and returned for west of Long's Creek.

From Long's Creek to Fredericton there were six catalogued businesses that were not surveyed/contacted based on belief of not being traffic related/dependent, closed for season, or unavailable. Personal interviews were also conducted with many of the businesses from Fredericton to Jemseg comparative study area. These were done

while delivering the surveys. Some did not want a formal survey, but were able to provide some information on the socio-economic impacts on the area. There were 16 personal interviews/informal discussions conducted. Out of those 16, four businesses returned surveys. There were seven interviews with those who did not want a survey and one interview with a former business owner, no longer operating (Loyalist Clock Co.)

Business Classification

There were 13 businesses along route 102 that were surveyed for this report. The different types surveyed are in Table 1. The other non surveyed businesses included a car repair garage, construction company, used car sales, catering business, horse stables, and closed seasonal businesses. These businesses serve the local area and are located within Fredericton city limits. Seven of the 13 surveys were returned giving a 52% rate of return. By speaking with some of the local business owners, inferential information was gathered about some of the businesses that did not return the survey.

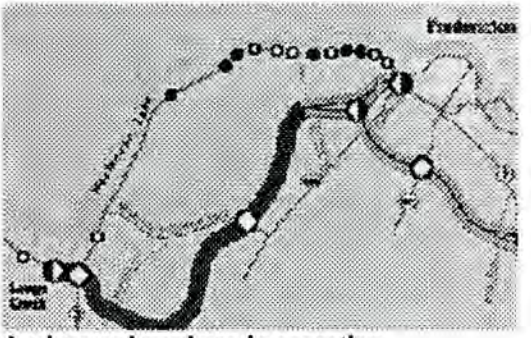
Table 1: Surveyed businesses

Surveyed by type	Percentage	Returned Surveys	Percentage
4 hotel/motels	31%	2 hotel/motels	29%
1 vehicle sales	8%	1 vehicle sales	14%
2 retail stores	15%	2 retail stores	29%
2 gas stations	15%	1 gas station	14%
1 convenience store	8%	0 convenience store	0%
2 cmpground/cabins	15%	1 cmpground/park*	14%
1 restaurant	8%	0 restaurant	0%

Fifteen of the 20 businesses are located within Fredericton city limits with another three located a few hundred metres outside the city limits. One hotel and one campground are located more than 8 km from the city limits, but the hotel does advertise itself as being from Fredericton. The campground has waterslides, and has reopened in the summer of 2001 after being closed for three years. Figure 2

shows the approximate location of each business along the route as a black dot, with returned surveys from businesses with white circles.

Figure 2: Map of study area: Long's Creek to Fredericton (Source: MRDC)



How long businesses have been in operation

All the surveyed businesses have been in business for at least 10 years, with 80% at least 20 years old. Other non-surveyed businesses also appeared to be well established, but no exact numbers were obtained. Within the city limits there were at least two new (a couple of years old) businesses, which included a used car lot and a catering business. The catering business is located in the old Fredericton tourist booth location. Only one business surveyed was less than 2 years old. The business was purchased in 2001 after not operating since the bypass opened in 1999. Prior to 1999, it had operated for over 10 years in the same capacity. Because the businesses are well established, they have experienced a variety of economic conditions. This leads to the presumption that the business operators are more seasoned to cyclical economic conditions.

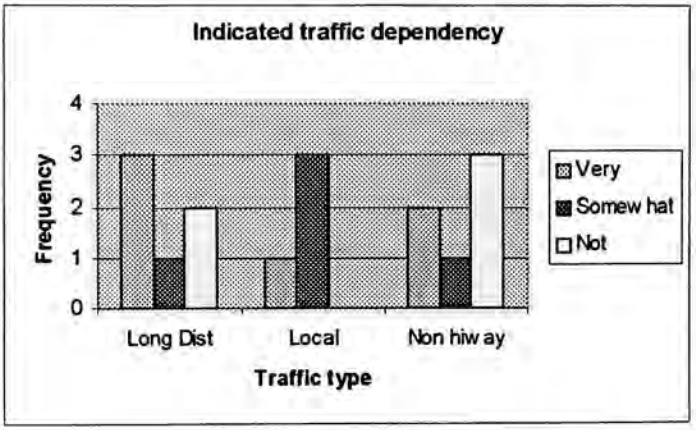
Table 2: Years in operation

Years in operation	Percentage
0-9	14%
10-19	14%
20-29	58%
30+	14%

Traffic Dependency of Businesses

Businesses were categorized by dependency on traffic. Long distance traffic includes drive by highway traffic that would normally only stop at the location because it is convenient and traffic coming from far away with that area as a destination. This traffic would consist of tourists, long haul trucks, etc. Local traffic includes commuter traffic that would normally stop at the location because it is convenient. The local traffic exists in spite of the highway bypass because of the many bedroom communities located throughout the area. Non-highway traffic included pedestrian traffic and local traffic that has the business as their destination.

Figure 3: Indicated traffic dependency



It is possible to correlate a business's reported traffic dependency to their percentage breakdown of that dependency. Each business has a different idea of what constitutes "very dependent". The three businesses that reported being "very dependent" on long distance traffic reported a pre-bypass percentage of their sales coming from that traffic as 35%, 70%, and 90% respectively.

Sales as a percentage of traffic (Pre-diversion traffic)

Half of the businesses reported sales of greater than 35% as coming from long distance traffic prior to traffic diversion in 1999. These were two motels and a gas station. The businesses with a 6-10% percentage of sales were a retail store and a recreational vehicle outlet. The one business with less than 5% is a retail furniture store. The three businesses that had greater than 61% of sales from local traffic were a gas station, retail store, and a retail furniture store. The two businesses with greater than 30% of sales coming from non-highway traffic are a motel and the recreational vehicle sales.

Sales as a percentage of traffic (Post-diversion traffic)

After the bypass in 1999, the two motel/hotels had their sales reduced from 70% and 90% of long distance traffic respectively, to 40% and 30% respectively. The gas station had its sales reduced from 35% of sales from long distance traffic to just 5%. The other three businesses that indicated zero to 10% of their sales pre-diversion were from long distance traffic had their sales reduced to 0-5%

The local traffic based businesses, like the gas stations and retail stores reported that 95-100% of their sales come from local traffic since the bypass. The motel/hotels reported a shift to non-highway traffic business, with 60% and 70% of their sales coming from non-highway traffic, respectively.

It is evident in Figures 4 and 5 the shift from long distance traffic to local and non-highway traffic for the businesses in the area. The most noticeable reductions were in the hotel/motel businesses; however the closer to Fredericton the business, the easier the transition was reported to be to local and non-highway traffic.

Figure 4: Sales as a percentage of traffic (pre-diversion)

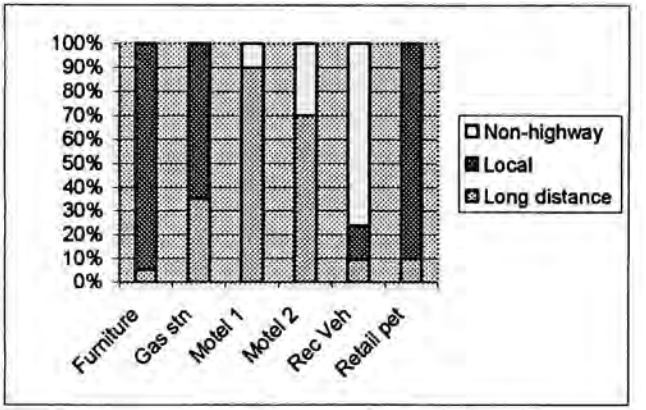
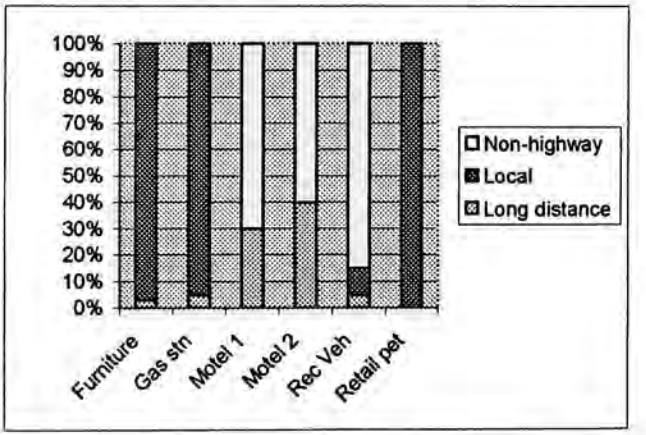


Figure 5: Sales as a percentage of traffic (post-diversion)



Statistical analysis of traffic shift

The shift from long distance traffic to local and non-highway traffic can be determined using parametric and non-parametric tests. In this case however, the data did not meet the distribution criteria in order to use the paired t parametric test. From both the inspection of the frequency distribution as well as assessing the normality using interquartile range versus standard deviation, it was determined that the data did not follow a normal distribution. Consequently a non-parametric statistical test was warranted (Mendenhall, 1995).

The Wilcoxon Signed Rank Test was used. This assigns a rank to each value in a set of paired data for the sake of comparison. A sum of negative values between sets is compared to a set of positive values to indicate a shift in data. The null hypothesis was that there was no difference between pre-bypass traffic sales distribution and post-bypass sales distribution.

Table 3: Wilcoxon Signed Rank Test Data

Wilcoxon Signed Ranks Test Alpha = .05

Long Distance Traffic as % of sales

% Before	% After	Diff	Rank
35	5	30	4.5
10	0	10	3
5	3	2	1
10	5	5	2
90	30	60	6
70	40	30	4.5
	Sum of pos. ranks		**21**
	Sum of neg. ranks		0

From statistical tables (Mendenhall, 1995), the comparison value of T_o equal to 2 had to be less than the sum of the negative ranks, which equaled zero. Consequently the null hypothesis is rejected, meaning that the post-diversion sales percentage distribution has been shifted from pre-diversion levels. This confirms the perception that traffic diversion has affected all these businesses.

Revenue change for businesses

Three businesses reported their change in dollar sales for one year after the bypass. The gas bar has since recovered some of their lost sales after a decline. Motel 2, due its proximity to Fredericton, has changed from attracting long distance traffic to attracting Fredericton bound travelers. Motel 1, because it is located farther away from the city, has had a harder time and is doing a lot of advertising. All of these businesses experienced a sharp decline during the first week. This can be due to people getting used to the new routing of the highway. Things improved for the businesses over the year as more effort was put into advertising. Other businesses in the area probably experienced similar sales declines and have rebounded, but they would not have been affected to the same degree.

Table 4: Percentage change in dollar sales after bypass

	1 week	1 month	1 year
Gas Bar	-35	-24	-25
Motel 2	-20	-20	+15
Motel 1	-70	-50	-40

Discussion of Traffic Volumes

In 1999, the NBDOT permanent counter recorded an AADT of 7540 from Long's Creek to Silverwood. Between Silverwood and the Hanwell Road, the counter recorded an AADT of 15300, as compared to the average AADT of 12500 by Geoplan in 1992. The local traffic growth rate is 2.5% per year. (McEwing, 2002)

Geoplan estimated that 5400 vpd would be diverted to the new highway based on their network program. This leaves local traffic accounting for 1400 vpd from Long's Creek to Silverwood. From Silverwood to the Hanwell Road, local traffic accounted for 7000 vpd.

Traffic Diversion and Estimated Economic Effects

Using the EIA estimates for the number of stops made in Sussex and the estimated money spent per stop, estimates can be

made for the annual revenue lost in the Long's Creek to Fredericton study area due to traffic diversion.

