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
2003

Proceedings Printed by

University of Saskatchewan
Printing Services

The Canadian Transportation Research Forum assumes no responsibility for the content of the papers published in these Proceedings, or for any errors or omissions in the printing of this volume. These papers are published by the CTRF as a means of disseminating transportation research and to encourage discussion on a broad range of issues during the CTRF Annual Conference.

**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

## 2003 ANNUAL CONFERENCE SPONSORS
## COMMANDITAIRES DE LA CONFÉRENCE 2003

Transport Canada / Transports Canada
Bombardier Transportation
Industry Canada / Industrie Canada
Canadian Transportation Agency / Office des transports du Canada
Statistics Canada / Statistique Canada
Canadian Pacific Railway / Canadien Pacifique
Canadian National Railways / Canadien National
LDK Engineering Inc.
Trimac
Reefer Sales & Service
GATX Inc.
KPMG Consulting
Taylor Raynaud Amar & Associates Inc.
Today's Trucking
CANAC Inc.
Bison Transport
VEMAX Management Inc.
IBI Group
Labatt Breweries of Canada
Canadian Freightways Limited

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

**2002 Semi-Annual Conference**
**CONFERENCE SPONSORS**
**COMMANDITAIRES DE LA CONFÉRENCE**

Saskatoon, Saskatchewan October 25, 2002

*Improving Canada's International Competitiveness Through Policy and Innovation: The Transportation Component*

Canadian Wheat Board
West Jet

## DONORS TO THE CTRF SCHOLARSHIP PROGRAM
## PARRAINS AU PROGRAMME DE BOURSES DU GRTC
## 2003-2004

Bombardier
Canadian National Railways
Canadian Pacific Railway
Canadian Transportation Education Foundation
Government of Quebec
Marine Atlantic
plus many individual donors

## SCHOLARSHIP WINNERS 2002-2003

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:

### CN SCHOLARSHIP ($4000)

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

### BOMBARDIER SCHOLARSHIP ($4000)

Louis-Martin Rousseau, Ph.D. Program, Universite de Montreal, CRT

### TRANSPORTATION INDUSTRY SCHOLARSHIP ($4,000)

Mr. Scott Deschenes, EIT, Transportation Engineering, University of New Brunswick

**2002-2003 STUDENT PAPER COMPETITION DONORS**
**PARRAINS DU CONCOURS DES ÉTUDIANTS EN 2002-2003**

Albert Stevens Fund
Jim Davey Trust Fund

ANNOUNCEMENT OF 2001-2002 STUDENT PAPER PRIZE WINNERS

**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

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

## EXECUTIVE - EXECUTIF
## 2002/2003

**President**
Gerry Kolaitis
VIA Rail Canada

**Executive Vice President**
Clarence Woudsma
University of Calgary

**Secretary**
Gail R. Sparks
VEMAX Management Inc.

**Vice President Finance & Treasurer**
Jan B. Bowland
BearingPoint

**Vice President External**
Barry Prentice
Transport Institute, University of Manitoba

**Vice President Meetings**
Gordon Baldwin
Statistics Canada

**Vice President Programs**
Roger Roy
Transport Canada

**Vice President Awards**
Garland Chow
Centre of Transportation Studies, UBC

**Immediate Past President**
Eric Hildebrand
University of New Brunswick

**Vice President Organization and Development**
Bill Raney
Ministry of Transportation Ontario

**Vice President Sponsorship**
Lloyd Ash
Bulk Plus Logistics

**Councillors:**

Harold Hefferton
Transport Canada

Michael Kieran
IBI Group

Paul Larouche
Bombardier Transportation

Marcel Leduc
Canadian National Railway

James Nolan
University of Saskatchewan

Paul Ouimet
Intervistas Consulting Inc

Rachid Raffa
Quebec Ministry of Transport

Jeff Rosenblum
Canadian Pacific Railway

Doug Shea
NF & LB Dept. of Works,
Services & Transportation

Gordon Tufts
Manitoba Transportation and
Government Services

**CTRF PAST RESIDENTS**
**PRÉSIDENTS ANTÉRIEURS DU GRTC**

| | | | |
|---|---|---|---|
| 2001-02 | Eric Hildebrand | | |
| 2000-01 | Gordon Tufts | 1982-83 | Neal Irwin |
| 1999-00 | Lloyd Ash | 1981-82 | Jim Telford |
| 1998-99 | Janet Weiss | 1980-81 | Albert Stevens |
| 1997-98 | Barry Prentice | 1979-80 | Merrienne Duncan |
| 1996-97 | George Clark | 1978-79 | Al Bach |
| 1995-96 | Doug Duncan | 1977-78 | Vic Stechishin |
| 1994-95 | Roger Roy | 1976-77 | Gordon Wales |
| 1993-94 | Bill Raney | 1975-76 | Bill Hughes |
| 1992-93 | Terry Phillips | 1974-75 | Norman Lee |
| 1991-92 | Andrew Elliott | 1973-74 | Michel Chevalier |
| 1990-91 | Mary Brooks | 1972-73 | Howard Mann |
| 1989-90 | Eugene Ludwick | 1971-72 | John Gratwick |
| 1988-89 | William Waters | 1970-71 | Richard Soberman |
| 1987-88 | Craig Dickson | 1969-70 | John Eyre |
| 1986-87 | Rod Taylor | 1968-69 | Ron Wilson |
| 1985-86 | Frank Trotter | 1967-68 | Harvey Romoff |
| 1984-85 | Karen Hecks | 1966-67 | Pierre Camu |
| 1983-84 | Ray Rohr | 1965-66 | Ray Cope |

**CTRF LIFETIME MEMBERS**
**MEMBRES À VIE DU GRTC**

R.L. Banks
Frank Collins
Ray Cope
Craig Dickson
John Gratwick
John Heads
W.B. Hunter (deceased)
Joe Howard
Neal A. Irwin
Donald MacKinnon
Allan D. McLeod
H.M. Romoff
Richard Soberman
Albert Stevens
William Waters

**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

**CANADIAN TRANSPORTATION RESEARCH FORUM**
209 - 15 Innovation Blvd.
Saskatoon, Saskatchewan
S7N 2X8
*www.ctrf.ca*

Telephone: (306) 242-6199
Fax: (306) 242-6199

---

**INVOICE FOR 2003 CTRF MEMBERSHIP**

| | |
|---|---|
| CTRF Membership for Calendar Year 2003 ($75.00) | $ _____ |
| GST at 7% ($5.25) | $ _____ |
| Student Membership for Calendar Year 2003 ($20.00) | $ _____ |
| GST @ 7% ($1.40) | $ _____ |
| TOTAL | $ _____ |

GST Registration No. R126274562 (If GST exempt, please indicate)

Please make cheque payable to Canadian Transportation Research Forum and mail to the address noted above. **PLEASE RETURN A COPY OF THIS INVOICE WITH PAYMENT IN ORDER THAT OUR DATABASE WILL CONTAIN ACCURATE INFORMATION RELATING TO YOUR MEMBERSHIP.**
**VISA and MasterCard are also acceptable.**

- π **VISA**
- π **MasterCard**

**Card Number** _____
**Expiry Date** _____
**Name on Card** _____

---

**Please complete the following to ensure accurate membership data. The information below will appear in the next published CTRF/TRF Directory.**

Name: _____ Title: _____

Company: _____

Address: _____

_____

_____

Telephone: _____ Fax: _____

e.mail: _____

Please indicate your language preference: θ English θ French

**Le Groupe de Recherches sur les Transports au Canada**
209 - 15 Innovation Blvd.
Saskatoon, Saskatchewan
S7N 2X8
***www.ctrf.ca***

Téléphone: (306) 242-6199
Télécopieur: (306) 242-6199

## FACTURE 2003

| | |
|---|---|
| Membre du GRTC pour l'année 2003 (75.00 $) | $ _____ |
| TPS (5.25$) | $ _____ |
| Membre étudiant du GRTC pour l'année 2003 (20.00$) | $ _____ |
| TPS (1.40$) | $ _____ |
| TOTAL | $ _____ |

Numéro d'enregistrement pour la TPS R126274562. (Si vous êtes exempté de la TPS, veuillez l'indiquer.)

Veuillez libeller votre chèque au nom du Groupe de Recherches sur les Transports au Canada et poster le tout a l'adresse ci-haut. **SVP RETOURNEZ UNE COPIE DE CETTE FACTURE AVEC VOTRE PAIEMENT AFIN QUE NOTRE BASE DE DONNÉES CONTIENNE UNE INFORMATION EXACTE SUR VOUS COMME MEMBRE DE L'ASSOCIATION.**

**VISA et MasterCard sont accéptes.**

- π **VISA**
- π **MasterCard**

**Numéro de Carte** _____

**Date d'Expiration** _____

**Nom Figurant sur la Carte** _____

**fournir les renseignements demandée ci-dessous afin de nous permettre d'avoir une information complète sur nos membres. Cette information va apparaitre dans le prochain répertoire du GRTC.**

Nom: _____ Titre: _____

Compagnie:

_____

Adresse:

_____

_____

_____

Téléphone:_____ Télécopieur:_____

Courrier électronique_____

Veuillez indiquer la langue de correspondance de votre choix.

θ anglais θ français




## C.I.T.T. Board of Directors 2002 - 2003

*Chair*
**John F. Chipperfield, CITT**
Rodair International Ltd.

*Vice Chair, Finance*
**Darren E. Christle, CITT**
Manitoba Transportation & Government Services

*Vice Chair, Development*
**Tony J. Sabino, CITT**
Canada Post Corporation

*Vice Chair, Rules*
**Tracey Raimondo, CITT**
A.A. Options Transport Consultants Inc.

*Vice Chair, Administration*
**A. Derrick Ronayne, CITT**

*Honorary President*
**Barry E. Prentice**
Transport Institute, University of Manitoba

*Immediate Past Chair*
**Susan Collins, CITT**
NOVA Chemicals Services Inc.

*Directors at Large*

**Patrick K. Bohan, CITT**
Halifax Port Authority

**Dawn-Ann Byers, CITT**

**Alan L. Cross, CITT**
Mutual Transportation Services Inc.

**Charles J. Gambin, CITT**
Compufreight Services Limited

**Kevin Guiney, CITT**
Canadian National

**Fraser Hansen, CITT**
Ryder Canada

**Michael Loughman, CITT**
Parmalat Canada

**Marc-Aurele Malaison, CITT**
Transport Morneau

*Area Council Chairs:*

**Dawn-Ann Byers, CITT**

**Gary R. Hains, CITT**
Kleysen Transport Ltd.

**Wade Petrishen, CITT**
Cogema Resources Inc.

**Reg Wightman, CITT**
Manitoba Transportation & Government Services

**Andrew Paxton, CITT**
WorldwideChain Inc.

**Ed Percy, CITT**
Canada Post
Corporation

**Jean Veilleux, CITT**
Thibodeau/Saguelac/
Marcan Transport Inc.

**Raymond Dufour, CITT**
New Brunswick
Community College

**Ron Carter, CITT**
Clearwater Seafoods
Limited Partnership

*Internal Auditors:*

**Daniel C. Jeffries, CITT**
Marketing Distribution
Concepts

**Ernie D. Solomon, CITT**
Evermon Consulting
Services Inc.

**C.I.T.T.**

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:

C.I.T.T.
10 King Street East, Suite 400
Toronto, ON M5C 1C3
Tel: (416) 363-5695
Fax: (416) 363-5698
Email: info@citt.ca

## Volume 1


**Session 1** **Changes in the Trucking Industry Structure / *Changements dans la structure de l'industrie du camionnage***

- Les nouvelles technologies de l'information et des communications et la concentration des entreprises de transport routier de marchandises. *Guy Normandeau, Henri Isaac, Jacques Roy* 1

**Session 2** **Ports and Marine Transportation / *Ports et transport maritime***

- Canada-U.S. Container Port Rivalries: Reprise. *Doug O'Keefe* 17
- Liner Shipping Strategy Selection: Lessons for Canadian Container Ports? *Darryl Anderson* 32
- Domestic Marine Transportation of Logs on Canada's West Coast. *Philip Davies* 48

**Session 3** **Grain Transportation / *Transport du grain***

- Perspectives of Wheat and Barley Importers on Logistics and Quality. *Erica Vido, Barry E. Prentice, Jake Kosior* 63
- Estimation of the Demand for Grain Transportation in North Dakota. *Alan Gabriel Dybing* 78
- Shuttle Train Adoption Strategies. *Weijun Huang, William W. Wilson* 91

**Session 4** **Panel Session / *Panel*** Airports Performance Benchmarking – *Performance de référence pour les aéroports* Chair – *Président Tae Oum*

- A Comparative Analysis of Productivity Performance of the World's Major Airports. *Tae H. Oum, Chunyan Yu.* 106

**Session 5** **Kyoto, Sustainability and Transportation / *Kyoto, développement durable et transport***

- Meeting the Kyoto Targets: Transportation Options, Opinions, and Outcomes? *Clarence Woudsma* 121
- Vertical Linkages of a Sustainable Transportation Network. *Yuri V. Yevdokimov* 136
- Freight Efficiency and Technology Initiative. *Nicole Charron* 148

**Session 6** **Rail Infrastructure / *Infrastructure ferroviaire***

- CPR Branch Line Discontinuance - Historical Perspective and Current Realities. *John Nash, Paul Clegg* 153
- Identifying Blackspots at Highway - Rail Grade Crossings in Canada. *Congming Ren, Liping Fu, Frank Saccomanno,* 168

**Session 7** **Intermodalism and Logistics / *Intermodalisme et logistique***

- Importance of Intermodal Connectivity and Bottleneck Elimination. *Barry Prentice* 183
- Intermodal Transport in Canada. *Joseph Monteiro, Gerald Robertson* 198
- Locating Warehousing and Logistics: Exploring the Link Between Transportation and Land Use in Calgary: 1963 - 2001. *Clarence Woudsma, John F. Jensen* 213

**Session 8** **Borders, IT, Costs and Security / *Frontières, TI, Coûts et Sécurité***

- Border-Related Costs Attributable to U.S.-Canadian Border Crossings. *John C. Taylor, Douglas R. Robideaux, George C. Jackson* 228
- Smart Borders and Safe Borders: Is there a Distinction? *Darren Prokop* 243

**Session 9** **ITS, GPS and Urban Transportation / *SIT, SPM et transport urbain***

- The Rapid Infiltration of the Canadian and United States Highway Transportation Marketplace by Roundabouts as a Transportation Revolution for Urban Areas. *Tony Redington* 262
- ITS and GPS Based Demand Responsive Public Transit. *Sarah J. Taylor, Ata M. Khan* 278
- Development of a Public Transit Information System: Use of GIS and ITS Technologies. *Sarah J. Taylor, Ata M. Khan* 293

**Session 10** **Panel Session / *Panel*** Urban Freight Transportation Research – Recherche sur le transport de merchandises en milieu urbain

- The Lower Mainland (Vancouver) Truck Freight Study. *D. Bickel, G. Chow, B. Clement, J. Mills, J. Wang* 308

**Session 11** **Security and Transportation / *Sécurité et transport***

- Emerging Security Shifts and Trends in U.S. Trade and Border Crossings. *Lisa Randall, Felix Ammah-Tagoe* 333
- Not Enough Hours in a Day. *A. James Park* 348
- Terrorism and Containers: Impact to Canadian Agriculture Importers and Exporters. *Shelley Thompson, David Spearin* 363

**Session 12** **Air Transportation After 9/11 / *Le transport aérien après le 11 septembre***

- Commercial Aviation – A Canada-United States Post September 11th Comparison. *Gordon Baldwin, Lisa Di Piétro, Robert Masse* 379
- The Contribution of Commercial Aviation to the Economy of Manitoba: An Economic Impact Assessment. *J. Jurgens Bekker, Barry E. Prentice* 394

**Session 13** **Assessing Transportation Infrastructure Projects / *Évaluation des projets d'infrastructure de transport***

- Economics and Finance Applied to the Life Cycle of Transportation Infrastructure. *Michael E. Kieran* 409
- Assessing the Impacts of Freight Transportation on Highway Capacity. *Edward Fekpe* 423

**Session 14** **Understanding Air Transport Demand / *Comprendre la demande de transport aérien***

- Evaluating Short and Long-Term Forecasts for Canadian Air Passenger Data Using Time Series Models. *Emir Emiray, Gabriel Rodriguez* 438
- The Impact of Travel Time and Cost Changes on the Demand for Short Haul Air Service: The Edmonton-Calgary Market. *Philip Davies, Geoffrey Horner* 454
- Airline Strategies Under Deregulation: Fares and Schedules in Three Low Density Routes in Alberta. *Philip Davies, Geoffrey Horner* 465

**Session 15** **Applied Methodologies – *Méthodologies appliquées***

- The Prediction of Shipping Accidents in Inland Waterways Using Formal Concept Analysis. *Ray R. Hashemi, Louis A. LeBlanc, Tetsuya Kobayashi* 478

## Volume 2


**Session 16** **Evolution in Transport Information Collection / *Évolution dans la collecte d'information de transport***

- Intelligent Transportation Systems. Border and Port Systems. Technology and Research Funding. *David Spearin, Peggy MacTavish* 493
- Electronic Collection of Air Transportation Statistics Pilot Project. *Garry Tulipan, Michel Villeneuve, Stephen Ellsworth* 508
- ITS Data Mining and Archive to Evaluate Nationwide Performance. *Edmond Chin-Ping Chang* 524

**Session 17** **Border Crossing Travel Time / *Temps pour traverser la frontière***

- Using Truck Tractor Logs to Estimate Travel Times at Canada-U.S. Border Crossings in Southern Ontario. *Robert Leore, Mireille Trent and Tony Shallow* 532
- Establishing Benchmarks for International Border Crossing Truck Travel Time. *Mark Lepofsky, David R. Ellis, Robert E.L. Davis* 547
- Crossborder Transportation Surveys: Let's Get Them Right! *Murray McLeod* 562

**Session 18** **Topical Air Subjects / *Sujets aériens du jour***

- Ultra Large Airlifters (ULAs): A North American Window of Opportunity. *Lt. Col. Woodgerd* 577
- Airship Fuel Tankers for Northern Resource Development: A Requirements Analysis. *Barry E. Prentice, Jim Thomson* 592

**Session 19** **ITS and Border Crossings / *SIT et Postes frontaliers***

- Using Supply Chain Technology to Improve Border Crossing. *Edmond Chin-Ping Chang* 607
- New Technology Adoption and the Implementation of E-Commerce in the Mid-Continent International Trade Corridor Region. *Heather Dawn Gibb* 615

**Session 20** **"The Neglected" / *"Les négligés"***

- The Canadian Courier Services Industry. *Joseph Monteiro* 625
- The Canadian Air Cargo Business. *Joseph Monteiro, Melanie Nera, David Krause* 642
- The Case of Nav Canada Revisited. *Michel Boucher* 659

**Session 21** **Security / *Sécurité***

- Air Security Fees and Highway Safety. *W.G. Waters II, Chunyan Yu* 676
- An Exploratory Benefit-Cost Analysis of Motor Carrier Safety Fitness Ratings in Canada. *Fred P. Nix, W.G. Waters II* 691

**Session 22** **Bus Transportation / *Transport par Autobus***

- Validation and Analysis of Computational Results from a Regional Assignment-Simulation Model to Evaluate Transit Signal Priority in Chicago. *Elaine Chang, Athanasios Ziliaskopoulos* 706
- Evaluating Accessibility to Employment by Public Transit from the Commuter's Perspective. *Christopher Fullerton* 721
- Bus Transportation – Towards Regulatory Reform in Intercity Busing? *Joseph Monteiro* 736

**Session 23** **Hydrogen and Transportation / *Hydrogène et transport***

- Participation in the Hydrogen Economy: A Transportation Economy. *Doug Duncan, Connie Van Rosmalen, John Spacek, Terry Zdan* 753
- Hydrogen Fuel Cell Vehicles and Demonstration Projects: Where They Are At. *Doug Duncan, Connie Van Rosmalen* 768

**Session 24** **Highway Conditions / *Conditions des routes***

- Theoretical Derivation for CBR Mathematical Expression. *X.Y. Wang, S. Tighe* 781

**Student Papers (Winners of 2001-2002 Student Paper Competition)**

**Undergraduate Category**

Effects of Highway Traffic Diversion on Roadside Businesses from Long's Creek to Fredericton, NB,
*Trevor Hanson, UNB* 796

Policy Proposal: Air Transport in Small Communities, *Phillip Seo & Mary Sie, UBC* 811

**Master's Category**

Real-Time Identification and Tracking of Recurrent Traffic Queues Based on Average Link Speed Using Loop Detector Data, *T. Nixon Chan, University of Waterloo* 825

A Survey-Based Approach to Measure Taxiway Delay and Predictability at Lester B. Pearson International Airport, *Yuval Grinspun, University of Toronto* 841

# LES NOUVELLES TECHNOLOGIES DE L'INFORMATION ET DES COMMUNICATIONS ET LA CONCENTRATION DES ENTREPRISES DE TRANSPORT ROUTIER DE MARCHANDISES

Guy Normandeau, MBA, UQAM/Dauphine
Henri Isaac, PhD, Université Paris Dauphine
Jacques Roy, PhD, HEC

## INTRODUCTION

L'industrie du transport routier des marchandises (TRM) traverse une période difficile. Elle doit faire face à une clientèle de plus en plus exigeante –et n'est plus considérée comme source de croissance de profits. Les entreprises doivent développer leur niveau de service et placer le client au centre de la chaîne logistique/distribution/transport. Ces dernières années, l'Internet et les progrès réalisés avec les nouvelles technologies de l'information et des communications (NTIC) sont venus transformer le milieu du TRM. On assiste à une pénétration des technologies servant à améliorer la transmission aux partenaires commerciaux de données telles les commandes, les dates d'expédition et de livraison, les factures, etc. Selon une étude américaine, le marché des systèmes mobiles de transport intelligent atteindra sa maturité vers 2010[1]. L'adoption de tels systèmes par les entreprises de TRM, combinée à la montée de l'Internet, pavent la voie à une réorganisation de cette industrie. Aujourd'hui fortement segmentée et peu concentrée, l'industrie du TRM amorce une mutation d'envergure qui risque de modifier substantiellement la structure de celle-ci.

En effet, nous croyons que les changements provoqués par l'implantation des NTIC ouvrent de nouvelles possibilités de collaboration et de partenariat entre les protagonistes de cette

industrie. Comme dans d'autres secteurs, alimentation ou pharmaceutique par exemple, nous sommes convaincus d'assister à un phénomène de concentration des entreprises de TRM dans les prochaines années. En France, une douzaine de grands groupes se sont constitués tels Géodis, Norbert Dentressangle, Giraud, GEFCO, CAT, etc.. Au Canada, ce modèle est plus récent et est bien illustré par l'entreprise TransForce. Ces groupes se sont constitués par processus de fusions et d'acquisitions du capital des entreprises constituantes. Comme dans la plupart des cas, une rationalisation s'ensuit et l'intégration des systèmes d'information joue un rôle clé dans le succès de ce type d'opération. Un autre modèle que nous avons investigué favorise aussi la concentration de l'offre de transport dans le marché. Il s'agit de réseaux de transporteurs supportés par des solutions TI intégrées telles ASTRE et FLO de France ou par un portail Internet de grande envergure, telle Transplace aux États-Unis.

Dans cette communication, nous traiterons plus en détail des nouvelles technologies de l'information et des communications utilisées dans l'industrie du transport routier, des impacts occasionnés par ces technologies sur les utilisateurs et sur l'organisation du transport routier de marchandises, et de l'émergence des réseaux d'entreprises supportés par les NTIC. Avant de conclure, nous illustrerons notre propos par plusieurs cas de figure tant européens que nord-américains. Il est important de souligner que nous avons délibérément exclu de notre analyse les sociétés spécialisées en logistique (les « 3PL » ) tout comme celles offrant des services d'affrètement sur internet. Ils ont pour effet de concentrer la demande de transport, faisant basculer le rapport de force en leur faveur. Au contraire, nous avons préféré nous attarder aux acteurs du transport routier de marchandises, ceux qui peuvent agir afin de concentrer l'offre, c'est-à-dire les transporteurs eux-mêmes.

## 1. Les TI dans le transport routier

### 1. a) Les technologies utilisées

Il y a un certain temps déjà que les entreprises de transport, particulièrement les grandes, exploitent des systèmes de communication comme l'EDI (échange de données informatisées). Cependant, un bon nombre d'entreprises se tournent aujourd'hui vers les applications d'Internet qui sont moins coûteuses. Elles sont basées sur des normes ouvertes, d'accès universel, dotées d'une puissance interface d'exploration de réseaux et accessibles en tout temps. Avec Internet, les opérations complexes nécessaires avec l'EDI pour relier entre eux des systèmes informatiques exclusifs et différents les uns des autres sont éliminées[ii]. Alors que les clients exigent des délais de livraison de plus en plus courts, les technologies devraient amplifier cette accélération des flux.

Cette prolifération de nouvelles données est rendue possible grâce à la présence des NTIC dans les véhicules, connues le plus souvent sous le vocable de système de repérage («tracing» et «tracking»). Ce système permet une meilleure coordination des liens d'information entre les trois joueurs impliqués dans un mouvement de marchandises à savoir : l'expéditeur (client chargeur), le transporteur et le consignataire (celui qui reçoit la marchandise). Cette coordination est cruciale pour une optimisation des mouvements de marchandises tout comme pour assurer un service de livraison juste à temps. On connaît les avantages que représente une rotation rapide des inventaires. Ainsi, une gestion efficace des liens de communication de l'information entre ces trois joueurs représente un atout concurrentiel indéniable[iii].

Plusieurs manufacturiers d'ordinateurs de bord pour les camions offrent une panoplie de fonctionnalités allant de la collecte et l'analyse de données véhiculaires jusqu'au service de messagerie permettant une communication d'information entre le véhicule et l'entreprise. Ainsi, le camion devient un nœud sur le réseau de l'entreprise de transport, sur celui de ses clients chargeurs et, par

extension, sur le réseau d'entreprises auquel peut être affiliée l'entreprise de transport.

### 1. b) L'impact des technologies sur les utilisateurs et sur l'organisation du transport routier

Les technologies disponibles aujourd'hui permettent l'optimisation des opérations de transport tels la gestion des itinéraires, la gestion de quais plus efficace (cross docking), un meilleur contrôle de rendement par équipement, l'automatisation de plusieurs processus administratifs, etc. De même, ces technologies rendront disponibles aux gestionnaires des statistiques de productivité de toutes sortes afin de mesurer les variables qui ont une incidence sur les coûts, comme : les déplacements à vide, le rendement des pneumatiques, la consommation de carburant, la performance du chauffeur, les temps d'arrêt du véhicule, le temps d'attente chez les clients, le rendement des configurations : moteur, transmission, différentiel, etc..

Subordonnées à l'implantation des NTIC, les transformations appréhendées sont nombreuses. Ces transformations auront un impact certain sur le processus de création de valeur dans les entreprises de transport routier de marchandises. Les économies d'échelle et la densité des flux générées par la création d'un regroupement et/ou d'un réseau d'entreprises procurent un avantage concurrentiel indéniable[iv]. Les gains de productivité et les économies de coûts que procureront les NTIC dans un contexte de réseau vont créer une pression à la baisse sur les tarifs attisant davantage la concurrence.

### 1. c) Les réseaux dans le transport routier

Il est de plus en plus clair qu'une des façons à privilégier par les transporteurs pour obtenir une augmentation de leurs revenus est l'alliance et le partenariat avec un réseau d'entreprises de transport. Ce phénomène connaît un essor grandissant en Amérique du Nord comme en Europe. Plusieurs de ces réseaux sont constitués soit par maillage horizontal, c'est-à-dire des entreprises ayant des opérations compatibles mais oeuvrant dans des marchés géographiques distincts,

ou soit par maillage vertical où plus particulièrement on recherche la complémentarité des opérations et des marchés dans une même zone géographique[v]. Dans les deux cas, ces alliances s'appuient sur le partage d'information, faisant converger vers le réseau, les données opérationnelles nécessaires à l'optimisation des flux de transport.

Pour qu'un réseau soit viable, plusieurs conditions doivent être respectées. Tout d'abord, un client chargeur qui fera affaires avec un réseau s'attend à un standard de service, peu importe le transporteur qui se présente à son quai. Ce n'est plus le logo de l'entreprise mais celui du réseau qui qualifie le transporteur. Le respect des normes du réseau devient une condition essentielle de fonctionnement pour tous ses membres. Cela permet de garantir au client chargeur une qualité et une régularité de service. Comme plusieurs transporteurs sont impliqués, il devient primordial que les véhicules faisant partie d'un réseau soient conformes à des normes techniques, que les conducteurs respectent les normes et les procédures propres au réseau et qu'il y ait un système informatique embarqué afin de gérer l'efficacité des déplacements (optimisation de flux) et les imprévus[vi]. Notons ici, que la formation des employés est certainement la meilleure façon d'arriver à rendre homogène, donc à mettre à norme, l'offre de service d'un réseau[vii].

Plus les systèmes d'information des entreprises membres d'un réseau seront intégrés à celui du réseau, plus ce dernier pourra prétendre à un haut degré d'intégration avec les avantages qui en découlent, c'est-à-dire qu'un haut degré d'intégration signifie une plus grande optimisation des flux et des mouvements de marchandises. Donc, on fait plus de mouvements de marchandises avec moins de camions. Évidemment, chaque camion travaille plus et rapporte plus. Ainsi, en réduisant les déplacements à vide on rentabilise davantage chaque pièce d'équipement[viii]. C'est d'un intérêt majeur. Pour y arriver, le réseau met en place une bourse de fret à accès interne, réservée aux membres qui y déposent leurs demandes de transport représentant un surplus à leur capacité, mais quelquefois semi-ouverte aux partenaires externes[ix]. Ainsi, « le réseau garantit un accès plus facile (sécurité d'approvisionnement) aux ressources détenues par les autres

membres »[x]. Sur cette bourse de fret, les prix pratiqués par les transporteurs sont dits normaux, à savoir le prix de revient en trajet simple plus une marge bénéficiaire raisonnable. C'est une autre condition essentielle à un réseau. Il y est interdit de pratiquer des prix à rabais (concurrence déloyale).

Pour mieux apprécier l'impact économique créé par l'apport des technologies dans un contexte de réseau, considérons l'exemple suivant. Faisons l'hypothèse qu'un camion roule 100 000 kilomètres par année et que le revenu moyen est de 1 $ du kilomètre parcouru. Supposons aussi que le camion circule 10 % de son temps sans cargaison payante. Quel serait l'impact si on réussissait à diminuer de 1 % les déplacements à vide d'un camion dans l'entreprise. Le revenu total généré par ce camion serait augmenté de 1 000[xi] $. Dans le cas où vous possédez 100 camions, cette économie représente 100 000 dollars supplémentaires.

Comme autre caractéristique d'un réseau, on retrouve les centrales d'achats qui permettent la négociation de prix plus avantageux dû au volume d'achats beaucoup plus élevé. Gérés isolément, ces faibles volumes de fournitures ne permettent d'obtenir aucune réduction de la part des fournisseurs[xii]. La massification des volumes d'achats par 10 permet de gagner une réduction tarifaire de 5 à 10 %. Par contre, du côté des obstacles on dénote l'hétérogénéité du matériel et l'individualisme des entrepreneurs[xiii]. En conséquence, la centrale offre aux adhérents de s'approvisionner à moindre coût. Ainsi, le réseau permet de réduire les coûts de production et d'augmenter les revenus générés par les équipements. Il s'ensuit une plus grande rentabilité. Par contre, puisque le réseau permet d'augmenter la productivité et la rentabilité des équipements, une partie de cette rentabilité sera redistribuée aux clients chargeurs sous la forme d'une diminution générale des prix. En France, la concurrence entre les réseaux de PME et les grands groupes de transport les y obligent.

## 2. Illustration des concepts à travers des cas tirés d'entreprises européennes et nord-américaines

Dans les pages qui suivent, nous tenterons d'illustrer notre propos par la présentation de cas d'entreprises évoluant chacun dans un contexte de réseau, solidement appuyés au niveau opérationnel par les nouvelles technologies de l'information et des communications. Les deux premières entreprises présentées, Géodis de France et TransForce du Canada, sont des cas classiques de grands groupes construits par fusions et acquisitions. Le troisième cas, Transplace, est selon nous le cas qui fera école. Il représente le modèle organisationnel qui risque de se développer le plus. Il s'appuie sur un noyau dur de grands transporteurs ayant la capacité financière d'implanter les technologies propices à brancher au réseau tout un tas de plus petits transporteurs et les clients chargeurs avec la logistique que tout cela comporte.

Pour faire contrepoids aux grands groupes de transporteurs qui se sont constitués en Europe, des PME se sont regroupées en réseau. Le phénomène est d'autant plus intéressant pour la PME isolée qui vit l'incertitude économique dans un environnement en transformation[xiv]. Ainsi, on retrouve en France plusieurs réseaux de PME regroupées par maillage horizontal ou par maillage vertical. Ces derniers constituent l'alternative pour une PME qui ne souhaite pas abdiquer devant les grands groupes de transporteurs. Donc, les deux autres cas sont des exemples de réseau de PME Transport en France, ASTRE et FLO.

Sauf pour les deux premiers cas, Géodis et TransForce, qui sont des cas d'intégration du capital, tous les autres mettent en lumière un phénomène qui prend de plus en plus d'ampleur avec les technologies du web, c'est la co-opétition. C'est-à-dire que des compétiteurs collaborent entre eux afin de réaliser une partie de leurs activités[xv].

**Le cas de Géodis**

Géodis est une société publique française de transport de marchandises dont l'actionnaire majoritaire est la SNCF. Elle est implantée dans plus de 40 pays et opère 660 centres d'exploitation afin de desservir ses 70 000 clients. Son parc compte 17 000 véhicules moteurs et ses installations regroupent 2 000 000 $m^2$ d'entrepôts logistiques en Europe. Elle possède des systèmes d'information modernes développés selon ses propres spécifications. Cette entreprise et ses nombreuses filiales bénéficient de l'appui de 25 368 collaborateurs.

Géodis, leader européen par la qualité de sa logistique opérationnelle, a noué un partenariat avec IBM Global Logistics (conseil aux entreprises pour la gestion logistique en ligne) qui apporte au groupe son savoir-faire mondialement reconnu dans le domaine des technologies de l'information. Ensemble, ces entreprises visent la performance et l'intégration des systèmes d'information en relation avec les processus logistiques.

Elles gèrent présentement le suivi des expéditions en ligne (tracking/tracing) pour la messagerie européenne, et pour les transports intercontinentaux par air et par mer. Pour la gestion des transports et des entrepôts, elles utilisent des systèmes d'information modernes qui privilégient la performance des flux opérationnels dans les entrepôts et les réseaux de transport et de distribution. Elles travaillent sur la mise en place de services interactifs « pratiques », et gèrent l'information sur le web via le serveur central (datahub) dont l'exploitation est confiée à IBM. Enfin, la prise des commandes électroniques ainsi que leur suivi s'effectuent soit par liaison EDI entre Géodis et ses clients, soit au moyen de stations installées chez les chargeurs, permettant le transfert des commandes par réseau commuté.

**Le cas de TransForce**

TransForce est une société publique canadienne cotée à la bourse de Toronto (TFI) qui regroupe plus de 20 filiales ayant des activités dans le secteur du transport routier de marchandises. Tout comme Géodis, TransForce se développe selon une logique de réseau. Les filiales ont des bases opérationnelles dans la majorité des provinces canadiennes allant de l'Alberta jusqu'à Terre-Neuve. Évidemment, le Québec et l'Ontario sont les deux principaux secteurs d'opérations avec les États-Unis.

Le développement et la croissance de TransForce sont dus en bonne partie à des efforts de fusions et d'acquisitions de transporteurs ayant des activités complémentaires tant au plan opérationnel que géographique (maillage à la fois vertical et horizontal).