It was estimated that 24.3% of vehicles made a stop in the Sussex area for goods and services (Fiander Good, 1996b). It is reasonable to assume then that given the fewer number of businesses that catered to motorists along the Long's Creek to Fredericton study area that a smaller proportion of vehicles would stop. Because the study area is much smaller than Sussex, a conservative estimate of 5% of vehicles making a minor stop was made. There would be 300 vehicles per day no longer stopping, therefore using a conservative estimate of $20 per stop, the estimated loss of revenue in 1999 was $2,190,000.

Cataloguing failed businesses

As of 1998, there were three businesses that have closed down due to financial trouble caused by the diversion of traffic. One gas station permanently closed its doors in Silverwood, and one convenience store has removed its gas pumps. A garden centre also closed its doors. This garden centre was purchased and now operates as a restaurant. A campground/waterpark closed in 1998 in anticipation of the bypass. It was purchased in 2001 and operated for the entire summer.

Recommendations by the businesses

Half of businesses reported a decrease in truck traffic being the greatest benefit, whether be it easier for their customers to enter the premises, or the reduction in noise. Two businesses reported the new road alignment gives people better access to their business. Two businesses reported there was no benefit to their business from the bypass.

Four businesses reported that their customers found it difficult to find their businesses due to the limited access and delay in signage. Three businesses reported that the decrease in sales was their greatest detriment.

Comparisons to West of Long's Creek

One traffic dependent business west of Long's Creek along the Trans Canada Highway was surveyed in order to provide some comparison to the Long's Creek to Fredericton bypassed area. This business has reported hiring people since the bypass of 1999, and has seen their percentage of sales from long distance traffic go from 50 % to 65 %. They attribute this increase to the bypass. They are now the only gas station with direct access to the highway until Oromocto, 45 minutes away. Their customers know this, and now stop there instead of patronizing the gas stations located along Route 102.

Comparisons to Fredericton to Jemseg businesses

The area from Fredericton to Jemseg was studied for the EIA to forecast the socio-economic impacts relating to the highway bypass. The EIA from 1994 identified 64 access points for businesses serving a total of 80 commercial businesses (Fiander Good, 1996a). The majority of businesses in the area from Fredericton to Maugerville are "typical [of] sprawl that is common around any municipality, an extension of the urban economy" (Fiander Good, 1996a).

There did not seem to be the same concern in this area towards the diversion of traffic that there was in Long's Creek to Fredericton. The majority of economic effects on these businesses come from external economic factors. This area will still benefit from Fredericton commuter traffic, as well as cottage traffic going to the lakes. The highway from Fredericton to Jemseg (Route 105) has been designated as a scenic route to Fredericton, and signage is now present on the new TCH east of Sheffield.

Discussion of Results

There are two main differences between the Long's Creek to Fredericton section of highway, and the Fredericton to Jemseg section. First, the Long's Creek to Fredericton section of highway is shorter, and the concentration of businesses is less. Second, there is a larger majority of businesses in the Long's Creek to Fredericton section that relied on the long distance drive-by traffic associated with the Trans Canada Highway. In Fredericton to Jemseg, many of

the businesses are agriculturally based, or serve the needs of the commuter traffic (Fiander Good, 1996).

Rate of Return Commentary and validity of data

For Long's Creek to Fredericton (west Long's Creek inclusive), eight out of 14 surveys were returned, a rate of return of 57%. While there are fewer businesses in this zone, higher proportions are/were traffic dependent, explaining the higher rate of return. Also, because the bypass happened in 1999, many of the business owners have had more time to ascertain impacts of the highway bypass, and several are involved in lobbying for adequate highway signage for their area.

Not all surveys were completed in their entirety therefore only information present in enough quantity to warrant a sample will be presented for determining trends. Individual businesses that provided unique and helpful information were noted.

Because of the low response rate to financial questions, financial and sales information cannot be satisfactorily correlated to represent local economic conditions in terms of a regression analysis. Rather, they are indicative of many other factors such as proximity to urban centres, local population base, base traffic flow in area, management styles, and response to the traffic diversion.

Sources of error

The main sources for error in this research may result in the financial information provided by the businesses since reductions/increases were often given as an estimate. It can be assumed with confidence that, while the provided financial information is not precise, it is accurate.

Another source for error results from the actual surveys themselves. As the bulk of surveying was done in late November 2001, by the time this report was finished and presented in late March of 2002, some of the issues, such as lack of highway signage, had been somewhat resolved.

Conclusions

Out of 20 businesses from Long's Creek to Fredericton, 13 were identified as traffic related, with seven returning surveys. By using a non-parametric statistical test, it was determined that there was a shift from their perceived long distance traffic dependency to local and non-highway traffic. The gas stations, hotels/motels, campgrounds, etc. recorded the greatest shifts in traffic dependency, which are all prevalent in the study area.

By comparing traffic data to the number and size of failed businesses, conservative estimates indicate a loss of $2 million to the local economy of Long's Creek to Fredericton in 1999. The types of businesses that have gone out of business since 1999 are gas stations and tourist outlets. The locations of these businesses were either outside Fredericton City Limits or just within, therefore it can be assumed that a high percentage of their business was drive by traffic. Because of their location, they were unable to capitalize on local traffic.

The diversion of traffic polarized the economic activity from Long's Creek to Fredericton. Highway customers now stop west of Long's Creek for gas and food whereas previously their stops would have been spread throughout the Long's Creek to Fredericton study area. The businesses closest to Fredericton have picked up the local commuter traffic business that became available when the Silverwood gas stations shut down.

References

Burdge, R.J. and Vanclay, F. 1995. Social Impact Assessment. *In* Environmental and Social Impact Assessment, 1995. *Edited by* D.A. Bronstein and F. Vanclay, John Wiley & Sons Ltd, West Sussex, England, pp. 31-60.

Fiander Good Associates Ltd and Washburn & Gillis Associates Ltd. 1996a. Environmental Impact Assessment Trans Canada Highway Fredericton to Salisbury Component Study Report: Socio-economic Considerations.

Fiander Good Associates Ltd and Washburn & Gillis Associates Ltd. 1996b. Environmental Impact Assessment Trans Canada Highway Fredericton to Salisbury Component Study Report: Final Environmental Impact Assessment.

Fiander Good Associates Ltd and Washburn & Gillis Associates Ltd. 1995. Environmental Impact Assessment Trans Canada Highway Fredericton to Salisbury Component Study Report: Transportation Issues and Assessment Alternatives.

Geoplan Consultants Inc. 1992. Fredericton to Moncton TCH Functional Planning Study

McEwing, B. 2002. Personal interview at his office, New Brunswick Department of Transportation, Kings Place, Fredericton NB, January 9, 2002

Mendenhall, W. and Sincich, T. 1995. Statistics for Engineering and the Sciences 4th edition. Prentice-Hall Inc. New Jersey, USA

NBDOT 2001. 1999 Traffic Flow Map. Prepared by Planning and Land Management Branch, New Brunswick Department of Transportation

Rau, J.G. 1980. Socioeconomic Impact Analysis. *In* Environmental Impact Analysis Handbook. 1980. *Edited by* J.G. Rau and D.C. Wooten. McGraw Hill, Inc. New York, USA, pp. 2.1-2.78.

Policy Proposal: Air Transport in Small Communities

Introduction

Purpose:

To investigate the implications of the termination of routes that Air Canada will no longer be under federal obligation to serve as of December 2002. These routes were agreed to be served for three years following the AC-CAI merger. Specifically, this paper will focus on probable small communities in British Columbia that will be affected by the expected loss of service. This case analysis may be further developed to encompass all small Canadian communities that face loss of air service.

What is at Stake?

"You can't continue to force [Air Canada] to serve those communities and then also say: 'You have to make a deal with [the federal government] to reduce your market share," commented the Minister of Transport David Collenette[1]. The Minister was addressing the current issue of ensuring feasible air services for thin, unprofitable corridors to small Canadian communities. Indeed, many industry experts predict that Air Canada will terminate flights to a significant number of small communities, impacting these passengers[2]. This issue must be looked at immediately because of the lack of interest from the American government to enter bilateral open-skies agreements in the wake of the September 11th crisis and the short 120-day minimum notice Air Canada needs to give for termination of routes as early as the end of 2002.

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[1] "Air Canada dominance untenable and must be curbed, says transport minister" Yahoo! Canada News, December 4, 2001, available at http://ca.news.yahoo.com/011204/6/f7n8.html

[2] Vision and Balance, Report of the Canada Transportation Act Review Panel, June 2001, available at www.reviewcta-examenltc.gc.ca

Stakeholders:

1. Small Communities affected by Air Canada terminating flights at the end of this year
2. Regional Air Carriers and Air Canada
3. Regional Airports
4. Government Policy Makers

Termination of BC Routes to Small Communities

Current Situation:

Air Canada agreed to continue serving all communities that were being served in December 1999, by AC, CAI, and their wholly owned subsidiary routes for three years as part of their agreement in the AC-CAI merger under Bill C-26[3]. The table on the following page shows the commitments that AC will be able to exit officially on January 4, 2003.

Table 1 Air Canada Domestic Air Service Commitments[4]

Yukon	Whitehorse	Ontario	North Bay
(1 point)		(cont'd)	Ottawa
Northwest Territories	Fort Smith		Sarnia
(3 points)	Hay River		Sault Ste. Marie
	Yellowknife		Sudbury
British Columbia	Castlegar		Thunder Bay
(16 points)	Cranbrook		Timmins
	Fort Nelson		Toronto/City Centre
	Fort St. John		Toronto/Pearson
	Kamloops		Windsor
	Kelowna	Quebec	Bagotville
	Penticton	(10 points)	Baie Comeau
	Prince George		Gaspe
	Prince Rupert		Iles-De-La-Madeleine
	Quesnel		Mont Joli
	Sandspit		Montreal

[3] Vision and Balance, Report of the Canada Transportation Act Review Panel, June 2001, available at www.reviewcta-examenltc.gc.ca

[4] [ibid]

	Smithers		Quebec City
	Terrace		Rouyn-Noranda
	Vancouver		Sept-Iles
	Victoria		Val D'Or
	Williams Lake	New Brunswick	Bathurst
Alberta	Calgary	(5 points)	Fredericton
(8 points)	Edmonton		Moncton
	Fort McMurray		Saint John
	Grande Prairie		St. Leonard
	High Level	Prince Edward Island	Charlottetown
	Lethbridge	(1 point)	
	Peace River	Nova Scotia	Halifax
	Rainbow Lake	(3 points)	Yarmouth
Saskatchewan	Regina		Sydney
(2 points)	Saskatoon	Newfoundland	Deer Lake
Manitoba	Thompson	(5 points)	Gander
(2 points)	Winnipeg		Goose Bay
Ontario	Kingston		St. John's
(12 points)	London		Wabush

The termination of small community routes and the subsequent negative effects on passengers is imminent to many industry experts.[5] However, the current *Airline Restructuring in Canada—2nd Interim Report* understands that "carriers which fly in remote, and mostly northern destinations are a key part of the entire Canadian network."[6] Because of this, the standing committee will have greater emphasis on this aspect of domestic air transport in its next interim report.

Focus on BC communities:

Not knowing what degree their service disruptions will cause in the coming year, passengers and communities are anxious to resolve the issue. This will take the resources of governments, other airlines, and providers of alternative forms of transportation to find an optimal

[5] Vision and Balance, Report of the Canada Transportation Act Review Panel, June 2001, available at www.reviewcta-examenltc.gc.ca

[6] [ibid]

alternative. Most likely, the termination of such routes will increase opportunities for small carriers that are capable of surviving in the thin, sparsely populated routes.[7]

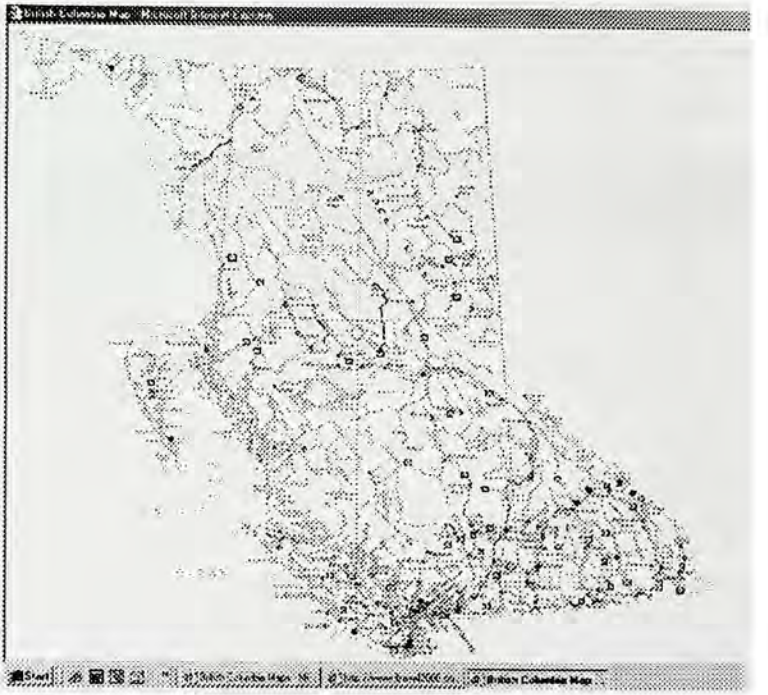
Taking a closer look at the affected British Columbia cities, the chart below, and map on the following page shows which routes AC, WestJet, and Air Tango serve. Please note that the recent introductions of Zip and JetsGo were intentionally not included in the analysis as of May 24, 2002 because they only have plans to fly to major cities.

Table 2 BC Cities Served by Major Carriers[8]			
Air Canada	*WestJet*	*Air Tango*	*Populations 2001*
Castlegar			7,002
Cranbrook			24,275
Fort Nelson			4,188
Fort St. John			16,034
Kamloops			86,491
Penticton			41,574
Prince Rupert			15,302
Quesnel			24,426
Sandspit			460
Smithers			5,414
Terrace			19,980
Williams Lake			25,122
Population			**270,268**
	Abbotsford	Abbotsford	147,370
	Comox		11,172
Kelowna	Kelowna	Kelowna	147,739
Prince George	Prince George		85,035
Vancouver	Vancouver	Vancouver	1,986,985
Victoria	Victoria	Victoria	74,125
Population			**2,452,426**
Combined Population			**2,722,694**
BC Population			**4,094,900**

[7] [ibid]
[8] Statistics Canada. Available on their website: www.statscan.ca

Map of BC[9]:

The map below highlights the communities that these three airlines are serving: (note: original version had full-size map pointing out affected small communities)



[9] Downloaded from the BC Adventures website:
http://www.bcadventures.com/adventure/travelroutes/maps.htm

The population of the smaller communities (270,268) to the population of the larger communities (2,452,426) is approximately 10%. The small communities do represent a significant portion of the province's population, but will most likely face very limited service, or none at all, after the December 2002 withdrawal of obligatory flights. It is these routes that may be too small to enjoy competition, let alone regular air services.

Barriers to Entry

Risky Business:

The air transportation industry is the first to enter the pit of economic downturns and the last to climb out due to the price sensitivity of the product. Following the past few years with the merger of CAI, bankruptcy of Roots Air and Canada 3000, many Canadians generalize that the Canadian airline industry is a challenging market place with high barriers to entry and risk of survival. Many of the barriers are similar to those of other industries, but the bar is higher for new airlines because of the product offered, and first experiencers of a recession. In addition to the common barriers of setting up a firm, there are also specific barriers. One must remember also that the level of barriers to entry depend on the type of entry.

Management Expertise:

New entrants in a new market need talented and quality management. Management is responsible for molding the firm to respond to market environments and changes. The entrants' business plan, created by the executives and managers, will determine the firm's goals, strategies, competitive advantages and execution. Without a competent management team to lead the firm during the lengthy economic lows of the industry, the new entrant will not survive.

Capital:

Sufficient capital is another common barrier to entry. Airlines have high fixed costs to revenues, which mean that profits are highly

sensitive to load factors and fare levels.[10] Acquiring the capital to start and the cost of capital are important to the financing of the company's operations. In addition to the difficulties of finding investors, the investors must adhere to regulations on ownership limiting the pool of potential capitalist. Furthermore, faced with spotty and extremely sensitive demand, it is very hard to determine the time to reach the break-even point.[11]

Airport Facilities:

A very significant airline-specific barrier to entry is the availability of airport slots. Availability of slots will determine the airline's city-pairs, and flight frequency—two sources of competitive advantage. If the airports of the new entrants' intended routes are at capacity and cannot open any slot, the new entrants will have to rework its strategic routes or wait until a slot opens up. Another potential barrier for small communities is the length of runways since it limits which types of aircrafts can safely land in the necessary distance.

Recommendations

Unfortunately for many small communities, the reality is that there lacks the demand to justify the need of a direct air carrier service. Our recommendation is to facilitate a network of niche market carriers serving the airports most affected by the termination of AC services. Indeed, many small regional air carriers exist throughout British Columbia. For example, the carriers flying to Vancouver International Airport's (YVR's) South Terminal include:[12]

1. Canadian Western Airlines
2. Hawkair
3. Helijet

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[10] Vision and Balance, Report of the Canada Transportation Act Review Panel, June 2001, available at www.reviewcta-examenltc.gc.ca

[11] Vision and Balance, Report of the Canada Transportation Act Review Panel, June 2001, available at www.reviewcta-examenltc.gc.ca

[12] Vancouver International Airport South Terminal retrieved from www.yvr.ca

4. Harbour Air Ltd
5. KD Air Ltd
6. Montair Aviation
7. North Vancouver Air
8. Pacific Coastal Airlines Ltd
9. Seair Seaplanes

Often carriers such as Hawkair have planes that can carry as much as 37 passengers[13]. We believe that these carriers or new entrants who own small aircrafts with 4 – 10 passenger capacity will be able to fill the void left behind after AC pulls out of the small communities and leaves no scheduled flights. In these communities, small carriers can act similar to an air-taxi service by providing unscheduled flights only when customers demand it.

Online Board: Application of Trucking Industry

To help facilitate the development of the local air carriers-airport network, there should be a computerized passenger-carrier matching service. This board, done in real-time, will serve to increase the visibility of loads, decrease some of the barriers to entry and promote small local carriers to do more charter flights to smaller airports.

Our recommendation is drawn from our past experience in the trucking industry. In the trucking industry, motor carriers are numerous, many of which are owner-operator companies. One of the greatest expenses is empty backhauls. For example, Joe's Trucking will accept a paper load from the local recycling plant in Vancouver to deliver to Trail, BC. However, because there are not very many shippers in Trail, the trucker will have to either deadhead to the nearest load available to go back home, head home empty, or wait until a load presents itself. All of these opportunity costs hurt the bottom line.

[13] Hawkair is a popular passenger airline operating two 37-seat Dash 8s serving the communities of Terrace, Kitimat, Prince Rupert, Smithers and Vancouver, B.C. Their aircrafts can be viewed at www.hawkair.net.

In recognizing this need to match truckers to suppliers, numerous online load-matching companies have been established on the Internet. These boards are called "load boards" and connect the buyers and sellers of road or intermodal transportation. Suppliers and load brokers will post freight, freight details, equipment requirements, and contact information on the digital board. Truckers and dispatchers, when needing a shipment to go back home will look on the digital boards for any loads that they can take. If they do spot a load, they will contact the supplier or broker via telephone, fax or e-mail. This can eliminate the trucker's deadhead miles, empty backhauls and increase utilization of equipment. For the buyer, the increased visibility of location of available truckers will reduce the time spent looking for a carrier to move or for buyers in remote locations, paying for the truck drivers' empty miles.

Amalgamated Information:

Although this form of e-Commerce in visibility and information exchange is highly used, the trucking load matching industry faces a problem of too many online boards.[14] Suppliers and carriers assume that the one that they are using are to best suited for their needs. If all of these online boards were to be amalgamated into one information database it would create a marketplace where all suppliers and carriers could have access to all the information. Because of technology requirements and the numerous motor transport carriers in the US and Canada, this is a highly idealistic and currently infeasible. However, because the online board that we are proposing would only address the needs of rural communities in Canada, it would be feasible for the short haul, for-hire carriers in Canada.

Proposal:

Our recommendation is for policy makers to implement a real-time online passenger-carrier board used only by rural airports to facilitate air services of small, short-haul for-hire air carriers.

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[14] New Load-Matching Landscape Heavy Duty Trucking, March 15, 2002. Available at http://www.truckinginfo.com/news/news_section_current.asp?news_section_id=5

How the System Would Work:

1. A potential passenger will contact the regional airport to specify:
    a. Date and time preference
    b. Type of flight (One-way or return)
    c. Bid fare

2. Regional airports will:
    a. Ensure the take-off time at the origin and landing-time at the destination cities are available
    b. Contact their list of aircraft owners who meet the minimum requirements (maximum distance aircraft can fly) of the specific routes

3. Aircraft owners will:
    a. Be notified of bid fares from passengers for specific routes
    b. Respond to the airport facilitator if they are available and willing to submit a counter-bid fare

Analysis: Stakeholder Incentives

Although the concept of individuals following their economic incentives seems quite obvious, policy makers must not forget that stakeholders will behave in their best interests[15]. As a result, the three primary stakeholders—regional passengers, aircraft owners, and regional airports—should have suitable motivations to use the proposed system.

Regional Passengers:

Regional passengers, who suffer from a loss of air service after December 2002, will need to find alternative transportation. Generally, those passengers who prefer air transport find land and marine transport infeasible (due to geographic concerns such as

[15] Brander, James A. Government Policy Towards Busines, 3rd ed. (p.18)

distance or lack of efficient road infrastructure). Simply put, they would prefer to fly if there were available aircrafts to transport them. Passengers will have a greater incentive to use the air-taxi system over other means because of its ability to connect buyers and sellers of air transport.

Aircraft Owners with unscheduled flights:

The owners of non-leisure aircrafts have incentives to maximize profits. When they are not using their aircrafts for their primary business function (such as fishing expeditions on the Northern Coast), the aircrafts are idle and not producing any revenues. Since this is a fleet of small aircrafts, they have lower fixed and variable costs than major air carriers. If there are profitable routes for small aircrafts, these owners will have an incentive to locate these passengers by using the proposed system.

Regional Airports:

Also in a position to maximize profits, airports have the incentive of increasing traffic flow to generate more revenues. Since airports have a high fixed cost to variable cost ratio, more flights allow fixed costs to be spread over more passengers. On an ongoing basis, this player has an aggregate incentive of increasing flights by connecting as many potential passengers and available aircrafts as possible. They have the most to gain from the proposed system and are integral in acting as a broker in facilitating the movements of passengers. Their high incentives from aggregate revenues will act as a key motivation to implement the proposed system.

National Airports Policy:

Extending the analysis to the all of Canada, it is important to look at the 726 airports in the National Airports Policy. Although the 26 major airports account for 94% of all air passenger and cargo movement in Canada, it would be a mistake to overlook the other 6% of air transport. The remaining 700 airports consist of Regional and Local Airports, Small Airports, and Remote Airports. The federal government will continue to operate and subsidize the Remote Airports. However, they are in the process of transferring the other

two airports to local governments and private leases, or closing the airports.[16] In order for the airports not to be closed, the federal government should have an implementation plan that will facilitate the future of air traffic movement in these smaller communities.