TransForce dispose d'une entente de partenariat stratégique, conclue récemment avec un transporteur américain de grande envergure (R&L Carriers) prévoyant une mise en commun de leur plate-forme technologique et la collaboration réciproque pour les facilités de terminus et de livraisons finales. Du coup, elle agrandit son réseau et son champ d'action aux États-Unis[xvi]. De plus, TransForce a une entente de partenariat technologique avec un manufacturier d'ordinateurs de bord pour véhicules lourds qui lui permet de faire évoluer cette technologie en fonction de ses besoins[xvii].

Transforce est un chef de file au Canada dans l'utilisation de l'informatique embarqué. L'entreprise déploie progressivement cette technologie sur tout son parc de véhicules, par le biais de ses différentes filiales. Cette entreprise utilise ces technologies pour mesurer l'activité du véhicule et du chauffeur. C'est, pour TransForce, un outil de gestion de la productivité qui peut être paramétré afin de connaître, par exemple, le temps d'attente passé chez un client, ou le temps que le moteur tourne au ralenti (Idle Time) sans motif valable. TransForce se sert aussi de l'informatique embarqué pour le suivi de marchandises (tracking/tracing) auprès de

ses clients, information accessible par le biais du site web de l'entreprise.

**Le cas de Transplace**

Transplace.com est un portail Internet développé dans le cadre du regroupement des plates-formes logistiques de 6 grands transporteurs américains. Il s'agit de Covenant Transport (qui détient 13 % du capital); de JB Hunt Transportation Services (28 %); de Swift Transportation (16 %); de MS Carriers (14 %); de US Xpress Entreprises (13 %) et de Werner Entreprises (16%). Par contre, la mise en place et le développement de ce portail ont permis le regroupement d'une capacité de transport de marchandises phénoménal. Selon les informations divulguées sur leur site Internet, à peine deux ans après la mise en service, ce portail regroupait aujourd'hui plus de 5 000 transporteurs représentant une force de traction de plus de 204 000 camions-tracteurs et plus de 415 000 semi-remorques[xviii].

Pour réussir un tel tour de force opérationnel, Transplace a développé et implanté une technologie appelée le «Dense Network Exchange»[xix]. La plate-forme de services DNE permet la synergie d'une multitude de clients chargeurs, de milliers de transporteurs et de divers modes de transport qui, jusqu'à maintenant n'était pas achevée en raison d'une fragmentation élevée de l'industrie du transport. Il y a 3 éléments critiques relatifs à la plate-forme DNE : les algorithmes d'optimisation ; la masse critique (ou densité suffisante) du fret et des avantages que procurent les réseaux ; et la technologie des systèmes d'information via le web.

La technologie développée par Transplace.com ne constitue pas le seul attrait pour les transporteurs adhérents. Ils ont aussi accès à une place de marché pouvant offrir jusqu'à 130 000 items à des prix extrêmement avantageux, considérant le pouvoir d'achat du groupe. On retrouve ainsi sur le portail toutes sortes de pièces et accessoires, des lubrifiants, du carburant, des uniformes, de l'assurance, de l'assistance routière d'urgence, des services de télécommunication,

des équipements usagés, du financement d'équipement, bref toute une gamme de produits et services utiles et nécessaires aux opérations de transport. Lorsque vous avez 204 000 camions et 415 000 semi-remorques à équiper de pneumatiques et que vous mettez en place un système d'approvisionnement électronique, les fabricants de pneus, par exemple, se doivent d'être ouverts à consentir des rabais, concurrence oblige.

Transplace.com utilise, en plus de la plate-forme de services DNE (Dense Network Efficiency), le programme CCM (Collaborative Continuous Moves)[xx]. Le programme CCM repose sur un système de relais. Les transporteurs collaborent pour amener un lot de marchandises à destination finale tout en optimisant leurs ressources humaines. Une entreprise prend en charge le transport de la marchandise sur son secteur. Dès que le véhicule arrive à la frontière de son secteur, c'est l'entreprise qui est sur le secteur limitrophe qui transporte la marchandise jusqu'au secteur suivant, et ainsi de suite. Elle en effectue 2000 par jour. De cette façon, les chauffeurs quittent moins souvent leur secteur et, par conséquent, ne s'éloignent pas de leur base. Ce programme constitue un avantage concurrentiel indéniable et difficile à imiter parce qu'il fournit aux chauffeurs plus de prévisibilité dans leur horaire et de meilleures conditions de travail À notre avis, cet avantage concurrentiel n'est pas à négliger d'autant plus qu'aux États-Unis tout comme pour le Canada et l'Europe, le secteur semble perdre son pouvoir d'attraction pour la jeune relève. À ce sujet, le rapport de la FNTR est pour le moins éloquent : «...le secteur ne semble plus aussi attractif qu'auparavant. Si bien que les personnes à former viennent à manquer. On connaît les raisons : conditions de travail jugées difficiles, rémunérations considérées comme insuffisantes, mauvaise image globale du métier autant de perception de nature à préoccuper les entrepreneurs, s'agissant du reflet de leur profession»[xxi].

Un autre élément important à soulever dans la stratégie de Transplace est qu'elle s'est associée à différents partenaires stratégiques, tels : IBM, fournisseur de solutions technologiques ; AWI, association regroupant une cinquantaine d'intermédiaires de transport et

logistique ; et Transora, place de marché (B to B) pour l'industrie des produits de consommation. Le partenariat avec IBM permet à Transplace.com de bénéficier de son expertise en e-business tandis que l'alliance avec AWI lui permet de fournir des services d'entreposage intégrés et de management transport.

**Le réseau ASTRE**

ASTRE est un réseau mis sur pied en 1992 regroupant aujourd'hui 180 chefs d'entreprises français bien intégrés sous la bannière du groupe. Avec ses 250 sites en Europe, ses 8 500 collaborateurs, ses 14 000 immatriculations et ses 1 500 000 $m^2$ d'entrepôts de transbordement, ASTRE est un réseau à la taille des grands groupes français de transport[xxii]. Ce réseau s'identifie comme un spécialiste des lots de petite taille (une à cinq palettes). Il assure à sa clientèle un suivi en temps réel de leur marchandise grâce à un système d'information générale (SIG) exploité au travers d'un intranet. Les membres de ASTRE doivent adhérer à une démarche de certification ISO. Ils ont un code d'éthique et de qualité commun à tous. Ils s'appuient sur une démarche rigoureuse et professionnelle de tous les collaborateurs du groupe[xxiii]. L'échange de savoir-faire des entreprises entre elles compte pour beaucoup dans leur structure de fonctionnement. La centrale d'achats mise en place par le réseau a permis des gains de 5 à 10 % sur les achats individualisés[xxiv]. Ils possèdent aussi leur bourse de fret interne.

**Le réseau FLO**

Le réseau FLO (France lots organisation) est né en 1995 des cendres d'un autre réseau UTE (1990). Il regroupe aujourd'hui 64 entreprises ayant 170 sites d'exploitation. Ses effectifs comptent 6 800 salariés et 5 000 unités motrices[xxv]. Le réseau dispose aussi d'une capacité d'entreposage de 660 000 $m^2$. Il offre une diversité de services sur l'ensemble du territoire et les NTIC supportent la fonction de coordination de façon efficace (utilisation des normes : EDI, EDIFACT, GALIA, GENCOD, EAN). FLO agit autant en lots complets qu'en lots brisés à l'échelle nationale et internationale. Tout

comme ASTRE, FLO dispose d'une plate-forme de distribution adaptée aux lots de une à huit palettes. Le réseau offre du transport spécialisé en citerne alimentaire, en unité sous température contrôlée, ainsi qu'une gamme élargie de services spécialisés. Il dispose lui aussi d'une centrale d'achats et d'une bourse de fret interne.

## 3. Les NTIC vont permettre de restructurer l'industrie du TRM

Dans cette communication nous avons cherché à démontrer la façon dont les nouvelles technologies de l'information et des communications permettent aux entreprises de TRM de mieux s'intégrer dans des réseaux d'affaires, via Internet, et de favoriser la concentration de l'offre de transport sur le marché. Cette collaboration virtuelle entre les entreprises offre des avantages concurrentiels indéniables, moins de dépenses et plus de revenus pour les transporteurs et des coûts de transport moins élevés pour les clients chargeurs.

Comme nous venons de le voir, les NTIC vont restructurer l'industrie du TRM et, loin de s'estomper, cette tendance connaîtra un essor sans précédent. Selon une étude du FNTR : « Cette révolution numérique, facteur de productivité et de croissance, risque aussi de provoquer une nouvelle ligne de fractures économiques et sociales entre ceux qui auront la réactivité et la volonté d'une part, la capacité et les moyens financiers d'autre part d'acquérir et de maîtriser ces nouveaux outils, et ceux qui ne les auront pas »[xxvi], l'appartenance à un réseau deviendra, pour ces derniers, une planche de salut sans équivoque.

Nous avons mentionné plus tôt que le cas Transplace fera école dans cette industrie. Certes, sa plate-forme technologique est imposante et constitue à elle seule un avantage concurrentiel important. Cependant, la collaboration des ressources afin d'optimiser continuellement les mouvements de marchandises (le « Collaborative Continuous Move ») est de loin l'avantage le plus important. Dans un contexte de rareté de ressources, comme une pénurie de chauffeurs de camions par exemple, cet avantage prend tout son sens. Cela permet

aux transporteurs membres de cette plate-forme de stabiliser leur main-d'œuvre en offrant des conditions de travail beaucoup plus intéressantes que la moyenne du secteur, en limitant les déplacements des chauffeurs. Le développement d'une main-d'œuvre de qualité et la rétention de celle-ci est un défi de taille dans une industrie qui déjà connaît son lot de problèmes à attirer la jeune relève, autant en Europe qu'en Amérique du Nord.

**Conclusion :**

La stratégie de Transplace s'appuie sur une vision du développement de la nouvelle économie au centre de laquelle la gestion de l'information joue un rôle clé. Le développement d'une telle masse critique avec autant de ramifications de services obligent les acteurs du TRM à une remise en question. Notamment, les gros transporteurs américains comme canadiens se doivent d'examiner des avenues semblables, c'est leur compétitivité qui est en jeu.

Pour la PME du TRM, deux options semblent se pointer à l'horizon. Dans le cas où le propriétaire dirigeant n'a pas de relève à qui céder son entreprise, vendre à un plus gros transporteur en phase de concentration semble inéluctable à moyen terme. Dans le cas contraire où la relève est bien présente, la PME a tout intérêt à prendre avantage d'une adhésion à un réseau afin de bénéficier de facteurs de compétitivité qu'elle ne pourrait obtenir autrement. Sa survie passera par l'organisation en réseau et la mise à norme opérationnelle que cela impose.

---

**Références bibliographiques:**

[i] The Market for Emerging Technology Applications in Transportation ; Market analysis and forecast, Hagler Bailey, 1999 Edition, p141.

[ii] Isaac, Henri, L'entreprise numérique : enjeux et conséquences des nouveaux systèmes d'informations, Revue française de gestion, numéro 129, juillet-août 2000, p. 4

[iii] Porter et Millar; How Information Gives you Competitive Advantage, Harvard Business Review, July-August 1985, Reprint 85415, p. 3

[iv] Grand et Leyronas, Réseau et valeurs: valeurs du réseau et réseau de valeurs, Communication dans le cadre des XIV[ièmes] journées Nationales des IAE, Nantes, avril 1998., p.4

[v] Lendjel, Emeric, Les réseaux de PME dans le transport routier de marchandises, Les cahiers de l'observatoire, Paris, Décembre 2001, p.15

[vi] Lendjel, Emeric, Les réseaux de PME dans le transport routier de marchandises, Les cahiers de l'observatoire, Paris, Décembre 2001, p.16

[vii] Contractual and regulatory explanations of quasi-integration in the trucking industry, Fernandez, Arrunada et Gonzalez, Working paper, University of Pompeu Fabra, Barcelona, Spain, 1998., p.6

[viii] Ibid, p.6

[ix] Ibid. p. 16

[x] Grand et Leyronas, Réseau et valeurs: valeurs du réseau et réseau de valeurs, Communication dans le cadre des XIV[ièmes] journées Nationales des IAE, Nantes, avril 1998., p.5

[xi] Scott Moscrip, Optimization : It's for Eveeryone, dans iTech, Transport Topics, Édition Hiver 2001, p.33

[xii] Contractual and regulatory explanations of quasi-integration in the trucking industry, Fernandez, Arrunada et Gonzalez, Working paper, University of Pompeu Fabra, Barcelona, Spain, 1998., p.3

[xiii] Prospective de l'évolution des marchés du transport routier de marchandises, Fédération National du Transport Routier (FNTR), Rapport de recherche, 2000, p. 46

[xiv] Grand et Leyronas, La pérénité des regroupements d'entreprises en transport, working paper, Comité National Routier, Paris, 1997, p.5

[xv] Tapscott, Ticoll & Lowy: Digital Capital, Harvard Business School Press, 2000, p. 25

[xvi] Site internet de TransForce, Communiqué de presse, le 5 novembre 2001 : Signature d'une nouvelle entente de partenariat avec R & L Carriers.

[xvii] Rapport annuel 2001 de TransForce, p.6

[xviii] Site internet de Transplace.com, Press release, 7 juillet 2000, p. 2
[xix] Ibid, p. ??
[xx] Site internet de Transplace.com, Press release, 2 juillet 2001, p. 1
[xxi] Prospective de l'évolution des marchés du transport routier de marchandises, Fédération National du Transport Routier (FNTR), Rapport de recherche, 2000, p. 45
[xxii] Brochure corporative de ASTRE. : La souplesse des P.M.E, la puissance du groupe, Association des transporteurs européens, 2002.
[xxiii] Ibid
[xxiv] Grand et Leyronas, La pérénité des regroupements d'entreprises en transport, working paper, Comité National Routier, Paris, 1997, p.3
[xxv] Brochure corporative de FLO : Chargeurs, adoptez le bon réflexe, 2002
[xxvi] Prospective de l'évolution des marchés du transport routier de marchandises, Fédération National du Transport Routier (FNTR), Rapport de recherche, 2000, p. 33

# Canada-US Container Port Rivalries: Reprise

## Introduction

*"The Panel suggests that the government should continually scrutinize the performance of Canadian ports relative to U.S. competitors, and be prepared to take policy action if the U.S. government funding seriously distorts competitive traffic patterns.* (Canada Transportation Act Review Panel, *Vision and Balance,* June 2001, p. 137)

This paper updates the article entitled *"The Future for Canada-US Container Port Rivalries"* that appears in the 2001 proceedings of the Canadian Transportation Research Forum. This update is timely due to various considerations discussed in the paragraphs that follow.

Canada's container ports are operating in a competitive environment that is undergoing radical change. Since September 11, 2001, public attention has focused on North America's container ports as key hubs of international trade that could expose the continent to more terrorist activity. Ports in Canada and the United States are being pressured to make costly security-related investments and to accommodate regulations that complicate their primary goal of rapid and efficient cargo movement from ships to port hinterlands.

This security imperative occurs on the heels of significant legislative change. The 1998 Canada Marine Act transformed the governance of major Canadian ports, increasing their local autonomy but limiting their financing. U.S. ports experienced the 1999 implementation of the U.S. Ocean Shipping Reform Act with confidential contracts and ocean freight rates no longer subject to public oversight. These changes were not reflected in the 1999 data used in the previous study.

Doug O'Keefe

The earlier study also did not capture the competitive impacts of recently completed or ongoing infrastructure investments of the U.S. container ports and their intermodal partners. On the Atlantic coast, the U.S. Congress approved $88.5 million for continued dredging at the Port of New York/New Jersey (NY/NJ) in November 2001[1]. By August 2002, NY/NJ had completed the deepening of berths at the Port Newark/Elisabeth terminal to 50 feet and awarded contracts to commence channel dredging[2]. On the Pacific coast, the $2.4 billion Almeda Corridor rail freight expressway opened in April 2002 eliminating over 200 at-grade crossings through 8 cities along a 20-mile route serving the ports of Long Beach and Los Angeles[3].

This update extends the previous analysis with data to year 2001. It does not capture the impacts of the recently completed infrastructure projects or the security initiatives. It may therefore serve as a baseline for future assessments of the impacts of these major changes.

This report uses two primary data sources, namely: Statistics Canada's Marine International Origin/Destination (O/D) database and the U.S. Department of Transport Maritime Administration's (MARAD) Annual Import Export Waterborne Databank which is based on Journal of Commerce P.I.E.R.S. data. The units of measure are tonnes of containerized cargo and Twenty-foot Equivalent Units (TEU) for containers with cargo, that is the Laden TEU (i.e., no empty containers). As in the previous report, there are some limitations with respect to the overall accuracy of the TEU data and the comparability of Statistics Canada and MARAD's data. These limitations might affect the reported totals but are not expected to significantly impact the comparative analysis. More detail is provided in the endnotes of this paper[4].

## Current Trends in the Ocean Container Shipping Industry

The twin scourges of overcapacity and bargain-basement freight rates continued to plague the ocean container shipping industry in 2000 and 2001. Drewry Shipping Consultants reported that while world container trade increased just 2.5% in 2001, effective ship capacity in

terms of available TEUs rose 6.3%, exacerbating the existing imbalance in supply and demand. Drewry forecasted that container trade would rise by 8.4% in 2002, which is significantly less than the annual rates over 10% registered through the 1990s, and that overcapacity would continue to increase through 2002 and 2003[5].

Throughout much of the 1990s, the ocean container industry responded to weak prices by seeking economies of scale through mergers and alliances that produced larger companies and by building larger containerships[6]. The trend to larger companies stalled in 2001, perhaps victim to the dramatic fall in profitability of nearly all of the industry's major players[7]. However the trend to larger ships continued.

The Fairplay Ship Register for December 2002 (see Table 1) shows ships over 3000 TEUs accounted for 21% of the world's active containership fleet up from 17% in December 2000. However, in terms of TEU capacity these larger ships accounted for slightly over 50% of the capacity versus 43% in 2000. The capacity growth was due mainly to Post-panamax-class (4500 + TEUs) with 35 ships adding 40% of the new capacity in 2002[8]. According to Fairplay, the largest ship delivered to date has a capacity of 10,000 TEUs.

**Table 1: World Container Fleet by Size, Capacity and Age**

| Size in TEUs | Share of Ships | Share of TEU Capacity | Average Age in Years |
|---|---|---|---|
| <501 | 17% | 3% | 15.6 |
| 501-1000 | 17% | 6% | 11.3 |
| 1001-2000 | 30% | 21% | 10.6 |
| 2001-3000 | 15% | 20% | 9.6 |
| 3001-4000 | 8% | 15% | 9.4 |
| >4000 | 13% | 36% | 4.5 |
| *Source:* Fairplay Ship Register, December 2002 | | | |

Much larger ships are on the drawing boards such as the 18,000 TEU Malacca-Max containership. Studies suggest that this behemoth

would have cost levels 16% less than 8,000 TEU Super-Post-Panamax ships[9] and might revolutionize bulk shipping with rates that would attract traditional bulk commodities[10]. But can this trend realistically be expected to continue?

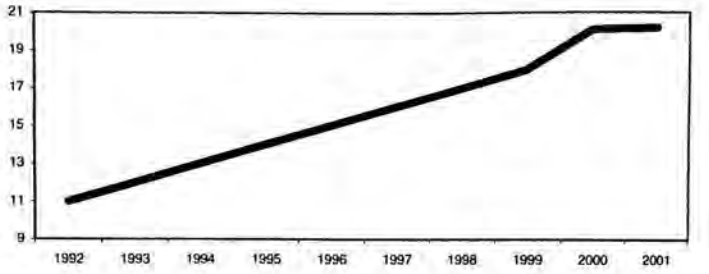
Cullinane and Khanna seem to suggest that there are limits to the economies of scale that depend on the length of the sea route as there are diseconomies for the time that the ships spend in port[11]. Martin Stopford found that the economies of scale diminish with size such that the benefits primarily accrue when upsizing smaller ships. Stopford estimated a cost saving of 20% per TEU when increasing ship size from 1,000 to 2,000 TEUs versus just 4% when increasing from 4,000 to 6,000 TEUs. Increased insurance costs particularly influenced this finding as underwriters have added higher war risk premiums on the larger ships[12]. Fewer ports are capable of handling post-Panamax ships and a cost saving of just 4% can quickly be eaten up by container transshipment costs.

If containership companies experience such declining economies, there could be a reversal in the trend to mega-containerships. It is still possible that a handful of super-ports could handle almost all of the international containers for North America. However, before making the substantial investment required to attract super post-Panamax ships, ports and their inter-modal partners must now consider the risk that the industry may decide to limit its investment in this technology.

## The North American Ocean Container Shipping Market

In 2001, North American ports (excluding Mexico) handled 20.2 million laden TEUs (i.e., containers with cargo) in trade with overseas ports. This market grew by just under 1% over 2000, far below the decade's average annual growth rate of 6.5%. Asia and Oceania remained the dominant trade route with 60% of the laden TEUs in 2001, followed by Europe with 23%. Container traffic in these trade lanes grew by 16% and 5% respectively, since 1999.

**Figure 1: Laden TEUs to/from Overseas Ports and Countries**
**(1992-2001, Millions of TEUs)**




Source: MARAD Annual Import Export Waterborne Databank and Statistics Canada's International Marine Origin/Destination database

Pacific coast ports accounted for 51% of the total traffic, because they dominated the Asia and Oceania trade lane. Atlantic coast ports handled 43.0% of the laden TEUs due mainly to traffic with Europe. Gulf coast ports handled almost all of the remaining TEUs as Great Lakes ports handled just 18,205 TEUs from/to overseas ports in 2001.

**Table 2: Millions of Laden TEUs Handled at North American Ports by World Region of Origin/Destination in 2001(1)**

| | North American Coast | | | Total |
|---|---|---|---|---|
| World Region | Atlantic | Pacific | Gulf | |
| Asia & Oceania | 2.35 | 9.63 | 0.04 | 12.03 |
| Europe | 3.65 | 0.38 | 0.56 | 4.58 |
| South & Central America(2) | 2.07 | 0.25 | 0.53 | 2.85 |
| Middle East & Africa | 0.57 | 0.07 | 0.11 | 0.75 |
| Total | 8.64 | 10.33 | 1.24 | 20.21 |

(1) Excludes Greenland, Ste. Pierre and ports on the Great Lakes and in Alaska. (approximately 20,000 TEUs)
(2) Includes Mexico. Total may not add due to rounding.
Source: MARAD Annual Import Export Waterborne Databank and Statistics Canada's International Marine Origin/Destination database

## Competition with U.S. Ports

In 2001, North America's top 20 container ports handled 96% of the laden TEUs exchanged with overseas ports. Since 1992, these Ports (see Table 3) experienced average annual growth rates (A.A.G.R.) of 6.5% with the rates at individual ports ranging from – 0.7% for Baltimore, MD, to 12.5% for Vancouver, BC.

The southern California ports of Los Angeles and Long Beach were the busiest ports with 3.4 million and 3.2 million TEUs respectively followed by New York/New Jersey (NY/NJ) with 2.4 million TEUs in 2001.

Canadian ports handled 11.7% of the laden TEUs handled by North American ports in 2001. Canada's major container ports, Vancouver, Montreal, and Halifax held positions 5, 8 and 15 with 1.0 million, 849 thousand, and 413 thousand TEUs respectively. Vancouver's and Halifax's A.A.G.R. exceeded the North American average by far, while Montreal was close to the average.

Overall 2001 was not a good year for Canadian container ports. While the total overseas TEU traffic for North America increased slightly from 2000 to 2001, the total for Canada declined by 1%. Hardest hit was the port of Montreal with a 3.5% decline, while Halifax experienced a decline of 0.5%. Vancouver gained just 1.6%, far below its annual average for the decade. U.S. ports experienced just a 1% gain in TEUs from 2000 to 2001, but the year-over-year change varied widely among the ports. NY/NJ, the main competitor for Montreal and Halifax, had a gain of 7.0%. Seattle and Tacoma, Vancouver's main competitors, suffered declines of 14.1% and 5.6% respectively.

The order of the ports changes when the data are expressed in terms of tonnes of containerized cargo. All 3 major Canadian ports move up in the standings, to 4$^{th}$, 6$^{th}$ and 14$^{th}$ for Vancouver, Montreal and Halifax respectively (see Table 4). It is difficult to tell if this variance

between TEU and containerized tonnage standings is due to the commodity mix handled at the ports or inconsistencies in TEU data.

**Table 3: Top 20 North American Ports for Laden TEUs Exchanged With Overseas Ports 2001 Compared to 1992**

| Port | TEUs 1992 | TEUs 2001 | Average Annual Growth Rate (%) |
|---|---|---|---|
| Los Angeles, CA | 1,638,483 | 3,425,460 | 8.5 |
| Long Beach, CA | 1,354,732 | 3,194,332 | 10 |
| NewYork/NewJersey | 1,289,215 | 2,352,453 | 6.9 |
| Charleston, SC | 564,423 | 1,158,720 | 8.3 |
| Vancouver, BC | 359,399 | 1,034,074 | 12.5 |
| Oakland, CA | 745,180 | 963,177 | 2.9 |
| Norfolk, VA | 516,286 | 884,070 | 6.2 |
| Montreal, PQ | 497,983 | 848,762 | 6.1 |
| Seattle, WA | 742,682 | 823,913 | 1.2 |
| Savannah, GA | 386,891 | 812,972 | 8.6 |
| Houston, TX | 368,137 | 783,307 | 8.8 |
| Miami, FL | 417,595 | 716,828 | 6.2 |
| Tacoma, WA | 556,186 | 610,558 | 1.1 |
| Port Everglades, FL | 209,580 | 415,639 | 7.9 |
| Halifax, NS | 161,593 | 413,501 | 11 |
| Baltimore, MD | 290,085 | 272,498 | -0.7 |
| New Orleans, LA | 190,053 | 217,130 | 1.5 |
| Portland, OR | 154,251 | 206,372 | 3.3 |
| Gulfport, MS | 70,692 | 132,278 | 7.2 |
| Wilmington, DE | 67,522 | 128,028 | 7.4 |
| Other Canada | 16,559 | 71,613 | 17.7 |
| Other U.S.A. | 886,517 | 765,348 | -1.6 |
| Total | 11,484,044 | 20,231,033 | 6.5 |

Source: MARAD Annual Import Export Waterborne Databank and Statistics Canada's International Marine Origin/Destination database

Vancouver experienced an increase in containerized tonnage of just under 1% from 2000 to 2001, compared to an 11.1% increase in the previous year. Vancouver continued to be the 3rd largest North American port to handle container tonnage exchanged with Asia and Oceania, with the same share of that traffic (10.3%) as in 1999. Asia and Oceania is the crucial trading region for Vancouver, accounting for almost 95% of its containerized cargo. Vancouver's main competitors on this trade lane, Seattle and Tacoma, both experienced a decline in their share of this trade since 1999. Their declines appear to have been to the benefit of Los Angeles and, surprisingly, NY/NJ which displaced Seattle from its 4th standing in 1999.

Montreal continued to be the leading container port on the European trade route in 2001 but its lead over NY/NJ declined from 1.13 million tonnes in 1999 to just 110 thousand tonnes in 2001. Montreal and NY/NJ together accounted for almost 40% of European origin-destination (O-D) container tonnage and have a longstanding rivalry in this trade lane. Europe is the crucial trading region for Montreal, accounting 95.5% of its containerized freight in 2001. NY/NJ is less dependent on the European trade lane than Montreal as it accounted for just 40.8% of its 2001container tonnage. Asia and Oceania accounted for a further 36.2% of the NY/NJ containerized tonnage.

Halifax has traffic distribution that is similar to NY/NJ with Europe and Asia & Oceania accounting for 55.8% and 24.3% respectively of its 2001 containerized tonnage. However, Halifax was not a major contender in either market with just 5.3% and 1.0% respectively of the tonnage on these trade lanes. Nonetheless, Halifax was the 6th placed North American port on the Europe trade route and 11th on the Asia & Oceania trade route.

Vancouver, Montreal and Halifax handled 96.6% of the overseas containerized tonnage handled by Canadian ports in 2001. Since 1999, Fraser River has emerged as Canada's 4th largest container port overtaking Saint John, NB. Fraser River's container tonnage grew from 188 thousand tonnes in 1999 to 467 thousand tonnes in 2001,

due to the relocation of a carrier from Vancouver[13] and various new services. Saint John handled 265 Kt of containerized freight in 2001.

**Table 4: Containerized Cargo Handled at North American Ports in 2001 by Region of Origin/Destination**

| Port | Europe | Middle East & Africa | Asia & Oceania | Central & South America | Total* |
|---|---|---|---|---|---|
| | Millions of Tonnes | | | | |
| Long Beach, CA | 0.81 | 0.09 | 22.19 | 0.67 | 23.76 |
| Los Angeles, CA | 1.16 | 0.29 | 19.92 | 0.69 | 22.06 |
| NewYork/NewJersey | 7.91 | 1.55 | 7.01 | 2.90 | 19.38 |
| Vancouver, BC | 0.13 | 0.08 | 9.57 | 0.30 | 10.08 |
| Charleston, SC | 4.69 | 0.86 | 2.68 | 1.66 | 9.89 |
| Montreal, PQ | 8.02 | 0.29 | 0.05 | 0.04 | 8.40 |
| Oakland, CA | 1.12 | 0.10 | 6.91 | 0.16 | 8.29 |
| Houston, TX | 4.10 | 1.00 | 0.51 | 2.17 | 7.78 |
| Norfolk, VA | 3.42 | 0.62 | 2.55 | 0.90 | 7.49 |
| Savannah, GA | 1.49 | 0.55 | 4.39 | 0.53 | 6.96 |
| Seattle, WA | 0.17 | 0.04 | 6.23 | 0.10 | 6.53 |
| Miami, FL | 1.20 | 0.13 | 0.74 | 3.83 | 5.91 |
| Tacoma, WA | 0.01 | 0.10 | 4.68 | 0.00 | 4.79 |
| Halifax, NS | 2.18 | 0.38 | 0.95 | 0.40 | 3.91 |
| Port Everglades, FL | 0.14 | 0.00 | 0.02 | 2.89 | 3.05 |
| Other U.S.A. | 4.28 | 0.63 | 3.87 | 7.65 | 16.43 |
| Other Canada | 0.06 | 0.01 | 0.34 | 0.39 | 0.80 |
| Total* | 40.89 | 6.72 | 92.61 | 25.28 | 165.51 |

*Excludes Ste. Pierre and Greenland.

Source: MARAD Annual Import Export Waterborne Databank and Statistics Canada's International Marine Origin/Destination database

## Competitive Issues for Canadian Ports

The statistics suggest that Canadian ports continued to compete successfully for North American container cargo despite the overall slowdown in this sector in 2001. Their 14% share of this market

compares favorably to Canada's 10% share of population, 7% share of retail sales and 8% share of manufacturers shipments for North America[14]. As the previous study discussed, the ports have substantial potential to capture much more traffic with their natural endowments and excellent rail and road access to all major North American markets. Whether the ports should attempt to maintain or enhance their market share is a question that can be studied by others.

If the ports are to maintain their current market share, they may need significant investments, assuming that the 2001 slowdown was an aberration and the growth rates of the past decade resume. There are also a number of competitive issues for Canada's ports relative to U.S. ports, particularly: financing capital investment[15]; costs and pricing of services[16]; and the potential impacts of increased Canada-United States border security[17].

**Financing Capital Investment:**

The 1998 Canada Marine Act (CMA) listed among its objectives "....making the system of Canadian ports competitive, efficient and commercially oriented." The Act achieves this objective in part by prohibiting Canada's major ports from using parliamentary appropriations to discharge liabilities and from pledging port lands for loan guarantees as these lands remain vested in the Crown. The CMA further requires the ports to pay an annual stipend to the federal government based on their gross revenues and to make payments to local municipalities in lieu of property taxes. In essence, Canadian ports are not eligible for subsidies under the Act and must secure private capital to finance investments with a pledge of the future revenues. It appears that the risks of such investments fall squarely on the shoulders of the Port Authorities and their private financiers.

In contrast, a study by Luberoff and Wider of Harvard's Kennedy School of Government concluded that U.S. ports often did not exercise sound business practice in funding multimodal facilities and routinely shifted the risks of such investments to tax payers[18]. In addition to port revenues, U.S. port authorities have the capability of

raising financing through the issuance of bonds (General Obligation (GO) Bonds and Revenue Bonds), loans, grants and taxation[19].

The extent to which U.S. ports use these financial instruments varies among regions and individual ports. The Marine Administration (MARAD) of the U.S Department of Transportation reported that for 2000 the ports financed US$898 million of capital investment through Port Revenues (48.1%), GO Bonds and Revenue Bonds (20.0%), Grants (16.0%), Loans (3.8%) and Other Sources (12.1%). MARAD was unable to determine funding sources for another US$160 million in port capital[20]. This US$1.1 billion was spread over 49 ports.

New York/New Jersey had the 2nd highest level of capital investment among US ports in 2000. NY/NJ's US$153 million investment was more than double the US$74 million reported by funding source by ports in the North Atlantic and probably comprised the bulk of funding for which MARAD could not determine the source. Seattle had the 5th highest level of capital investment among U.S. ports in 2000 with US$50 million.

An accurate comparison of Canadian and U.S. ports in terms of the extent and the efficiency of their capital investments is complicated due to the variety of port types. Some U.S. ports such as NY/NJ and Seattle are non-operating ports, essentially landlords who lease port facilities to private operators. Canadian ports operate some facilities while others are leased to operators and yet others are privately owned. Investments by private owners and operators are not reflected in the port authorities' accounts. Investments by other government agencies may be included if they are in the form of a grant.

Nonetheless, MARAD's *Public Port Finance Survey Report for FY 2000*[21] suggests that Canadian ports generally have less capital invested than their U.S. port competitors but generate better returns on that investment. Vancouver's construction-in-progress was valued at 47% of Seattle's while its total assets were 28% of the U.S. competitor. Vancouver's net income was US$2.1 million less than Seattle's, but represents a 5.0% return on total assets versus just 1.6%

for Seattle. Similarly the construction-in-progress for Montreal and Halifax combined was less than 1% of the NY/NJ's and their combined total assets were less than one-quarter of NY/NJ's total marine assets. However, where NY/NJ had a net loss over US$6 million, Montreal and Halifax combined net income was almost US$7.7 million. The federal port lands appear to have been included with the assets of the Canadian ports.

The Canadian ports performance relative to their U.S. competitors is likely understated as payments in lieu of taxes and the federal stipend appear to have been deducted to arrive at net income.

**Table 5: Comparison of Selected Canadian and US Ports 2000 Financial Performance (US$ '000)**

| | Seattle | Vancouver | NY/NJ | Montreal | Halifax |
|---|---|---|---|---|---|
| Operating Revenue | 99,250 | 56,683 | 114,290 | 40,878 | 11,880 |
| Marine | 28.0% | 56.2% | 43.8% | 85.9% | 81.2% |
| Other | 72.0% | 43.8% | 56.2% | 14.1% | 18.8% |
| Operating Expense | 95,075 | 33,058 | 102,980 | 38,758 | 7,510 |
| Other Income | 14,678 | (6,900) | (17,372) | 2,288 | (1,093) |
| Net Income (NI) | 18,853 | 16,725 | (6,062) | 4,408 | 3,277 |
| Total Assets (TA) | 1,176,670 | 331,906 | 1,028,703 | 182,385 | 62,349 |
| Construction in Progress | 58,562 | 27,555 | 130,607 | 827 | 267 |
| NI/TA | 1.6% | 5.0% | -0.6% | 2.4% | 5.3% |

Source: MARAD *Public Port Finance Survey Report for FY 2000*

**Costs and pricing of services:**

In choosing among container ports the ocean container shipping company or freight forwarder must consider the costs for the ocean journey, port interface, transshipment and inland journey. While ports may be able to influence their costs, they have less influence over the costs of other service providers, including intermodal services and marine services provided by other government agencies.
A complete analysis of the costs and pricing of these services is beyond the scope of this report, but there are other studies that

suggest that Canadian ports have an edge in these areas as well. A study by the Australian Productivity Commission found that average Canadian rail freight rates were 9.5% lower than American rates in real terms[22].