Example of How the System Works:

A businessperson, Tom wants to fly from Terrace to Fort Nelson but there are no available scheduled flights to arrive for his meeting. For this flight, he has a maximum willingness to pay of $600, but specifies to the airport facilitator an opening bid price of $300. He submits a bid much lower than his willingness to pay in order to benefit from some consumer surplus.

A sightseeing airline manager receives a notice from the airport notifying him that their aircrafts meet the requirements for the origin-destination pair and asks for a counter-bid. He checks that this flight does not coincide with his business operations and prepares a counter-bid. Although he has a minimum willingness to sell of $400 to cover the costs of the flight and reasonable profits, he counter offers with $700.

The airport staff would facilitate the bid and counter-bid process until a final price is reached. In this example, with a maximum willingness to buy of $600, and a minimum willingness to sell of $400, a reasonable estimate is that a fare of $500 would be reached. Both participants are satisfied because they keep some of their consumer surplus and producer surplus. The system provides the appropriate marketplace for the transactions to occur. Indeed, this system is best suited to passengers who do not have feasible alternatives to air travel, and aircraft owners who want to make more money aside of their primary business activity. Regional airports will enjoy more frequent flights. Ideally, all three parties benefit from the transaction.

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[16] UBC Commerce 444: Air Transportation Class Notes

Summary

Air Canada will terminate services to many small communities in British Columbia, and the rest of Canada. Once this occurs at the end of this year, a niche market will open up for small regional carriers to serve these passengers. With the barriers to entry, government policy-makers must take actions to create incentives for aircraft owners to fly these specific routes.

Based on the analysis of the airline structure in small and rural communities in British Columbia and the application of the freight brokering system in the trucking industry, a recommendation to facilitate competition across the local air carriers in these communities was discussed. This recommendation involves the implementation of a commercial Internet "load board" that would be run by regional airports to match the needs of passengers and availability of equipment by carriers.

Bibliography

Air Canada. Air Canada Annual Report 2000
http://www.aircanada.ca/about-us/investor/ar2000_e.pdf

Air Canada. Air Canada Partners http://www.aircanada.ca/services/partners/ifp202a.html

Air Canada. Air Canada Reports Fourth Quarter and Year 2001 Results [released February 2002] http://micro.newswire.ca/releases/February2002/07/c9565.html/13213-0

BC Adventures. BC Travel Maps
http://www.bcadventures.com/adventure/travelroutes/maps.htm

Bendel, John. "New Load-Matching Landscape" in Heavy Duty Trucking, March 15, 2002.
http://www.truckinginfo.com/news/news_section_current.asp?news_section_id=5

Bird, Jerry W. "Sandspit, Queen Charlotte Islands: Gateway to Canada's Galapagos, Gwaii Haanas National Park " www.airhighways.com/sandspit.htm

Brander, James A. Government Policy Towards Business, third revised edition (John Wiley et Sons Canada, Ltd: Toronto, 2000).

Canadian Transportation Act Review. "Preparing for Service Termination" in Vision and Balance http://www.reviewcta-examenltc.gc.ca/english/pages/final/ch7e.htm

Hawkair. www.hawkair.net

Oum, Tae. "UBC Commerce 444: Air Transportation Class Notes"
http://www.commerce.ubc.ca/

Prince George Chamber of Commerce. http://www.pgchamber.bc.ca/

Statistics Canada. "BC Cities Served by Major Carriers", 2001. http://www.statscan.ca/

Thorne, Stephen. "Air Canada dominance untenable and must be curbed, says transport minister," in Yahoo! Canada NEWS, December 4, 2001.
http://ca.news.yahoo.com/011204/060f7n8.html

Transport Canada. Transportation in Canada—2000 Annual Report
http://www.tc.gc.ca/pol/en/anre2000/tc0013fe/htm

Ward, Debra. Airline Restructuring in Canada—Second Interim Report
http://www.tc.gc.ca/pol/en/Air/report2/airline_restructuring_table_of_contents

Wong, Craig. "Small-market airline service declining and analysis suggest it will get worse," in CANOE Travel News, November 22, 2001.
http://www.canoe.ca/TravelNews2/011122_smallmarket-cp.html

Real-Time Identification and Tracking of Recurrent Traffic Queues based on Average Link Speed Using Loop Detector Data

T. Nixon Chan, University of Waterloo
(Winner of the Albert Stevens Award in the Master Category of the 2001-2002 Student Paper Competition)

INTRODUCTION

A *traffic queue* is defined as the contiguous region of congested traffic that results when traffic demand exceeds capacity. For most of the time, queues are formed on a recurrent basis due to typical travel patterns during the peak hour. Therefore, automatic queue identification and tracking of recurrent queues on a freeway corridor are very useful for traffic monitoring and for determining the impact of an incident on traffic flow. The information on a queue can be delivered to drivers through changeable message signs (CMS) that inform drivers of the current traffic condition on the freeway.

A number of queue-tracking models have been developed in the past. For example, Payne and Thompson (1998) attempted to identify queue-zone between loop detector stations on the basis of the boundary between "queue" and "no-queue" using only "spot" speeds at loop detector stations. However, the selection of boundary is very subjective and does not have a theoretical background. Similarly, Hellinga and Lee (2001) developed a model to identify the true location of a tail of a queue between two loop detector stations on the basis of queue theory and shock wave theory. However, these two models estimate the location of the queue solely based on "spot" speeds at loop detector stations. Therefore, they are unable to capture the variation of traffic condition within the section between

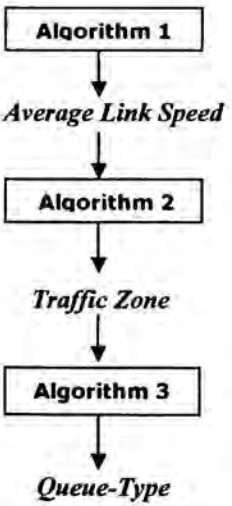
loop detector stations. In order to consider the traffic condition within the road section, average link speed within the road section needs to be estimated.

The objective of this paper is to develop a model for real-time identification and tracking of recurrent queue based on average link speed (from the travel time estimation algorithm) using loop detector data. The detailed methodology for estimating travel time and queue-tracking is presented in the following sections.

METHODOLOGY

The proposed model can be summarized in three simple steps. Details of each step are discussed in the following sub sections.

For each time interval:



Calculate average link travel time for each link formed between two loop detector stations. Then calculate average link speed based on the average link travel time.

Based on average link speed, "traffic zone" is determined.

Traffic zones from previous step are then presented to this algorithm to estimate the queue-type of a road section. The algorithm predicts queue-type on a real-time basis.

Algorithm 1—Travel Time Estimation Algorithm

The model estimates travel time in the following steps:

1. The model first calculates the "one-minute moving average speed" (OMA-Speed) across all lanes then averages them to calculate the "final speed" (S_f) of both upstream and downstream loop detector

stations. For each road section, the upstream "final speed" is denoted as S_{f1} and the downstream "final speed" is denoted as S_{f2}.

OMA-Speeds are used to reduce the large variations associated with the detector data.

2. Travel time is calculated from the following relationship between speed, distance, and time.

$$t_n = 3.6 * \frac{d}{S_{fn}} \quad (1)$$

where:

t_n = estimated travel time (sec) at loop detector station "n"
d = distance (m) between the two successive loop detector stations
S_{fn} = final speed (km/h) at the station "n"
n = loop detector station ID (upstream = 1, downstream = 2)

3. The model calculates travel time based on the average travel time calculated from the two "final speeds" at the two loop detector stations. This is described in Equation 2 as follows.

$$t_f = \frac{t_1 + t_2}{2} \quad (2)$$

where:

t_f = final travel time (sec) of the road section
t_1 = travel time (sec) at upstream loop detector station using Equation 1
t_2 = travel time (sec) at downstream loop detector station using Equation 1

Substituting Equation 1 into Equation 2, results in:

$$t_f = \frac{3.6 * \frac{d}{S_{f1}} + 3.6 * \frac{d}{S_{f2}}}{2} = 1.8 * d * \left[\frac{1}{S_{f1}} + \frac{1}{S_{f2}}\right] \quad (3)$$

where:

t_f = final travel time (sec) of the road section
S_{f1} = OMA-Speed (km/h) at upstream loop detector station
S_{f2} = OMA-Speed (km/h) at downstream loop detector station
d = distance of the road segment (m)

As a result, the final travel time (t_f) between a pair of loop detector stations can be calculated using Equation 3. The average link speed can be calculated using Equation 4.

$$S_{link} = 3.6 * \frac{d}{t_f} \qquad (4)$$

where:

S_{link} = average link speed (km/h) between the two loop detector stations
d = distance of the road segment (m)
tf = final travel time (sec) of the road section

It should be noted that if speed and/or volume data (such as, due to noise or breakdown of loop detectors) are missing, the data at the next upstream/downstream loop detector station was used instead.

Algorithm 2—Traffic Zone Identification Algorithm

The proposed model is modified from the methodology of identifying traffic queue suggested by Payne and Thompson (1998). Unlike their original study - instead of using "spot" speeds as the threshold speed to identify queue existence, this study uses average link speed or speed difference calculated from the travel time estimation model as the threshold speed.

The traffic zone identification algorithm in this study utilizes three categories of traffic conditions defined by Kerner and Rehborn (1996) as follows; 1) "Free Flow", where vehicles are able to change lanes and to pass; 2) "Synchronized Flow", where vehicles are not able to pass due to a higher density as in free flow, and 3) "Traffic Jam" where vehicles are moving very slow or at a high density condition.

To define the traffic zone categories, two threshold speeds, namely **FREE** and **BREAK**, must be determined. The FREE threshold speed is used to identify the boundary between free traffic flow and synchronized traffic flow, and the BREAK threshold speed is used to identify the boundary between synchronized traffic flow and traffic jam. The traffic zone categories are summarized below:

Traffic Zone Category	Criteria
Free Flow (FF)	S_{link} > FREE
Traffic Jams (TJ)	S_{link} < BREAK
Synchronized Flow (SF)	Otherwise

where S_{link} is the average link speed of a road section

Algorithm 3—Queue-Type Identification Algorithm

The objective of the queue-type identification algorithm is to identify whether a queue exists within a road section. Queue types are categorized in the following five categories: (1) head-of-queue, (2) tail-of-queue, (3) in-queue, (4) no queue, and (5) inclusive queue. A head-of-queue zone represents the road section *downstream* of the queue body where traffic returns to uncongested conditions. Similarly, a tail-of-queue zone represents the road section *upstream* of the queue body where traffic first becomes uncongested. All zones, if any, lying between the head-of-queue and tail-queue zones are categorized as in-queue zones. If no tail-of-queue has been identified, then the current head-of-queue section becomes "queue" (a.k.a "inclusive queue"), where queue only forms within the one specified road section, not on the adjacent road sections.

The steps of identifying queue-type is as follows: (1) Initialize all road section to no-queue; (2) identify all head-of-queue conditions; (3) find the associated tail-of-queue for each head-of-queue and label all road sections in between, if any, as in-queue; and (4) if no tail-of-queue has been identified, then the current head-of-queue section is labeled as "queue."

The methodology of identifying queue-type is as follows. Queue-type is identified starting from the downstream road section (head-of-queue is always identified first) to upstream road sections. *Figure 1* illustrates the queue-type identification methodology.

As shown in the *Figure 1*, in order to identify a head-of-a-queue or a tail-of-a-queue for any road section, two upstream/downstream road sections are required. The reason for this requirement is the uncertainty of queue identification under synchronized flow condition. This uncertainty can be overcome by comparing adjacent road sections. All possible cases have been illustrated in *Figure 1*.

Therefore, a minimum of 5 road sections (two upstream and two downstream depends on situation) is required in order to justify the identification.

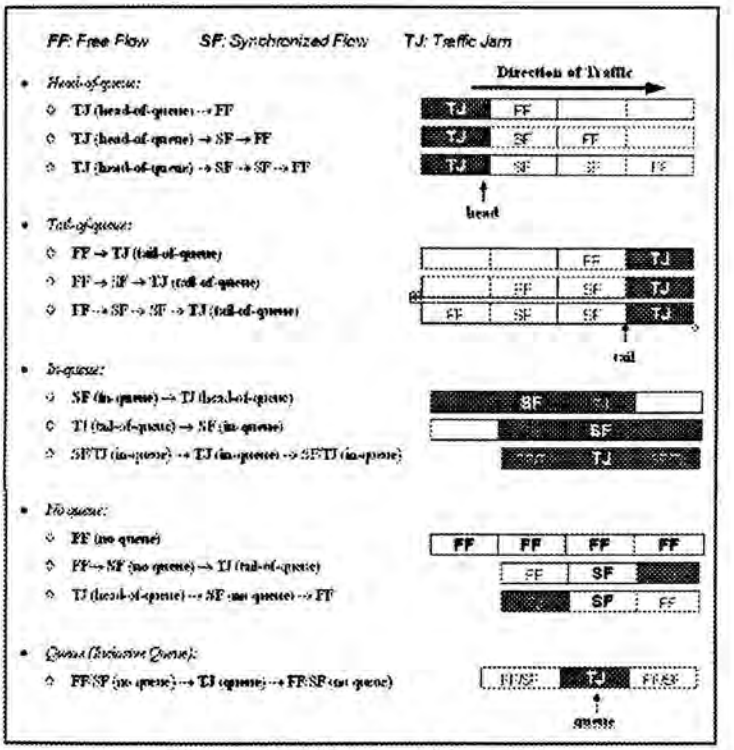


Figure 1: Identification of Queue-Type

CALIBRATION

The model was calibrated using video images recorded on a 500-meter stretch of the Gardiner Expressway in the City of Toronto and the corresponding loop detector data. Since the results observed from the video images are subjective, an alternative method called

the "rescaled cumulative arrival curves" [N-Curves] (Cassidy and Bertini, 1999) was used to verify the results.

Determination of FREE Threshold Speed

Procedures

FREE threshold speed is defined as the free flow speed. It can be estimated from the relationship between volume and occupancy for a 24-hour period at any loop detector station on the freeway. The fitted linear slope of the high volume area is assumed to be the FREE threshold speed.

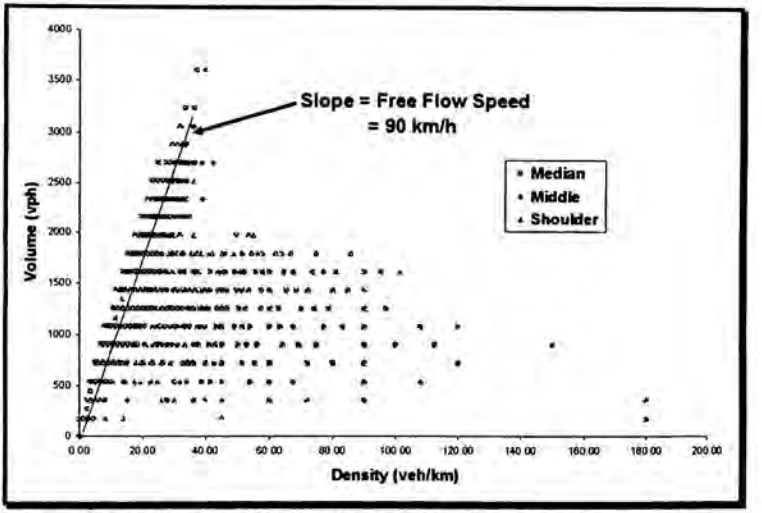


Figure 2: FREE speed Estimation on Gardiner Expressway using data at station dw0010dwg on May 14, 2001

Results

As shown in the volume-density relationship (*Figure 2*), FREE speed has been estimated to be 90 km/h. It was assumed that the similar volume-density relationship would be observed at all other detector stations as the speed limit on the freeway is 90 km/h.

Calibration of BREAK Threshold Speed

Once the FREE speed is calculated, the next step is to calibrate the **BREAK** threshold speed. There are two ways to calibrate the BREAK threshold speed. The first calibration utilizes the video image and the second calibration utilizes the N-Curves.

Calibration with Video Image

Procedures

The first calibration process is described as follows:

1. Visually identify the queue-types from the video image every 20-second interval at the road section shown in *Figure 3*.
2. Objectively identify the queue-types using Algorithm 3 for a range of possible BREAK speed.
3. Compare the "observed results" with the "model results" for the given BREAK speed, and then calculate the percentage of error associated with each BREAK speed.
4. Identify the BREAK speed with the lowest percentage error.

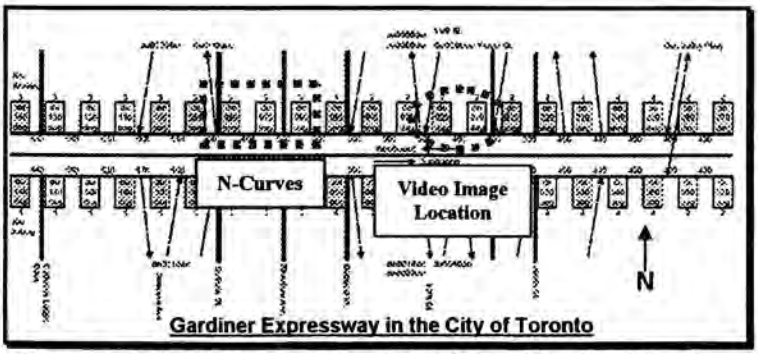


Figure 3: Video Image Location (recorded on Monday, May 14, 2001) and Freeway Location tested with the N-Curves

Description of Video Image

The video image was recorded on Monday, May 14, 2001 on a 500-meter stretch of the Gardiner Expressway between Bay Street and York Street in the City of Toronto. The expressway is instrumented

with dual-loop detectors located approximately every 500-meter in all lanes; the detectors data are polled every 20 seconds. Also, the westbound section experiences recurrent congestion every weekday during the PM peak period (3PM -6PM) and the section of roadway between two loop detectors contained no on-ramps or off-ramps. The entire section of roadway could be viewed from atop the CN Tower. This permitted video recording to be made at a height of 345-meter above the roadway.

Results

The lowest percentage error was about 14.41% when BREAK speeds are in the range of 68km/h - 74 km/h as shown in *Figure 4*. Since one BREAK threshold speed should be used for this freeway for simplicity, the mean speed of 71 km/h (approximately 80% of the FREE speed) was chosen. Since the visual identification of "queue-type" was subjective, the model was calibrated using an alternative method called "re-scaled cumulative arrival curve" (N-Curve).

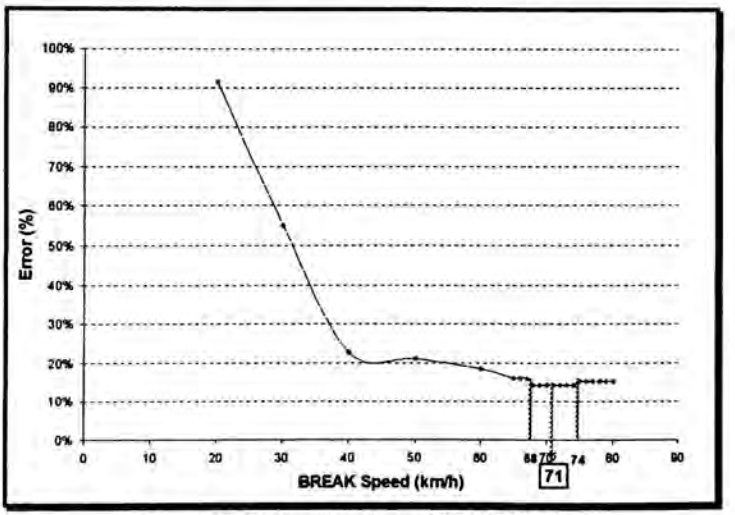


Figure 4: Determination of BREAK Speed

Calibration with N-Curves Theory

The queue-tracking model was validated by comparing the actual location of queue using the re-scaled cumulative arrival curve *(N-Curve)* proposed by Cassidy and Bertini (1999). The curve represents the cumulative counts of vehicles which pass the given detector station. Other than the curve for the most upstream station, the curves of all the downstream stations will be shifted horizontally such that they match the curves for the upstream station. Each curve will be shifted by the average free-flow trip time from its respective location to the most upstream loop detector station. Average free-flow trip time is determined based on the free-flow speed of the freeway (in this case, it is 90 km/h) and the distance of the road section(s). Eventually, when queue does not exist on a road section for a certain time period, the two curves at two successive detector stations will overlap each other. Following these shifts, any vertical displacements between the curves can be interpreted as the excess vehicle accumulations (i.e. the number of vehicles in a queue) due to traffic delays. At the point where excessive vehicle accumulation is found, the time and the location of the queue formation can be identified. To evaluate the performance of the model, this observed time of queue formation was compared with the predicted time and "queue-type." However, the constraint with N-Curve is the road section of any two consecutive stations must not contain any on-ramp and off-ramp if the ramp volumes are not provided.

Results

The selected section tested with N-Curves is shown in *Figure 3*. The section does not contain any on-ramp or off-ramp.

For the purpose of this study, the calibration process compared the time when traffic state changes (e.g. from no-queue to head-of-queue). In order to identify a head-of-queue, two curves must overlap each other (which indicate no-queue) for a certain time period then start to split apart at which traffic volume increases at the upstream loop detector stations.

The N-Curves for the selected freeway section is shown in *Figure 5*, while the model's results are shown in *Figure 6, 7, and 8*

for the same location at different time period. As shown in *Figure 5*, there is a sudden increase in vertical displacement between the two station curves of dw0060dwg (upstream station) and dw0070dwg (downstream station). The vertical displacement continues to increase until around 6:19PM when it became constant. This indicates a decrease in spot speed at the upstream station in comparison with the downstream station—at the time when a sudden increase in vertical displacement occurred. This traffic condition can be classified as a head-of-queue formation. This formation occurred between station dw0060dwg and dw0070dwg at around 3:36PM in N-Curve while the model (from *Figure 6*) indicates the head-of-queue occurred at 3:38PM. As a result, there was a two-minute delay of queue detection.

When the vertical displacement between the curves became constant at 6:19PM, this implies the section between the two loop detector stations was in the middle of a queue (i.e. in-queue) between 6:19PM and 7PM when the volume reaches at capacity. From *Figure 7*, the model indicates that the road section experienced the transition from head-of-queue to in-queue. Also, the decrease in the rate of volume change after 7 PM indicates the traffic became less congested after the PM peak period and consequently, the queue started to dissipate (i.e. the location of a tail of a queue gradually propagates towards downstream of traffic stream). The model clearly reflects this evolution of a queue that was observed from the N-Curves as shown in *Figure 8*. Based on the comparisons above, the suggested model generally showed consistent results with N-Curves in terms of queue movement.