Similarly, according to a study done for Consulting and Audit Canada, Canada collected CA$65.96 million on 348 million tonnes of marine cargo in 2000, while U.S. government agencies collected CA$1,399.64 million on 2,233 million tonnes[23]. This suggests that Canadian marine user fees average about 19¢ per tonne versus 63¢ per tonne for U.S. marine user fees. The U.S. Harbor Maintenance Tax, which was declared unconstitutional for exports in 1998 but is still being applied to marine imports, accounted for almost 71% of the U.S. marine services fees.

However, the Consultant and Audit Canada report did not include port related expenses. It is difficult to say what effect the inclusion of such charges would have on the analysis. It should be noted that the cost advantage of a weak Canadian dollar affected the outcome of both these studies.

**Potential impacts of increased Canada-US boarder sercurity**

The shock of September 11th heightened the sense of vulnerability of U.S. citizens and prompted U.S. Customs Services to tighten security at all points of entry. At this time, the impact of tightened security on Canadian ports that serve as North American gateways for U.S. O-D containers is not clear, but it could be negative[24].

U.S. Customs implemented its Container Security Initiative (CSI) in December 2002 requiring that the contents and pertinent information on exporters and importers of all containers onboard ships headed for the U.S. be reported to Customs 24-hours before the container is loaded onto the ship. Major U.S. container ports were quick to react to the possibility that CSI could cause traffic diversion to Canadian and Mexican ports. U.S. Customs responded by seeking reciprocal

agreements with the Canada and Mexico and encouraging them to adopt similar timeframes for advance customs reporting[25].

US Customs has stated their intention to implement similar advance reporting for goods transiting the Canada-U.S. border. U.S. Customs proposed that trucks submit cargo information electronically 4-hours in advance of loading goods in Canada destined to the U.S. and 24-hours in advance of loading goods in the U.S destined to Canada. Similarly, rail shipments would require advance reporting of 4-hours and 8-hours for southbound and northbound cargo, respectively. An outcry from industry and carriers prompted Customs to further consult on these timeframes, but it seems that some form of advance reporting at the Canada-U.S. border will become mandatory[26].

Could new customs procedures that cause a bottleneck at the Canada-U.S. border be detrimental to Canadian container ports as intermodal investments at U.S. ports come to fruition? According to Containerisation International, a number of new initiatives being undertaken by railroads, port authorities and ocean carriers should reduce the bottlenecks at U.S. ports even as intermodal volumes continue to increase[27].

## Closing Comment

Canadian container ports continue to compete successfully with U.S. container ports for North American container traffic. Despite competitive pressures, they also appear to have remained fiscally responsible.

---

[1] Dredging News Online VI Issue 68, Nov 23, 2001 **URL:** www.sandandgravel.com/news/news/news_510.htm

[2] Port of New York/New Jersey Dredging Project Status Report, Oct 16, 2002 **URL:** www.panynj.gov.commerce/dredge1002.htm

[3] *TR News*. Alameda Corridor Freight Rail Expressway Opens. No 221, July-Aug 2002, p.45

[4] Statistics Canada derives TEU statistics from container counts by size of container reported on Custom's A6 General Declarations. These data are not reconciled with manifest data. MARAD's TEU statistics are derived from the weights of container cargo reported on ships' manifests. TEU origin/destination are the country of export/ import for P.I.E.R.S. while the Statistics Canada data use country of port of loading/ unloading. TEUs by world region for

Statistics Canada data were derived by apportioning reported TEUs based on the weight of containerized freight by region.

[5] Drewry Shipping Consultants Ltd. *Drewry Annual Container Market Review and Forecast 2002.* Oct, 2002.

[6] Tirschwell, P. Mergers reshape shipping. *Journal of Commerce.* 5 January 1998. P8.

[7] Beddow, Matthew. Down but not out. *Containerisation International* V35 I10 Oct 2002, p36-39

[8] Willmington, Robert. Shrewd Investments *Containerisation International* V35 I11 Oct 2002, p43-47

[9] Wijnolst, Niko. Mallacca-Max: the ultimate container carrier. Delft University Press, 1999.

[10] Kosior, J.M. R.I.P. Bulk: Here Come the Malacca Max Containerships. Unpublished paper submitted to the Canadian Transportation Research Forum 31st Annual Conference.

[11] Cullinane, K and Khanna, M. Economies of Scale in Large Container Ships. *Journal of Transport Economics and Policy.* V33, Part 2. May 1999. P185-207.

[12] Dekker, Neil. Size isn't everything. *Containerisation International* V35 I6 June 2002, P51

[13] *Lykes Lines moves Vancouver operations to Fraser Surrey Docks.* Canadian Sailings. July 9, 2001 p 12.

[14] O'Keefe, Doug. *The Future for Canada-U.S. Container Port Rivalries.* Canadian Transportation Research Forum Conference Proceedings. 2001

[15] Sparks Companies, Inc. *Canada /US Port Competitiveness Study, Final Report Prepared for Transport Canada.* Feb 2000 **URL:** www.tc.gc.ca/pol/en/report/port_competitiveness_study/default.htm

[16] Consulting and Audit Canada. *Cumulative Impact of Federal Fees on the Commercial Marine Industry in Canada: Synthesis of Background Information.* March 2002 **URL:** www.cmc-ccm.com/report-TreasuryBoardStudy.html

[17] Kuzeljevich, Julia. *Stretching the boundaries* Canadian Transportation and Logistics. **URL:** www.ctl.ca/research/infrastructure/features/boundaries.asp

[18] Luberoff D. and Walder J. U.S. Ports and the Funding of Intermodal Facilities: An Overview of Key Issues. *Transportation Quarterly.* V.54, No 4, Fall 2000 p23-45.

[19] Ibid. Sparks Companies, Inc.

[20] MARAD *United States Port Development Expenditure Report.* Dec 2001 **URL:** www.marad.dot.gov/publications/index.html

[21] MARAD *Public Port Finance Survey Report for FY 2000.* Nov 2001. **URL:** www.marad.dot.gov/publications/index.html

[22] Australian Productivity Commission. *An Assessment of the Performance of Australian Railways* **URL:** www.pc.gov.au/inquiry/rail/finalreport/supplement/index.html

[23] HLB Decision Economics Inc. *Comparison of Marine User Fees in Canada and the United States, Final Report* Mar 2002. **URL:** http:www.cmc-ccm.com/report-TreasuryBoardStudy.html

[24] Association of Canadian Port Authorities. *Port Government Interface: Focus on Security Still!* Feb, 2003 **URL:** www.acpa-ports.net/03prtgov.pdf

[25] *Port shopping could undermine security.* Fairplay.V.345 I.6189 Aug 29, 2002 p29

[26] Toews, Bonnie, Smyrlis, Lou. *Choke Point.* Canadian Transportation and Logistics. V.106 N.2 Feb2003, p20-24.

[27] *Stacked against bottleneck.* Containerisation International's Regional Review. Sept 2002. p.32-36.

# Liner Shipping Strategy Selection: Lessons for Canadian Container Ports?

Darryl Anderson, Policy Manager
Rail/Intermodal & Marine, Alberta Transportation

**Abstract**

As the 21st century unfolds, liner shipping companies and Canadian container ports find themselves in the familiar position of creating and implementing a corporate strategy in the face of difficult market conditions. This paper will examine the experiences of two shipping companies, one of which has successfully pursued a co-operative market strategy, the other a competitive one. The strategies of the two (Maersk-Sealand and Canadian Pacific Ships Ltd.) will be examined in the light of relevant economic theories, and in terms of their relevance to Canadian ports. The paper will conclude by suggesting that further research is required into a new model of corporate strategy known as *co-opetition*. Such a model may well help reconcile the often-conflicting economic evidence that emerges when comparing purely co-operative corporate strategies, with purely competitive ones.

## 1. INTRODUCTION

The liner shipping industry and port business is highly competitive. In 2002, although the world's top 20 carriers controlled 82 percent of the global container capacity, the industry is highly fragmented, with over 500 carriers operating world-wide. These carriers serve over 200 world ports, 60 of which handled in excess of a million twenty-foot equivalent units (teu) per annum in 2001.

The top three container ports handled 17.9, 15.5, and 8.1 million teus per annum, respectively (*Containerisation International* Online Library 2002). Table A lists the five major container markets. To serve their markets, the liner companies organise into conferences, form alliances, or participate in stabilisation or slot charter agreements (although some firms work independently).[1]

| **Table A: Estimated Container Shipping Volume 2000** | |
|---|---|
| Container Shipping Markets | Millions of teus |
| Intra-Asia | 16 |
| TransPacific | 11 |
| Asia-Europe | 6 |
| TransAtlantic | 4 |
| Regional Markets | 32 |
| Total | 69 |
| (Source: CP Ships Ltd. 2002) | |

During the period 1993 to 2001, market conditions were such that real freight rates fell by five percent on the TransPacific, four percent on the TransAtlantic, and six percent on the Asia-Europe trade lanes, a trend shipping companies have been attempting to reverse. For example, in August 2002, *Containerisation International Online* news service reported that nine conferences or stabilisation/discussion agreements had announced general rate increases of between $80 and $200 on various trade lanes.

[1] A 'conference' is a group of two or more vessel-operating carriers that provide for the carriage of cargo (on a particular route/geographical area) and that have agreed to operate under uniform or common freight rates and any other agreed conditions with respect to the provision of services. 'Alliances' refers to three groups of mainly global carriers, with each carrier making a substantial contribution of ships on a long-term basis across the three main East-West markets. 'Joint service' agreements are distinguished from alliances by their smaller scale, narrower geographic range and sometime shorter duration, or a combination of these factors. 'Slot' charters are agreements between two or more carriers to buy, sell or exchange a fixed amount of cargo capacity over a given time period (CP Ships Ltd. 2002).

As a result, liner shipping companies and Canadian container ports find themselves in the familiar position of creating and implementing corporate strategies in response to challenging and shifting market conditions.

## 2. CO-OPERATION AND COST LEADERSHIP

Liner firms offer regularly scheduled ocean transport service. That such firms have historically employed co-operation as a corporate strategy is evident in the fact that Canada and other countries have enacted legislation that encourages such behaviour (such as the *Shipping Conferences Exemption Act, 1987* or SCEA). SCEA exempts certain shipping conference practices from the antitrust provisions of the *Competition Act*. This type of legislation was enacted in the belief that increased financial stability for vessel owners would promote world trade by facilitating fast, frequent and reliable shipping services (Stopford 1995). Corporate co-operation is often the strategy selected by firms seeking to enter new markets or share in the cost and risk of developing new technologies (Kogut 1997). Companies considering such a strategy should investigate whether there is anything inherent in the economic structure of their industry that would make a co-operative strategy desirable. To help answer this question with respect to the liner industry, a review of *core theory* will now follow.[2]

### 2.1 CORE THEORY INSIGHTS

*Core theory* uses the cost and demand structures of firms to draw conclusions about the nature of the industry's market structure.

[2] The relevancy of *core theory* in justifying the continued anti-trust exemption status granted shipping companies under legislation such as SCEA is the subject of debate (OECD 2002).

The theory postulates that a combination of increasing returns, capacity constraints, and variable demand will lead to mismatches between capacity and demand. These mismatches can frequently disrupt the stable and efficient functioning of a price system, even in large markets. Under such circumstances, no stable equilibrium results from the competitive process. Such a state is called an *empty core*. Table B highlights the necessary cost and demand conditions for an *empty core* to exist, and the possible implications on strategy selection.

**Table B: Core Theory Strategy Implications**

| Cost Structure | Demand Structure | |
|---|---|---|
| | Finely Divisible | Indivisible |
| Nonhomogeneous costs curves. | ***Empty Core***: Collusive or monopolistic market structures. Firms should engage in co-operative behaviour since competition is infeasible. | Competitive strategy feasible. |
| Subhomogeneous cost curves. | Competitive strategy feasible. | Competitive strategy feasible. |

(Source: Adapted from Pirrong 1999)

Pirrong's (1999) study using *core theory* represents one economic argument in favour of a co-operative strategy. The study demonstrated that the liner shipping industry is characterised by indivisible 'avoidable' costs (i.e., voyage) and divisible demand. As such, the industry has the necessary characteristics for an *empty core* to exist, and that there are indeed circumstances in which there is an inherent economic incentive to engage in co-operative behaviour. As a result, participating in one of the liner industry's co-operative arrangements holds out the promise of being financially beneficial to the ship owner because it helps restore market equilibrium.

The following section will explore how technology in the container shipping industry influences scale economies, and the impact that this phenomenon may have on corporate strategy selection.

## 2.2 SCALE ECONOMIES

Kogut (1997) observes that the selection of corporate strategy within industry follows three distinct phases. The first phase commences once a given technology level becomes widely attainable and the industry attracts new participants. The second phase is characterised by industry participants entering into one of many possible types of co-operative arrangements (i.e., alliances, joint-ventures, and so on), while the final stage is marked by a termination of the co-operative relationship. The reasons for these three phases is that as technological opportunities become established market opportunities, co-operative arrangements frequently convert to outright buy-outs as firms seek to fully capture the economic benefits of economies of scale.

A firm's choice of technology determines its production costs. Ship owners and port executives should be aware that for any given output level, there is an optimal production technology that will yield the lowest unit cost. In industries such as shipping, it is usually more cost-effective to produce on a large scale than on a small scale. Scale economies refer to the phenomenon of long-run unit costs declining as output increases. For example, in the process of constructing a larger vessel, building costs do not rise in direct proportion to the ship's increased cargo carrying capacity. In a similar fashion, the transport costs per unit of vessel carrying capacity fall as vessel size increases. However, with any given technology, there exists some level of output at which the scale economies are exhausted. At this point, the minimum unit cost of production is reached.

Kamshad (1997) refers to this least unit cost range of production level as the 'minimum efficient scale' (MES). For example, increasing ship size from 1,000 teu to 2,000 teu, saves 20 percent in the per unit cost of transport; from 2,000 teu to 4,000 teu, seven percent is saved; and from 4,000 to 6,000 teu, four percent is saved (Containerisation International Online, 2002, 'Size isn't everything'). In liner shipping, the MES appears to correspond to the post-panamex vessel of 6,000 to 8,000 teus.

Hoffmann (1998) observes that new technologies lead to a changing cost function. In ports and shipping, these changes result in an increase in fixed costs as compared to variable costs. This shift in the relative size of fixed and variable costs, leads to important management implications. In the long run, companies must be able to adapt their technology or cost of production in such a way that it is as close as possible to the long-run MES set by the industry leader. Accordingly, Lim (1998) argues that global liner[3] firms on the mainstream trade routes have no alternative but to deploy large container ships if they want to remain competitive, because it is the post-panamex vessels that have set the MES industry standard. The next section will examine how Maersk-Sealand has successfully used a co-operative market strategy based on scale economies.

## 2.3 MAERSK-SEALAND'S APPROACH

The A.P. Moller subsidiary Maersk-Sealand is the world's largest liner company. In 1999, Sealand became part of the A.P. Moller conglomerate when Sealand Service was acquired from CSX Corp. The company operates in more than 100 countries on six continents. It has 325 offices with 10,000 employees.

[3] Global carriers generally deploy significant ship capacity and operate extensive service networks, operating in most trade lanes in the major markets, as well as in some regional trade lanes. Regional carriers, generally focus on a number of smaller trade lanes within the major East-West markets, or regional markets.

In 2002, the firm had a fleet of approximately 263 vessels with a total carrying capacity of 712,235 teus. In addition, it owned or operated approximately 24 container terminals located in the United States, Europe, the Mid-East and Asia (Maersk-Sealand 2002).

Maersk-Sealand actively pursues a strategy of co-operation, as evident by its participation in conferences and stabilisation agreements. For example, the firm is a member of the following six agreements (*Containerisation International Online* Library 2002):

- Australian/South East Asia & South Asia Trade Facilitation Agreement;
- Canadian Transpacific Stabilisation Agreement;
- Canada Westbound Rate Agreement;
- Europe/Mediterranean Trade Agreement;
- Europe West Africa Trade Agreement; and
- Straits/New Zealand Discussion Agreement.

During the past decade, Maersk's corporate behaviour followed the pattern noted by Kogut in Section 2.2. Maersk and Sealand have been involved in a gradually expanding co-operative venture since entering into a vessel-sharing agreement in 1991. By 1995, the two firms had formed a global operating alliance. Finally, in 1999, the co-operative relationship ended in a merger (Containerisation International Online, 'An age of giants'). It is instructive to note that because of CSX Corp.'s weakened financial position, the co-operative arrangement with Maersk ended at the point where CSX Corp. did not have the capital required to invest in the new technology post-panamex vessels (CSX Corp. 1999).

The strength of A.P. Moller's balance sheet also enabled the company to purchase significant new post-panamex tonnage.

Table C reveals that Maersk-Sealand vessels are on average newer than those of Canadian Pacific (CP) Ships Ltd. or the world fleet generally. The use of newer and larger vessels by the company is consistent with the recent trend in new ship construction where post-pananmex tonnage has accounted for 40 to 50 percent of the new capacity deployed in recent years (Containerisation International Online, 2002, 'Shrewd investments?'). Maersk-Sealand is trusting that the economies of scale realised by being the world's largest liner firm, together with its investment in new post-panamex tonnage, will position the company as the industry leader in terms of the 'minimum efficient scale.'

**Table C: 2002 Fleet Profile (TEU Carrying Capacity)**

| Ship Age (Years) | Maersk-Sealand | CP Ships | World Fleet |
|---|---|---|---|
| 0-4 | 40% | 34% | 36% |
| 5-10 | 31% | 34% | 28% |
| 11-20 | 19% | 28% | 23% |
| >20 | 11% | 4% | 13% |

(Source: Containerisation International Online Library 2002)

## 3. COMPETITIVE DIFFERENTIATION AND FOCUS

As discussed in Section 2.1, core theory provides important insights into why liner owners might wish to engage in co-operative market strategies. Nevertheless, other economic evidence suggests that the container shipping industry is also prone to competitive behaviour.

### 3.1 CONTESTABILITY THEORY INSIGHTS

Three conditions are necessary for a contestable (i.e., competitive) market to exist. The first condition requires that potential market entrants and incumbent firms be symmetrically placed in terms of production.

This means that firms must be governed by the same regulations and have access to equivalent production technology, and that customers must perceive industry output as being of the same quality. The second condition requires the absence of sunk production costs. This is likely to occur when deployed capital is reusable, saleable, moveable, or rentable. The third condition is that the industry's pricing practices must be such that they prevent responsive pricing by incumbent. Should these conditions exist, potential market entrants are able to compete successfully. Liner firms are able to withdraw if conditions so warrant, and recoup the amount incurred in consequence of their initial entry (apart from normal depreciation charges) (Gilman, 1994).

Davies' (1986) study demonstrated that the necessary conditions for a contestable market existed in the Canadian liner trades. Entry and exit were frequent, hit-and-run entry common, very large-scale entry occurred, and the quantitative impact of entry was often substantial. In addition, all firms were operating under the same carriage of goods laws and legislation such as SCEA. If core theory suggests that the long-run equilibrium in the liner industry is more likely to occur when the participants engage in co-operative behaviour, what reason exists for a firm to undertake competitive action? A firm might engage in competitive behaviour as a preemptive strategy. It may be seeking to control a major portion of the market by discouraging rivals from expanding, or to deter entry into new trade lanes. In the liner industry, a competitive strategy of preemption is consistent with short-run behaviour because firms often mistake one another's intentions, misread signals, or misjudge their relative strengths and staying power. Thus, in the long run, problems occur in the shipping industry when too many firms try to preempt one another, and transport capacity becomes overbuilt (Lim 1998).

The use of competitive tactics is also consistent with the third phase of technological diffusion noted by Kogut in Section 2.2.[4]

## 3.2 ECONOMIES OF UTILIZATION

As we have seen in Section 2.2, cost leadership in liner shipping is increasingly associated with scale economies associated with the ownership of post-panamex vessels. However, ship owners need to carefully evaluate the potential gains from pursuing a strategy based on economies of scale with the potential financial benefits that might arise from increasing their vessel's utilisation level. Increasing capacity utilisation spreads the fixed costs of existing ships and personnel over a larger volume, while economies of scale imply that an activity operating at full capacity is more efficient at a larger scale.

Mistaking capacity utilisation for scale economies can lead shipping executives into a false conclusion that their costs will continue to fall if they expand vessel capacity. Lim (1998) notes that theoretically, the larger the ship, the cheaper the cost per teu/mile. On the other hand, the situation faced by most ship owners is that the larger the ship, the lower the actual utilisation level. This may arise because of trade lane imbalances or other factors. Liner shipping customers require fast and reliable service at regular and frequent intervals. Firms, such as Maersk-Sealand, must be able to generate sufficient cargo to fill large ships on a frequent basis. For example, one transpacific string of post-panamex vessels would require a 40 percent market share of the China/United States West Coast trade route to achieve proper scale economies.

[4] The first phase of technological diffusion in container shipping began in the mid 1950s. The second phase was marked by the introduction of the panamex size vessel, and the third phase was the deployment of post-panamex tonnage in the early 1990s.

This market share would equate to at least a 90-percent, cargo-carrying utilisation level (Containerisation International Online, 2002, 'Size isn't everything). Thus, the selection of corporate strategy and the choice of what technology (i.e., vessel size) to deploy must fully consider trade lane cargo volumes and the impact that this may have on vessel and container terminal utilisation levels.

The next section will examine the actions of CP Ships to discover ways in which a strategy based on differentiation and focus can be implemented to compete in the container shipping industry.

## 3.3 CANADIAN PACIFIC SHIPS' APPROACH

CP Ships is the world's eleventh largest container shipping company. It became a separate entity in 2001 with the breakup of Canadian Pacific Limited into five separate firms. In 2002, the firm operated a fleet of 78 mid-size vessels (2,000 to 4,000 teus) in four major regional markets. The company participates in joint service agreements with other container shipping companies in nearly all of its trade lanes. However, CP Ships maintains that the economic benefits of such co-operative arrangements are generally less than could otherwise be achieved through mergers and acquisitions. For example, alliances and joint agreements have generally not reduced inland transport, container fleet and administrative costs in a significant way (CP Ships Ltd. 2002). By selectively expanding its service, improving vessel frequency and transit times, and improving the efficiencies of inland transportation networks, CP Ships seeks to deliver a consistently reliable, tailor-made inter-modal supply chain solution. Their differentiation strategy is build on the strength of their six individual brands. Within each of the 24 trade lanes, in which CP Ships operates, it seeks to offer two or more brands.

For example, Canada Maritime and Cast serve the US/Canada via the Montreal-North Europe trade lane, and ANZDL and Contship Containerlines serve the US West Coast-Australasian trade lane (CP Ships Ltd 2002).

CP Ships' competitive behaviour is evident by the nine acquisitions it has completed in the last decade. In addition to strengthening their position in key regional markets, the purchases have often involved the turnaround of under performing liner firms (CP Ships Ltd. 2002). The company not only engaged in timely preemptive strategic behaviour, it has also acquired assets at or near bargain prices. This action may have helped CP Ships achieve a cost structure similar to the industry's leading MES, even with a significantly smaller vessel size. For example, the average size of a CP Ships vessel is approximately 2,100 teus.

CP Ships is presently completing an $800 million vessel replacement program of medium-sized 2,000 to 4,000 teu size ships. Table D shows that the intent of this program is to increase the firm's cargo carrying capacity with 'owned vessels' rather than operate the CP fleet with chartered tonnage. The intent of the program is not to increase the average vessel size of their fleet by deploying post-panamex tonnage.

**Table D: CP Ships Target Fleet After Replacement Program**

| | Ships | | % Capacity | |
|---|---|---|---|---|
| | 2000 | 2003 | 2000 | 2003 |
| Owned | 21 | 46 | 28% | 77% |
| Long-term charter | 12 | - | 19% | - |
| Medium-term charter | 4 | 8 | 8% | 6% |
| Short-term charter | 40 | 18 | 45% | 17% |
| Total | 77 | 72 | 100% | 100% |

(Source: CP Ships Ltd. 2002)

When entering new markets, CP Ships' competitive strategy is to utilise slot charters agreements when the anticipated economic benefits of deploying their own vessels are not justified. The justification may be in terms of the size of the investment risk, or where cargo volumes in that specific trade lane are likely to be small initially (CP Ships Ltd. 2002). Some analysts may be tempted to argue that this is evidence of co-operative rather than competitive strategy; however, it is important to note that in the context of the liner shipping industry, slot charters are the weakest form of a commercial relationship. CP Ships' market penetration strategy acts to increase the contestability of markets, rather than weaken competition. By observing CP Ships' behaviour, it is clear that the tools of differentiation and focus are used successfully to compete in an industry strongly influenced by the presence of scale economies and a long-term economic incentive to engage in co-operative behaviour.

## 4. CONCLUSIONS

The analysis in this paper revealed that a "one-size-fits-all" approach to corporate strategy is not a requirement for those engaged in the liner business. Successfully implementing a co-operative or competitive strategy depends on a firm's knowledge of the economic characteristics of their own industry, and the differences between initiatives intended to achieve short-run goals and actions conducive to long-run market equilibrium. Firms also need to review their own operations and their position on the technology curve compared to their rivals, and assess their financial ability to seize market opportunities.

Canadian port executives need to utilise current and sound research to help them understand the economic characteristics of the container terminal business.

This, combined with the insights gleaned from observing the behaviour of their major customers, is essential to choosing the right corporate strategy. To be effective, port executives will need to prove to ship owners that their marketing, port development and financial plans have recognised the trends driving value creation in the liner industry. They must also prove that their specific management actions are compatible with the companies they seek to attract, whether this is a liner firm deploying a strategy based on co-operation and cost leadership, or one emphasising differentiation and focus. The strategy lesson highlighted in this paper suggest that efforts by the Association of Canadian Port Authorities (CPAs) (as noted in the 2002 Review of the *Canada Marine Act*) to promote policies that will help them achieve a cost structure and economies of scale consistent with the industry's leading MES, is indeed vital for their international competitiveness. Policies aimed at increasing CPA's financial flexibility, the ability to raise capital, and the freedom to develop ports lands, need the support of federal decision-makers because without these tools CPAs will be restricted in their ability to attract new investment in terminal technology and cargo handling facilities.

For those interested in the future direction of port and liner policy, further research into whether it is desirable for firms to engage in co-operative or competitive behaviour is required. Research by Song (2003) utilises a conceptual framework called *co-opetition*: a mixture of competition and co-operation. *Co-opetition* suggests that firms engaged in the same or similar markets should consider a win-win strategy, rather than a win-lose one. Such a model may well help liner industry and port executives alike reconcile the often-conflicting evidence in the literature that suggests an either/or approach to corporate strategy.

The concept of *co-opetition* would seem to occupy the middle ground between the co-operative and competitive approaches outlined in this paper. Thus, it may well prove useful as an analytical framework for assessing issues surrounding future Canadian port and liner policy.

## 5. REFERENCES

Canadian Pacific Ships Limited. Documents accessed December 17, 2002 through the Internet on the Canadian System for Electronic Document Analysis and Retrieval (http://www.sedar.com/hompage_en.htm) or the United States Securities and Exchange Commission (http://www.sec.gov/edgar.shtml): *'Supplemented Short Form PREP Prospectus CP Ships – CP Ships Limited C$127,500,000', 8,500,000 Common Shares, 27th June 2002'*; *'Short Form Prospectus – US$200,000,000' CP Ships Limited, 10 3/8 Senior Notes Due 2012, 30 September 2002'*; *'Securities & Exchange Commission – Amendment No. 1 to Form 2-F CP Ships Ltd.'*

CSX Corp. Document accessed December 17, 2002 through the Internet on the United States Securities and Exchange Commission, (http://www.sec.gov/edgar.shtml): *'CSX Corp. Form Type: 10-K for the period ending December 31, 1999'*.

Containerisation International Library (CI-Online). Subscription content accessed December 13 and 14, 2002 through the Internet (http://www.ci-online.co.uk): Fleet Statistics – World Ranking. *'Déjà vu'* Saturday 1st June 2002; *'Size isn't everything'* Saturday 1st June 2002; *'An age of giants'* Wednesday 12th September 1999; *'WTSA loses Maersk Sealand'* Thursday 1st August 2002; *'Carriers continue general rate restoration program'* Thursday 1st Aug. 2002; *'Shrewd investments?'* Friday 1st Nov. 2002.

Davies, J. 1986, 'Competition, Contestability and the Liner Shipping Industry', in *Maritime Transport*, eds M. R. Brooks, K. Button & P. Nijkamp, Edward Elgar Publishing, Inc. Northampton Massachusetts, USA.

Gilman S. 1994, 'Contestability and Public Policy in Liner and Short Sea Shipping', in *Maritime Transport*, eds M. R. Brooks, K. Button & P. Nijkamp, Edward Elgar Publishing, Inc. Northampton Massachusetts, USA.

Hoffmann, J. 1998, 'Concentration in liner shipping: its causes and impacts for ports and shipping services in developing regions', *Transport Unit of the International Trade, Financing and Transport Division*, Economic Commission for Latin America and the Caribbean. Accessed December 17, 2002. http://www.eclac.cl/transporte/perfil/documents.asp?tipo=tmar

Kamshad, K. 1997, 'The keys to profit maximization', in *Mastering Management*, eds T. Dickson & G. Bickerstaff, Pitman Publishing, London, England.

Kogut, B. 1997, 'Globalization and alliances in high technology industries, in *Mastering Management*, eds T. Dickson & G. Bickerstaff, Pitman Publishing, London, England.

Lim, S. 1998, 'Economies of scale in container shipping', *Maritime Policy & Management*. Vol. 25, no. 4, pp. 361-373.

Maersk-Sealand (The A. P. Moller/Maersk Group) content accessed December 13, and 17, 2002 through the Internet: (http://www.maersksealand.com and http://www.maersk.com)

Organisation for Economic Cooperation and Development, 2002, *Competition Policy in Liner Shipping Final Report*, OECD Transport Division. Accessed February 23, 2003. http://www.oecd.org/EN/home/0,,EN-home-52-nodirectorate-no-no-no-25,00.html

Pirrong, S. 1992, 'An Application of Core Theory to the Analysis of Ocean Shipping Markets', in *Maritime Transport*, eds M. R. Brooks, K. Button & P. Nijkamp, Edward Elgar Publishing, Inc. Northampton Massachusetts, USA.

Song, D. 2003, 'Port co-opetition in concept and practice', *Maritime Policy & Management*. Vol. 30, no. 1, pp. 29-44.

Stopford, M. 1995, *Maritime Economics*, Routledge, London.

**Domestic Marine Transportation of Logs on Canada's West Coast**

In 2002 Transport Canada Pacific Region published a comprehensive analysis of the freight transportation system in British Columbia, entitled Freight Transportation in British Columbia: Final Report [1]. In the course of gathering data for this report, several anomalies in available cargo data were identified. The most significant of these was a substantial difference between Statistics Canada domestic marine cargo volumes and those reported by local port authorities, particularly the Fraser River and North Fraser Port Authorities which oversee transportation activity on the Fraser River in B.C.'s Lower Mainland. These two port authorities between them reported traffic of around 39.3 million tonnes in 2000. Statistics Canada figures indicate traffic of only 2.8 million tonnes in total for the Fraser River.
The largest discrepancy is in the volume of logs transported. For 2000, the two Fraser River authorities reported a total of 22.0 million tonnes of logs. Statistics Canada recorded a total of only 2.7 million tonnes for the whole West Coast.
Statistics Canada gathers data on coastal marine traffic through carrier surveys. Unfortunately, the effectiveness of the carrier surveys has been undermined by low response rates. This paper analyses data

[1] Freight Transportation in British Columbia : Final Report (TP13909 E); IBI Group in association with Sandwell Inc., Jonathan Seymour & Associates Inc., McElhanney Consulting Services Inc., DLM Engineering Inc. (Prepared for Transport Canada Pacific Region). (Vancouver, B.C.), 2002.

from the British Columbia Ministry of Forests and other forest industry sources to arrive at a more realistic estimate of the volume of logs transported by water on Canada's West Coast.

**The Coastal Transportation System for Forest Products**

In 1996 the BC Ministry of Forests commissioned Simons Reid Collins and Pierce Lefebvre Consulting to analyse woodflows in the Vancouver Forest Region. This region includes virtually all of the coastal area to a point north of Terrace and Prince Rupert, Vancouver Island, and the Queen Charlotte Islands. This study [2] provides an excellent overview of the marine transportation system for forest raw materials and by-products, and detailed estimates of actual volumes in 1995. The following description of the coastal transportation system for forest products is based primarily on this source, supplemented by more current information.

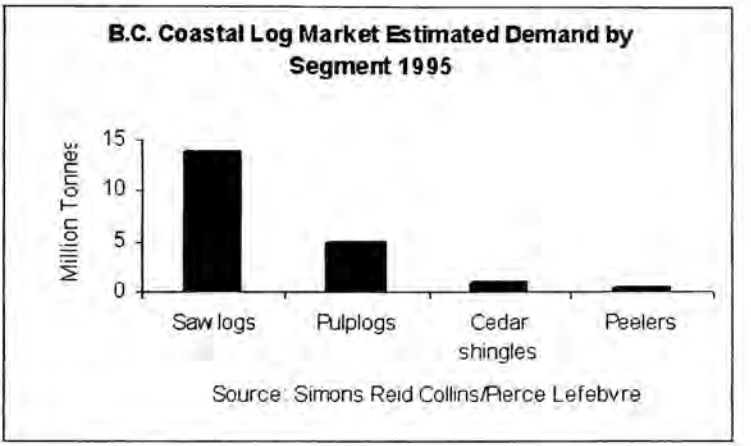
The majority of timber on B.C.'s coast is harvested from Crown land. Logging rights are primarily allocated through forest tenures granted to large firms. However, logs harvested from a particular firm's tenure are not necessarily processed at the same firm's mills. The coastal sawmills tend to be specialized either by wood species or product, and in order to match their timber supply to their mill requirements firms may trade large portions of their harvested timber to other companies. Logs are traded or sold on the Vancouver Log Market, which is

---

[2] Analysis of Woodflow in the Vancouver Forest Region Simons Reid Collins/Pierce Lefebvre Consulting (1996), study commissioned by BC Ministry of Forests.

primarily a communications network rather than a geographic location. Prevailing market prices are the prices of logs delivered in booms to the Howe Sound-Fraser River area which is the most common centre of physical exchange. The majority of Vancouver Log Market transactions consist of trades between coastal forest companies rather than cash transactions. In 1995, Vancouver Log Market Volumes accounted for 25% of the harvest in the Vancouver Forest Region. [3]

Estimated volumes for the four major segments for the coastal log market in 1995 are shown below[4]:

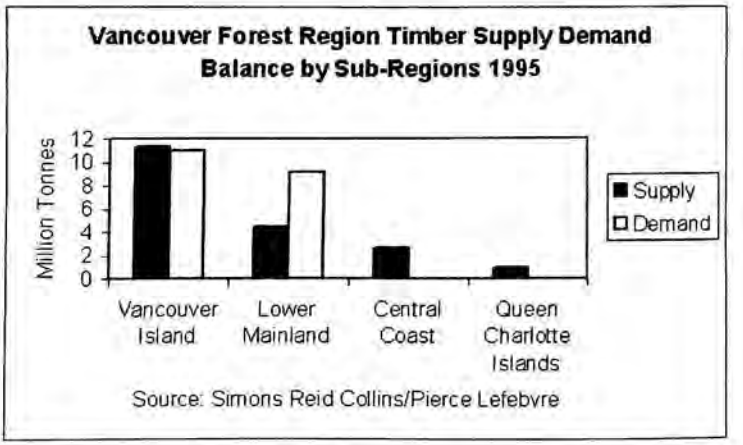



[3] Simons Reid Collins/Pierce Lefebvre p. 6.

[4] In order to facilitate comparisons between forest industry data (typically expressed in cubic metres of wood fibre) and Statistics Canada tonnage figures, the Statistics Canada conversion factor of .8009 tonnes per cubic metre is used to convert log volume to tonnage throughout this paper.

Sawlogs are used to make lumber. Pulplogs are processed into wood chips for making pulp and paper products. Peelers are used to make veneers or plywood.

The 1996 study estimated that the net timber supply for the Vancouver Forest Region totalled the equivalent of 19.4 million tonnes in 1995. This was supplemented by imports from the interior and North Coast areas of B.C. of around 400,000 tonnes and from the U.S. of around 300,000 tonnes; and reduced by around 100,000 tonnes of log exports, leaving an available log supply of around 20 million tonnes. The distribution of supply and demand between sub-regions in 1995 is shown below:




The Lower Mainland region consumes substantially more timber than is locally available, while the Central Coast and Queen Charlotte regions have very limited primary processing facilities.

The tug and barge system used for transporting logs on B.C.'s coastal waterways provides a very efficient system for allocating wood fibre to maximize log value. The majority of logs are towed in log booms. Barging is required in areas which are subject to high waves, such as the west coast of Vancouver Island and the Queen Charlottes. Costs of towing are very low. For example, the B.C. Ministry of Forests estimates the cost of transporting logs by towing from Port Hardy on the north end of Vancouver to Howe Sound at the equivalent of only around $2.20 per tonne. Barging costs are higher but still low relative to land transportation costs.

Logs are often transported to centrally located sites for sorting into uniform grades which can then be redistributed based on mill requirements. Howe Sound is the largest sorting area, with throughput of the equivalent of around 10 million tonnes of logs. Much of this is then delivered to the Fraser River for storage.

**Data Analysis**

The coastal forest harvest in B.C. in 2000 was 23.6 million metres[5] or the equivalent of 18.9 million tonnes. Of this, 75.8% was harvested from Crown land; the remainder from private land. The percentage of this which is transported by water is estimated to be around 93%.[6] This implies total coastal volume of 17.6 million tonnes of logs.

The B.C. Ministry of Forests maintains a large database on timber harvest and movements as part of the system used to assess the level

[5] Source: Coast Forest and Lumber Association.
[6] Coast Forest and Lumber Association.

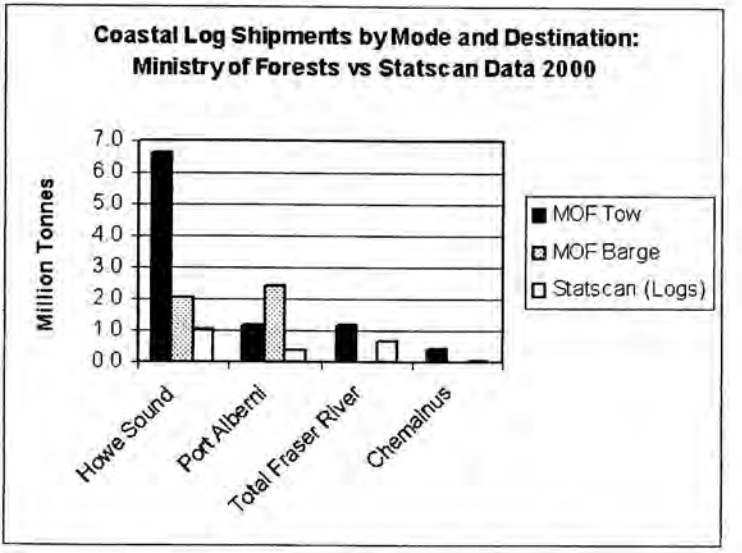
of stumpage to be paid to the Crown for timber harvested on Crown land. This system includes information on timber mark (incorporating information on harvest location and company), volume, trucking distance, and marine origin and destination. Stumpage is based on the market value of timber, minus the costs incurred in transporting it to market. For purposes of estimating market value, four appraisal points are used: Port Alberni, Chemainus, Gambier Island (Howe Sound), and the Pitt River Bridge (Fraser River). Logs are assumed to travel by the lowest cost method to the closest appraisal point. Therefore the figures may not reflect actual shipment destinations, but should relatively accurately reflect the origin of the logs. The Ministry assumes logs are towed where practical (i.e. in sheltered waters) and barged in areas exposed to rougher seas such as the West Coast of Vancouver Island and the Queen Charlottes.

For purposes of this analysis, figures on coastal log shipments from the Ministry of Forests appraisal system for 2000 were compared to Statistics Canada figures for the same year. Shipments from each origin point were aggregated to provide an annual total and then compared to Statistics Canada origin-destination statistics:

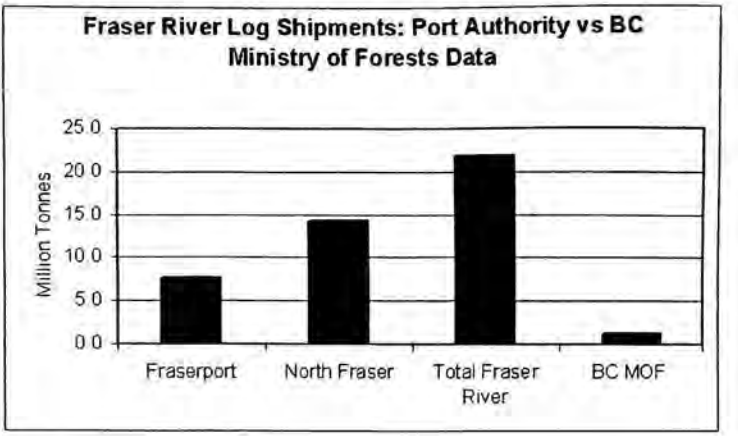
**Coastal Log Shipments Statistics Canada versus BC MOF**

('000 tonnes)

| Destination | Statscan (Logs) | MOF Total | MOF Barge | MOF Tow |
|---|---|---|---|---|
| Port Alberni | 404.9 | 3654.5 | 2458.9 | 1195.6 |
| Total Fraser River | 679.7 | 1216.6 | 0.0 | 1216.6 |
| Howe Sound | 1093.5 | 8711.5 | 2093.1 | 6618.4 |
| Chemainus | 65.0 | 422.4 | 0.0 | 422.4 |
| Total | 2243.2 | 14005.0 | 4552.0 | 9453.0 |




A comparison with statistics from the Fraser River and North Fraser Port Authorities is given below:




The significant difference between the port authorities' data and the data from B.C. Ministry of Forests appraisal data may be due to the following factors:

(1) Shortcomings in the destination detail of Ministry of Forests data. The appraisal system allocates logs to appraisal points based on minimum transportation cost. For most origin points, Howe Sound is closer than the Fraser River. In fact, the only logs allocated to the Fraser River by the appraisal system originate from upriver – origins such as Harrison Lake and Silverhope Creek.

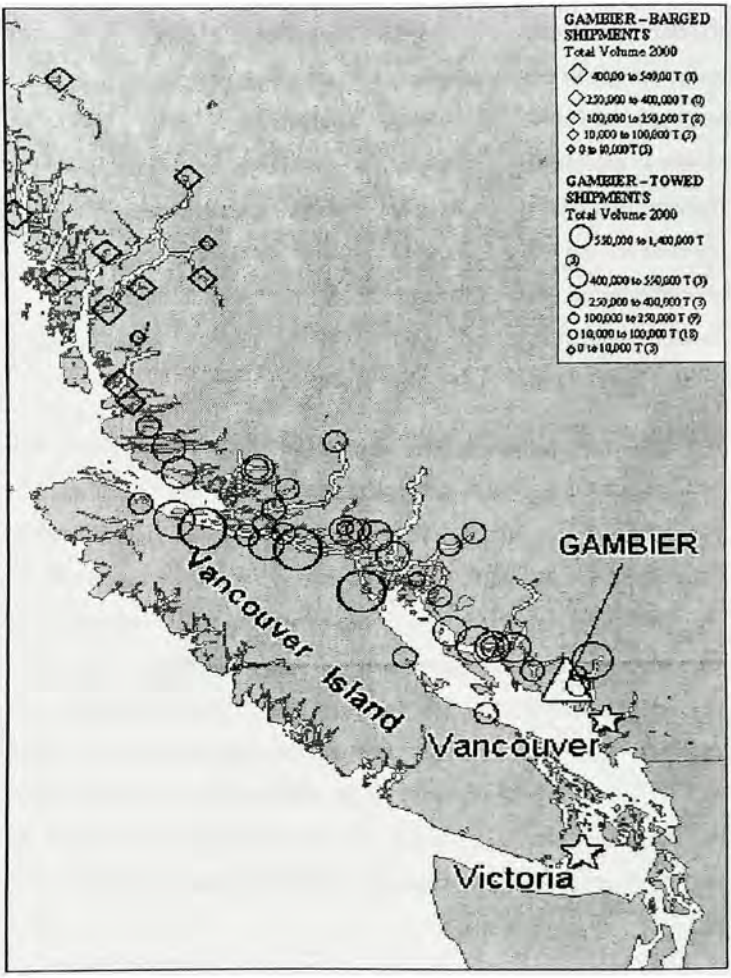
(2) Logs are actually shipped first to Howe Sound, where they are sorted and subsequently towed for storage and/or use along the Fraser River.

There is a degree of double counting between the two Fraser River authorities due to their proximity. Each counts the logs which cross their boundaries, so logs destined for Fraserport but routed via the North Arm of the river would be counted by both port authorities.

**Geographical Information System Analysis**

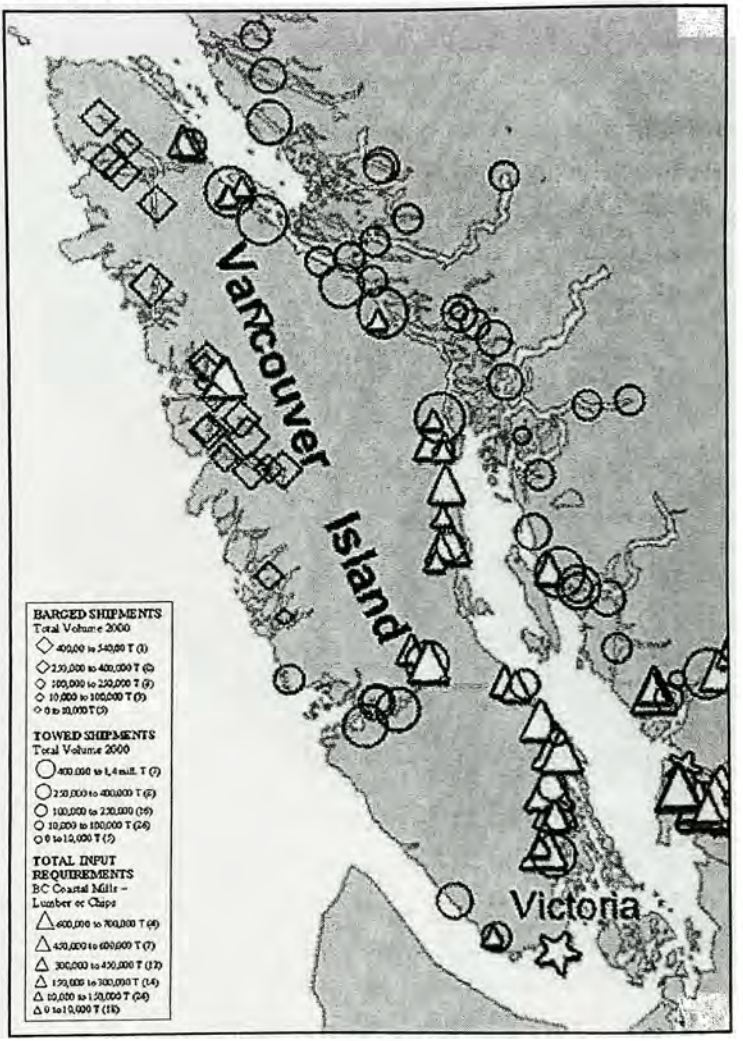
In order to analyze the Ministry of Forests data in more detail, the origin and appraisal points have been geocoded and the data converted for use with MAPINFO software. This allows mapping of the data for easier viewing. Map 1 shows barge and tow shipments allocated to Gambier Island, which accounted over 60% of shipments recorded by the Ministry of Forests for 2000.

**MAP 1: Log Shipments Allocated to Gambier Island – South Coast 2000**



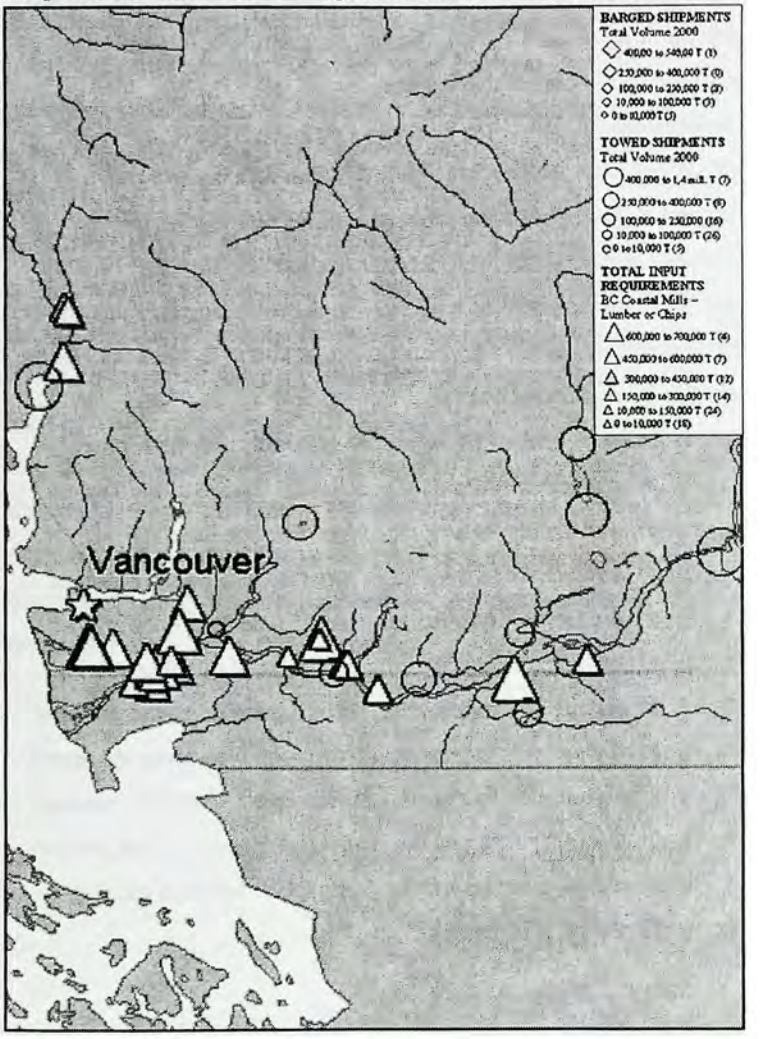
The Ministry of Forests also publishes statistics on timber processing facilities in the province. Analysis of this data allows us to draw some conclusions regarding the final destination of the logs. For this purpose, log input requirements of coastal lumber and chip mills have been estimated based on their output capacities, and the locations geocoded. This allows us to see where both the origin and destination points for timber harvested on Crown lands. Map 2 depicts timber volumes by origin and mill locations on Vancouver Island:

**MAP 2: Timber Origins and Lumber and Chip Mill Locations – Vancouver Island 2000**



Map 3 shows the large concentration of mills on the Fraser River in the Lower Mainland.

**Map 3: Mills and Timber Origins in the Lower Mainland 2000**



The GIS model provides an ideal platform for analysing forest product shipments. This analysis can be extended to the movements of mill byproducts to achieve estimates of total coastal movements, and with some additional information can be extended to estimate land transportation flows in the Interior.

**Conclusions**

This paper has analysed forest industry data to compile a more detailed and accurate estimate of coastal log movements than is available from existing Statistics Canada data. On the basis of this analysis it appears that the total volume of coastal log shipments is in the neighbourhood of 18 million tonnes, or almost 7 times the volume reported by Statistics Canada.

Geographical analysis of BC Ministry of Forests data on timber origins and mill locations lends support to the claims of the Fraser River and North Fraser River Port Authorities that their log throughput vastly exceeds the figures reported by Statistics Canada for their traffic. However, the estimate of 18 million tonnes of total coastal traffic suggests that a significant degree of double counting exists. This may be an inevitable aspect of relying on carrier surveys as a source of data on forest commodity movements, given the nature of the coastal transportation system. However, while double counting may be a problem for flows on the Fraser River, it is a minor problem for the Statistics Canada system for data capture which is missing more traffic than it is recording.

The current system of gathering coastal marine transportation flows is not working. This paper has shown an alternative method relying on BC Ministry of Forests data.which provides information on the three quarters of log flows which originate from Crown land. Perhaps attempting to collect directly data from the forest industry would be more productive

Acknowledgements: Many individuals provided information or assistance which was invaluable in preparing this paper. I would particularly like to thank the following individuals: Ian May of the Council of Forest Industries; Brian Zak of the Coast Forest and Lumber Association; numerous individuals at the BC Ministry of Forests, but particularly Greg Lawrance and Steve Fletcher; Ed Kargl of Fraserport; and Karl Kliparchuk and Andrew McIntosh of McElhanney Consulting for assistance in preparing the maps. Responsibility for all conclusions reached and opinions expressed in this paper rests solely with the author.

# Perspectives of Wheat and Barley Importers on Logistics and Quality

Erica Vido, Graduate Student and Barry E. Prentice, Director
Transport Institute, University of Manitoba, and Jake Kosior, SCSI

## Introduction

Grain supply chains have been studied repeatedly from the shipper's perspective, but the scope of such efforts usually end at the port of export (Prentice, 1998). Consequently, end-users views of the supply chain are subject to scant analysis. This is a reflection of the emphasis that has been placed on the problems related to farmers, but it is also a function of the difficulty in under-taking meaningful research of global markets. In addition to the problems of language and travel, it is difficult to identify a meaningful sample of importers that are representative. The literature suggests a qualitative approach, but before this could occur, one would need to know whether a problem worthy of the research investment exists.

This paper reports the results of a survey that was undertaken to assess the end-users' perspectives of the wheat and barley supply chains. The initial purpose was to identify buyers who would be willing to participate in trial shipments of grain in ISO containers (Kosior, Prentice and Vido, 2002). A global survey was undertaken identify potential collaborators and to explore the logistical problems of the end-users. Although agreement in principle to conduct trial shipments in containers were reached with several importers, delays and lack of cooperation on the part of the Canadian industry precluded this phase of the research. Nevertheless, the survey yielded interesting insights on the grain supply chain that suggest the export of grain in container load quantities could have great appeal to some end-users.

**Methodology**

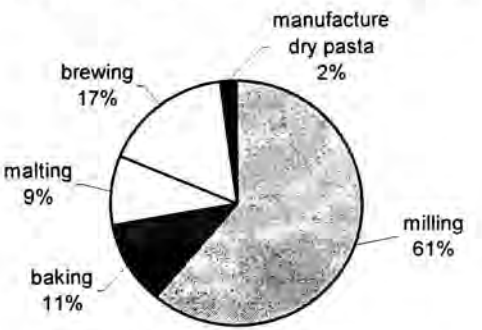
The Transport Institute conducted a global survey of wheat and barley importers during the summer of 2000. Survey participants were identified through the Canadian International Grains Institute, Canadian Consular offices abroad and Internet websites. The target population included processors of wheat, durum, barley or their derivatives. Approximately 2500 companies outside North America were solicited for information. Many did not qualify, but among the numerous responses, 53 companies provided meaningful replies. A high self-selection bias makes statistical inferences about the buyers' perspectives of the grains supply chain unreliable, although some useful insights and anecdotal observations were obtained.

The dataset was checked for internal consistencies and entered into machine-readable form. Global grains industry participants come from "all walks of life" with many differences including industrial activity, global location, size, language, etc. Many discussion-oriented or open-ended responses differed only in jargon rather than meaning. A post-field collapsing process was used to group together these responses.

**Survey Results**

In total 25 countries are represented in the aggregate sample[1]. The Middle East and Africa comprise only 8 percent of the sample. Consequently, only responses from Europe, South America and Asia-Pacific are discussed in the regional analyses. Figure 1 illustrates the industrial activity of the 53 companies included in the sample.

**Figure 1: Primary Industrial Activity of Importers**



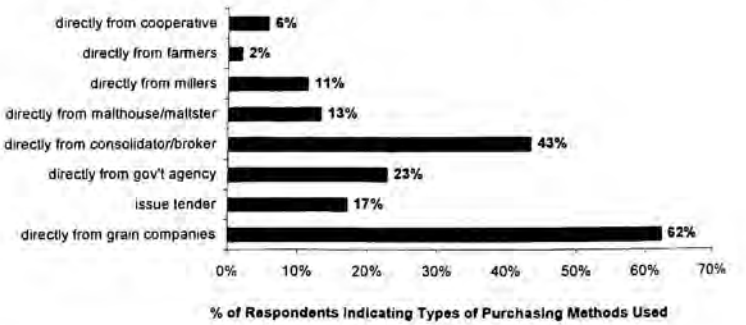

sior

The survey was targeted at importers that were involved in milling, baking, malting, brewing or some combination. Almost three quarters of respondents process wheat into flour products. One European company manufactures dried pasta products, while the rest process barley into either malt or beer (or both). A Japanese beer manufacturer also produces roasted barley tea and is included in the brewing category.

**Grain Purchasing Practices**

While these companies use a variety of means to source grain, almost two thirds buy directly from grain companies. Government agencies still account for one quarter of the sales. The grain sourcing methods are illustrated in Figure 2. Although not shown, about half the respondents use more than one source for their purchases.

**Figure 2: Method of Purchasing Wheat and Barley**

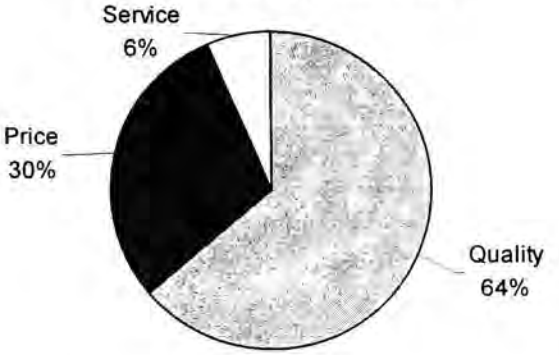



**Factors in the Grain Purchase Decision**

Respondents were asked to rank the factors that influence their grain purchasing decisions. The results are illustrated in Figure 3. Grain quality is reported to be the most important influence on purchasing

decisions, with 64 percent of respondents giving quality the first rank. Price was identified as most important by 30 percent, only six percent of respondents ranked service as the most important influence on grain purchasing decisions.

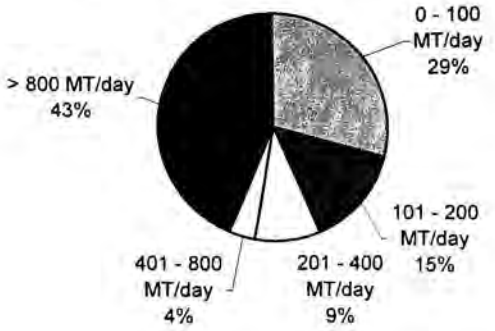
**Figure 3: Most Important Influence on Purchasing Decisions**




**Plant Consumption and Storage Capacity**

Daily plant consumption rates were estimated by dividing reported average storage capacity by delivery frequency. Figure 4 summarizes the daily plant consumption rates for the sample. Almost 45 percent of these companies reported low plant consumption rates (i.e. less than 200 MT/day).

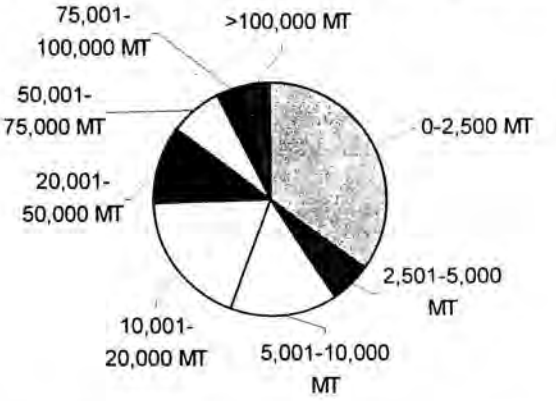
**Figure 4: Daily Plant Consumption**




Average storage capacity of the survey's participants is illustrated in Figure 5. Fewer than half (46 percent) have a storage capacity greater than 10,000 MT. Thirty-five percent have storage capacities less than 2,500 MT.

Storage capacities vary by region. The mean storage capacity for European processors is approximately 10,000 MT, with only one quarter of the respondents above the mean. The average storage capacity for South American processors is higher at 29,000 MT, with 64 percent of respondents in this group reporting storage capacities greater than 10,000 MT. Asia-Pacific processors have the greatest amount of storage with a mean capacity of 40,000 MT. Fifty-seven percent of this group has storage capacities greater than 10,000 MT. These data would suggest that the European food manufacturers would be a best target for containerization, or a Just-in-time approach to delivery.

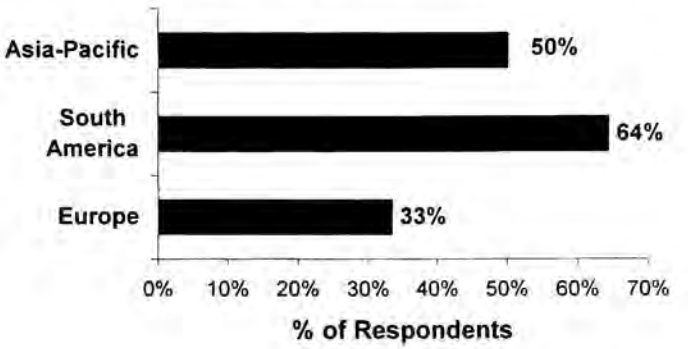
## Figure 5: Average Storage Capacity




**Supply Chain Performance**

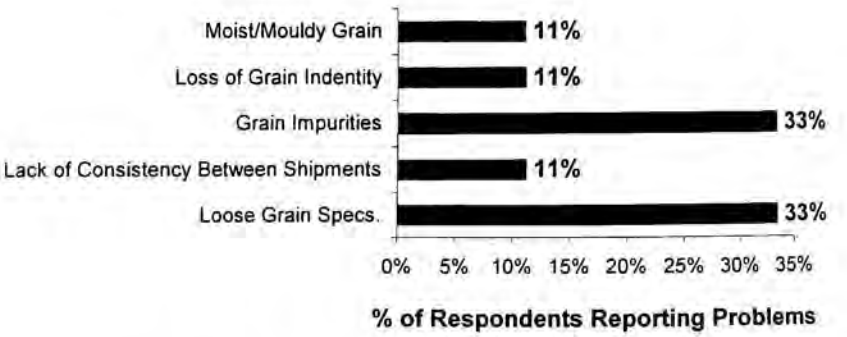
Half of the respondents indicated deficiencies with their current supply chain. This is illustrated in Figure 6. The supply chain problems vary among the Europe, South America and Asia-Pacific respondents. Consequently, these issues are discussed separately for each region.

## Figure 6: Reports of Supply Chain Problems



As presented in Figure 7, only one third of European grain processors reported experiencing difficulties with their current supply chains. Grain impurities and loose grain specifications create the biggest problems. When shipments arrive with loose specifications, recipes and production systems must be adjusted, creating delays and adding to costs. One Spanish brewer indicated that when suppliers do not adhere to the specifications, the shipment must be returned. When this happens, they have no inventory to continue production and the plant must shut down. A Norwegian miller claimed that bulk Canadian grain is occasionally blended with bulk U.S. grain in the grain terminals at the Port of Rotterdam, creating inaccurate grain specifications. Grain impurities also add to delays and costs, as the shipment must be cleaned before production can begin.

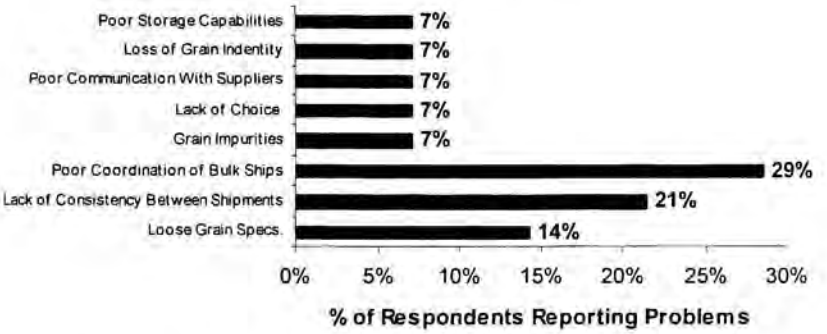
**Figure 7: Logistical Problems Europe**




A Norwegian brewer indicated that they would like to reduce stock levels and develop a more responsive supply chain. In addition, they would like a broader range of varieties and grain origins. The bulk transport system causes tremendous difficulty because it is unable to keep costs low with smaller consignments of varied products.

Figure 8 presents the supply chain problems reported by South American respondents. The leading complaint is bulk ship coordination. For small consignments of grain, it appears to be difficult to locate suitable ships. At the time of the survey, one Brazilian miller was in the process of developing a buying consortium with other grain importers to reduce logistics costs.

**Figure 8: Logistical Problems South America**




A miller in Venezuela revealed that only one berth for unloading bulk grain exists at the port and is shared by all parties. Frequently, ships must wait for the berth to become available, adding costly demurrage charges.

Lack of consistency between shipments and loose grain specifications also create significant problems for South American grain processors. Occasionally, grain arrives at the port with different quality specifications than what was originally ordered. A miller in Peru indicated that a shipment of grain was transshipped through a third country where it was commingled with other grain varieties. Costs

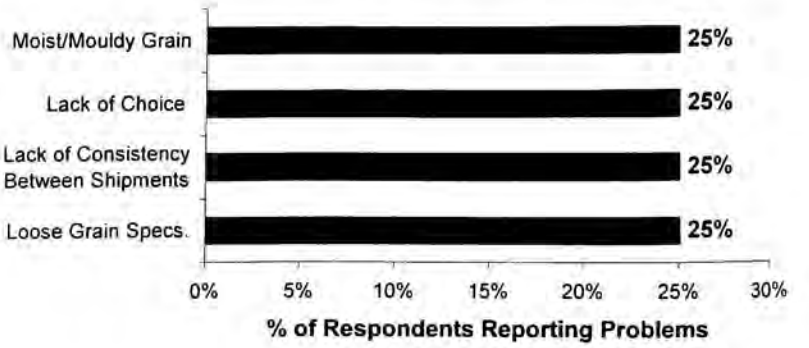
are added when time is needed to adjust production practices between each shipment.

Poor storage capability in South America creates opportunities for containerized grain shippers. A Brazilian miller indicated severe infestation problems from January to October. This could be alleviated with containerized JIT deliveries.

Finally, a few South American grain processors complained about the effects of Mercusor. Member countries pay stiff duties on grain imported from other regions, which limits their choice. Additionally, they criticize Argentina's inferior classification system, on the basis that grain identity is frequently unknown and grain specifications are repeatedly inaccurate.

The logistical complaints of the Asia-Pacific grain importers are presented in Figure 9. In Asia-Pacific, half of the respondents indicated problems with their current supply chains. A miller in Japan complained that the Japan Food Agency limits the choice of

**Figure 9: Logistical Problems Asia-Pacific**

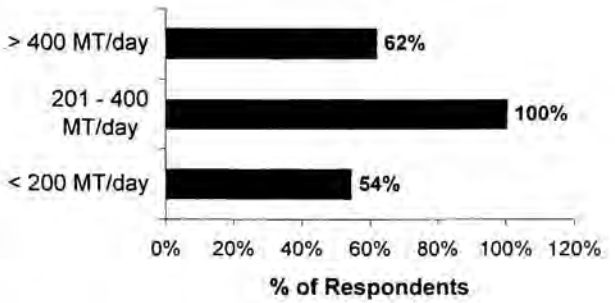


grains available to processors. The JFA sets standards and purchases grain from exporters based on these standards. Consequently, it is difficult for some Japanese specialty processors to obtain unique or distinctive product specifications required for their needs.

Finally, loose grain specifications, lack of consistency between shipments and moist grain require their time and resources to adjust recipes and production systems.

The logistical problems identified by the survey's participants were also viewed in the context of plant size (as proxied by daily plant consumption). These data are presented in Figure 10. All respondents reporting between 201 and 400 MT also reported at least some supply chain problems.

**Figure 10: Reports of Supply Chain Problems**




The various supply chain problems reported across the three main plant size strata are presented separately. Figure 11 presents the issues identified by companies with low daily consumption rates (200 MT/day and less). Significant problems are experienced with bulk ship coordination. This is likely because locating bulk ships suitable for small grain consignments is difficult and can be expensive. In this

survey the problem seems to be exclusively South American, and readers are cautioned to recall the limited size of the group.

**Figure 11: Logistical Problems**
**< 200 MT/day**

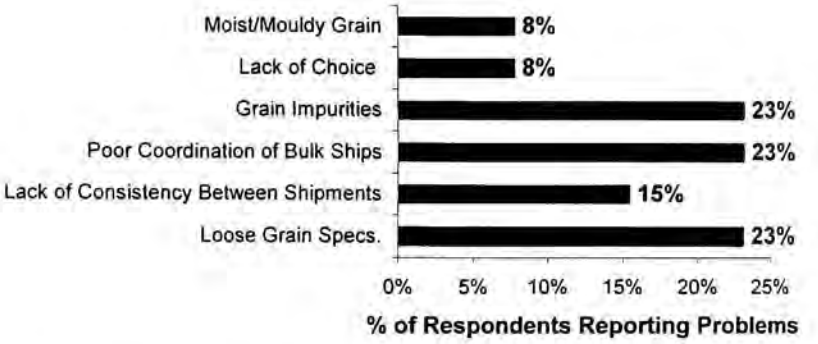
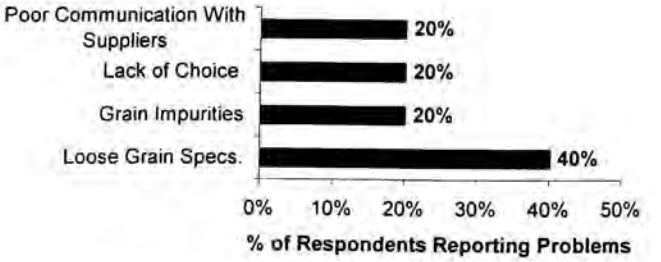



Figure 12 presents the logistical problems reported by the mid-sized grain importers (201-400 MT/day). This size of importers placed

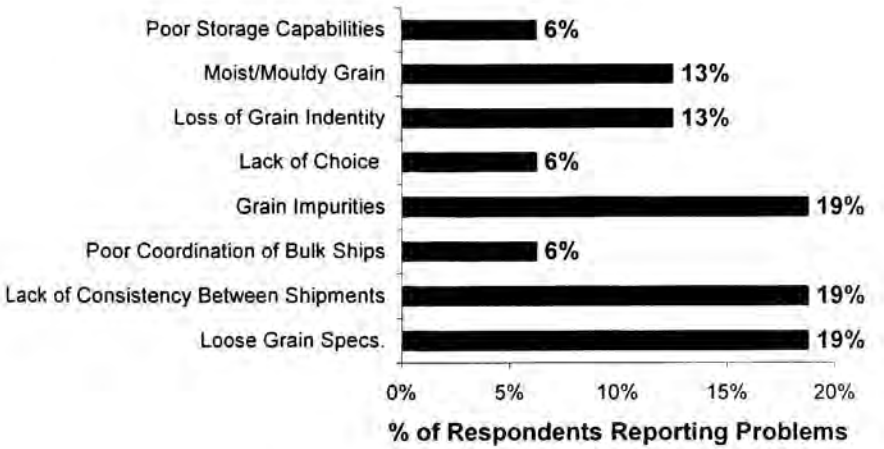
**Figure 12: Logistical Problems**
**201 - 400 MT/day**



most focus on loose grain specifications. Depending on how one wishes to interpret their other complaints, they are primarily related to quality, rather than movement.

The logistical problems of the larger importers (greater than 400 MT/day) are presented in Figure 13. The issues raised by the largest importer group are more varied than those of the smaller importers. No doubt these complaints are also more specific to the individual situation, like the case of moist or moldy grain.