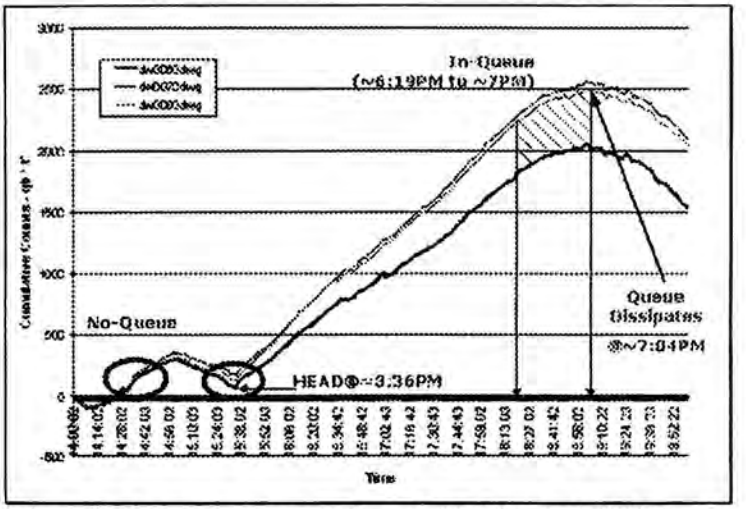


Figure 5: N-Curves at stations from dw0060dwg to dw0080dwg on May 14, 2001

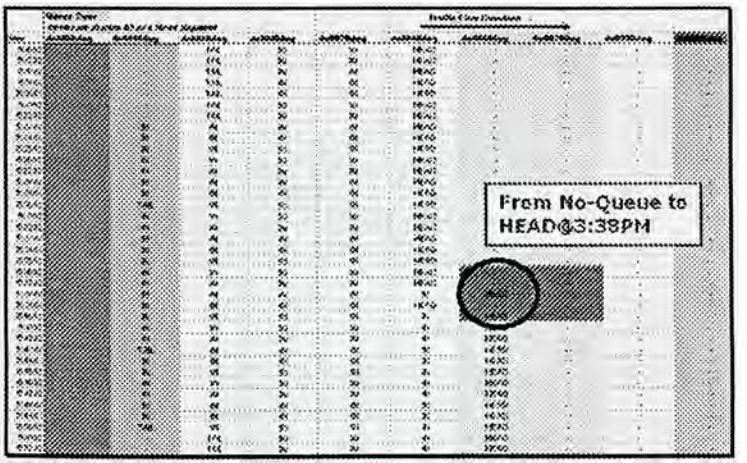


Figure 6: Model Results on May 14, 2001 around 3:30PM

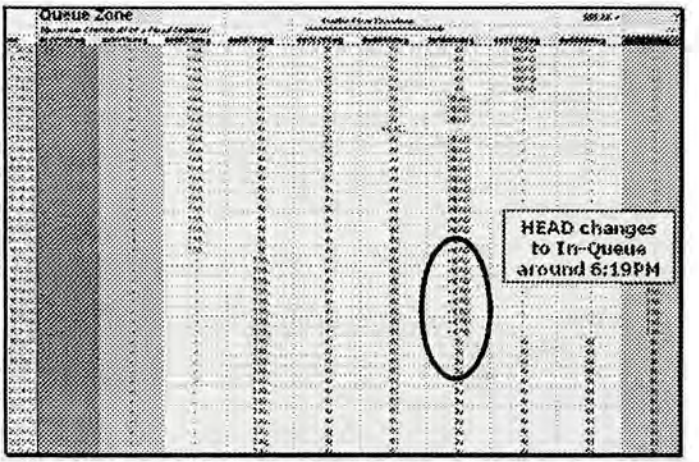


Figure 7: Model Results on May 14, 2001 around 6PM

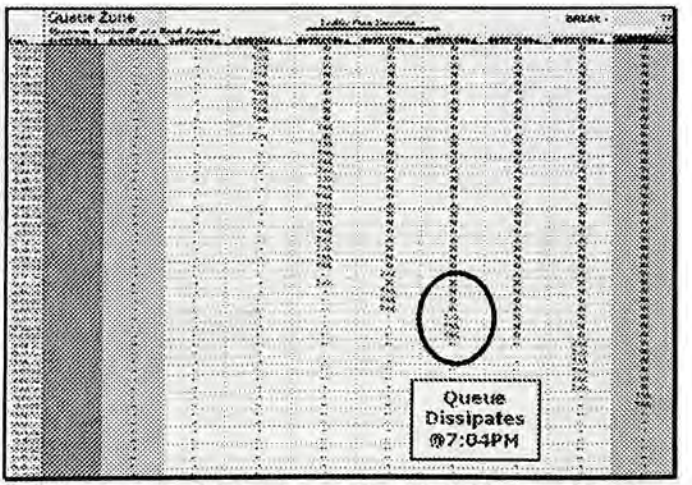


Figure 8: Model Results on May 14, 2001 around 7PM

Please note that the BREAK speed was calibrated to be 77km/h to derive the above results. This is different from the BREAK speed calibrated using video image (which is 71km/h). With the BREAK speed at 77km/h, the error with respect to video image increased to 15.25% from 14.41%.

Similar analysis was completed on four other days for the same time period (2PM-7PM). The results are summarized in *Table 1*.

Table 1: Summary of BREAK Speeds Range

Date	BREAK Speeds Range (km/h)	Mean Speed (km/h)
December 07, 1998	70-78	74
December 08, 1998	65-77	71
December 09, 1998	76-78	74
December 10, 1998	66-72	69
May 14, 2001	77-78	77.5
		73.1

The BREAK speed ranges for these five days are within 65-78 range. The mean BREAK speed across all the dates is 73.1 km/h with a mode of 77 km/h. Since the range of BREAK speeds is very small, instead of using the mean speed as the fixed BREAK threshold speed for this freeway, the mode speed was suggested for this model.

In summary, the suggested FREE threshold speed for the model is 90 km/h (which is the speed limit of the freeway) and the suggested BREAK threshold speed for the model is 77 km/h (which is about 85% of the FREE threshold speed).

VALIDATIONS

As stated above, BREAK threshold speed was suggested as 77 km/h. The next step is to validate this BREAK speed. The speed should be validated with the "true" results observed from the video image. However, video image were only recorded on Monday, May 14, 2001; therefore, the results derived using the mean BREAK speed

will be denoted as the "true" results and will be used to validate with the BREAK speed 77 km/h.

The difference of the percentage error between the "true" results and the model results are summarized in *Table 2*.

Table 2: Validation Results

DATE	Dec. 7/98	Dec. 8/98	Dec. 9/98	Dec. 10/98	May 14/01
ERR%	5.0%	9.4%	3.0%	8.1%	2.3%

The average percentage error is about 5.56% with the highest error percentage at 9.4% on December 8, 1998. This percentage error is quite low considering the application of one single BREAK speed.

In addition, the above percentage error only represents the difference between the results derived from the mode BREAK speed and the mean BREAK speed; it does not represent the "true" percentage error. Therefore, a conservative percentage error should be made between the real "true" results with the "model" results. The percentage error between the model and the video image is 15.25%; the percentage error between the model and the mean BREAK speed results is 9.4% (on December 8, 1998); the combined percentage error is 24.65% (around 25%). This is the upper bound percentage error between the real "true" results and the "model" results. As a result, the model can identify a queue on the Gardiner Expressway with an accuracy of 75%.

Conclusions and Recommendations

In conclusion, this model can successfully identify and track a queue in real-time on the selected freeway with the two fixed threshold speeds. The accuracy of he model prediction was generally high in spite of simple assumptions. This model overcomes the limitation of the two existing models (Payne/Thompson and Hellinga/Lee) by using link speeds rather than "spot" speeds. This model is highly recommended for practical uses in automatic freeway management system and can be integrated with other ITS applications. This

model can provide an extensive queue-type identification diagram of any freeway corridor.

In future studies, further calibration is suggested for the BREAK threshold speed if video image is available on the same road section collected on different days. Also, the calibration is recommended for other urban freeways (e.g. Highway 401 in the City of Toronto) where the traffic congestion recurrently occurs. It appears that on-ramp and off-ramp on freeways would not affect the queue identification process because the average link speeds reflect the effect of traffic delay caused by the traffic entering from/exiting to ramps. This needs to be confirmed in future studies.

REFERENCES

Cassidy, M. J. and Bertini, R. L. (1999). Some Traffic Features at Freeway Bottlenecks. Transportation Research Part B 33, pp. 25-42.

Hellinga, B. and Lee, C. (2001). Freeway Queue Tracking Using Loop Detector Data. Submitted for the presentation at the 81st Annual Meeting of Transportation Research Board, Washington, D.C.

Kerner, B. S. and Rehborn, H. (1996). Experimental Properties of Complexity in Traffic Flow. Physical Review E, Volume 53, Number 5: R4275.

Payne, H. and Thompson, S. (1998). Identification and Tracking of Recurrent Traffic Queues. Submitted for the presentation at the 78th Annual Meeting of Transportation Research Board, Washington, D.C.

A Survey-Based Approach to Measure Taxiway Delay and Predictability at Lester B. Pearson International Airport

Yuval Grinspun (Transportation Engineer)
IBI Group
Email: ygrinspun@ibigroup.com

Eric J. Miller (Professor)
Department of Civil Engineering
University of Toronto
Email: miller@civ.utoronto.ca

Executive Summary. This study focuses on developing taxiway delay estimates for Toronto's Lester B. Pearson International Airport (Pearson) and comparing the values to US airports that have a high number of aircraft movements. A Monte Carlo simulation is used to examine the predictability of delay at Pearson and to determine where improvements would have the most impact. Analysis followed a survey-based approach that proved to be more robust, transparent. The results indicate that passengers at Pearson experience high taxi-in and taxi-out times, due to both large travel distances as well as high levels of delay. The Monte Carlo simulation indicated both the taxi-in and taxi-out times to be unpredictable, but with a significant opportunity to improve the predictability of the taxi-out time through a reduction of delay. Initiatives such as NAVCanada's Airport & Airspace Performance Monitor (AAPM) will offer researchers an opportunity to gain further insight into the causes of delays and predictability. Combined with the results of this study, airport planners will be able to identify where technological or operational improvements will have maximum effect.

A Survey-Based Approach to Measure Taxiway Delay and Predictability at Lester B. Pearson International Airport

Yuval Grinspun (IBI Group), Eric J. Miller (University of Toronto)

This paper is an excerpt of a graduate thesis completed in Spring, 2002, at the University of Toronto [1]. For an in-depth discussion of the data collection methods, taxi time models and sensitivity analysis, please refer to the thesis paper.

1. INTRODUCTION

With no practical alternative to long distance travel, the aviation industry grew significantly in the late 20th century. For the first time, demand exceeded capacity on a regular basis at airports across the continent. Infrastructure to support the growing number of trips was not developed rapidly enough to meet demand, and this resulted in longer runway queues, as well as taxiway and terminal building congestion. Continued resistance to airport development has in turn resulted in increased emphasis on operational improvements.

In 2000-2001, the Federal Aviation Administration (FAA) determined that technology improvements could provide a capacity increase of 3-8%, while operational enhancements could boost it an additional 5-10% [2,3]. For North American airports with little potential to grow (due to physical constraints or political resistance), this is a very significant, and worthwhile, venture.

To plan future improvements, one must first understand both the causes and the magnitude of the problem. This study focuses on developing taxiing delay estimates for Toronto's Lester B. Pearson International Airport (Pearson) and comparing the values to other North American airports with high passenger volumes. A Monte Carlo simulation is used to examine the predictability of delay at Pearson and to determine where improvements would have the most impact. Obviously, predictable delay is preferred because airlines, passengers and airports are then able to proactively adapt or shift their operations accordingly.

Data for this study came from the following sources:

- visual surveys at Lester B. Pearson International Airport;

- the FAA's Consolidated Operations and Delay Analysis System (CODAS) database; and
- planning departments at: Toronto's Pearson Airport (YYZ), Orlando International Airport (MCO), Las Vegas McCarren International Airport (LAS), Denver International Airport (DEN), St. Louis-Lambert International Airport (STL), Minnesota-St. Paul International Airport (MSP), Dallas-Ft. Worth International Airport (DFW), Boston Logan International Airport (BOS), and Charlotte Douglas International Airport (CLT).

2. THEORETICAL FRAMEWORK

The airside of an airport can be divided into four component systems: the runways, the gates, the apron and the taxiways. Each of the four components plays a different role, and thus each has different constraints affecting its maximum throughput.

Although aircraft interact with one another as well as with other vehicles on the airside system, most of the delay incurred while on the apron or taxiway is waiting for a runway or a gate. Thus, while the primary purpose of the apron and taxiway is to provide a route between the runway and gate, they also provide space for aircraft to queue for deicing (if required), takeoff, to cross a runway, or for a gate that is occupied or blocked to free up. That said, delay incurred on the taxiway due to congestion can be significant under some circumstances [4].

2.2 Taxi-In

To determine how much delay an aircraft experiences during taxi-in or taxi-out, one must examine the different components of each. The taxi-in time runs from when the wheels touchdown to when the aircraft docks at the terminal gate. This interval can be broken down into the following components:

1. Runway occupancy time;
2. Unimpeded taxi-in time; and
3. Taxi-in delay.

To isolate delay, the average runway occupancy time and average unimpeded taxi-in time will be independently quantified and

subtracted from the average taxi-in time. The resulting delay can be a result of congestion, interaction with controllers, weather or wind effects, waiting for the gate to free up, pilot behaviour, or unexplainable circumstances.

2.3 Taxi-Out

The taxi-out time runs from when the tug begins pushing the aircraft away from the gate until the aircraft receives takeoff clearance. It can be divided into the following components:

1. Pushback time;
2. Unimpeded taxi-out time;
3. Taxi-out delay;
4. Runway queue delay; and
5. Deicing time (when applicable).

As with the taxi-in process, this study isolates the delay components by removing the pushback time and the unimpeded taxi-out time from the average taxi-out time. Since the study focuses on a time of year with favorable weather conditions (and therefore no associated deicing time), the resulting total delay represents the taxi-out delay and the runway queue delay.

2.4 Taxi Time Predictability

A Monte-Carlo simulation is performed to examine the predictability of taxi times at Pearson. Each of the components of the taxi-in and taxi-out time was modeled independently. The standard deviation of the resulting taxi times is used as a measure of delay predictability.

3. UNIMPEDED TAXI TIMES

Due to the variable's theoretical nature, unimpeded taxi time (the time a plane would take to taxi given that there are no delays) cannot be measured directly. Even if one were to measure the taxi times for aircraft that experience no taxiway congestion or runway queue delay, one cannot determine what level of delay is caused by such factors as weather or tower communication. Two methods were considered to determine the unimpeded taxi time:

1. Perform regression analysis on a data set with *taxi time* as the dependent variable and *number of aircraft in arrival queue* and *number of aircraft in departure queue* as the independent variables. The unimpeded taxi time would be a result of inserting values of 1 and 0 for the appropriate independent variables.
2. Find appropriate values for characteristics of aircraft taxiing (i.e., unimpeded straight-line speed, turning time), and apply to the average route covered by the aircraft during taxi. This method was ultimately used in the analysis for the reasons discussed in this section.

3.1 Using Regression to Model Unimpeded Taxi Times

In the development of the Consolidated Operations and Delay Analysis System (CODAS) database, the FAA recognized the use of an unimpeded taxi time for analyses [6]. However, rather than developing new data directly relating to the unimpeded taxi time, the FAA tried finding unimpeded taxi times using a statistical analysis of existing data.

Using the gate-out and wheels-off variables, CODAS calculates how many vehicles are in the departure queue at each minute of the day. Aircraft that have pushed back from the gate (gate-out) but have not yet taken off (wheels-off) count towards this value. Similarly, CODAS calculates the arrival queue using the wheels-on and gate-in variables. These values are calculated for each departure for the minute after the flight pushes back from the gate. A regression analysis is performed with taxi-out time as the dependent variable and number of aircraft in taxi-out and taxi-in queues as the independent variables. After the regression is complete, the unimpeded taxi-out time is estimated by setting the departure queue to 1 and the arrival queue to 0. A similar process was used in developing unimpeded taxi-in times.

This study attempted to use the regression-based method to find Pearson's unimpeded taxi times. However, due to inaccuracy and insufficient precision in the data, the results could not be relied upon for this project. The data set consisted of gate departure/arrival times entered at the terminals and wheels-on and takeoff-clearance times entered by controllers. In several cases aircraft were logged as having arrived before landing, or taken off before departing. More

importantly, the only data available for this study had insufficient precision (only went to the minute) to make the results useful. It would have been beneficial to have a regression analysis on Pearson data for the sake of having a direct comparison to the second method.

3.2 Using Taxiing Behaviour to Model Unimpeded Taxi Times

The second method of determining the unimpeded taxi times involved finding an unimpeded taxiing speed, and applying that to average taxi route characteristics calculated from Jeppesen and Canada Air Pilot maps.

3.2.1 Unimpeded Taxi Speed Survey

To determine the average aircraft velocities when taxiing, a visual survey was performed from the roof of Pearson's Terminal 1 parking garage. The survey measured the taxi times of aircraft taking different paths with varying *distance traveled* and the *number of turns*. A regression analysis of this data, with *taxi time* as the dependent variable and *distance traveled* and *number of turns* as the independent variables, would find the average speed that aircraft travel at when taxiing and whether or not turning should be accounted for.

The final data set contains 251 observations with 30 or more observations for each grouping of *aircraft size*. More importantly, the t-statistics for the final models (shown in bold) are very strong reaffirming a link between the dependent and independent variables. Other categories of stratification were tested, including *number of engines* and *body type* but were found to be less influential than *aircraft size*. The regression results are summarized in Figure 1.

Figure 1: Summary of Unimpeded Taxi Speed Survey Regression Models (final models bolded)

Trial		Sample Size	Adj. R-Square	Speed			Turns	
				Coef.	km/h	t-statistic	Coef.	t-statistic
1	All	243	0.888	0.083	43.4	26.36	19.86	4.59
2	All	243	0.879	0.093	38.7	41.85	-	-
8	**H, M**	**170**	**0.907**	**0.079**	45.6	**22.92**	**23.27**	**4.55**
10	**L, P**	**62**	**0.918**	**0.099**	36.4	**26.09**	-	-

An analysis of aircraft behaviour found that medium and heavy aircraft have similar attributes when unimpeded, as do light and propeller aircraft. In general, the larger aircrafts moved faster on straight-aways (45.6 km/h) but had to slow down for turns (time to turn 90-degrees = 23 seconds). On the other hand, the light and propeller aircraft traveled slower (36.4 km/h) but were not affected by turns (time to turn = 0 seconds), as indicated by a low t-statistic. The final analyses incorporated these two groupings.

Due to data limitations, it was assumed that aircraft composition and taxiway configuration at US airports is similar enough to Pearson to justify applying the regression results to all the airports in the sample. The first assumption is likely to be true because all the airports considered in this study handle large passenger volumes and therefore will have a significant percentage of medium and heavy aircraft, as opposed to light or propeller aircraft. Examining the effect of taxiway configuration and layout on taxiing speeds and ease of turning would be a large undertaking with results that would be of interest to airport planners. However, this analysis was beyond the scope of study.

3.2.2 Average Taxi Distance

The average taxi distance analysis used Jeppesen Maps (or Canada Air Pilot maps in the case of Pearson) in combination with aircraft movement by-runway and/or by-terminal distributions to approximate the average distance that aircraft travel when taxiing.

By weighting the average taxi distances and number of turns based on terminal-runway distributions, we are able to account for runway configuration. If one configuration is used more frequently, or if a runway is operated generally in one direction, this would manifest itself in a greater percentage of traffic for that runway. Similarly, if one terminal has more gates or is busier than another, that terminal would yield a greater total traffic. Finally, if traffic controllers decide to direct flights from certain terminals to certain runways, or vice versa, then that cell in the matrix would stand out.

In cases where joint distributions were not available, it was assumed that the distributions for terminals and runways were independent. This was shown to be a valid conservative estimate [1].

The results of the unimpeded taxi speed survey can be combined with the average taxi-in and taxi-out route for each airport to develop unimpeded taxi times.

3.3 Comparison of Regression-based vs. Survey-based Unimpeded Taxi Times

The unimpeded taxi-in and taxi-out times using both the regression-based and survey-based methods are presented in Figures 2 and 3. The differences between the unimpeded taxi times for the two methods attempted are quite noticeable. For the taxi-in time, the regression-based method estimated an average of 1.3 times the magnitude of the survey-based method, while for the taxi-out times this factor increased to 2.6.

Figure 2: Unimpeded Taxi-In Time

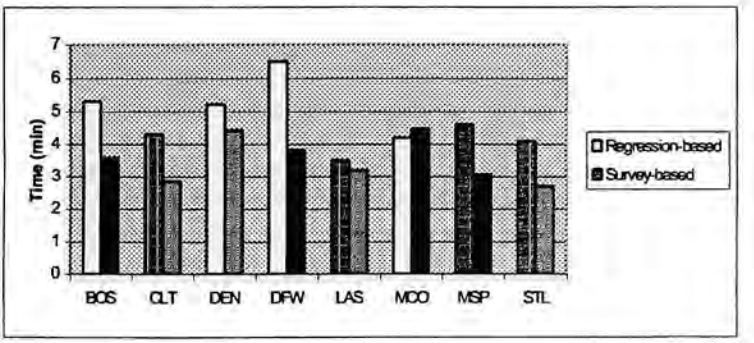
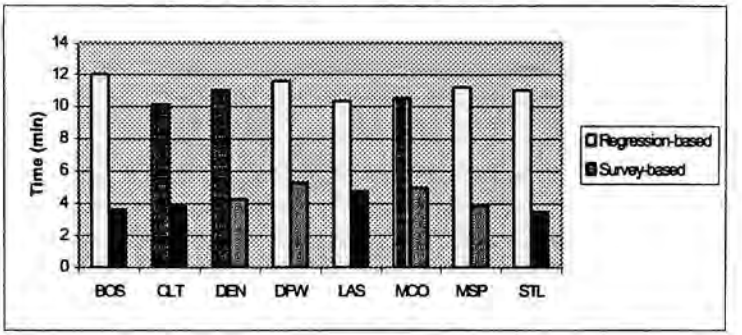


Figure 3: Unimpeded Taxi-Out Time



Various reasons explain the different results between the two methods. First, the regression-based analysis fails to eliminate any systematic delay arising from pilot behaviour, traffic control processing and directing, unhooking during pushback or engine startup. This is more significant for the taxi-out time because there are more opportunities (deicing, taxiway/apron congestion, runway queue) for systematic delay.

Second, the regression-based method does not take into account any information regarding runway configurations or their use. In its discussion of CODAS, the FAA noted this as a major limitation, as well as the fact that the database does not have data on all flight activity. Rather, it only contains flights with OOOI (OUT-OFF-ON-IN) data available resulting in the exclusion of smaller air carriers, commuters, air taxis, general aviation, cargo, military and international flights.

The major limitation of the survey-based approach, as described earlier, relate to the need of applying pilot behaviour characteristics (i.e. speed, time to turn) across to other airports. Airports wishing to improve their delay estimates could perform visual surveys to obtain similar information, but significant differences in pilot behavior are unlikely.

Because of its transparency and strong theoretical foundation, the survey-based method was used for analysis.