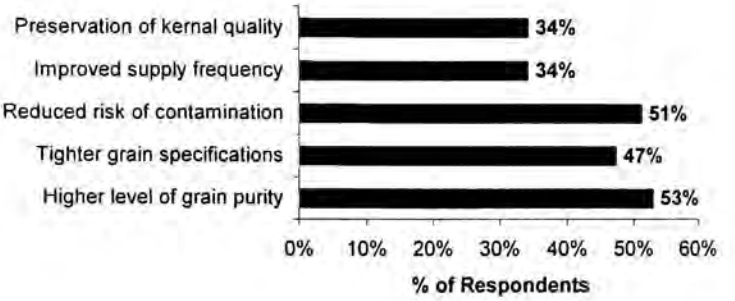
**Figure 13: Logistical Problems > 400 MT/day**




Survey respondents were asked to identify the specific supply chain improvements that they would like to see. These issues are presented in Figure 14 represent half the respondents. The surveyed importers would like greater certainty of quality and more frequent shipments. It should be emphasized that none of the participants are currently

receiving grain in containers. These results however, point to a strong level of interest. Indeed, importers were identified who where willing to participate in trial shipments in containers to test their effectiveness.

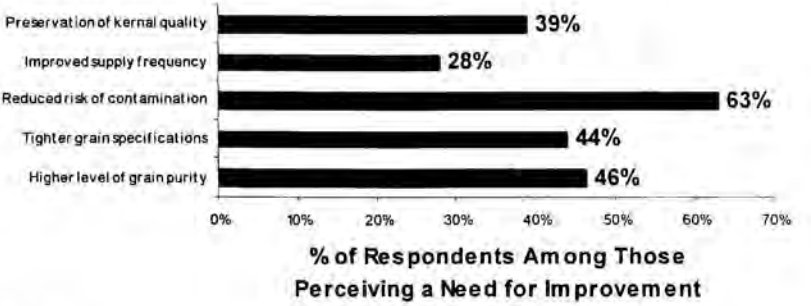
**Figure 14: Desired Supply Chain Improvements**




It is one thing to want an improvement in the supply chain, and quite another to be willing to pay more for such improvement. The respondents were asked which improvements they would pay more to receive. These data are presented in Figure 15.

Respondents' willingness to pay for a specific supply chain improvement provides an indication of the severity of a problem. Sixty-three percent of those respondents perceiving a need for improvements indicate that the risk of contamination is a serious problem. Whether they are giving an easy answer to a survey, or would really accept a higher price in return for higher quality, as defined by the factors identified, is not known. It certainly challenges the notion of the entrenched bulk-handling providers that they are protected by lower transportation costs.

**Figure 15: Willingness to Pay for Improvement**




**Conclusions**

The global grains industry exhibits significant variations in both input markets and industrial activity. Millers, bakers, maltsters, and brewers possess differing plant sizes and storage capacities and use different supply sourcing methods. The survey results suggest that the current system of bulk shipping is proving inadequate in satisfying all the needs of these grain processors.

Logistical and product quality problems threaten the profitability of some processors who operate with tight timelines and narrow margins. Vessel demurrage is a preventable expenditure. Costs incurred adjusting recipes, equipment, etc. are largely avoidable.

Many processors serve smaller niche markets. They require more specific quality attributes and more secure supply chains to guarantee the consistency of their products. While not all grain importers appear to be willing to pay higher prices for such service, a significant minority indicated that they would.

The desirability of identity preservation may extend beyond the typical notions of keeping GMO varieties of grain separate from non-GMOs in the supply chain. For example, two importers complained

that U.S. grain is mixed with Canadian grain at their ports because of transshipping. In addition to loss of identity, importers complained about impurities and moldy grain. These problems could likely be avoided by containers and indicate a feature of IP grain shipping that could be employed to enhance sales.

A container system can provide temporary storage that could be desirable for some importers. A small amount of Canadian grain shipped in containers could be blended with domestic stocks without tying up limited storage space. This may be useful for millers with storage capacities less than 10,000 MT. or daily plant consumption less than 200 MT/day. Clearly, a prima facie case exists for a more in depth examination of end-user interest in a JIT container-based grain supply chain.

**References**

Kosior, Jake, Barry E, Prentice and Erica Vido. *A Mixed Logistics Strategy for Grain: The Competitiveness of Containers versus Bulk.* Winnipeg, MB: Report Prepared for PFRA*, Agriculture and Agri-Food Canada, October 2002.

Prentice, Barry E. "Re-engineering Grain Logistics: Bulk Handling versus Containerization" *Transportation Research Forum.* Proceedings Issue: 40th Annual Meeting (1998): 339-352.

---

[1] Europe: Belgium, Czech Republic, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom; South America: Brazil, Chile, Colombia, Costa Rica, Panama, Peru, Venezuela; Asia-Pacific: Japan, Malaysia, Philippines; Middle East: Oman; Africa: South Africa

* Acknowledgement: This article was derived from a study sponsored by the PFRA. The opinions expressed are the sole responsibility of the authors.

# Estimation of the Demand for Grain Transportation in North Dakota

*Alan Dybing, Graduate Student, Transportation and Logistics, North Dakota State University, Fargo, ND*

## INTRODUCTION

North Dakota is the leading state in the United States in production of spring wheat, durum wheat, and barley. According to the North Dakota Agricultural Statistics Services, North Dakota's production of spring wheat, durum wheat, and barley in 2000 account for 42%, 71%, and 31% of the United States' total production for these commodities respectively. Of the total production for these commodities in 2000-2001, 84-95% is shipped outside the state of North Dakota to processors or terminal markets (Vachal 2001).

Most elevators face two options for grain transportation: truck and rail service. The decision of which mode to choose is dependent on various factors, most importantly of which is the rate associated with each mode. Cost minimization is key when making mode choice decisions for shipping grain. Shipment and elevator characteristics play a role in modal choice selection as well. They determine whether an elevator can take advantage of discounted rates, whether additional shipments are needed, geographic location of terminals, and the nature of services available.

Estimation of the elasticity of demand for each shipment mode will be a useful tool for understanding the nature of rail-truck competition. As mentioned above, most North Dakota elevators face two transportation choices: truck and rail. Demand elasticities may provide an indicator of whether rates are dominated by a particular

mode. If a competitor mode dominates the shipment, the dominated mode will have a high demand elasticity. A high elasticity shows that a small percentage increase in price causes a large percentage shift to the competing mode. Moreover, demand elasticities at different shipment distances will provide insight into the distances where rail and truck compete.

A current and accurate estimation of the elasticity of demand for transportation services is also useful for regulatory purposes. When deciding appropriate rates for regulatory purposes, the elasticity of demand is useful for determining the amount of dead weight loss to society from various pricing alternatives, and the effect(s) of any proposed regulated rates on social welfare. In cases where the firm experiences increasing returns to scale, the regulator cannot force marginal cost pricing, since it would result in losses to the firm. However, a second best solution is possible by setting price inversely to the elasticity of demand. This is referred to as Ramsey Pricing, and when firms have increasing returns to scale (MC<AC), it can be used to minimize DWL without excessive injury to provider firms.

A third potential use of demand elasticity estimates may be in assessing the incidence of cost changes on transportation users and firms. Recently the transportation environment was confronted with fluctuations in the prices for fuel inputs. Several observers commented on the likely effect of fuel price increases on freight transport costs. However, knowing the effects of increased prices depends heavily on knowledge of supply and demand conditions. The relative elasticities of supply and demand will determine the price effect. If the elasticity of demand were low relative to the supply, the effect on price would be high. On the other hand, a relatively high elasticity of demand would result in a smaller effect on price change as a result of increased fuel prices.

## METHODOLOGY AND DATA

### Scope

This study attempts to quantify responsiveness in grain transportation modal choice based upon several characteristics using an econometric model. The representative firm in this case is a typical grain elevator within the state of North Dakota. The commodities shipped from these elevators to be examined are hard red spring wheat (HRSW) and barley. The destinations are Minneapolis and Duluth, MN. It is assumed that these elevators have acted rationally and minimized their production costs by using optimal inputs to produce a given quantity of output.

The large number of elevators, and the lack of uniformity in size or capacity in North Dakota present a problem in the area of data collection. This study aggregates the transportation volumes by mode to the nine Crop Reporting Districts (CRDs) in the state. Each district is believed to have similar crop and producer characteristics as well as similar geographic locations.

### Derived Demand

The demand for grain transportation is treated as an input demand or derived demand. The finished product for North Dakota grain elevators is grain delivered at the destination. Transportation is an input used in the production process. By treating transportation in such a manner, the demand for the services can be obtained through the firm's cost function using Shephard's Lemma. Since the cost function shows the minimum cost of producing a given amount of output, it can be used to describe the firm's production technology (Bitzan 2000).

### Factors Examined

When estimating demand for transportation services, it is necessary to establish factors that affect the demand for transportation. The main factor that affects transportation modal choice for grain elevators is the rates of the respective modes. Since the main goal of grain

elevators is to maximize profit/minimize cost in the production of grain at the destination, the lowest cost option is the optimal choice.

Most elevators face two choices when making modal decisions: truck and rail. These modes have different service characteristics that this study attempts to quantify through demand estimation. The first is average elevator track capacity, which is included as a proxy for railroad service. If an elevator receives better service due to an ability to ship in larger volumes, and a practice of doing so, the elevator will be more likely to use rail. Conversely, if the elevator does not receive the same quality of service due to its smaller rail shipments, the elevator may be less likely to use rail.

Distance to the destination is another factor that affects modal demand. As distance to the destination increases, so does the cost of transportation, including costs associated with increased transit time, both for the shipper and the shipping provider. It is assumed that the degree to which each mode will be affected is different.

**Model Specification**

Each elevator is assumed to have a link-specific minimized cost function. This function describes the minimum cost of transporting a given quantity of output to a given destination using optimal combinations of railroad and truck services.

Past studies have assumed that grain transport services are separable from other inputs in the production function. "In other words, modal decisions are assumed to be independent from other factor decisions such as the optimal combinations of labor and capital." (Wilson 1982) Some studies have gone a step further to assume that transport costs to each destination are separable from total transportation costs. "This implies that each link-specific transportation technology is unaffected by the transportation activity levels of all other links (destinations) and the amounts of non-transport inputs used in the production." (Oum 1979) The same assumptions are made in this study, and the firm's link-specific transportation cost is estimated separately using a transportation cost function.

The firm's link-specific transportation cost function can be specified as follows:

(1) $C = C(w_i, q, t_j)$

- "which [represents] the minimum cost of producing output q, given prices of w (factor prices), and technological characteristics of inputs (e.g. length of haul)" (Bitzan 2000).

The given output, in this case, is the total amount of a commodity shipped from an elevator to Duluth or Minneapolis. Factor prices include rail and truck rates. Technological characteristics include elevator track capacity, length of haul, and a time variable to measure changes over time.

If the elevator's transportation cost function, or even the functional form was known, estimation would be a simple process. However, neither is known. It is necessary to choose a functional form that does not impose many restrictions on what the function should look like. According to Bitzan (1999), "One way to approximate an unknown function,..., is to perform a Taylor series expansion with a remainder." Friedlander & Spady (1980) show that the translog cost function can be thought of as a second order Taylor series expansion of an arbitrary function." Following the derivation in Bitzan (1999), an application of the function to this study is shown below:

$$\ln C(w_i, q, t_j) = \alpha_0 + \Sigma\alpha_i \ln w_i + \beta \ln q + \Sigma\gamma_j \ln t_j + 1/2\, \Sigma\phi_{ii}(\ln w_i)^2 + \Sigma\theta_i \ln w_i q + \Sigma\Sigma\omega_{ij} \ln w_i t_j + 1/2\, \rho(\ln q)^2 + \Sigma\zeta_{ij} \ln t_j q + 1/2\, \Sigma\varphi_j(\ln t_j)^2 + \varepsilon$$

- where $w_i$ = input prices (i = rail, truck)
$t_j$ = characteristics (j = time, track capacity, distance)
q= quantity shipped

By applying Shephard's Lemma to this transportation cost function, the factor share equations for each transportation input are obtained. This is the conditional input factor demand. From this, the input price and cross-price elasticities can be estimated.

$S_i = (x_i w_i)/C$

From this share equation, the own-price and cross-price elasticities can be obtained (Berndt and Wood 1975).

$\varepsilon_{ii} = \phi_{ii}/S_i - 1 + S_i$

$\varepsilon_{ij} = \phi_{ij}/S_i + S_j$

To account for changes in demand due to different commodities and destinations, four link-specific models are estimated. A model is constructed for each commodity to each destination. As mentioned previously, this provides a link-specific cost and share function model for each commodity and destination.

**Data Sources**

Much of the data for this study was obtained from the Grain Movement Database at the Upper Great Plains Transportation Institute. The database provides the monthly commodity shipments by mode from elevators in the state of North Dakota. It also provides the track capacity and storage capacity by elevator.

Truck rate data was estimated from a rate estimation approach. A survey of elevators from across the state resulted in an average per-mile rate of $1.05. To approximate the truck cost, a representative elevator near the geographic center of each CRD is chosen. The rationale for this approach is that not all modes are available to each elevator in the CRD. By using a representative elevator that represents the combination of the characteristics of all of the elevators in the CRD, a cross-section of the elevators' behavior can be obtained.

Seasonality in truck rates is implied by the nature of the fertilizer backhaul from Minneapolis and Duluth during the spring of the year. As the backhaul will have a large impact on the rate charged to the shipper, or whether the shipment will be made at all, seasonality must be included in the estimation of truck rates. The truck rates were adjusted for seasonality by applying the average monthly Minneapolis HRSW basis index to the truck cost estimates. Since historical truck rate data is not available, it was necessary to adjust the current rates to adequately represent past rate data. Past data was estimated by adjusting current rates by a trucking producer price index obtained through the Bureau of Labor Statistics.

Railroad rate data was obtained from Burlington-Northern Santa-Fe. Because rates differ by geographic location and elevator size, this study calculated a weighted average rail rate for each CRD, weighted by elevator track capacity. In calculating this average, it is assumed that each elevator will use the largest rail shipment size possible. (i.e. use the 52 car rate for 52 car elevators) Thus, rail rates by CRD represent the weighted average available to the elevators. For truck rates, A representative elevator near the geographic center of each CRD is chosen. The rationale for this approach is that not all modes are available to each elevator in the CRD. By using a representative elevator that represents the combination of the characteristics of all of the elevators in the CRD, a cross-section of the elevators' behavior can be obtained.

**Estimation Procedures**

The transportation cost function and share equations were simultaneously estimated as a Seemingly Unrelated Regression (SUR) system. Due to the nature of the data used in this model, the initial SUR results were tested for simultaneity using the Hausman F-test. The test indicated that rates for all models save one were not exogenous and subsequently were estimated using 3 Stage Least Squares estimation.

## RESULTS AND CONCLUSIONS

**Table 1 - Elasticity Elasticity Estimates**

| | HRS Wheat | | Barley | |
|---|---|---|---|---|
| | Mpls | Duluth | Mpls | Duluth |
| **Own-Price** | | | | |
| Rail | -0.464 | -0.248 | -0.771 | -0.822 |
| Truck | -1.151 | -0.463 | -1.988 | -1.386 |
| **Cross Price** | | | | |
| Rail-Truck | 0.464 | 0.248 | 0.771 | 0.822 |
| Truck-Rail | 1.151 | 0.463 | 1.988 | 1.386 |
| **Service Characteristics** | | | | |
| Rail-Quantity | 1.209 | 1.183 | 1.118 | 1.289 |
| Truck-Quantity | 0.253 | 0.351 | 0.88 | 0.856 |
| Rail-Distance | 0.586 | -1.298 | 0.77 | 0.782 |
| Truck-Distance | -0.818 | -4.982 | -3.043 | -1.972 |
| Rail-Rail Car Capacity | 0.154 | -0.523 | -0.816 | 1.151 |
| Truck-Rail Car Capacity | -1.168 | -2.3 | -0.087 | 0.076 |

### Own-Price Elasticities

Truck own-price elasticities are, with the exception of one case (HRSW to Duluth) greater than unit elastic, where rail own-price elasticities are mostly inelastic. As mentioned in the introduction, a mode with a high own-price elasticity indicates that the mode is dominated by its competitor.

A truck carrier may look at the elasticity of demand for their service and notice that a one-percent decrease in price will bring about a greater than one-percent increase in truck shipments, therefore increasing revenue. It is likely that such carriers are not able to reduce rates since they are already pricing near to marginal cost. The own-price elasticities of truck transportation seem to indicate that the trucking firms are pricing near to MC, and further rate reductions would result in decreased profits.

By the same token, a rail service provider faces inelastic demand for rail transportation in all cases. By increasing rates, the rail provider could increase revenues. Economic theory tells that a firm would not price in the inelastic portion of demand. This implies that railroads do not have complete freedom to set rail rates. Reasons for this may include the maximum reasonable rate guidelines or geographic and spatial competition.

Increased fuel prices may or may not have an effect on the rates for transportation services. Whether or not or how much they may be affected depends on the relative shape of the supply and demand curves. Figure 1 demonstrates the effects of increased fuel prices on transportation rates. It is a simplified demonstration used to illustrate the concept rather than a representation of the current situation due to the lack of information on the current supply elasticities for transportation.

**Figure 1 - Demonstration of Effects of Increased Fuel Prices**

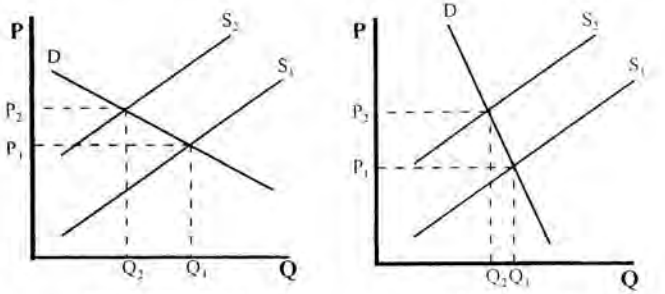



Figure 1 shows two different supply and demand scenarios for transportation. In both situations, supply is held constant to demonstrate the principle. An increase in fuel price would result in a shift in supply from S1 to S2. Demand would remain constant. When demand is elastic, the magnitude of the change in price due to

the supply shift is small in comparison to the shift when demand is inelastic. If demand is inelastic, the fuel price increases are passed on to the transportation buyers through increased prices. If there is inelastic demand, the producer bears the price increase.

In the two modes examined in this study, one is elastic while the other is inelastic. While the actual elasticity of supply for each mode is not known, the possible effects of a fuel price increase can be approximated assuming the elasticities of supply are similar. Since truck demand is elastic, it is reasonable to assume that an increase in fuel prices would be primarily absorbed by trucking firms. Rail transportation has an inelastic demand. Therefore, increases in fuel prices would be passed on to rail transportation buyers through increases in rail rates.

**Service Characteristic Elasticities**

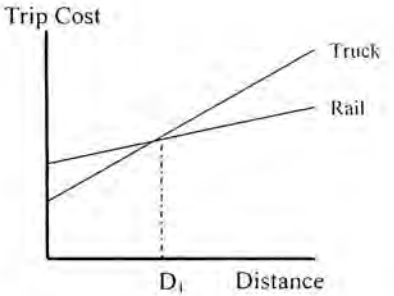
The first characteristic elasticity measured the change in demand for rail or truck services brought about by changes in the total quantity shipped from an elevator. As the above table shows, the elasticity for rail service with respect to quantity shipped is always greater than unit elastic, while the truck elasticities are always inelastic. There are two possible implications of this difference in mode elasticities. First, it demonstrates that if an elevator increases volume of shipped grain, in all likelihood they will ship a greater proportion of the increased quantity by rail than by truck. Secondly, if an elevator has a higher quantity of grain to ship, it is likely already choosing rail.

The elasticity of demand of truck and rail service with respect to distance provided the results expected. It is expected that as length of haul increases, the usage of truck transportation will decrease. In most cases, the elasticity of demand for truck transportation with respect to distance is negative, with large elasticities common. This shows that as distance increases, the demand for truck transportation decreases. Koo, Tolliver, and Bitzan (1993) shows that "trucks have a comparative advantage for short hauls because they have relatively insignificant fixed and terminal cost components compared to other

modes of transportation which offset relatively higher lineaul costs over short distances."

Figure 2 shows a demonstration of the impact of linehaul versus terminal costs. Truck transportation starts at a lower point on the Y-axis due to the significantly lower terminal costs as mentioned above. The slope of the line representing truck is higher than the line representing rail, demonstrating the higher variable cost per unit shipped by truck. At distance $D_1$ the trip cost for truck and rail are equal and for all distances greater than this, rail will become the least cost mode of shipment.

**Figure 2 - Demonstration of the Impact of Linehaul vs. Terminal Costs**




The elasticities of demand for rail transportation with respect to distance are predominately positive and less than one. As distance increases by one-percent, the amount of rail transportation increases less than one-percent, but increases nevertheless. As distance from Minneapolis and Duluth increases, rail becomes even more dominant.

The final service characteristic elasticity is rail and truck transportation with respect to elevator track capacity. As elevator track capacity increases, the elevator is assumed to be able to take advantage of improved rail service as train size increases. The results were expected to be positive for with respect to rail and

negative with respect to truck transportation. The results were not as expected and the variation explained by the rail car capacity variable may not be entirely due to rail car capacity.

**Acknowledgements**
The author would like to thank John Bitzan for all of his assistance and expertise in the completion of this study. The author would also like to thank Denver Tolliver, William Wilson, and Won Koo for their involvement.

## REFERENCES

Bitzan, John. "The Structure of Railroad costs and the Benefits/Costs of Mergers." Research in Transportation Economics. 5 (1999): 1-52

Koo, Won W., Tolliver Denver D., and Bitzan, John D. "Railroad Pricing in Captive Markets" An Empirical Study of North Dakota Grain Rates." *Logistics and Transportation Review* 29, no. 2 (1993).

Friedlaender, Ann F. and Richard H. Spady. "A Derived Demand Function for Freight Transportation." *The Review of Economics and Statistics* 62, no. 3. (Aug. 1980): 432-441

Oum, Tae Hoon. "A Cross Sectional Study of Freight Transport Demand and Rail-Truck Competition in Canada," *Bell Journal of Economics* 10, (1979):374-88/

Oum, Tae Hoon. "Derived Demand for Freight Transport and Intermodal Competition in Canada," Journal *of Transport Economics and Policy* 13, no. 2 (1992) : 149-68

Vachal, Kimberly. *North Dakota Grain and Oilseed Transportation Statistics, 2000-01.* North Dakota State University, Upper Great Plains Transportation Institute, no. 140 (September 2001).

Willson, William W. *Estimation of Demand Elasticities for Transportation Modes in Grain Transportation.* North Dakota State University, Department of Agricultural Economics, no. 159 (June 1982).

# SHUTTLE TRAIN ADOPTION STRATEGIES

*Weijun Huang, Upper Great Prairie Transportation Institute, North Dakota State University, USA*
*William W. Wilson, Dept. of Agribusiness & Applied Economics, North Dakota State University, USA*

## INTRODUCTION

Several U.S. and Canadian railroads have been in the process of developing and offering more sophisticated mechanisms for grain shipping: shuttle train operations. The cost advantage available to the shuttle-equipped facilities has implications for producers, elevators, local processors, and rural communities. A 100+ car shuttle train can load 440,000 bushels of grain and move a third more grain with a third less cars. Shuttle rail rates are, in today's grain industry, the most competitive. Rail rates have a substantial effect on the reach of an elevator's draw area. Shuttle rates provide elevators with an opportunity to penetrate a new grain draw territory. The additional territory attributed to shuttle train rates is estimated to be 18 to 76 percent farther than the most distant market available to the elevator when it utilizes unit train rates, depending on commodity and location (Vachal, 2001).

Although shuttle has been introduced for several years and its cost efficiency is seen by most elevators and railroads, there are many situations where, particularly, a large number of elevators in shuttle service areas still are not included in this program.

Shuttle adoption is largely affected by the geographic location, agricultural production and competitors. It is more a location decision for a group of elevators other than an individual elevator. Studies on shuttle program adoption are scarce and tended to focus on the individual elevator basis or the effects of policy changes.

This study takes all elevators in a large area as a sample to analyze shuttle adoption, which emphasizes more on geographic factors analysis. For example, how does the distance between two nearest competitive elevators affect an elevator's shuttle adoption decision? How does the shuttle adoption by a close competitive elevator affect an elevator's own shuttle adoption decision, etc.? This study addresses the issue, which is critical to the future of the shuttle train adopter: factors that affect shuttle train adoption.

## Data and Scope

For the purposes of this study and the availability of information, only elevators on the BNSF, UP and CP railroads are studied. Elevator level data used in this study are developed from several sources. One is the database of elevators obtained from these three railroads. Another source is the Membership Directory distributed by the Grain & Feed Associations of the Nine States (2000, 2001): North Dakota, South Dakota, Montana, Minnesota, Colorado, Kansas, Nebraska, Oklahoma and Texas. Originally, over 2400 elevators came from these data sets. About 5% of the elevators observations were unusable and deleted. After the deletion, 2309 useable observations left and used for estimation. All of those deleted elevators are much smaller in storage capacity than the average sizes of the other elevators, this deletion does not bring on a large deviation to the final analysis result.

Another data source is the website published by United States Department of Agriculture (USDA) and National Agricultural Statistics Service (NASS), which gives all geographic data and the aggregate agricultural data for five years, 1996, 1997, 1998, 1999, and 2000. Crops included in this study are wheat, corn for grain and corn for silage, soybean, sorghum for grain and sorghum for silage, barley and sunflower seed.

## Elevator Market Structure

**Market Structure.** It is reasonable to expect that the strategies of any one elevator will affect every other elevator. Because of the elevators' geographies and characteristics, they do not have monopoly powers. In the elevator industry, competitions are among a few service providers, 8.7 on the average in a county in this study, especially with the nearest competitor elevator. Such "close" competition engenders in each firm a concern for the actions of competitors.

**Competition**. When firms are direct competitors, the strategic choices of one directly affect the performance of the other. This is the case for elevator market since services (products) among elevators are homogeneous and close substitutes. Main differences among them are the locations or the distances to farmers.

Before any elevator adopts shuttle in a county, every elevator has its own geographic market. Therefore, every elevator has its own service area. They only compete in the marginal area where farmers are indifferent to which elevator they should sell their crops. However, once one elevator has adopted shuttle, this balance changes immediately. The discount obtained by the shuttle adopter from the railroad makes the elevator able to mark up its board price offered to farmers, and this leads to a re-dividing of geographic market. The areas that are not in the marginal area before will become the marginal market after one elevator adopts shuttle.

Elevator industry is under a blockaded entry condition for adopting the shuttle train, the first adopter needs to do nothing to deter entry because it requires large amounts of fixed investments or new adopter may expect post entry profits to be low. The more elevators adopt shuttle in an area, the less the adopter can attract farmers from other elevators.

Exit is the reverse of entry –the withdrawal of a product or service from a market. However, exit barriers can limit the incentives for the firm to stop producing (Besanko, 2000), for example, relationship-specific productive assets will have low resale value. This barrier is the main barrier for an elevator to exit since most elevators focus on very limited business areas beside its service. Their assets have very limited values for other usages. The largely sunken costs are not refundable.

In an elevator market, quantity competition, increasing total purchasing amount results in decreasing board prices, is not the nature of competition in this market as a whole. Any increase in board price by one elevator will only lead to attract farmers away from the nearest competitor elevator because the crop production is a variable that is not affected by elevators' competition. Even if two elevators increase their board prices at the same time, the total amount of crop they could buy from farmers is still the same. It cannot increase total market demand—the total crop production volume.

However, after one elevator adopts shuttle, the formal balance is broken down. Since elevators must make upfront investments in facility to adopt shuttle, competition can be unstable. After an

elevator adopts shuttle, it can get its market share increased dramatically. The additional miles that producers would travel for the higher elevator board prices are 3, 20 and 24 miles respectively if the board prices are increased by 2, 5 and 10 cents per bushel, assumes that the only difference is in board piece (Novak, 2000). Elevators' services are homogeneous in general. This intensifies price competition.

This result forces its competitor to take reaction: either exit the market because a large part of its customers moves away to its competitor; or get the lost market share back from its competitor and from other elevators by increasing its board price. The second solution can only be reached by adopting shuttle in order to get discount rates from railroads. If not, it is impossible for this elevator to compete for long because it cannot get any extra revenue from this market to cover the increase in its board prices.

When only one elevator adopts shuttle, it can reap a fruitful benefit. If its competitors fight back, in the end, no one can gain any positive result from this game. The following example can illustrate this procedure.

Assume that there is an elevator I, surrounded by A, B, C, J in a county and every elevator occupies a square area. If elevator I adopts shuttle as a first mover and its draw area will increase 50 percent (Vachal, 2001) from the original area. If this increase expands out evenly in all direction, this increase comes, mathematically, from its neighbors, about 12.5% from each of these four elevators.

One of the neighbors of I, elevator J, takes a tit for tat reaction, adopting shuttle to get the lost market back from. However, for the area neighboring with I, J can only return to its original boarder line. The result is that when J adopts shuttle, it can only increase its draw area by about 37.5%, I can only increase by about 37.5% from original areas now.

If all elevators surrounding I and J adopt the same strategy eventually, every elevator returns to the same draw area as before they adopt shuttle.

When several elevators are competing in the same area, the first t adopter can also gain significant early-mover advantage. Another advantage is it creates a structural entry barrier to its competitor,

economies of scale and scope. As discussed above, the market potential for elevator is relatively certain and it does not change dramatically over the years. When economies of scale are significant, this first adopter could gain a larger market share and have a cost advantage.

The dedicated productive assets have a low resale value, and are a big exit barrier. This is the most important reason that makes a non-adopter elevator not willing to accept the fact that his competitor elevator move first, adopting shuttle, and do not follow it or even exit this market. The sunk cost arise because an elevator that has already committed to a particular business has invested in resources and organizational capabilities that are likely to be specific to that business and are this less valuable if that elevator switches to another business, which means an even bigger loss.

The Prisoners' Dilemma is a key feature of decisions in this market. The prisoners' dilemma arises because in pursuing its self-interest, each party imposes a cost on the other that it does not take into account. No cooperative equilibrium can be reached after one elevator's first move. If non-adopter does not adopt shuttle after its neighbor has adopted it, the only results it can get is its business situation gets worse and worse, eventually exits this market, or it fights back to its competitor, first adopter, by adopting shuttle also. The first result is unfavorable to the non-adopter. The second one is unfavorable to both elevators, and eventually it will drive them to the noncooperative equilibrium, both of them offer higher board prices to farmers. While this outcome is unfortunate from the viewpoint of the elevators' owners, it is important to note that this is a favorable outcome from the viewpoint of farmers and society.

Both situations are not good to follower: fight back will lead to prisoner dilemma because of the fixed market potential; doing nothing to competitor's challenge or even exit is unendurable.

**Model Specification**

An elevator payoff from adopting shuttle is a function of agronomic characteristics, competitive factors, its own-elevator characteristics, and other variables.

Expected payoffs from adoption depend on the rate spreads got from railroad, high handling efficiency of large volume and more

volume of grain purchased from larger draw areas and the costs of adoption and investment, while payoffs from non-adoption depend on the outside option, i.e. opportunity costs of non adopting shuttle.

Most of these variables are not directly observable. It is not possible to directly observe the expected payoff of an elevator, or revenue and costs of an elevator are not observed. What is observed is whether the elevator adopts the shuttle. Adoption is observed. Instead, proxies can be used to measure the adoption strategy.

To avoid the complications of such a framework, the difference between expected payoffs from adoption and non-adoption is modeled as a reduced form and estimate the decision as an empirical model, using Logit procedure.

The empirical model is defined as follows.

$$P_{shuttle}(Shuttle1_i = 1) = 1 / (1 + e^{-f(\beta_0 + \beta_i X_i)})$$

where P(.) is a probability function, $X_i$ (a row vector of explanatory variables,) and $\beta_i$ is a vector of coefficients (to be estimated) which represent the influence of the explanatory variables on the profitability of the shuttle adoption.

**Variable Definition.** $Shuttle1_i$: The decision of Shuttle adoption to locate at elevator location i. It is a dependent variable. Is 1 if shuttle adopted; 0 if not adopted.

$RrUP_i$, $RrCP_i$ and $RrBNSF_i$ (1 or 0) are railroad companies UP, CP and BNSF. They are binary variables. These variables measure how an elevator on a specific railroad line is willing to adopt shuttle program, or how a railroad company affects the shuttle adoption. Since only two binary variables among these three can be included in the model. Here UP and CP are tested.

$Cap1_i$ (1,000,000 Bushels) is an elevator's own storage capacity. Larger capacity elevators are expected to realize lower per bushel costs and thus, have a longer survival time (Vachal, etc. 1997). An elevator with a large storage capacity needs less investment on its shuttle adoption because it possesses a larger infrastructure already. Vachal (2001) found that 10 to 15 million bushels handle volume for an elevator is required for a feasible shuttle operation.

$Cap2_j$(1,000,000 Bushels) is the storage capacity of the nearest competitor elevator. An elevator feels less pressure from its neighbor elevator with small capacity because a small rival is usually weak.

$Shuttle2_j$ (1 or 0): It is a binary variable that shows whether or not the nearest competitor elevator has adopted shuttle. This simplification is due to the incapability to calculate all the distances and spatial correlations among all the huge amount of elevators that needs special software to deal with.

$Nearele_i$ (Miles) is the distance between elevators to its nearest competitor elevator. If the value of this variable is large, then competition is weak from competitor. As discussed above, this also neglects the effects of all other elevators. However, this simplification still does, to a very large degree, reflect the distance impact on shuttle adoption decision to any elevator. Berwick (2001) found that the draw area for the shuttle facilities is estimated to be a 60-mile radius. Where shuttle facilities are built, truck traffic over local and state roads in the draw area would significantly increase.

$Noinfip_i$( # of elevators in the county). The more competitors in a market, the weaker the competition is in that market.

$Yield_i$ (Bushels/Acre): It is the average crops production per acre for the main crops in the county. If this variable is high, with the same draw distance, the volume handled is larger. The figures used in the analysis are firstly averaged from main crops for each year of 1998 to 2000 and then is averaged to a single year figure.

$SD_i$ (Bushels/Acre): The standard deviation of yield of crops in a county. Large fluctuation in production means uncertainty and high risk for elevator's investment.

$Herfindahl_i$ (between 0 and 1): It is the Crop Herfindahl Index of crops diversities. It equals the sum of the crop production share of all crops in that county. Let Si represent the crops concentration ratio, Herfindahli = $\Sigma$ $(Si)^2$. If this index is high, the production of the main crops is high. It is easier for elevator to load or unload grain than if it has to switch from one crop to another.

$Eledenfip_i$ (1, 000 Acre / Per Elevator): It is the density of elevators in a county.

$Croppro_i$ (1, 000, 000 Bushels): Total crop production of the county that elevator locates in.

$Proele_i$ (1, 000, 000 Bushels / Per Elevator) measures the average main crops production per elevator in the county.

$Area_i$ (1, 000 Acres): The area of the county that the elevator locates in. When the amount of elevators in a county is given, this variable could directly measures the distance for farmers to deliver their crops to the elevator and how elevators are dispersed.

$Portdis_i$ (Miles): The distance from an elevator to the nearest port. This variable is to determine the impact of barge competition.

**Estimation Procedure and Result**

Shuttle adoption model is estimated by putting the original data into it with different combinations. 15 variables are tested. The variables that are not significantly important are dropped from the model, and those that are significant all the time are kept. Those that are in between are estimated again by checking their correlation coefficients. If it is correlated with several other variables, it is dropped. Marginal effects of each variable are estimated to show the changes in dependent variable, given a change in each independent variable.

The basic selection criteria are based on Chi-square distribution of 10 degree of freedom at 5% level of significance. These significant variables are: $RrUP_i$, $RrCP_i$, $Cap1_i$, $Cap2_j$, $Shuttle2_j$, $Nearele_i$, $Noinfip_i$, $Yield_i$, $Herfindahl_i$ and $SD_i$. The variables that are not significant are removed after estimation: $Croppro_i$, $Area_i$, $Eledenfip_i$, $Proele_i$, $Portdis_i$. Although they are not included in the model, they do give a good illustration to the other variables and the model itself. Each variable is discussed in three groups, competitive impacts, agronomic impacts and own-elevator characteristics in the following. The statistical results of these 15 variables and the empirical results of the base model are shown in the Table 1 and 2.