4. DELAY

The taxi-in and taxi-out time is an aggregation of different components that were each independently modeled. The unimpeded taxi-in time, runway occupancy time and delay combine to form the total taxi-in time. The taxi-out time is a combination of the unimpeded taxi-out time, pushback time and delay.

In addition to the unimpeded taxi speed survey, visual surveys were used to determine the runway occupancy time and the pushback times. Total taxi-in and taxi-out times for the 8 US airports were extracted from the CODAS database. Similar information was obtained for Pearson from the Airport Authority's planning department. Removing the runway occupancy and unimpeded taxi-in component from the total taxi-in resulted in a value for taxi-in delay for each airport. Similarly, removing the pushback and unimpeded taxi-out component from the total taxi-out resulted in an aggregate delay (including delay due to the runway queue and taxiway congestion).

Figures 4 and 5 show the total taxi-in and taxi-out times broken down by component. It is clear that passengers at Pearson experience high taxi times relative to the other airports. The total taxi-in time (9.9 min) is nearly double the times experienced in Charlotte (5.3 min), Las Vegas (5.2 min), Orlando (4.8 min), St. Louis (5.6 min) and Minnesota-St. Paul (5.9 min). This stems from the fact that not only does Pearson have the largest unimpeded taxi-in time, but it also has one of the highest levels of delay (only Dallas-Ft. Worth has more).

Figure 4: Taxi-In Times by Component

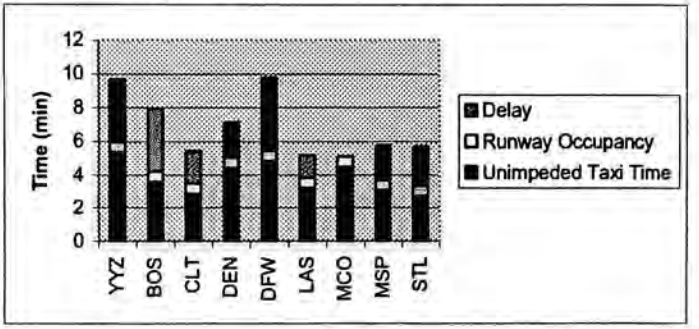
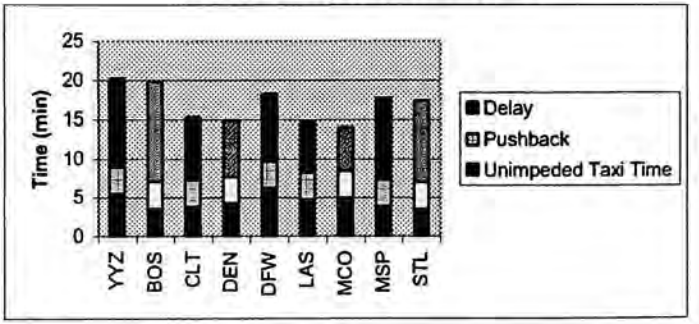


Figure 5: Taxi-Out by Component



The differences are less extreme with the taxi-out times. Although Pearson has the highest unimpeded taxi-out time (5.5 min), its delay (11.6 min) is comparable to Boston (12.4 min), Minnesota-St. Paul (11.2 min) and St. Louis (10.3 min). The most likely explanation for the closer values is that a significant component of the taxi-out delay is runway queue delay and that these four airports have more serious runway capacity issues.

4.2 Delay Predictability

Whenever a problem causing delay arises at an airport, its schedule of departures and arrivals is adjusted accordingly. The less prepared the airport is to deal with such issues, or the more severe the nature of the problem, the greater the level of adjustment that is ultimately imposed. This in turn affects airports across the continent, as they must reschedule to accommodate the delayed flights from the originating airport. This is a very complex problem forcing airports to allow for some flexibility in their scheduling so that only serious issues impact their overall performance. Thus, predicting delay is very important for planning and scheduling of flights.

To measure the predictability of delays at Pearson, a Monte Carlo simulation was developed for both the taxi-in and taxi-out times. Using random variables applied to individually modeled distributions for the various components of the taxi time, delay values were generated for individual aircraft.

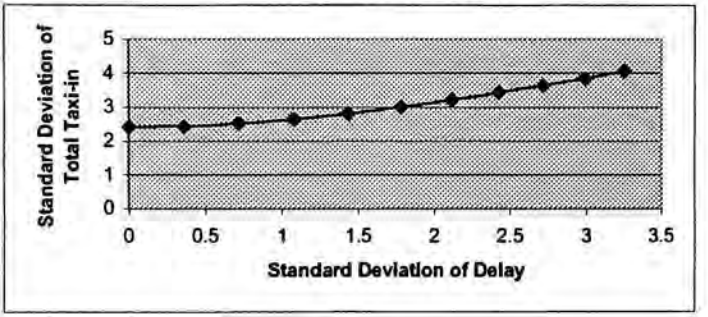
4.2.1 Taxi-In Time

Figure 6 summarizes the results of the Monte Carlo Simulation for the total taxi-in time. The average taxi-in time was 10.29 minutes with a standard deviation of 3.07 minutes. This uncertainty comes mostly from delay and also from the unimpeded taxi-in time. The uncertainty in the unimpeded taxi time occurs due to the runway-terminal distribution. It would be unrealistic to eliminate this variance, as it would involve planning which runway and terminal an aircraft would use in advance of it departing from its origin. Furthermore, if one were to make the delay completely predictable (i.e., a standard deviation of 0), as demonstrated in Figure 7, it is unlikely that one would be able to lower the standard deviation of the total taxi-in time below 2.4 (the value for unimpeded taxi-in time), which constitutes a drop of 1.3 minutes. Thus, it may not be economical to invest towards improving the predictability of taxi-in times.

Figure 6: Monte Carlo Simulation Summary for Taxi-In Time

UT		Rwy Occ		Delay			Taxi-In Time			
Avg	StDev	Avg	StDev	Avg	StDev	Max	Avg	StDev	Max	Min
5.31	2.41	0.62	0.17	4.37	3.58	21.25	10.29	3.07	24.14	2.02

Figure 7: Predictability (Standard Deviation) of Delay vs. Total Taxi-In Time



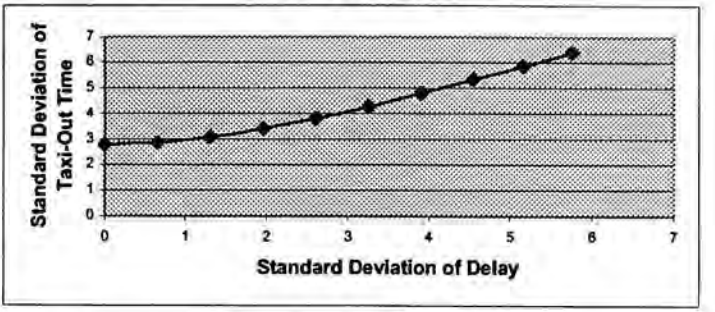
4.2.2 Taxi-Out Time

Figure 8 summarizes the results of the Monte Carlo Simulation for the taxi-out time. As expected, the standard deviation for the overall taxi-out time was larger (6.22 minutes) than for the overall taxi-in time (3.07 minutes). When compared as a fraction of the overall time, the predictability of taxi-in and taxi-out times were equal (standard deviation was equal to 30% of the total). However in the case of the taxi-out time, the delay component is dominant. Whereas the unimpeded taxi-out time is as predictable as the unimpeded taxi-in time, its contribution to the overall predictability is much less in the case of the taxi-out process. The pushback time is less reliable than the runway occupancy time, but again, the delay component is clearly the most significant contributor to the overall unpredictability. In fact, reducing the standard deviation for delay would have an almost equal reduction in the overall predictability for the first 3-4 minutes (Figure 9).

Figure 8: Monte Carlo Simulation Summary for Taxi-Out Time

UT		Pushback		Delay			Taxi-Out			
Avg	StDev	Avg	StDev	Avg	StDev	Max	Avg	StDev	Max	Min
5.45	2.63	3.46	0.90	11.77	6.75	43.33	20.68	6.22	48.68	3.24

Figure 9: Predictability (Standard Deviation) of Delay vs. Total Taxi-Out Time



Further encouraging improving the taxi-out time predictability over the taxi-in time is the fact that it is much easier, and less costly, to reschedule an aircraft while it is holding on the ground. An aircraft that has taxied-in with an exceptionally high or low level of delay can have its turnaround time adjusted. Adjusting for an aircraft in the air can involve rescheduling other flights for the destination airport and can lead to a propagating delay.

5. CONCLUSIONS

Having accurate estimates of delay and the predictability of taxi times is important before deciding whether technological improvements, operational adjustments, or expanding an airport will solve the congestion problems currently experienced at North American airports.

To see how Toronto's Pearson Airport compared to its North American equivalents, average unimpeded taxi time and delay values were calculated for each airport. In general, Pearson did not fare too

well, having amongst the highest unimpeded taxi-in and taxi-out times (attributable to its relatively spread out airside system), as well as a high level of delay (most likely due to insufficient runway capacity).

A Monte-Carlo simulation of Pearson airport was performed to examine the predictability of the total taxi times and equivalent delays. The simulation results were very conclusive. In terms of predictability, the taxi-in time at Pearson airport can only be marginally improved. On the other hand, the predictability of the taxi-out time can be improved on nearly a 1-to-1 basis by decreasing the standard deviation of the delay.

In addition to the primary conclusion, the thesis paper suggests a few directions for further research. The most important step will be to incorporate data from NAVCanada's Airport & Airspace Performance Monitor. This data source, which will log different portions of the taxi-in and taxi-out times, will allow researchers to identify the size of the delay components associated with the runway queue and the deicing time [5]. In turn, this can lead to generalized applications capable of modeling each delay component individually. Other significant research opportunities include identifying the effects of different weather conditions on aircraft taxiing behaviour.

The most significant shortcoming of this project was its inability to identify the fraction of the total taxi-out delay spent in the runway queue. Runway capacity is the largest bottleneck in most North American airports. To quantify how much delay is attributed to congestion at the runway is an important step toward developing appropriate delay-reducing measures. NAVCanada's AAPM and similar initiatives taking place around the globe look to be a significant step towards achieving this goal because they offer a breakdown of the taxi times. At the same time, conceptual models must continue to evolve so as to accurately simulate the complex system.

The potential for reducing delay and improving its predictability is significant, and the benefits from realizing this potential (through operational and technological advancement) would serve the objectives of many players. Airlines would lose less money from aircraft burning fuel while waiting. This would equally benefit the environment, as unnecessary emissions would decrease. Airports

would have greater control over their schedules, making the air traffic controllers' workload more manageable. Finally, travelers would appreciate the shorter, more predictable, times taxiing.

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REFERENCES

1. Y. Grinspun, "Taxiway Delay and Predictability at Lester B. Pearson International Airport", Masters in Applied Science Thesis at the University of Toronto, 2002
2. Federal Aviation Administration Staff, *Airport Capacity Benchmark Report 2001*, Federal Aviation Administration, 2001
3. N. Pujet, B. Delcaire and E. Feron, "Input-Output Modeling and Control of the Departure Process of Congested Airports", *American Institute of Aeronautics and Astronautics*, 1999
4. H. R. Idris et al., "Observations of Departure Processes at Logan Airport to Support the Development of Departure Planning Tools", 2nd USA/Europe Air Traffic Management R&D Seminar, 1998
5. NAVCanada Staff, "Technology and Innovation Solutions", *www.navcanada.ca*, March 2002
6. Office of Aviation Policy and Plans Staff, *Documentation for the Consolidated Operations and Delay Analysis System*, Office of Aviation Policy and Plans – Federal Aviation Administration, 1997

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