**Table 1. Variables Statistical Results**

| Variable | Mean | Unit | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| $Shuttle1_i$ | 0.07796 | 1 or 0 | 0.26816 | 0 | 1 |
| $RrBNSF_i$ | 0.68168 | 1 or 0 | 0.46592 | 0 | 1 |
| $RrUP_i$ | 0.26028 | 1 or 0 | 0.43888 | 0 | 1 |
| $RrCP_i$ | 0.05803 | 1 or 0 | 0.23385 | 0 | 1 |
| $Nearele_i$ | 4.1988 | Miles | 7.5061 | 0 | 129 |

| | | | | | |
|---|---|---|---|---|---|
| $Cap1_i$ | 1.345 | Million-bushel | 2.5531270 | 0.001 | 32 |
| $Cap2_i$ | 2.210 | Million-bushel | 4.1652397 | 0.002 | 32 |
| $Shuttle2_i$ | 0.159 | 1 or 0 | 0.3657024 | 0 | 1 |
| $Area_i$ | 712.1 | 1,000 Acres | 468.9 | 82.43 | 3984.5 |
| $Croppro_i$ | 11.97 | Million-bushel | 8.223586 | 0 | 65.47 |
| $Proele_i$ | 1.9105 | Million-bushel / elevator | 1.971 | 0 | 25.11 |
| $Herfindhal_i$ | 0.456 | 0 to 1 | 0.4981334 | 0 | 1 |
| $Yield_i$ | 20.11 | Bushels/Acre | 14.465 | 0 | 65 |
| $SD_i$ | 3.266 | Bushels/Acre | 1.9496 | 0 | 10.37 |
| $Portdis_i$ | 222.503 | Miles | 131.768 | 1 | 666 |
| $Noinfip_i$ | 8.713 | # of elevators in county | 6.205 | 1 | 29 |
| $Eledenfi_i$ | 139.147 | 1,000 Acres /elevator | 191.56 | 8 | 2,295 |

**Table 2. Maximum Likelihood Estimates and Marginal Effects**

| Variables | Parameter Estimate | Wal Chi-square | Pr >Chi-square | $\partial P(shuttle1_i = 1) / \partial X_i$ |
|---|---|---|---|---|
| Intercept | -3.2938 | 147.3847 | <.0001 | |
| $Cap1_i$ | 0.1894 | 41.2109 | <.0001 | 0.009843891 |
| $Shuttle2_i$ | *1.5191* | 72.2716 | <.0001 | 0.078953827 |
| $Cap2_i$ | -0.0502 | 4.8131 | 0.0282 | -0.002609099 |
| $Nearele_i$ | -0.0321 | 4.1658 | 0.0412 | -0.001668368 |
| $Noinfip_i$ | -0.0312 | 3.2411 | 0.0718 | -0.001621591 |
| $Herfinda_i$ | 0.3732 | 4.1383 | 0.0419 | 0.019396727 |
| $Yield_i$ | 0.0136 | 10.4402 | 0.0012 | 0.000706848 |
| $SD_i$ | -0.067 | 1.5429 | 0.2142 | -0.003482263 |
| $RrUP_i$ | 0.4007 | 4.8619 | 0.0275 | 0.020826014 |
| $RrCP_i$ | 0.6627 | 3.4036 | 0.0651 | 0.034443224 |

$Shuttle2_j$: This variable most significantly affects the dependent variable and the sign of the parameter is positive. This means that if an elevator adopts shuttle, its nearest competitor elevator would take a tit-for-tat strategy as their competitors did in order to guard against a worse competitive situation. Although it is possible for non-adopter to operate at the same board prices as before, non-adopter eventually will face a decision between upgrading facilities and backing off from this market. Both of these two decisions are critical to any elevators. From the result, if one elevators adopts shuttle, the other elevator is more likely to adopt shuttle to prevent itself from being expelled from its market and to maintain the same market position.

$Cap2_j$: This variable shows a weak impact on the shuttle adoption decision. Although it also has a negative sign of parameter as expected, it is much smaller than $Cap1_i$. It shows a fact that the storage capacity of an elevator is much more sensitive than the storage capacity of its nearest competitor elevator. If an elevator's storage capacity is large, it has a big pressure on its neighbor because it is easy for it to adopt shuttle.

$Nearele_i$: Estimation result shows that the distance between two elevators has a negative effect on shuttle adoption. If two elevators are close, the competition is more severe and it may stimulates an elevator to adopt shuttle first even if it does not want to. If the distance is long between them, they will feel less competition pressure from each other, therefore, they have less desire to make changes. If the distance between these two elevators is far away, the pressure from competition is weak, this factor would not be big enough to stimulate elevator to adopt shuttle.

$Noinfip_i$: This variable has a negative value of parameter as expected. In general, the more elevators in a county, the less severe the direct competitions are. In a competitive market, such as only a few elevators in a county, one firm makes any marketing efforts will lead to an immediate reactions from its competitors. On the other hand, if every firm is satisfied with its present situation and does not want to stimulate a new round competition that might lead to the result of Prisoner Dilemma, an innovation effort probably could be hard to take. The situation is just the same here: if there is an elevators in a county, the chance of this elevator adopts shuttle is

lower than if there are fewer elevators in the same country. Any increase in the number of elevators just decreases the competition among elevators, and therefore decrease the intention to adopt shuttle.

$Yield_i$: The estimation result shows a positive sign of the parameter, which means that if the yield of crops in a county is high, an elevator has a high tendency to adopt shuttle; if yield is low, elevator is less likely to adopt shuttle. In the estimation, this variable always shows a significant effect on the dependent variable, $Shuttle1_i$, and its parameter value never changes much when changing different variables in the model. When have this variable in the model, the variables, $SD_i$, $Proele_i$ and $Produ_i$ become insignificant, and these result are coincidently identical with the result of correlation test.

If yield is high, an elevator with a specific storage capacity would have a smaller draw area, or with the same draw area, its handling volume is high, then the average cost for every bushel is low. A high yield helps elevator to adopt shuttle.

$Herfindahl_i$ shows a significant and positive effect on the dependent variable. In any models with different variables in them, this variable never changes its significance. Therefore, it stays in the model. All nine States in this study have big difference for this index. Some counties are close to each other, their crop $Herfindahl_i$ indexes differ a lot. If crop $Herfindahl_i$ index is high, then there are fewer crops in this county. Therefore, elevators deal with fewer types of grains. With the same handling capacity, high crop Herfindahl index means high volume for every single crop handled that helps adoption because two main requirements for shuttle adoption are large volume and high loading and unloading capacity. If an elevator deals with too many kinds of crops, it increases the level of difficulties for it to reach the economy of size.

$SD_i$ is the only variable that exceeds 5% significant level. However, it still is kept in the model since the standard deviation of yield of crops in a county does reflect the fluctuation in production. It is the only market factor to mean uncertainty and risk for elevator's investment. On the other hand, this variable does not have strong correlation with other variables.

$Cap1_i$ shows an always-significant impact in the estimations among all the variables in the base model with a positive value of

parameter. Positive sign shows that the large storage capacity elevator is more likely to adopt shuttle. If the storage capacity is high, the average fixed handling costs are lower for elevator. On the average, high storage capacity also means high handling volume. This result is consistent with the 'shakeout' theory, small-share firms exhibited high rates of exits, and small-scale plants were most likely to close in a declining industry (Ghemawat and Nalebuff, 1985,1990; Londregan, 1988 and Liberman,1998).

$RrUP_i$: The result shows that if an elevator is on the UP rail line, it is more likely to adopt Shuttle. UP is positive factor. In any estimations with different variables included in the models during the estimations, this result always keeps the same and never changed much. Therefore, it implies that UP is a railroad willing to assist shuttle adoption.

$RrCP_i$ also has the result as expected, a positive effect on the shuttle adoption. Although the percentage of elevators that adopted shuttle on the CP rail line is lower than that on the UP line, this variable has a larger effect than $RrUP_i$. This result may be explained in two reasons. One is that CP does have a strong effect and has effective policy on the shuttle adoption on the elevators that are on its rail line. Another reason is that the number of elevators that are on the CP rail line studied in this study is too small. Only 10 elevators from 134 elevators on the CP rail line adopted shuttle. Since only three railroads are studied, and if $UP_i$ and $CP_i$ both show the positive effects on adoption, $BNSF_i$ must show a negative effect on the adoption. This is confirmed in the estimation. However, this result is contradictory to many people's thoughts. BNSF has the largest number of elevators on its rail line and is the biggest grain carrier in the USA, and its promotion action on shuttle adoption in recent years was most impressive. The reason for this result implies that although BNSF has a large number of elevators on its rail line, the percentage of elevators that have adopted shuttle, 6.35%, is still low compared with other two, 11.65% and 7.46% in these nine States.

Other variables also help to explain the effective influences although they do not show significant effects or show a correlation

with the variables discussed above if they are included in the model. They are also discussed as follows.

$Portdis_i$ has the least relationship to dependent variable in the estimation. Therefore, water transportation is not an important factor here to affect the shuttle adoption since its competition pressure is not strong enough. This variable shows a negative sign of parameter, which indicates that if a port is far away from an elevator, the elevator is less likely to adopt shuttle because the competition from other mode of transportation is weaker, and the pressure to make change is smaller. It fits the economics theory.

This result reflects a fact that in the long time development of different transportation modes, the locations of ports and rail lines are chosen with the market demand and economics evolution. Only one new technology change or adoption is not strong enough to change the pattern of the transportation structure or pattern. Besides, after an elevator adopts shuttle, it can only increase a not-very-large draw distance. Compared with the average distance to the nearest elevator, 7.5 miles, the average distance from elevator to port, 131.8 miles, is too large. It is excluded out of model at early stage of estimation.

$Croppro_i$ shows a correlation with three variables, $Yield_i$, $SD_i$ and $Proele_i$ in the correlation test. If $Croppro_i$ is in the model, it always shows insignificant effect on the dependent variable. For this reason, it has to be dropped from model.

$Proele_i$ shows a different result. Actually, this variable is related to the volume of elevator handling volume. It is the combination of two variables: total crop productions and the number of elevators in that county. From the estimation result, this variable also shows the least significance, like $Portdis_i$. It has a very small impact on shuttle adoption in the model. In addition, this variable has a correlation with $Yield_i$. It is deleted from model.

$Area_i$ shows the insignificant effect in the different models with different variables combinations. If it is in the model, it also changes $Nearele_i$ from significant to insignificant. $Nearele_i$ is the function of $Area_i$ and $Noinfip_i$ and including both of them in the model can lead to correlation. $Area_i$ cannot be considered in the model. This result fits the real world situation because the areas of different counties are divides them, based on the other standards.

Eledenfip$_i$ is very similar to Noinfip$_i$ in influence on shuttle1$_i$. It has a relatively high correlations to Noinfip$_i$ and Nearele$_i$. It is dropped from the model because Noinfip$_i$ is a better variable.

**Marginal effects.** The partial derivative with respect to each variable in the model can be used to integrate the marginal effects shown in Table 2.

From the calculation results, as expected, all signs have the same signs as they are in the model. This suggests that all variables have the same trends of changes as they were presented in the model.

From Table 2, Shuttle2$_i$, RrCP$_i$ and RrUP$_i$ have the higher marginal effects. Yield$_i$, Nearele$_i$ and Noinfip$_i$ have the lower marginal effects.

## CONCLUSIONS

This study is an extension of the exit and exit theory applied in the elevator industry. The results are consistent with those of similar studies did before.

Shuttle technology adoptions by the elevators present the new trend. The competitive structure is changing as adoptions continue and more elevators exit the industry. Many elevators are induced to adopt the shuttle train by railroads and other elevators' movements.

The estimation results of the shuttle adoption model illustrate the importance of own-elevator characteristics, agronomic characteristics and competitive factors. Elevator's own storage capacity, railroad companies UP and CP (and BNSF), nearest competitor elevator's shuttle adoption, the average crops yield for the main crops, Herfindahl index of crops diversities have positive effects on an elevator's shuttle adoption decision. On the other hand, size or storage capacity of the nearest competitive elevator, standard deviation of yield of crops in a county, distance between an elevator to its nearest competitor elevator and the number of elevators in a county have negative effects on an elevator's adoption.

The nearest competitor elevator's shuttle adoption has the biggest effect on shuttle adoption, indicating that adoption is more likely to occur at elevator that has a neighbor who has adopted shuttle train. Another competitive characteristic, railroad companies, UP and CP, also have positive and strong influences on shuttle adoption, it also means BNSF has a negative effect on an elevator's shuttle adoption.

Herfindahl index of crops diversities is the next factor that has positive and strong effect on adoption. An elevator's own storage capacity or size is also an important positive determinant of adoption.

## REFERENCES

1 ) Berwick, Mark, John Bitzan, Brenda Lantz, Denver Tolliver and Kimberly Vachal. "North Dakota Strategic Freight Analysis: Agricultural Sector — Summary Report," MPC 01-127.5, Upper Great Plains Transportation Institute, North Dakota State University, Fargo, October 2001.

2 ) Besanko, David, David Dranove and Mark Shanley. "*Economics of Strategy*," John Wiley & Sons. Inc., New York, 2000.

3 ) Bulow, J., J. Geanakopolos, and P. Klemperer, " Multimarket Oligopoly: Strategic Substitutes and Complements," *Journal of Political Economy*, 93, 1985, pp.488-511.

4 ) Ghemawat, P. and B. Nalebuff, "Exit", *RAND Journal of Econometrica*, 54, 1985, 943-60.

5 ) Lieberman, Marvin B., "Post-Entry Investment and Market Structure in the Chemical Processing Industries," *Rand Journal of Economics*, 1987, 18, 533-49.

6 ) Lieberman, Marvin B., "Empirical Evidence, Exit from declining Industries: 'Shakeout' or Stakeout'?", *Applied Industrial Economics*, Cambridge University Press, New York, 1998, 18, 98-119.

7 ) Longdregan, J., "Exit vs. survival in the petroleum refining industry", Mimeo, Carnegie-Mellon University, January, 1988.

8 ) *Membership Directory*. Grain & Feed Association: North Dakota, South Dakota, Montana, Minnesota, Colorado, Kansas, Nebraska, Oklahoma, Texas, 2000, 2001.

9 )Novak, Patrick and Shannon Schlecht. "Strategic adoption of 100 car loading elevators in North Dakota", Work Report, Dept. of Agricultural Economics, North Dakota State University, Fargo, North Dakota State University, March 2000.

10 ) United States Department of Agriculture, National Agricultural Statistics Service, http://www.usda.gov/nass/aggraphs/cropmap.htm.

10 ) Vachal, Kimberly. "Shuttle Trains," *North Dakota Strategic Freight Analysis*, MPC Report No. 01-127.3, Upper Great Plains Transportation Institute, North Dakota State University, Fargo, October 2001.

11 ) Vachal, Kimberly, John Bitzan and Bridget Baldwin. "*Implications of a North American Grain Marketing System for Prairie Transportation & Elevators*," MPC Report No. 97-84, Upper Great Plains Transportation Institute, North Dakota State University, Fargo, September 1997.

# A Comparative Analysis of Productivity Performance of the World's Major Airports

Tae H.Oum and Chunyan
Faculty of Commerce and Business Administration
The University of British Columbia
Vancouver, B.C.
tae.oum@commerce.ubc.ca; Chunyan.yu@commerce.ubc.ca
In cooperation with The Global Airport Benchmarking Task Force of Air Transport Research Society (ATRS)
www.atrsworld.org

## Abstract

This paper measures and compares productive efficiency of 50 major airports in Asia Pacific, Europe and North America by computing 'gross' total factor productivity (TFP), further analyzing TFP by regression models, and by computing 'residual' TFP. It also examines the effects of ownership structure, business diversification strategy, and extent of outsourcing on airport's productivity. Our results show that larger airports are expected to achieve higher "gross" TFPs, whereas airports with a larger percentage of international traffic are expected to have lower "gross" TFPs. Airports' ownership structure does not appear to have any significant effects on their productivity performance, and airports with higher passenger satisfaction level do not appear to have lower productivity. Our results also indicate that airports that diversify and expand their non-aeronautical activities such as concessions and other commercial services are likely to achieve higher TFP levels. Based on the results on residual TFPs, Seoul, Seattle, Boston, Sydney, Los Angeles, Vancouver and Calgary are the top efficiency performers, and Frankfurt, Munich, and Airport Authority of Thailand are the low efficiency performers among our sample airports. The 'residual' TFPs are, on average, higher for the airports in the Asia Pacific region than the North American airports, which, in turn, are higher than the European airports.

## 1. Introduction

As the move toward airport commercialization and privatization continue, it becomes increasingly more important for airports to ensure they are providing the best possible services in the most efficient manner. To do this, airports need to know the best practices over various dimensions of airport operations within the industry. This will enable each airport to identify where and how much improvement should be made in order to be on a par with the industry's best practices. At present, there is no accepted industry practice for measuring and comparing airport performance in a consistent and systematic manner.

Airports are a complicated business, where wide range of services and facilities are brought together to facilitate, for both passenger and freight, the interchange between air and surface transport (Doganis, 1992). Airports vary greatly in terms of how these services and facilities are provided. Some airport operators provide most of the facilities and services themselves, while others rely on airlines, specialist agents, or third parties to provide many of the services. The extent of an airport operator's direct involvement in the various activities at the airport will affect the cost and revenue structure of each airport, and thus must be taken into account in assessing and comparing airports. Most studies recognize this problem, but few have explicitly dealt with the issue. Doganis, et al (1995) is perhaps the only exception. They identify a set of "standard set of activities" and adjust the data accordingly in an attempt to provide comparable measures across sample airports. However, by focusing on individual activities independently, and ignoring the "non-standard" activities, they fail to take into account of the interdependence and/or complimentary between the performance of the various activities as well as failing to recognize the fact that many airports attempt to introduce innovations to their operations and diversification has become an important business strategy.

Because of the complex nature of airport operation, most of the previous studies tend to simplify the problem by focusing on certain aspects of airport operation or certain group of airports with similar operating environments. For example, Gillen and Lall (1997)

and Pels, Nijkamp and Rietveld (2001) separate airport operation into landside and airside, and develop separate DEA models to evaluate the productive efficiency of landside and airside operations, respectively. Different methodologies have been used to measure airport performance with a variety of input and output variables. For example, Martin-Cejas (2002) estimates a translog cost function to examine the productive efficiency of 40 Spanish airports. Parker (1999) analyzed the performance of BAA before and after privatization using DEA as well. Hooper and Hensher (1997) examine the performance of six Australian airports over a 4-year period using the TFP method.

It is important to develop performance measures which will provide meaningful comparisons across the airports, and to identify the best performers in the airport industry and to determine the main variables that could help improve airport performance. In addition, performance studies can also provide answers to the following questions: are private airports more efficient than their public counterparts? Does contracting out (outsourcing services) improve productivity performance? what is the impact of commercial business on airport's productivity performance? The answers to these questions would be helpful in policy decisions to choose the best framework to organize the airport system.

The objective of this paper is to provide a meaningful comparison of airport productivity performance, and to investigate the relationships between the productivity measures and airport characteristics and management strategies in order to better understand the observed differences in airport performance. In particular, the paper examines how different ownership structure, business diversification strategies, and extent of outsourcing affect airports' performance. In the process, we also identify the impact of airport operating characteristics including average aircraft size, proportion of international traffic, and service quality on the observed performance measure. As some of these factors are beyond control of airport operators, and the observed performance may not reflect an airport's true efficiency level, a residual (net) productivity performance indicator is measured and compared after removing the effects of such factors.

The paper is organized as follows: section 2 describes the sample airports and some key statistics; section 3 presents empirical results. Section 4 examines the factors that may explain the observed differences in airport productivity; and summary and concluding remarks are given section 5.

## 2. Sample Airports and Output and Input Variables

Our sample includes 50 airports, representing different sizes and ownership structures and located in Asia Pacific, Europe, and North America. Table 1 shows operating characteristics of some of the sample airports[1]. The data is compiled from various sources including International Civil Aviation Organization (ICAO), Airport Council International (ACI), the US FAA, International Air Transport Association (IATA), airport annual reports and direct communication with airports. Readers are referred to ATRS (2002) for details.

To measure airport productivity, one must first identify outputs that an airport produces and the inputs it uses in producing these outputs. The most commonly used output measure for airports is the number of passengers served, as most airports serve mainly passenger traffic. Air cargo, however, is becoming increasingly important for many airports. Therefore, this paper considers air cargo as a separate output. Passengers and cargo can be considered as final outputs of an airport. In this regard, airports also produce an intermediate output in aircraft movements. However, airports tend to impose a separate charge for their services related directly to aircraft movements, which is, to a certain extent, independent of the charges they impose on passengers and cargo. Therefore, aircraft movements are not strictly an intermediate output. In this report, we consider aircraft movements as one of the airports' outputs. In addition to passenger traffic, cargo traffic and aircraft movements, airports also generate revenues from concessions, car parking, and other services. These services are not directly related to aeronautical activities in a traditional sense, but they are becoming increasingly more important

[1] See ATRS (2002) for a complete list of airports.

**Table 1 Airport Characteristics and Service Quality Rating, 1999**

| | Passengers (000) | Passengers /Aircraft | % international | % Aviation Revenue | Passenger Satisfaction* |
|---|---|---|---|---|---|
| **Asia Pacific** | | | | | |
| **HKG** | 29610 | 165 | 100% | 59% | 4.03 |
| **KIX** | 20000 | 169 | 57% | 46% | 3.87 |
| **PEK** | 21659 | 110 | 26% | 71% | 2.99 |
| **SEL** | 33284 | 157 | 46% | 44% | 3.09 |
| **SIN** | 26065 | 149 | 100% | 41% | 4.31 |
| **SYD** | 23258 | 75 | 38% | 32% | 3.82 |
| **Thai-AAT** | 27289 | 150 | 73% | 62% | 3.60 |
| **Europe** | | | | | |
| **AMS** | 37668 | 90 | 99% | 57% | 4.05 |
| **ARN** | 16410 | 63 | 62% | 56% | 3.88 |
| **CPH** | 17403 | 58 | 87% | 53% | 4.35 |
| **FRA** | 45839 | 104 | 81% | 66% | 3.59 |
| **MAD** | 25467 | 91 | 49% | 63% | 3.55 |
| **MAN** | 17767 | 96 | 83% | 54% | 4.18 |
| **MUC** | 21283 | 71 | 63% | 59% | 3.82 |
| **ZRH** | 20875 | 68 | 93% | 49% | 3.99 |
| **North America** | | | | | |
| **BOS** | 26929 | 54 | 16% | 46% | 3.44 |
| **CVG** | 21772 | 46 | 5% | 60% | 4.13 |
| **DFW** | 59729 | 72 | 7% | 39% | 3.85 |
| **DTW** | 34038 | 61 | 10% | 57% | 3.23 |
| **HNL** | 22184 | 64 | 23% | 21% | 3.44 |
| **IAD** | 19652 | 42 | 19% | 56% | 3.55 |
| **IAH** | 33051 | 71 | 15% | 44% | 3.88 |
| **LAX** | 62491 | 82 | 25% | 36% | 3.39 |
| **MCO** | 29204 | 82 | 8% | 30% | 3.89 |
| **MIA** | 33899 | 65 | 46% | 38% | 3.44 |
| **MSP** | 33137 | 65 | 5% | 34% | 3.97 |
| **ORD** | 72157 | 81 | 13% | 65% | 3.73 |
| **SEA** | 27705 | 64 | 9% | 50% | 3.91 |
| **SFO** | 40387 | 92 | 18% | 48% | 3.55 |
| **YUL** | 8298 | 37 | 48% | 31% | 3.64 |
| **YVR** | 15983 | 44 | 47% | 29% | 4.25 |
| **YYC** | 7800 | 30 | 28% | 32% | 3.91 |
| **YYZ** | 27780 | 65 | 55% | 57% | 3.67 |

* IATA Global Airport Monitor

for airports around the world. Thus, we consider a fourth output that consists of revenues from commercial or non-aeronautical services. A non-aeronautical (commercial) output index is constructed by deflating the commercial or non-aeronautical revenues by Purchasing Power Parity (PPP). The index is normalized at sample mean for analysis and statistical work, and then re-normalized at Vancouver International Airport (YVR) = 1.0 for easier presentation and interpretation. Inclusion of non-aeronautical output allows us to examine efficiency implication of airport diversification strategies.

On the input side, we consider four general input categories: (1) labor (measured by the number of full time employees who work directly for an airport operator; (2) capital, a consistent measurement of capital input is rather complicated as airports have very different ownership structures and accounting systems involving infrastructure and facilities. Thus, we have to use some physical capacity measures as a proxy for capital inputs. In particular, we consider three physical capital input measures: number of runways, number of gates, and total terminal area; (3) soft cost input, which is measured by all expenses not directly related to capital and personnel, and is considered to reflect the extent of an airport's outsourcing activities. As it is measured in monetary terms, and airports operate in countries with very different price levels, purchasing power parity (PPP) is used as a deflator to derive a consistent quantity measure for soft cost input. A soft cost input index is computed by normalizing the series at sample mean. Inclusion of the soft cost input allows us explicitly to take into account of airports' outsourcing activities. Exclusion of the soft cost input would bias productivity comparisons significantly in favor of the airports that outsource much of their services.

### 3. Productivity Measurement and Empirical results

As airports produce multiple outputs using multiple inputs, it is difficult to define a consistent overall productivity measure. Thus, partial measures of productivity are commonly used to assess differences in performance. These partial productivity measures generally relate a particular output to a single input factor. For example, airport passengers per employee is a labour-based partial productivity measure. A large variety of "performance ratios" have

been used. These measures are easy to compute, require only limited data, and are intuitively easy to understand. However, the productivity of one particular input factor (such as labour) depends on the consumption of other inputs (such as outsourcing); high productivity performance in one input may come at the expense of low productivity of other inputs. Total factor productivity, on other hand, provides a comprehensive picture of airport productivity performance. Total factor productivity (TFP) is the amount of aggregate output produced by a unit of aggregate input, and essentially a weighted average of all partial factor productivities.

We use the so-called endogenous-weight TFP (EW-TFP) method (Yoshida, 2002) in this study to compute the TFP index of our sample airports. The EW-TFP method estimates a flexible production transformation function, which allows decreasing, increasing, or constant returns to scale, as well as any degrees of substitution between the inputs and outputs. A productivity index is then computed using the estimated production function.

Four output variables (aircraft movements, number of airport passengers, cargo volume, and non-aeronautical output) and five input variables (labour, number of runways, terminal size, number of gates, and soft cost input) are considered in estimating the production transformation function and compute the TFP index. A close examination between terminal size and number of gates indicates that the two variables are highly correlated, and as such, there might be multicollinearity problem in estimating our production transformation function. Therefore, we compute two alternative TFP measures; The difference between the two sets of TFP indexes lies in whether the terminal area is included as an input factor, while all other input and output variables remain the same. TFP1 includes number of gates and number of runways as capital input, but not the terminal size, whereas TFP2 includes terminal size as well as number of gates and number of runways as the capital input. Table 2 reports on the TFP results. On the basis of TFP1, Minneapolis/St. Paul, Los Angeles, Seoul, Boston, Auckland, Sydney, Newark and Seattle are the high performers whereas Dusseldorf, Washington National, Edmonton, Christchurch, Geneva, Vienna, Montreal, Munich and Frankfurt are the low performers. The average TFP1 for the North America airports is 0.85

**Table 2 Gross and Residual Total Factor Productivity (YVR=1.00)**

| | Gross TFP1 | Gross TFP2 | Residual TFP1* | Residual TFP2* |
|---|---|---|---|---|
| | | **Asia Pacific** | | |
| AKL | 1.322 | 1.253 | n/a | n/a |
| CHC | 0.381 | 0.387 | n/a | n/a |
| HKG | 0.762 | 0.820 | 0.839 | 0.884 |
| KIX | 1.072 | 1.031 | 1.006 | 0.995 |
| NRT | 0.912 | 0.748 | n/a | n/a |
| PEK | 0.732 | 0.665 | 0.811 | 0.774 |
| SEL | 1.428 | 1.953 | 1.044 | 1.208 |
| SIN | 0.922 | 0.932 | 0.929 | 0.951 |
| SYD | 1.251 | 1.399 | 1.031 | 1.084 |
| Thai-AAT | 0.469 | 0.560 | 0.678 | 0.743 |
| | | **Europe** | | |
| AMS | 0.577 | 0.721 | 0.716 | 0.808 |
| ARN | 0.692 | 0.779 | 0.860 | 0.909 |
| CPH | 0.801 | 0.840 | 0.923 | 0.953 |
| DUS | 0.196 | N/A | 0.504 | n/a |
| FRA | 0.445 | 0.446 | 0.615 | 0.630 |
| GVA | 0.385 | n/a | n/a | n/a |
| MAD | 0.718 | 0.721 | 0.809 | 0.816 |
| MAN | 0.734 | 0.778 | 0.884 | 0.916 |
| MUC | 0.418 | 0.479 | 0.665 | 0.711 |
| VIE | 0.390 | 0.567 | n/a | n/a |
| ZRH | 0.802 | 1.156 | 0.901 | 1.071 |
| | | **North America** | | |
| BOS | 1.370 | 1.664 | 1.007 | 1.084 |
| BWI | 0.645 | 0.720 | n/a | n/a |
| CLT | 1.043 | 1.093 | n/a | n/a |
| CVG | 0.751 | 0.915 | 0.759 | 0.802 |
| DCA | 0.296 | 0.400 | n/a | n/a |
| DEN | 0.792 | 1.066 | n/a | n/a |
| DFW | 1.073 | 1.286 | 0.769 | 0.821 |
| DTW | 0.682 | 0.949 | 0.702 | 0.799 |
| EWR | 1.250 | n/a | 0.952 | n/a |
| HNL | 0.956 | 0.958 | 0.902 | 0.896 |
| IAD | 0.579 | 0.687 | 0.732 | 0.779 |
| IAH | 0.903 | 1.079 | 0.813 | 0.871 |
| JFK | 0.621 | n/a | 0.740 | n/a |
| LAX | 1.439 | 1.719 | 0.925 | 1.008 |
| LGA | 0.529 | 0.665 | n/a | n/a |
| MCO | 0.860 | 0.823 | 0.786 | 0.755 |
| MIA | 1.106 | 1.202 | 0.932 | 0.976 |
| MSP | 1.559 | 1.524 | 0.981 | 0.948 |
| ORD | 0.916 | 1.366 | 0.722 | 0.859 |
| SEA | 1.230 | 1.230 | 0.930 | 1.168 |
| SFO | 0.900 | 1.027 | 0.794 | 0.838 |
| SLC | 0.598 | 0.786 | n/a | n/a |
| YEG | 0.359 | 0.494 | n/a | n/a |
| YUL | 0.393 | 0.503 | 0.737 | 0.813 |
| YVR | 1.000 | 1.000 | 1.000 | 1.000 |
| YYC | 0.813 | 0.824 | 0.995 | 0.983 |
| YYZ | 0.645 | 0.724 | 0.766 | 0.814 |

which is about 50% higher than the European average (0.56), but 10% lower than the Asia Pacific average (0.925). There are only minor differences in the 'gross' TFP rankings between TFP1 and TFP2 measures. In particular, Seoul, Los Angeles, Boston, Minneapolis-St.Paul, Seattle, and Sydney are among the top 8 performers, and Washington National, Edmonton, Christchurch, Vienna, Montreal, Munich, and Frankfurt are among the lowest eight performers in terms of TFP2 measures.

It is important to note that the amount of input factors may have been under-estimated for the airports that have airline-operated terminals (owned or on long term lease basis). The inputs employed by airlines in operating such terminals should be added to the inputs used by the airports before calculating TFP index. However, we were unable to obtain the necessary input data from the airlines to correct for this potential problem. Consequently, the inputs for those airports may have been underestimated, and thus TFP overestimated. For example, Korean Air operates its own terminal at Seoul Kimpo, and Qantas operates a domestic terminal at Sydney. As such, these TFP measures for these airports may have been over-estimated.

## 4. Factors influencing productivity performance

The total factor productivity (TFP) measures presented in Section 4 are the observed or gross productivity levels of the airports. They are affected by many factors, some of which are beyond the managerial controls of the airports. This section examines the effects of these factors on airports' productivity performance. In particular, we examine the effects of ownership, business diversification strategy, outsourcing, service quality, and airport operating characteristics.

### *The Effects of Ownership Structure*

We classify three types of airport ownership structure: (1) public ownership where government has 100% ownership of the airports including those that have been commercialized, but still owned by governments, such as the Canadian airports; (2) majority public ownership; (3) majority private ownership.

**Table 3. The Effects of Ownership Structure**

| | Average TFP* |
|---|---|
| Public | 1.101 |
| Majority Public | 1.082 |
| Majority Private | 1.054 |
| | **P-Value:** |
| Public vs Majority Public | 0.929 |
| Public vs Majority Private | 0.803 |
| All three groups | 0.966 |

* TFP1 is used. Results with TFP2 is similar.

As indicated by our ANOVA analysis (Table 3), ownership structure does not appear to have any significant effect on airports' productivity. This result is consistent with those on airline productivity that found that degree of managerial autonomy (Oum and Yu, 1998), rather than ownership is more important.

Regression analysis was conducted to examine the effects of other factors on productivity performance, including both controllable and uncontrollable factors. In this study, the following variables are regarded as beyond managerial control (i.e., 'uncontrollable' by management), and are also considered as indicators of airport operating characteristics:

- **Airport size**: Airport size can vary by managerial design and efforts in long run, but not very likely in short run.
- **Average aircraft size**: Average aircraft size is measured by passengers per aircraft movement. It depends on the length of the runway(s), geographical location of the airports (intercontinental gateway airports tend to have larger aircraft), etc.
- **Composition of airport traffic**: This is measured by the percentage of international traffic. This variable depends mostly on the geographic location of the airport.

The regression also includes a number of other variables that airport operators have at least partial controls:

- **Business diversification**: the share of aeronautical revenue in total revenue is used as an indicator for airport diversification strategy. Some airports focus on the traditional airport business, thus derive most of their revenue from aeronautical activities. Others have expanded into businesses which are not traditionally part of an airport operator's area.
- **Extent of outsourcing**: the share of soft costs in an airport's total non-capital costs' is used as a proxy for the extent of outsourcing as we don't have sufficient data on actual outsourcing activities.

- **Service Quality**: IATA's overall passenger satisfaction score is used as an indicator of airports' service quality.

Table 4 reports on the regression results.

## *The effects of Airport Operating Characteristics*

**Average aircraft size** was not statistically significant (with T-value under 0.1). There is a moderate level of correlation between the average aircraft size and percentage of international traffic, which may partly explain the insignificance of average aircraft size in our TFP regressions. In any case, we decided to remove this variable from our final set of TFP regressions.

**Table 4 TFP Regression Results**

Dependent variable: LTFP=log (TFP1)

| | *Coefficients* | *T Value* |
|---|---|---|
| Intercept | -2.122 | -2.866 |
| Airport Size | 0.350 | 2.658 |
| %International | -0.109 | -1.176 |
| Pass. Satisfaction | 0.655 | 0.961 |
| %Aviation | -0.566 | -2.569 |
| Asia Pacific | 0.097 | 1.252 |
| Europe | -0.057 | -0.642 |
| R Square | 0.511 | |
| Sample Size[2] | 36 | |

* all variables except dummies are in natural log.

**Airport size** is significant with a positive coefficient, indicating that large airports are expected to have higher 'gross' TFP level. There is weak evidence for a negative relationship between TFP and **the percentage of international traffic** variable in our TFP regression in Table 4. This implies that the airports with heavy reliance on international passengers are expected to have lower 'gross' TFPs as international traffic requires more services and resources than domestic traffic.

### *The Effects of Passenger Service Quality*

Overall passenger satisfaction does not seem to have any significant effect on TFP. Therefore, improving passenger satisfaction levels do not appear to have any negative impacts on an airport's productivity. This

may be because entrepreneurially oriented and efficient airports tend to pay more attention to passenger services as well.

***The Effects of Business Diversification strategy***

Aeronautical revenue share has a significant negative coefficient, indicating airports concentrating on aviation activities tend to have lower TFP levels. Many airports attempts to increase revenues from non-aeronautical commercial sources so that they can reduce landing and/or terminal charges to attract more airlines to the airports. Such revenue diversification strategy appears to help improve airports' productive efficiency as well.

***The Effects of Outsourcing***

There does not seem to be any apparent relationship between total factor productivity and the share of soft costs in total non-capital costs which was consequently not included in the final regression. This result appears to be in contrast to the common belief that outsourcing would help improve an airport's productivity and efficiency. However, since the soft input cost share alone does not reflect the types of outsourcing activities, the statistical insignificance of our outsourcing variable needs a further and in-depth investigation.

***Residual Total Factor Productivity***

As discussed earlier, the gross TFP measures reported in the first two columns of Table 2 are influenced by many factors, thus they may not reflect the true efficiency of an airport. In order to compare airport productive efficiency, a 'residual' TFP index is computed, using the regression results in Table 4, after removing the effects of uncontrollable variables (airport size and %international) from the 'gross' TFP values. The residual TFPs are reported in the last two columns of Table 2 beside the gross TFPs. As expected there are smaller variations across the airports when comparing residual TFPs than the variations observed in gross TFPs. This is because some of the gross TFP differentials have been explained away by the variables in the TFP regression: airport size, %international passengers and % aviation revenue in the total airport revenue. The top 10 performers in terms of the residual TFP1 measures are Seoul, Sydney, Boston,

Kansai, Vancouver, Calgary, Minniapolis-St.Paul, Newark and Seattle. Especially, Seoul, Seattle, Boston, Sydney, Los Angeles, Vancouver and Calgary are also among the top 10 performers even when the residual TFP2 is used as the measure of efficiency. On the other hand, Frankfurt, Munich, and Airport Authority of Thailand are among the bottom five low performers in terms of both residual TFP1 and residual TFP2.

Although our TFP regression results are not statistically significant, the airports in Asia-Pacific region appears to be, on average, 5-6% higher efficiency than the airports in North America, which in turn, are 6-10% more efficient than the European airports in our sample. These TFP differentials are far less than the 'gross' TFP differentials stated earlier because much of the 'gross' TFP differentials have been explained by the factors included in the TFP regression (airport size, percentage of international passengers, passenger satisfaction measure, and percentage of aviation revenues). On average, the Asia Pacific airports in our sample are more efficient than the North American airports, which in turn are more efficient than the European airports.

## 5. Summary and Conclusions

This paper measures and compares the productive efficiency of 50 airports in Asia Pacific, Europe and North America. The paper also examines the effects of ownership structure, business diversification strategy, and extent of outsourcing on airport's productivity. The measured 'gross' productivity numbers are affected by many factors, some of which are beyond airport's management control, thus they may not reflect the true efficiency of the airports. As such those 'gross' productivity numbers should not be used to benchmark or compare efficiency performance across airports. Therefore, this paper also computed 'residual' TFP indices after removing the effects of the 'uncontrollable' factors in order to compare true productive efficiency of the airports. The uncontrollable factors include airport size, average aircraft size, and percentage of international passenger traffic. The main results of our research are summarized below.

(a) On average, the 'gross' TFP measures for North American airports are 50% higher than that of European airports, but 10% lower than that of Asia Pacific airports. Even after removing the effects of 'uncontrollable' factors on TFPs, Asia Pacific airports

on average appear to be more efficient than North American and European airports, as indicated by our 'residual' TFP measures.

(b) Seoul, Los Angeles, Boston, Minneapolis-St.Paul, Seattle, and Sydney are the consistent top 'gross' TFP performers while Washington National, Edmonton, Christchurch, Vienna, Montreal, Munich, and Frankfurt are consistently the bottom 'gross' TFP performers.

(c) Seoul, Seattle, Boston, Sydney, Los Angeles, Vancouver and Calgary are among the top 10 performers in terms of residual TFPs. It is fairly clear that these airports are more managerially efficient. On the other hand, Frankfurt, Munich, and Airport Authority of Thailand are among the bottom five low performers after removing the effects of variables beyond managerial control (airport size and percentage of international passengers).

(d) The TFP regression results revealed the following:
   a. Larger airports are expected to achieve higher TFP because of the economies of scale in airport operations, not necessarily because they are more efficient than smaller airports;
   b. Airports with a larger percentage of international traffic are expected to have lower 'gross' TFP levels;
   c. Ownership structure does not appear to have any significant effect on airports' observed productive performance;
   d. Improving passenger satisfaction level does not appear to have any significant negative effect on an airport's productivity;
   e. An airport that diversify and expand their non-aeronautical activities such as concessions and other commercial services are likely to achieve a higher TFP level by taking advantage of the demand complementarity between traffic volumes and commercial services;

This paper concerns primarily with airports' productive efficiency, which is not necessarily strongly correlated with airports' profitability or financial structure. Nor did this study address the question of airport user charge levels or efficiency or effectiveness of airport security measures and performance. In future studies, these important issues will need to be addressed as well as continuing to measure and benchmark the productive efficiency performance.

**Reference**

Air Transport Research Society (ATRS) (2002), *Airport Benchmarking Report: the Global Standard for Airport Excellence*, Vancouver.

Doganis, R.(1992), *The Airport Business*, New York: Routledge

Gillen D.W. and Lall A., (1997), "Developing measures of airport productivity and performance: An application of data envelopment analysis", a paper presented at Air Transport Research Group Conference, Vancouver

Hooper P.G. and Hensher D.A., 1997. "Measuring total factor productivity of airports: An index number approach", *Transportation Research E*, 33 (4), 249-259

*Martin*-Cejas, R.R. (2002), "An Approximation to the Productive Efficiency of the Spanish airports network through a deterministic cost frontier", *Journal of Air Transport Management*, 8, 233-238

Oum, T.H. and C. Yu (1998), *Winning Airlines: Productivity and Cost Competitiveness of the World's Major Airlines*, Boston: Kluwer Academic Publishers

Parker D., (1999) "The performance of BAA before and after privatization", *Journal of Transport Economics and Policy* 33, 133-145.

Pels, E. P. Nijkamp and P. Rietveld (2001), "Relative Efficiency of European Airports", *Transport Policy* 8, 183-192

Yoshida, Y. (2002). "Airport-efficiency measurement: Methodologies, data requirements and Monte-Carlo experiments", a paper presented at the 6th Air Transport Research Society Conference, July, Seattle.

**Meeting the Kyoto Targets: Transportation Options, Opinions, and Outcomes?**

Clarence Woudsma, Associate Professor, Department of Geography, University of Calgary, 2500 University Dr. N.W., Calgary, AB, T2N 1N4, cwoudsma@ucalgary.ca

Abstract

The 1999 report entitled "*Transportation and Climate Change: Options for Action*", represents the culmination of a great deal of effort by a great number of stakeholders. The National Climate Change Secretariat commissioned the work of various "tables" with the expressed mandate to "examine the impact, costs and benefits of implementing the Kyoto Protocol and the various implementation options open to Canada". Since the recent ratification of Canada's participation, this summary report has taken on new life. What is the future going to be like for Canada's transportation sector in this new "Kyoto" world? Are the solutions going to come largely from technology, from changing consumer behaviours, or from a potpourri of possible strategies? This paper is a critical evaluation of the aforementioned report, but also, a breakdown of transportation's emissions picture, and a discussion of the most likely options to be pursued. While auto emissions are often at the forefront of GHG and transportation discussions, an attempt at balance is provided herein, with the freight sector's situation also addressed. Given the scope of the challenge ahead, this paper is by its very size, a summative discourse rather than a precise prescription.

## 1. Introduction

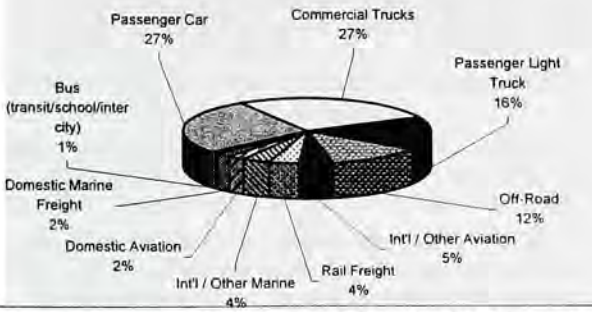
The Canadian government's recent decision to ratify our commitment to the Kyoto Accord represents for many, a bold step forward towards a more sustainable future. To others, it represents the start of more repressive government

intervention in the marketplace and a general drain on our economy. The goal of this brief chapter is to critically examine both sides of the Kyoto coin, from the transportation standpoint, and to explore what meeting the targets might mean.

## 2. Climate Change and Transportation

The main greenhouse gases, in order of importance, are carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), sulphur hexafluoride (SF6), perfluorocarbons (PFCs), and hyrdofluorocarbons (HFCs) (Environment Canada, 1999). Globally, emissions associated with energy production are dominant but in some countries, including Canada, transportation is the largest contributor to GHG emissions. It is not surprising that the U.S. is the largest source of GHG emissions in absolute terms, nor is it surprising that Canada ranks near the bottom. However, on a per capita basis, Canada would rank near the top. From a transportation point of view, Schafer and Victor (1997) argue that there is a direct relationship between increases in personal average income and traffic volume, and they further posit that the prominence of the automobile as the mode of choice for much of the world will continue well into the

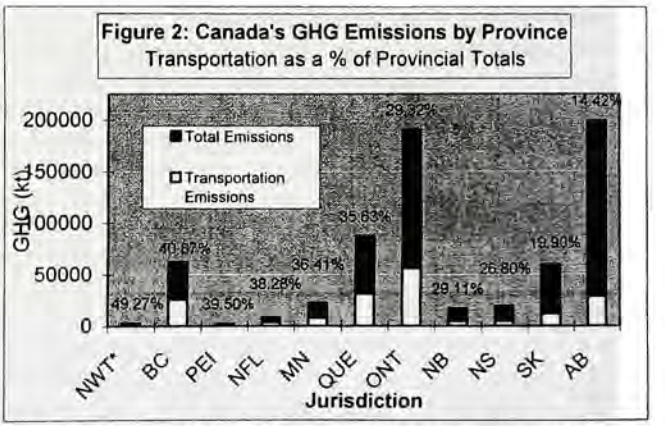
**Figure 1: Source of Transportation GHG Emissions (1997)**




source: Transportation Climate Change Table (1999a) "Transportation and Climate Change: Options for Action"

future. Therefore, not only is transportation a major contributor, but its importance in both absolute and relative terms is likely to increase.

It is well known that within Canada, transportation is the largest single source of GHG emissions. Within the transportation sector, Figure 3 presents the breakdown of emissions. One important observation is that, even within transportation, there is considerable variability in emissions among the various modes. The emissions associated with moving people represent 51% of the total transport emissions while moving freight is 37% and the "off-road" category 12%. Off-road is a catch-all category that includes everything from lawnmowers and leaf blowers to all-terrain vehicles, tractors and excavators to name a few.

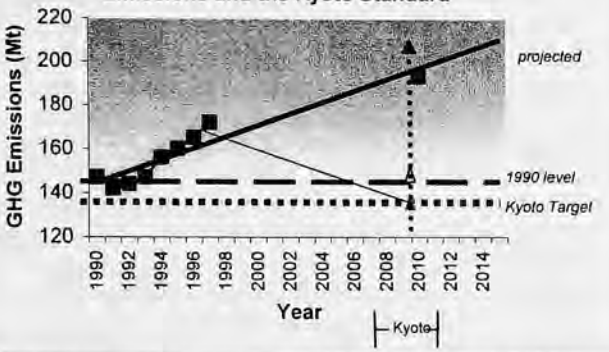



source: Environment Canada (1999) "Canada's Greenhouse Gas Inventory" Appendix F note :"Northwest Territories" means that all three territories are accounted for in these data.

The size of the bars in Figure 2 represents the total amount of emissions in each province, while the white portion of the bar and the percentage figure at the top of each bar indicate the contribution of the transportation sector in each province. The

provinces are presented in order based on the percentage of the emissions that are from transportation, with the highest (NWT) on the left and the lowest on the right (Alberta). NWT's high proportion can be explained by the lack of energy generation and industrial activity while Alberta's low transportation value is associated with oil and gas production, which reduces the relative contribution of the transportation sector in that province.

**Figure 3: CanadianTransportation Greehouse Gas Emissions and the Kyoto Standard**




source: adapted from "Chart 2.3 Kyoto Protocol Implications Transport Sector GHG Emissions Projections, 1990-2020" Transportation Climate Change Table (1999a) "Transportation and Climate Change: Options for Action"

The projected emissions (Figure based on our current activity levels and trends into the future suggest that by the year 2010, our transportation emissions would be significantly higher than what they are to day. In order to potentially comply with the Kyoto Protocol, transportation emissions in 2010 would have to be at the 132 Mt level (represented by the horizontal dotted line). The challenge is how to resolve this obvious gap between projected emissions and the Kyoto commitment.

In early 1998, the federal, provincial and territorial Ministers of Energy and the Environment met and were directed by the Provincial Premiers and the Prime Minister (based on their discussions at a First Ministers meeting) to "examine the

impact, costs and benefits of implementing the Kyoto Protocol and the various implementation options open to Canada". (NCCS, 2001, Origins Section, Paragraph 2). The National Climate Change Secretariat was thus created out of these meetings to facilitate a process for meeting this directive. The process it initiated is one of the most comprehensive attempts to evaluate the options for dealing with GHG emissions.

### 3. Options For Action: A Summary

The Transportation Issue Table had a budget of 2.1 million dollars, which sounds impressive, but given the scope of their work, it can be argued that this represents a fraction of what was needed. The Table (hereafter meaning the Transportation Issue Table) was divided into sub-groups along modal and approaches-to-reduction lines. In addition to the activities of the Table's subgroups, 24 analytical studies completed by various private consulting firms were also commissioned in areas ranging from the potential for increased taxation as a means to reduce emissions to assessing modal shifting (from truck to rail for example) and integration between modes (intermodal). Each of the studies dealt with options for reducing GHG emissions from transportation. Over 100 different reduction measures were examined as part of this process and these measures were assessed using a broad set of criteria that included potential for reduction, public support, cost-effectiveness, ease of implementation, economic impact, and equity effects. All of this activity and the summary and recommendations for reducing emissions are contained in the publication Transportation and Climate Change: Options for Action (TCCT, 1999a), hereafter referred to as the Options Report.

Table 1 represents a summary of the measures evaluated by the Table.

Table 1: Summary of Measures Evaluated by the Transportation Issue Table

| Five Transportation Table Themes | | Reduction (Mt) | Cost ($ / tonne) | Measures |
|---|---|---|---|---|
| Passenger | Most Promising | 3.7 | -$97 | telecommuting, car sharing, driver education, tax exempt transit pass, transit smart cards, ferry/aviation efficiency codes |
| | Promising | 10.1 | $46 | enhanced transit (ITS, pricing, service), increased bicycle use, parking pricing in cities, natural gas ferries |
| Road | Most Promising | 5.0 | -$38 | enforce speed limits, ITS, synchronize traffic signals |
| | Promising | 1.5 | -$4 | high occupancy vehicle lanes, expanded ITS, more frequent road surfacing |
| Vehicles and Fuels | Most Promising | 0.0 | | none |
| | Promising | 8.9 | $52 | improve truck / bus efficiency, alternative fuel incentives, harmonized vehicle target (25%), expand alternative fuel infrastructure, ethanol 10% of all gasoline |
| Freight | Most Promising | 2.0 | $6 | truck driver training, marine codes of practice |
| | Promising | 7.0 | -$3 | raise rail equipment efficiency, long trucks in 3 provinces where currently not allowed, truck scrappage, truck lubricants, limit trucks to 90 kph, truck load matching |
| Off-Road | Most Promising | 0.0 | | none |
| | Promising | 4.3 | | fuel efficiency standards, public awareness campaign, voluntary program with manufacturers |
| TOTAL | Most Promising Total | 10.7 | The Total emission reduction from these measures is 42.5Mt, which represents 78.7% of the reductions needed to comply with the Kyoto Protocol. | |
| | Promising Total | 31.8 | | |

The cost of each measure was derived from both the monetary and non-monetary costs and benefits of each measure. The

negative value suggests that these measures actually provide a net benefit when considering factors such as reduction in travel time, reduced travel activity and changes in consumer surplus or choice (TCCT, 1999a). The application of the evaluation criteria for each measure resulted in it being placed into one of four categories: Most Promising, Promising, Less Promising, and Unlikely.

None of the measures presented in Table 2 would be considered radical by those familiar with reduction strategies. The measures include a mixture of technology, policy change, market mechanisms (pricing and taxation) and behavioural change. The mixture of measures on the technology side run the gamut from alternative fuels, better lubricants, and fuel efficiency standards to a heavy emphasis on the potential for Intelligent Transportation Systems (ITS) to lead to more efficient transportation systems and thus reduced emissions. On the behavioural side, measures such as telecommuting and education and driver training appear in the Most Promising and Promising categories. Noticeably absent in Table 2 is the subject of increased fuel taxes. In the Options Report, however, fuel taxes represent the sixth theme or implementation package. The reason it is not included in Table 2 is because of the admitted inability of the subgroup to come to any sort of agreement on its potential. The question of the role of fuel taxes is indeed contentious, and one scenario examined was a tax level that would double the current price of gas for most consumers. It was argued that this would both reduce travel and help to spur on the adoption of other measures. However, this was deemed as a very unlikely response. A more likely measure discussed by the Table would see a very small tax increase, such as one cent per litre, which would lead to a reduction in emissions of approximately 7.5 Mt.

The key observation from Table 2 is the fact that taken together, these Most Promising and Promising measures, if implemented, would lead to 79% of the transportation

reductions needed. In order to reach the target, measures in the Less Promising and Unlikely category would have to be included. It is important to keep in mind that the intent of the Tables work was not a prescription or a policy setting exercise, but rather an opportunity to identify and assess the costs and benefits of different reduction options (TCCT, 1999a).

The conclusions contained in the Options report deal largely with the packages of measures already presented here (TCCT, 1999a). Additional conclusions include recognition that there is no single technology or solution that will achieve the goal of meeting the Kyoto-reduction targets and an expressed need for a flexible implementation strategy that meets regional and local needs.

**4. Discussion**

The Options Report is clear about the objectives and scope of the Table's mandate, and the authors of the report attempt to identify its shortcomings and make cautious statements concerning the results of their work. For example, "this report is not intended to provide a prescription for implementing different measures" and "the work of the Table represents a comprehensive but initial look at the potential for reducing GHG emissions from transportation in Canada" (TCCT, 1999a, pg.xiii). Furthermore, they identified a number of areas that, in their estimation, needed more work. The persistent issue of data availability was high on their list. Given the breadth of their examination and the traditional paucity of reliable freight and other transport data, this comes as no surprise. Further, the authors were clear that some of the measures were evaluated largely through estimates and simulations. Measures such as ride-sharing programs and HOV (high-occupancy vehicle) lanes have been employed for years, and the actual impacts have been identified (Anderson and Woudsma, 1997). Other newer measures have not yet been implemented and, therefore, are subject to greater uncertainty both in how they would work in a specific location and how they would interact with existing policies . Another concern is the lack of analysis in

areas such as regional differentiation in impacts and the potential for intercity rail and bus transportation. Regional differentiation is clear and there is no doubt that the provinces would have different perspectives on which measures would work in their area. Gillen and Morrison (2000) contend that this lack of recognition of provincial differences, particular as it relates to the costs and benefits of reduction strategies is one of the more critical shortcomings of the Options Report and the Table's work. Finally, the Table has argued that there needs to be a mechanism for taking action with the most frequently mentioned model being the U.S. Transportation Equity Act For The 21st Century. (TEA-21). This Act is a top-down approach in terms of providing billions of dollars in funding (Federal U.S.), but bottom-up in terms of action. A major fund is made available and states and metropolitan areas can apply to this fund to support transportation infrastructure and programs, provided that there is a demonstration of improved transportation efficiency, which typically results in reduced emissions and improved air quality.

The Options Report was, however, not the end of the process for the Table members. A series of stakeholder workshops were organized across the country, early in 2000, following the release of the report. Stakeholders were invited to make submissions to the Table concerning their review of the report or their view on emissions reductions and transportation in general. These workshops were summarized in a companion report to the original Options report (Matheson, 2000). It is safe to say that the reaction to the Options report was mixed. This is not surprising given that hundreds of people who participated and the many written submissions that were received. Groups ranging from the Canadian Vehicle Manufacturers' Association and the Canadian Petroleum Products Institute to the New Brunswick Lung Association and the Dene Nation were represented.

Certain stakeholders felt that the measures in the Options Report did not go far enough and that its tone was too timid,

whereas others felt the measures were overly optimistic and their costs underestimated (Matheson, 2000). Others took exception with the methodologies employed (Gillen and Morrison, 2000) and from a regional standpoint, contributors stressed that the needs of rural areas and the North should not be overlooked in developing strategies.

One of the major issues raised across the country was the fact that land use was not addressed within the measures examined. The link between transportation and land use has long be recognized ( Moore and Thorsnes, 1994), especially in the context of dealing with urban congestion issues (Anderson et al., 1996) although not all would agree that by making our cities more compact we will see auto trip reductions (Crane, 1999). Yet, in order for alternatives to automobile use to be viable, it is argued that our cities and their current sprawled land use patterns need to be redesigned. This argument can extend to consider freight movement as well (Woudsma, 2001). Given the central role that urban form plays in transportation decisions, many felt that its omission from consideration by the Table was glaring.

Despite differing perspectives, a number of common threads were evident in the reaction to the report. A consistent call for leadership from both the public and private sectors was argued as being essential to making these measures work. In addition, a call for greater cooperation between governments, stakeholders, and transportation-service providers was also repeatedly made (Matheson, 2000). There was considerable agreement on many of the measures, including more contentious ones like higher fuel taxes to improve infrastructure and to help support low-emission modes like transit.

**5. Summary and Potential**

This discussion of the Options Report has highlighted one major effort that was directed at evaluating options for reducing transportations contribution to GHG and the lengths the Table went to solicit input from a broad spectrum of transportation stakeholders. It does not represent specific programs with

measurable reductions but, it represents an important and comprehensive first step in meeting the Kyoto reduction targets.

The efforts of Table are impressive in some respects: comprehensive, inclusive, focused on mitigation measures that would go a long way in helping Canada to meet its targeted reductions. Now that ratification by Canada has occurred, it will be interesting to see if these ideas are followed through with. One of the key challenges is that we must make these changes while our major economic partner, the U.S., has turned their back on Kyoto. There is little doubt that technology options are often in the forefront, but there is also little doubt that at the end of the day, it will be the individual consumer that will bear the brunt of meeting Kyoto from a transportation standpoint.

Technology options most relevant include efforts to improve "company average fuel consumption" (CAFC) standards and emissions standards for both cars and diesel trucks. Expected to capture 9.6% of the needed transport emission reducations, this measure was placed in the Promising rather than Most Promising category because of the significant costs associated with achieving these reductions. An important and well known consideration is the "take back" effect in which gains in fuel efficiency are "taken back" by consumers who increase vehicle kilometers traveled (Greene et al.,1999). Newman and Kenworthy (1999) point out that while the U.S. doubled the fuel efficiency of new cars between 1973 and 1988, their consumption of oil increased by 20%. From a freight standpoint, a similar argument can be made with "Just In Time" and "Quick Response" logistics resulting in more trucks on the road, often at a lower capacity utilization (Woudsma, 2001). For example, it has been estimated that emissions from heavy-duty diesel trucks increased 50% during the 1990-1999 period. Technology may be able to deliver a more efficient vehicle, but there is a tendency to respond with increased travel, and consequently, the potential for technology-based solution may be overstated.

In addition to emission standards, the other technology options with the most promise are alternative fuels and intelligent transportation systems. Each is controversial, with the market capture of alternative fuels limited and long term and ITS mixed – if you make travel easier, are you going to reduce emissions? Interestingly, the Government of Canada Action Plan 2000 on Climate Change has committed $500 million to new measures and, according to some sources, among the likely initiatives are 1) negotiating new vehicle fuel-efficiency targets with the automobile industry and the United States and 2) tripling Canada's ethanol production capacity (for blending with gasoline) (Bramley, 2001).

There exists an extensive body of literature that deals with the non-technological side of auto/truck movement. The premise of much of this work is that it will be necessary to reduce aggregate auto driving activity or at least slow its growth in order to address congestion and air-quality concerns in major urban centers. There are behaviours to be changed in relation to large truck freight movements. Examples include programs to discourage leaving diesel vehicles idling for long periods and the encouragement of increased use of intermodal options. However, part of the difficulty is that there are often many decision makers involved (shippers, freight forwarders, carriers, drivers, etc) and there are numerous associated costs. Partial support for this perspective is evident in the Options Report, where the majority of measures associated with freight have a technological focus.

Focusing on people movement, Transportation Control Measures (TCMs) are a class of policy instruments designed to reduce trips and vehicle kilometres traveled (VKT) (Anderson and Woudsma, 1997). Categories of TCMs include those related to 1) mode shifting, 2) trip scheduling, 3) flow improvements and 4) vehicle-stock improvements. The first two affect the level and demand for trips and are often referred to as transportation demand management (TDM) measures

(MacRae, 1994). Litman (2001a) provides a comprehensive review of over 50 different TDM strategies, from volunteer-oriented ridesharing programs that reduce single-occupant vehicle use to incentive programs like tax-exempt transit passes to more aggressive measures like road tolling/pricing.

On a more general front, Litman (2000) has argued that the Table's analysis of TDM measures undervalues their potential contribution because, among other reasons, their analysis incorrectly assumes that shifting trips away from automobiles reduces consumer benefits because it increases travel time. He argues this assumption is wrong because consumers will alter their mode choice under positive incentives, only if it enhances their net benefit. Other concerns about the veracity of TDM emission-reduction estimates include a focus on journey-to-work travel and overstating the potential for volunteer-based initiatives. Given that in major cities, it is now recognized that the majority of trips and vehicle kilometers of travel are not work related, measures that focus solely on journey to work have limited scope for impact (Anderson and Woudsma, 1997). TCMs and TDMs have enjoyed a long period of implementation, especially in the U.S. where federal infrastructure funding is tied to meeting emission reductions through these measures. Extensive listings of implemented projects and their results are available from agencies like the Office of Transportation and Air Quality (EPA, 2001). Often, the results from volunteer-based implementations demonstrate that the level of volunteer use does not meet forecasted levels and is difficult to sustain (Diggins et al. 1999).

ENDNOTE:
This is a revised version of a longer chapter forthcoming. Please contact the Author for further information.

References

Anderson, W P , Kanaroglou, P.S and E.J. Miller (1996) "Urban Form, Energy and the Environment. A Review of Issues, Evidence and Policy", Urban Studies, 33(1), 7-35

Anderson, W.P. and C.G. Woudsma, (1997) Transportation Control Measures and the Urban Environment: A Comparative Review, in Proceedings of the 32nd Annual Conference of the Canadian Transportation Research Forum, University of Saskatchewan, Saskatoon, pg.43-58
Bramley, M., (2001), Emission Reductions Elusive as Governments Idle on Climate Change, Encompass Magazine, Volume 5, No.3, retrieved from the WWW, March, 2001 at http://www.encompass.org/5-3/emission.htm
BTS – Bureau of Transportation Statistics, (2000) North American Transportation in Figures, U.S., BTS, Washington, DC
CBC – Canadian Broadcast Corporation (2000), Canada Criticized for Climate Talks Collapse, Web Posted, November 27th, 2000, retrieved from the WWW, March, 2001, at http://cbc.ca/cgi-bin/templates/view.cgi?/news/2000/11/25/climate001125
Crane, R. (1999), The Impacts of Urban Form on Travel: A Critical Review, Lincoln Institute of Land Policy, Working Paper, Cambridge, MA, Retrieved from the WWW, March 2001, at http://www.lincolninst.edu/workpap/wpap13.html
Difiglio, C., (1997), Using Advanced Technologies to Reduce Motor Vehicle Greenhouse Gas Emissions, Energy Policy, Vol. 25, Issue 14/15, pp. 1173-178
Dunn Jr., J.A. (1999) The Politics of Automobility, The Brookings Review, Vol. 17, Issue 1, pp.40-43
Diggins, L.D., Schreffler, E.N., and Kaefer, D.K., (1999) Assessing TDM Deregulation in Southern California: SB 836 Evaluation of Rule 2202 Voluntary Ridesharing and Other Replacement Measures, Proceedings of the Transportation Research Board Annual Conference, January, 1999
Environment Canada, (1998) Canada Country Study. www.ec.gc/climate/ccs/ccs_e.htm
EPA, Environmental Protection Agency (2001), Transportation Control Measures Database, Office of Transportation and Air Quality, retrieved from the WWW, April 2001 at http://www.epa.gov/oms/transp/traqtcms.htm
The Futurist, (2000), "Environmental Issues to Watch For", The Futurist, Vol. 34, No. 4, p10
Gillen, D. and W.G. Morrison, (2000) "Warped Tables", Alternatives Journal, Vol. 26 Issue 2, p. 17
Gillen, D., Li, J., Dahlgren, J., and Chang, E. (1999) Assessing the Benefits and Costs of ITS Projects Volume 1 Methodology, California PATH Research Report UCB-ITS-PRR-99-9, Institute for Transportation Studies, University of California, Berkeley
Glassman, J.K., (2000), "Forget Kyoto", The Wall Street Journal, Nov. 28, 2000, p. A26
Greene, D.L., Kahn, J.R., and Gibson, R.C. (1999) Fuel Economy Rebound Effect for U.S. Household Vehicles, The Energy Journal, Vol. 20 Issue 3, pp. 1 - 24
Hagler Bailly (1999) Strategies to Reduce GHG Emissions from Passenger Transportation in Urban Canada, report prepared for the National Climate Change Process Transportation Table Passenger (Urban) Sub-Group, Toronto, 103 pgs.
Hogarty, T.F. (1999), Gasoline: Still Powering Cars in 2050?/ A Geologist's Rebuttal, The Futurist, Vol. 33, Issue 3, pp. 51-55
IBI Group (1999) GHG Reduction Benefits of the Deployment of Intelligent Transportation Systems on Canada's Road/Highway Network – Final Report, Submitted to the Transportation Climate Change Table, June 1999, Ottawa, 87 pgs.
IPCC (Intergovernmental Panel on Climate Change), (2001) Climate Change Report 2001: Synthesis Report, Summary for Policy Makers. United Nations Environment Program www.unep.org
Kydes, A.S., (1999) Energy Intensity and Carbon Emission Responses to Technological Change: The U.S. Outlook, The Energy Journal, Vol. 20, Issue 3, pp. 93-112
Maples, J.D., Moore Jr., J.S., Patterson, P.D., and Schaper, V.D., (2000) Alternative Fuels for U.S. Transportation, Report Prepared for the Transportation Research Board, Committee on Alternative Transportation Fuels, Retrieved from the WWW, March 2001 at http://www.ott.doe.gov/facts/papers.htm
Orski, C.K. (1999) In Search of 'Livability' – A Commentary, Transportation Quarterly, Vol. 53, No. 4, pp. 7-13.
Rowan, M. (2000) Kyoto commitment threatens Canada's standard of living: more discussion needed on the agreement's implications, Plant, Vol 59 No. 15, Oct. 23rd, p. 24
Rees, W.E., (2000) Mything Out on Sustainablity, Encompass Magazine, Volume 5, No.2, retrieved from the WWW, March, 2001 at http://www.encompass.org/5-2/myth.htm
Environment Canada (1999), Canada's Greenhouse Gas Inventory – 1997 Emissions and Removals with Trends, Environment Canada, Cat. No. En49-8/5-9E, Ottawa, 149 pgs.http://www.unfccc.de/resource/docs/1997/sbi/19a1.pdf
TCCT - Transportation Climate Change Table, (1999a), Transportation and Climate Change: Options for Action, Options Paper of the Transportation Climate Change Table, Ottawa, Canada
TCCT - Transportation Climate Change Table, (1999b), Transportation Climate Change Table Progress Report To Transport Deputy Ministers And National Climate Change Secretariat, Authored by the Transport Climate Change Table, March 1999, Retrieved from the WWW on March18, 2001, at http://www.tc.gc.ca/envaffairs/english/climatechange/prog_reports/Mar31_Progress_Report_English.htm

NCCS – National Climate Change Secretariat (2001), Website for the National Climate Change Process, Authored by the National Climate Change Secretariat, Retrieved from the WWW on Jan. 15, 2001, at http://www.nccp.ca/html/index.htm
Matheson, G., (2000), Companion Report: Stakeholder Reivew of the Transportation Climate Change Table's Option Paper, Prepared by Marbek Resource Consultants for the Transportation Climate Change Table, April, 2000, retrieved from the WWW, March, 2001 at http://www.tc.gc.ca/envaffairs/english/ttableconsultations/
MacRae, K.M., (1994), Transportation Demand Management; A Policy Challenge, Canadian Energy Resource Institute, Calgary, Canada, 282 pgs.
Moore, T., and P. Thorsnes, (1994), The Transportation/Land Use Connection, American Planning Association, Planning Advisory Service, Report Number 448/449, Chicago, pg 137
Litman, T., (2001a), Online TDM Encyclopedia, Victoria Transport Policy Institute, retrieved from the WWW, March, 2001, at http://www.vtpi.org/tdm
Litman, T., (2001b), Evaluating TDM, Assessing Benefits and Costs, Victoria Transport Policy Institute, retrieved from the WWW, March, 2001, at http://www.vtpi.org/tdm/tdm14.htm
Litman, T., (2000), How Canadian Climate Change Emission Reduction Analysis Undervalues TDM, Victoria Transport Policy Institute, retrieved from the WWW, March, 2001, at http://www.vtpi.org/climate.htm
Sierra Research, Inc., (1999) Transportation and Climate Change: Alternative and Future Technologies for Reducing Greenhouse Gas Emissions From Road, Report Prepared for the Vehicle Technology and Fuels Sub-Group of the Transportation Table on Climate Change, Sacremento, California
Woudsma, C.G., (2001), Understanding the Movement of Goods Not People: Issues, Evidence and Potential, Urban Studies, Vol. 38, No. 13 pp 547-570

# Vertical Linkages of a Sustainable Transportation Network

Dr. Yuri Yevdokimov, University of New Brunswick

## Introduction

The initiative of early studies in sustainable transportation belongs to the Organization for Economic Cooperation and Development (OECD) who in 1994 set in motion the Environmentally Sustainable Transport (EST) project. Nine countries contributed to the project with case studies based on internationally recognized and accepted six criteria: (i) noise, (ii) land use, (iii) emissions of carbon dioxide, (iv) emissions of nitrogen oxides; (v) volatile organic compounds, and (vi) particulate matter. The case studies were based on *a scenario approach* with respect to the "business-as-usual" projections for the year of 2030 in relation to conditions in 1990. Basic results of the EST project were presented at the International Conference on Environmentally Sustainable Transport in Vienna (Austria) in October 4-6, 2000.

A turning point in the history of sustainable transportation was the OECD Conference "Towards Sustainable Transportation" held in 1996 in Vancouver (Canada). The so-called Vancouver Principles for Sustainable Transport were formulated as follows: (i) access, (ii) equity, (iii) individual and community responsibility, (iv) health and safety, (v) education and public participation, (vi) integrated planning, (vii) land and resource use, (viii) pollution prevention, and (ix) economic well-being.

However, analysis of the OECD materials points at the following deficiencies of the existing approach to sustainable transportation:

- inability of the Vancouver principles to provide quantifiable criteria for a sustainable transportation system;
- methodological failure of the scenario approach to capture the essence of a sustainable transportation;
- narrow treatment of transportation.

Since in general sustainable development includes three components – the economy, society and environment – sustainability criteria have to reflect all three. Over the years, economic, social and environmental aspects have traditionally been treated as separate issues. This is reflected in the criteria commonly used to assess these components. The Vancouver principles suffer from the same weakness. They suggest a set of criteria for a sustainable transportation system that are not easily

quantifiable nor consistent with the existing system of national accounting.

Methodological failure of the scenario approach to evaluate sustainability of transportation is as follows. Scenario approach is based on the cost-benefit framework that involves cost-benefit analysis or its modifications such as cost-effectiveness analysis, life-cycle costing, multi-criteria analysis, multi-criteria analysis with ordinal scales and some others. These methods were designed to evaluate specific projects. As such, they all suffer from the same drawback – assessment of marginal changes within an existing framework – while sustainability is a long-run concept that is associated with structural changes of the system under study over time rather than marginal changes.

Finally, all existing models of transportation systems are subject to a conventional transportation market analysis. It means that demand for transportation and supply of transportation are specified in terms of basic microeconomic concepts of demand and supply. However, traditional notion of demand for and supply of transportation does not consistently describe production and consumption of transportation services. Multiple transportation services are produced and consumed in transportation networks. Transportation networks are essential to the functioning of societies and economies and provide the infrastructure for the movement of people and goods over space and time.

Therefore, an alternative methodology to address sustainability of transportation is needed to avoid the above-described shortcomings.

**Methodology**

As follows from the above discussion, transportation networks are an element of the integral system "economy-environment-society". According to Nagurney (2000), the existence and utilization of transportation networks are fundamental to the development of modern economy. However, negative effects of transportation such as congestion, pollution, increased land use and consumption of non-renewable resources demand our urgent attention.

In her monograph, Nagurney (2000) addresses the problem of sustainable transportation in the following way: can transportation networks last, given the growing demand for transportation, on the one hand, and the desire to alleviate the associated negative effects on the other? Although valid in its formulation, the question can be broken in two interrelated questions:

- what is the underlying process of the growing demand for transportation?
- what types of constraints should be imposed on such a process to achieve sustainability of transportation?

This paper is dedicated to the answering first question. In this regard, it is necessary to model an evolution process of a transportation network within the existing economic system.

It is obvious that transportation does not exist on its own. Other sectors of an economy generate demand for transportation. In turn, in the process of satisfying this demand, transportation generates demand for goods and services in other sectors of the economy. Such a structure implies that transportation network is linked with other components of the economic system and evolves over time along with these components. In this study, the above-mentioned links are called vertical linkages. Therefore, in order to understand the evolution process of the transportation network, vertical linkages should be identified, and analytical framework to capture them should be designed.

Since we are interested in the evolution process, which is dynamic process in a mathematical sense, some initial conditions should be specified first. The initial conditions should be associated with (i) economic fundamentals such as consumer preferences and technology, and (ii) some macroeconomic characteristics of the system under study. Macroeconomic characteristics include two sets of economic variables: (i) policy variables such as, for example, social rate of time preferences, shares of inputs of production, rate of technological progress and others, and (ii) exogenous macroeconomic variables such as population, labour force, capital stock, foreign trade, natural resource stock and others.

The major economic objective of the system is to produce as much of different goods and services as possible given the system's institutional infrastructure, resources and fundamentals. As a result of

this goal, demand for transportation arises in different forms:

- demand for commercial transportation, both freight and passenger, by businesses;
- demand for commercial transportation by households;
- demand for personal transportation by households.

Demand for commercial transportation by businesses arises as a factor demand since transportation is regarded as an input in producing goods and services. Demand for commercial transportation and personal transportation by households arises as a trade-off based on the existing structure of prices in the economy and people's preferences.

The demand should be met by providing transportation services in the transportation network at the least cost. One curious fact that arises from such a framework is: households are both producers and consumers of personal transportation. Therefore, we assume that the demand for personal transportation is always satisfied. However, in terms of the network effects discussed later, personal transportation adds traffic to the network.

Production of transportation requires the following factors of production: (i) transportation labour, and (ii) transportation capital. Transportation labour can be viewed as labour hours of operators of transportation vehicles. In turn, transportation capital consists of two components: (i) transportation fixed facilities or immobile capital, known as infrastructure, and (ii) transportation vehicles or mobile

capital.

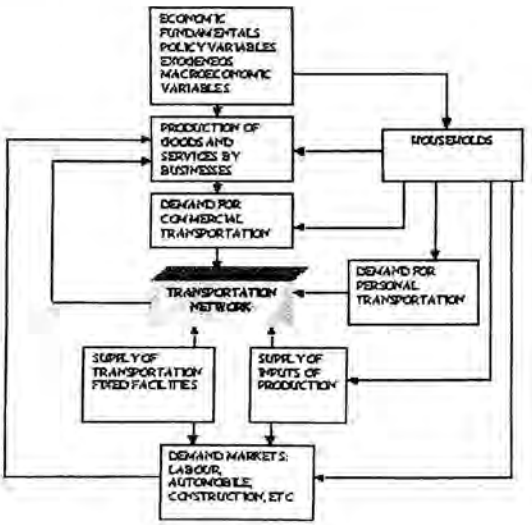
Since demand for personal transportation is always satisfied, production of commercial transportation is the focal point in this framework. Commercial transportation is provided by private companies who share transportation fixed facilities (infrastructure) provided by the government. Such a framework is more consistent compared to the traditional market analysis of transportation because it allows us to incorporate:

- heterogeneuity of transportation services;
- mixed ownership of transportation capital;
- network effects.

Utilization of different factors in production of transportation generates demands for goods and services in other sectors of the economic system. In transportation literature these markets are sometimes called demand markets (Rothengatter, 1999). Transportation labour creates demand in labour market, transportation mobile capital creates demand in automobile market, and transportation immobile capital creates demand in construction. In addition, production of personal transportation creates demand in automobile market as well. Of course, here it is possible to talk about some transportation-specific government structures (for example, Transport Canada), transport related entrepreneurship and some other specific transportation related skills that create demand for education and other aspects of human

capital and supporting institutions. For simplicity, these are not taken into account at the present.

In terms of the entire economic system, transportation adds value to producing goods and services plus value, added by demand markets as a result of production of transportation. Therefore, contribution of transportation to economic growth and development can be evaluated through the value added by transportation and demand markets in this framework. The above-described system can be represented graphically by the following chart:



**Analytical framework**

In terms of analytical framework, evolution of the entire system can be captured through the system dynamics approach. The system dynamics approach is based on relationships between state and flow variables organized in feedback loops. The following two basic elements of the approach are:

*Intrinsic dynamics relationships*: Intrinsic dynamics captures the relationship between state and flow variables. For example, investment is an addition to the stock of capital goods. In terms of the system dynamics approach, investment is a flow variable while stock of capital goods is a state variable. The intrinsic dynamics relationship is:

$$K_{t+1} = K_t + I_t$$

where $K_{t+1}$ and $K_t$ are stocks of capital goods in time periods $t+1$ and $t$ respectively, and $I_t$ is investment in period $t$.

*Constraints:* Constraints determine the feedback loops. For example, if there is a constraint on transportation fixed facility due to its limited capacity, then the evolution of the transportation network will proceed in loops through intrinsic dynamics until the constraint is satisfied. Another function of a constraint is to capture the persistence of a system. Persistence of a system is defined in terms of how long the system lasts before it is changed to a new state (Batabyal, 2002). In this interpretation, constraint plays the role of a threshold.

Therefore, application of the system dynamics approach implies that an economic system under study evolves according to the state-flow relationships organized in feedback loops subject to constraints. In order to implement this framework, analytical methods coupled with computer modelling should be applied. Analytical methods refer to a mathematical description of the relationships among economic variables – a mathematical model. Such a description must be based on economic theory to identify some specific functional forms.

In addition, in the designed model, transportation system must be described as a network in terms of the network's capacity and capacity utilization. It is argued in the literature on industrial organization that whenever sunk cost and the degree of uncertainty are very high, the right market structure should be that of a network (Gentzoglanis, 2001). As a matter of fact, transportation is characterized by both, high sunk cost and high uncertainty (see Boyer, 1998). Therefore, according to economic theory transportation should be analysed as a network industry with all the associated network effects. The fact that transportation services are consumed in a transportation network results in two network effects: (i) congestion in consumption, and (ii) positive network externalities. As well, fixed capacity of a transportation network causes congestion in production. Therefore, all these effects should be properly incorporated in analytical framework because otherwise a sub-optimal level of transportation would result (Yevdokimov, 2001).

## Conclusion

The problem of sustainable transportation should be addressed in a broader macroeconomic context since transportation networks are an integral part of an economy. Interaction of a transportation network with other sectors of the economy can be captured through the system dynamics approach. Applied to the problem of sustainable transportation, the approach describes evolution of the transportation network over time as a component of the evolution of the entire macroeconomic system. In such a setting, vertical linkages of the sustainable transportation network with other sectors of the economy are reflected through state-flow relationships organized in feedback loops subject to various constraints. Within such a structure, transportation itself must be modelled as a network industry with all the associated effects.

## References

Batabyal, A., "The Persistence of Ecological-Economic Systems: Alternate Measures and their Properties", *Department of Economics Research Paper*, Rochester Institute of Technology, Rochester, NY

Boyer, K.D., *Principles of Transportation Economics,* Addison Wesley Longman, 1998

Gentzoglanis, A., "Networks and Proximity: An Empirical Analysis", *Paper Presented at the ACEA Conference,* September 2001

Nagurgey, A., *Sustainable Transportation Networks,* Edward Elgar Publishing, 2000

Rothengatter, W., "Economic Assessment of EST - Scenarios of the OECD", *Proceedings of the Ottawa Workshop "The Economic and Social Implications of Sustainable Transportation"*, OECD, 1999, 49-94

Yevdokimov, Yuri, "The Economics of Transportation Networks", *Proceedings of the 30th Atlantic Canada Economic Association Conference*, Fredericton, September 28-30, Volume 30, 2001, 42-66

## FREIGHT EFFICIENCY AND TECHNOLOGY INITIATIVE

### 1. BACKGROUND

Two key trends in the freight transportation sector pose a significant challenge in reducing greenhouse gas (GHG) emissions in this sector. First, freight movement, as measured in tonne-kilometres, is expected to increase by 60 % between 1990 and 2020, causing GHG emissions to increase at about the same pace. The greatest growth in freight movement will take place in the air (104%) and trucking (94%) sectors, followed by rail (56%). The level of activity in the marine sector is foreseen to decline by 17% over the period. Since transportation is a derived demand, the high freight movement growth stems from a fast growing Canadian economy. It is noteworthy to mention that the two areas of most rapid growth, air and trucking, are also the most GHG-intensive modes. Aviation GHG emissions will double by 2020 while truck emissions will increase by 70%.

Second, Canada's economy, and the transportation sector in particular, has become and will continue to be more integrated with the world economy, mostly with the U.S one. For example, the introduction of NAFTA and deregulation policies forces Canadian carriers to compete with U.S. firms in both countries. As a result of the globalization of the Canadian economy, the response of our major trading partners, notably the U.S., to climate change is an important consideration in developing the freight transportation measures.

As part of the national climate change process, the Transportation Table on Climate Change studied a range of voluntary measures to reduce GHG emissions from the freight sector. Examples of such measures include codes of practice, driver training, and load matching services. Through the Table's consultations, industry called repeatedly for a voluntary approach, at least initially, for the first

climate change business plan. Moreover, the Enhanced Voluntary Table concluded that voluntary actions have an essential role to play in helping reduce GHG emissions. In this context, the Government of Canada, through its Action Plan 2000 on Climate Change, initiated the Freight Efficiency and Technology Initiative, a program designed to encourage the freight transportation sector to voluntarily reduce its GHG emissions while reducing its operating cost (fuel and maintenance cost) and increasing its operating efficiency.

## 2. PROFILE OF THE INITIATIVE

### a) Objectives

The FETI is a 5-year, $14-million initiative that was launched in November 2001. It consists of three components: i) voluntary agreements; ii) training and awareness amongst freight operators and shippers; and iii) a demonstration program. Each component of the program is described in more detail below.

### b) General Description

*b. 1) Voluntary Agreements*

Under this component, the federal government is working to sign agreements with the associations representing carriers to commit the freight industry to undertake voluntary actions leading to measurable and verifiable GHG emission reductions. The agreements will specify clearly or provide for the specification of:

- the emission reductions targets;
- the overall strategy to achieve the emission reductions; and,
- collaborative actions the industry and the federal government will undertake.

*b.2) Training and Awareness*

To strengthen the freight sector's participation in voluntary agreements, training and awareness is essential to highlight opportunities related to lower GHG emissions. In this context, the training and awareness component of the freight initiative is intended to provide carriers and shippers a better understanding of the impacts of climate change and to engage them to take a leadership role in reducing their GHG emissions. One tool adopted to achieve this goal is the promotion of codes of practice for each freight mode. The codes of practice provide guidance to industry on environmental issues, namely GHG emissions reduction measures, eco-efficient operations, and best operational practices. To that end, in November 2002, the FETI hosted a successful international workshop on aviation operational measures for fuel and emissions reductions. The workshop promoted a circular developed by the International Civil Aviation Organization that identifies practices to reduce fuel use and emissions. An eco-labeling initiative is another tool that the program is considering to provide guidance to shippers on cost effective options of reducing GHG emissions while ensuring competitiveness and meeting stringent international environmental standards for products.

Since the trucking sector accounts for the bulk of the GHG emission from the freight sector, more targeted actions for this sector are being undertaken under the awareness portion of the freight program through the expansion of the existing FleetSmart program of Natural Resources Canada.

*b. 3) Demonstrations*

The Transportation Table studied a wide range of innovative technologies and operational practices that currently exist in the marketplace and have a good potential to reduce GHG emission in the freight transportation sector. However, these technologies and practices are not widely used. For example, they include:

- improved navigational systems for aviation;
- automatic stop/start equipment for existing rail locomotives;
- information and ITS technologies to improve intermodal shipment tracking and management;
- satellite-tracking to allow motor carrier to more efficiently dispatch vehicles and plan their routes; and,
- vehicle monitoring and control systems to achieve more fuel-efficient truck driving.

To address this low-penetration rate issue, the Freight Sustainability Demonstration Program administered by Transport Canada was implemented to demonstrate and encourage the take-up of innovative technologies and best practices that can contribute to GHG reduction from *all* freight modes. An independent selection committee selects all demonstration projects through a competitive process. Projects may be supported for up to 50% of eligible costs to a maximum of $250,000 over a two-year year period. Funding from all federal department sources cannot exceed 50% of the eligible costs, which include the planning, implementation and monitoring costs of the project. The eligible funding recipients are the private sector and not-for-profit organizations.

In the course of the first round of the program, the following four projects are being funded:

- *Kelsan Technologies Corp.* of B.C., in partnership with *BC Rail*, will demonstrate a friction-reducing technology that applies a liquid to the top of the rail to reduce friction, wear and fuel consumption;
- *Southern Railway* of B.C., using ZTR Control Systems' SmartStart, will demonstrate an anti-idling device that automatically stops and starts locomotives to reduce fuel consumption, wear and noise while keeping the locomotive operational;
- *Athabasca Northern Railway* of Alberta, using Kim HotStart Diesel Driven Heating System (DDHS), will demonstrate an anti-idling device that keeps locomotives operational while

shut down by automatically warming the engine and charging the batteries; and

- *Nexus North Inc.* of Manitoba, in partnership with *Via Rail*, will demonstrate an inter-modal service that will transport goods to remote northern communities more efficiently, thereby improving service and reducing GHG emissions.

A total of eight rounds of funding will be undertaken over the life of the program.

## 4. CONCLUSION

The Freight Efficiency and Technology Initiative has been designed as a voluntary measure to reduce GHG emissions in the freight sector. It encourages continuous efficiency improvements within the freight sector. The program represents a unique opportunity for companies to contribute to GHG reductions while saving money on fuel and other operating costs. The Government of Canada is counting on each mode of transportation to contribute to the program.

# CPR Branch Line Discontinuance – Historical Perspective and Current Realities

John Nash & Paul Clegg
Canadian Pacific Railway Company

## Introduction

Since 1933 the Canadian Pacific Railway (CPR) has discontinued the operation of 6,298 miles of track in Canada and transferred by sale or lease a further 2,307 miles to other railway operators.[1]

The purposes of this paper are to describe:

- The statutory provisions governing the discontinuance and transfer of lines and how these provisions fitted in with the overall scheme of economic regulation of federal railways;
- The implementation of the statutory provisions by the regulatory body; and
- The positions and strategies adopted by parties opposing railway line discontinuances.

## *Railway Act* – 1933 to 1967

In 1933 Parliament amended the *Railway Act* by requiring the railways to seek the approval of the Board of Railway Commissioners

[1] The number of miles discontinued excludes 889 miles of track that were transferred to other railway companies subsequent to the issuance of a discontinuance order.

for Canada prior to discontinuing the operation of a railway line.[2] The amendment was an outcome of the Duff Royal Commission (1931-32), and accompanied the enactment of the *Canadian National – Canadian Pacific Act, 1933*. Prior to the amendment, the railways were free to discontinue operations without Board approval, unless precluded from doing so by special act of Parliament or by contract.

The 1933 amendment to the *Railway Act* did not set out principles to guide the Board in deciding whether to approve railway applications to discontinue the operation of lines. However, by 1935, the Board had adopted the principle of "*whether the loss and inconvenience to the public consequent upon the abandonment outweigh the burden that continued operation of the railway line would impose on the railway company*" as its standard in ruling upon such applications.[3]

The federal government did not provide compensation to the railways in the event that a discontinuance application was denied on public interest grounds. This was consistent with the general perspective that the railways were "monopolies" and could afford to cross-subsidize "uneconomic" services out of the earnings from profitable services.

The parties evolved their positions during the 1930s, and these positions did not fundamentally change for the next 60 years. The railways' position was simple: the lines in question were incurring losses and they should be relieved of this financial burden. The recurring themes advanced by intervenors in opposition to the railways' applications can be summarized as follows:

- The discontinuance of the line would impose higher costs on shippers by requiring them to deliver their goods to more distant stations.[4]

---

[2] 23-24 Geo. V c. 47 (1933) specified that "*The Company may abandon the operation of any line of railway with the approval of the Board, and no railway may abandon the operation of any line of railway without such approval.*"
[3] *CN – Tweed Subdivision (Ont.)*, 26 J. O.R.R. 162 (1935)
[4] For example, *CPR – McAuley Subdivision (Man.)*, 23 J.O.R.R. 302 (1933)

- Municipal road costs would increase because of the altered flow of traffic.[5]

- The cessation of operations would result in the end of the affected communities or in their financial ruin.[6]

- Although the line may be currently unprofitable, future agricultural, mining and industrial developments will increase the volume of originating traffic.[7]

- The frequency and scheduling of the services provided by the railway was inconvenient to both passengers and shippers of freight, which explained their poor patronage.[8]

- The railway received a subsidy towards the construction of the line from a level of government, which obligated the railway to continue operating the line regardless of the losses incurred.[9]

- Compensation should be paid to those parties adversely affected by a decision of the Board to approve the railway application.[10]

The root causes for the future rationalization of the railway networks began to surface in the 1930s. These were the advancement in automotive technology and the accompanying development of the paved highway network. The emergence of a competing mode drained the railways of both freight and passenger traffic to the point where lines that were previously profitable became a financial burden.[11]

---

[5] For example, *CPR – McAuley Subdivision (Man.)*, 83 C.R.T.C. 94 (1961)
[6] For example, *CPR – McAuley Subdivision (Man.)*, 23 J.O.R.R. 303 (1933)
[7] For example, *CPR – Lardeau Subdivision (B.C.)*, 25 J.O.R.R. 256 (1935)
[8] For example, *CN - Aston Subdivision (Que.)*, 25 J.O.R.R. 316 (1935)
[9] For example, *CPR – Orford Mountain Railway (Que.)*, 25 J.O.R.R. 473 (1935)
[10] For example, *CN – Middleton Subdivision (N.S.)*, 28 J.O.R.R. 429 (1939)
[11] For example, *CPR – Orford Mountain Railway (Que.)*, 25 J.O.R.R. 475 (1935)

Line discontinuances displayed a cyclical pattern over the period from 1933 to 1967. There was a flurry of discontinuances in the 1930s before they came to a virtual halt around 1942 because of the needs of the Second World War. Notwithstanding the cessation of hostilities in 1945, line discontinuances remained at a low level throughout the latter half of the 1940s and over the 1950s. It was only after 1960 that the discontinuances began to increase. This pattern is shown in Table 1 (p. 5).

Although the table shows that the number of discontinued miles was relatively modest, the railways had been filing applications since the early 1960s that had been deferred for consideration by the Board. By the fall of 1966, these deferred applications totalled 4,087 miles of track in Manitoba, Saskatchewan and Alberta.[12] The applications were on hold for political reasons: the Conservative government had requested a delay because 1962 and 1963 were election years and the subsequent Liberal government requested a further delay to give it time to consider the findings of the MacPherson Royal Commission on Transportation.[13]

## ***Railway Act* As Amended By The *National Transportation Act* – 1967 to 1987**

In 1959 the federal government appointed a Royal Commission on Transportation (MacPherson Royal Commission).

The Commission concluded that the railways were no longer monopolies because of the emergence of pervasive truck competition, and within this environment, the railways could no longer afford to cross-subsidize uneconomic services. The Commission identified the

[12] *Calgary Herald*, 16 September 1966, p. 1
[13] Gibberd, J.D., Wesley, P., *An Analysis of Railway Transport Committee Decisions 1967 –1980*, Research Branch, Canadian Transport Commission, Report 1982/06E, August 1981, p. 62

operation of light density branch lines as an uneconomic service and a major drain on the railways' financial resources.

| Table 1<br>CPR Line Discontinuances - 1933 to 2002 | | | | |
|---|---|---|---|---|
| Period | Miles Discontinued | | | Annual Average |
| | Prairies | Other | Total | |
| ***Railway Act*: 1933 – 1967** | | | | |
| 1933-1942 | 0 | 192 | 192 | 19 |
| 1943-1959 | 12 | 89 | 101 | 6 |
| 1960-1967 | 242 | 254 | 496 | 62 |
| Total | 254 | 535 | 789 | 23 |
| ***National Transportation Act*: 1967-1988** | | | | |
| 1967-1974 | 0 | 136 | 136 | 19 |
| 1975-1988 | 1,441 | 850 | 2,291 | 168 |
| Total | 1,441 | 983 | 2,426 | 117 |
| ***National Transportation Act, 1987*: 1988-1996** | | | | |
| 1988-1996 | 490 | 1,608 | 2,098 | 268 |
| ***Canada Transportation Act*: 1996-2002** | | | | |
| 1996-2002 | 877 | 108 | 985 | 152 |
| **Grand Total** | **3,062** | **3,234** | **6,298** | **90** |

Although the MacPherson Royal Commission submitted its report to the federal government in 1961, it was not until January 1967 that the *National Transportation Act* (*NTA*), which also amended the *Railway Act*, was passed to implement the Commission's findings. A new discontinuance regime for branch lines was created, which contained two key features:

- The payment to the railways of the "actual loss" associated with the operation of an uneconomic branch line ordered retained in the public interest by the Canadian Transport Commission or protected from discontinuance by a Prohibition Order.

- The authorization of the Governor in Council to prohibit the railways from applying to discontinue the operation of branch lines for such period as specified in the Order. (These Orders were known as Prohibition Orders).

During the 1970s, the federal government initiated a series of studies to address the future of Prairie branch lines.[14] As a result of these studies in combination with earlier government announcements, Prohibition Orders were issued that protected, at the end of 1980, 4,419 miles of CPR grain branch lines in Manitoba, Saskatchewan and Alberta from discontinuance until 1 January 2000. This mileage represented 78 per cent of the total CPR grain branch line mileage in these provinces when the *NTA* was enacted in 1967. [15]

On the Prairies, the branch line subsidy program was essentially an indirect program to subsidize the Crow rates. In 1982, the branch line claims filed by the railways for Prairie lines totalled $339.3 million, or 96 per cent of the claims filed for all lines in Canada. When the *Western Grain Transportation Act* (*WGTA*) came into force in 1984, the branch line subsidy program for Prairie lines was transferred from the *Railway Act* to form part of the government commitment paid under the *WGTA*.

Table 1 (p. 5) shows that line discontinuances under the *NTA* sharply increased from the level recorded during the preceding period, although there was little activity before 1975. Between 1967 and 1974, the Commission gave higher priority to such matters as the development of the Costing Order and the applications to discontinue passenger train service over the discontinuance applications for the small number of Prairie lines that had been left unprotected.[16]

---

[14] Hall Commission (1977), Prairie Rail Action Committee (1979) and report of Mr. Doug Neil (1979)

[15] Only one Prohibition Order was issued protecting a line outside of the Prairies and that was for the Canada Southern (CASO) line in southwestern Ontario in 1985

[16] Gibberd, J.D., Wesley, P., *op. cit.*, p. 85

Between 1967 and 1988, 59 per cent of the CPR discontinued mileage was located in the Prairie provinces. This reflected an overdue pruning of the grain branch line network. A total of only 254 miles of grain lines had been discontinued between 1933 and 1974 (four per cent of the total Prairie branch line network), and no line had been discontinued over the 11-year period from 1964 to 1974 inclusive.

***National Transportation Act, 1987* – 1988 to 1996**

From the early 1980s, pressure began to build for changes to the regime enacted by the *NTA*. This was in response to developments in the United States (the *Staggers Rail Act of 1980*) and the perception among shippers that the *NTA* was weighted in favour of the railways.

As a result of these pressures, the *National Transportation Act, 1987* (*NTA, 87*) came into force on 1 January 1988. In addition to introducing greater competition into the railway industry, the *NTA, 87* revised the line discontinuance process. These revisions were intended to provide the railways with greater freedom to reconfigure their networks in line with the more deregulated rate environment.

The major changes introduced by the *NTA, 87* as they related to line discontinuances were as follows:

- If a line was determined by the National Transportation Agency to be "uneconomic" and there was not a reasonable probability of it becoming "economic" in the foreseeable future, the Agency was required to order its discontinuance.

- If a line was determined by the Agency to be "economic" or there was a reasonable probability that it would become "economic" in the foreseeable future, the Agency was required to order the discontinuance of the line unless the operation of the line was required in the public interest.

- The authority of the Governor in Council to issue Prohibition Orders was terminated. However, the existing Prohibition Orders were to remain in effect until such time as they expired or were revoked.

The key difference from the previous regime was the repeal of the Agency's power to take public interest considerations into account in deciding whether an "uneconomic" line should be discontinued.

As a result of this change, intervenors to railway discontinuance applications focused their efforts on attempting to demonstrate that:

- Although the line may be currently "uneconomic", there was a reasonable probability of it becoming "economic" in the foreseeable future because of purported traffic growth.[17]

- The railway's methodologies in calculating the revenues and costs associated with the line were flawed, and that the substitution of more proper methodologies would show that the line was "economic" because it did not incur an "actual loss". [18]

- The railway "demarketed" the line by undertaking initiatives to reduce the volume of traffic using the line, with the purpose of making the line "uneconomic".[19] A related claim was that the shipper would have originated more traffic if the railway had provided more frequent train service and a proper supply of suitable equipment.[20]

- The Agency's consideration of the application should include more profitable segments of the same line or other lines. [21]

---

[17] For example, *CPR – Boundary Subdivision (B.C.)*, Agency Decision 547-R-1988
[18] For example, *CN – Chester Subdivision (N.S.)*, Agency Decision 251-R-1991
[19] For example, *CN – Chapais Subdivision (Que.)*, Agency Decision No. 45-R-1990
[20] For example, *CN –Mamora Subdivision (Ont.)*, Agency Decision No. 506-R-1990
[21] For example, *CPR – D.A.R. (N.S.)*, Agency Decision No. 350-R-1989

- The railway did not enjoy the right to discontinue the operation of a line because the line was leased rather than owned or because the line was subject to constitutional protection.[22]

CPR discontinued 2,098 miles of track under the *NTA, 87* (Table 1, p. 5). The greater part (77 per cent) was located in provinces outside of the Prairies. The higher level of line discontinuances and the change in the relative geographical mix from the previous period was due to the three major factors:

- The Prohibition Orders protected Prairie branch lines from discontinuance.

- The financial situation in the late 1980s and early 1990s required CPR to place special emphasis on the operations and size of the network in eastern Canada.

- The removal of the Agency's power to take public interest considerations into account in determining whether an "uneconomic" line should be discontinued.

The *NTA, 87* made it easier to transfer lines to other railways, and particularly to provincially-regulated railways, unless the Agency determined that the transfer would not be in the public interest. The transfer of lines to provincially-regulated railways was facilitated by a provision that automatically revoked any declaration that the line in question was "a work to the general advantage of Canada" upon its transfer.

The transfer of lines to provincially-regulated railways was further assisted by the 1990 Supreme Court decision in *United Transportation Union v. Central Western Railway Corporation.*[23] In

---

[22] For example, *CPR – D.A.R. (N.S.),* Agency Decision No. 350-R-1989 and *CN – Prince Edward Island Subdivisions (P.E.I),* Agency Decision No. 348-R-1989

[23] [1990] 3 S.C.R. 1112

this case, the Court ruled that the Central Western – a railway incorporated by an act of the Alberta legislature -- was not subject to the Canada Labour Code because it was outside of federal jurisdiction for two reasons: it was not, by itself, a federal work or undertaking and it was not an integral part of a federal work or undertaking.

The railways did not take immediate advantage of their enhanced ability under the *NTA, 87* to transfer lines. However, line transfers sharply increased after 1993. Over the four-year period from 1994 to 1997 inclusive, CPR transferred 1,230 miles of track to short line operators in eastern Canada. The level and pattern of line transfers is shown in Table 2.

Table 2
CPR Line Transfers

| Period | Miles Transferred | | | Annual Average |
|---|---|---|---|---|
| | Prairies | Other | Total | |
| ***National Transportation Act*: 1967-1988** | | | | |
| 1967-1988 | 82 | 0 | 82 | 4 |
| ***National Transportation Act, 1987*: 1988-1996** | | | | |
| 1988-1993 | 255 | 14 | 269 | 54 |
| 1994-1996 | 0 | 273 | 273 | 109 |
| Total | 255 | 287 | 542 | 72 |
| ***Canada Transportation Act*: 1996-2002** | | | | |
| 1996-2002 | 427 | 1,256 | 1,683 | 259 |
| **Grand Total** | **764** | **1,543** | **2,307** | **68** |

***Canada Transportation Act* – 1996 to 2003**

A Commission was appointed by the Minister of Transport under Section 266 of the *NTA, 87* to conduct a review of federal transportation legislation, and it submitted its report in January 1993.

The Commission concluded that the measures enacted in 1987 to enhance railway competition "*have indeed benefited the shippers they were intended to serve.*" However, the Commission went on to say that "*the situation faced by the railways has deteriorated and may become very serious in this decade*", and identified "*the rigidities of railway cost structures which have been unresponsive to revenue declines*" as the major source of the railways' difficulties. To rectify the situation, the Commission recommended, "*the easing of restrictions on track rationalization*", which "*have forced the maintenance of oversized rail networks for both of Canada's Class 1 railways*".[24]

The Commission's findings were subsequently incorporated in the *Canada Transportation Act* (*CTA*), which was passed in 1996 to replace both the *NTA, 87* and the *Railway Act*. In regard to line discontinuances, the *CTA* removed the requirement for a railway to seek the approval of the Canadian Transportation Agency prior to the discontinuance of a line, and a more commercial process was enacted in its place. The scheme for line discontinuances set out in the *CTA*, as amended by Bill C-34 in 2000, is briefly summarized as follows:

- After a line has been on a discontinuance plan for at least 12 months, the railway company may advertise its availability for transfer.

- If a party expresses an interest in the line, the railway and the prospective purchaser have six months to reach an agreement.

- If no agreement is reached, the railway is required to offer the line at a price at not more than net salvage value to successive levels of government.

---

[24] National Transportation Act Review Commission, *Competition in Transportation - Policy and Legislation in Review*, Supply and Services Canada, 1993, Vol. 1, pp. 82-94

- If a level of government does not acquire the line, the line may be discontinued.

In addition, the *CTA* and Bill C-34 contained the following provisions that were specific to Prairie grain lines:

- In 1995, the Minister of Transport requested the Agency to review certain low density branch lines. As a result of this review, the *CTA* included a provision that required the railways to discontinue the operation of 535 miles of track set out in a schedule to the act.

- Under Bill C-34, if a grain dependent branch line is discontinued, the railway is required to pay $10,000 per mile in each of the first three years to affected municipalities. (The grain freight rates had previously included an amount related to line discontinuances.)

Finally, the *CTA* terminated the branch line subsidy program and removed the requirement for Agency approval of a line transfer negotiated as a commercial transaction.

The Governor in Council revoked the outstanding Prohibition Orders at the same time that the *CTA* came into effect.

The termination of the traditional regulatory approach to line discontinuances brought about by the *CTA* has altered the nature of the opposition to discontinuances. Under the current regime, the focus has been to:

- Minimize the price at which a level of government would pay to acquire a line, if it wished to continue to operate the line or to use the land for non-railway purposes.

- Make it more costly for a railway to discontinue the operation of a line compared to the alternatives of either continuing to operate

the line or to transfer the line to third parties for continued rail operation.

Examples of the current focus include:

- The advancement of positions to reduce the value of ferrous material and land in Agency net salvage value determinations.[25]

- An effort to exclude the value of assets funded under the Branch Line Rehabilitation Program from the calculation of net salvage value.[26]

- The enactment of municipal by-laws requiring the railways to restore the land upon discontinuance and an effort to include these costs in net salvage determinations. [27]

- The zoning of the right-of-way for only railway or transportation purposes.[28]

- The enactment of a process within the Saskatchewan *Railway Act* covering the "dismantling" of a railway line as distinct from the "discontinuance of service" over the line. The "dismantling" process is a carbon copy of the federal line discontinuance procedure. [29]

In addition, parties have objected to the discontinuance of lines on the basis that the railway has not complied with the process set out in the *CTA*.[30]

---

[25] For example, *CN – Chatham Subdivision (Ont.)*, Agency Decision No. 467-R-1996
[26] Denied in *CN – Cudworth Subdivision (Sask.)*, Agency Decision No. 33-R-2000
[27] Denied in *CN – Cudworth Subdivision (Sask.)*, Agency Decision No. 445-R-2000
[28] For example, *CPR v. City of Vancouver* 2002 BCSC 1507
[29] Section 22.1 of S.S. c. R-1.2 as amended by c. 36 (2001)
[30] For example, *CPR – Wood Mountain Sub. (Sask.)*, Agency Decision No. 706-R-1996

Table 1 (p. 5) shows that CPR has discontinued the operation of 985 miles of track under the *CTA*. However, over the same period, CPR has transferred 1,683 miles of track to short line operators (Table 2, p. 10). The discontinued mileage represented track with low volumes of traffic that was of little interest to other railway operators.

**Line Discontinuances by Province**

Table 3 shows the proportion of the total CPR mileage, net of the core line from Montreal to Vancouver via Toronto, which has been discontinued since 1933.

Table 3
Relative Impact Of CPR Line Discontinuances By Province
1933 – 2002

| | Total Mileage | Core Line Mileage | Net Mileage | Miles Discontin'd | Percent Discontin'd |
|---|---|---|---|---|---|
| NS | 288 | 0 | 288 | 230 | 80.0 |
| NB | 637 | 0 | 637 | 495 | 77.7 |
| PQ | 1,688 | 47 | 1,642 | 940 | 57.2 |
| BC | 2,059 | 548 | 1,511 | 772 | 50.1 |
| ON | 3,503 | 1,428 | 2,075 | 990 | 47.7 |
| AB | 2,701 | 332 | 2,369 | 1,017 | 42.9 |
| MB | 1,761 | 300 | 1,461 | 502 | 34.3 |
| SK | 4,555 | 415 | 4,140 | 1,352 | 32.7 |
| **Total** | **17,193** | **3,069** | **14,124** | **6,298** | **44.6** |

The table shows that CPR has discontinued the operation of 44.6 per cent of its total track mileage, net of the core line, since 1932. The province with the greatest number of miles that have been discontinued is Saskatchewan (1,352 miles) followed by Alberta (1,017 miles). However, there were more miles of track in Saskatchewan than in any other province by a considerable margin. New Brunswick and Nova Scotia are the provinces in which the

greatest proportion of route mileage has been discontinued (more than 75 per cent in each province). The provinces proportionately least affected by line discontinuances have been Saskatchewan and Manitoba.

**Conclusions**

The following conclusions can be drawn from the above summary of the line discontinuance process over the past 70 years:

- There has been a progressive relaxation of the restrictions placed on the railways to discontinue the operation of lines. This has been the result of the transformation of the railways from "monopoly" suppliers of transportation services to participants in a highly competitive multi-modal transportation market. The termination of "public interest" considerations as a factor in the line discontinuance process is the most visible evidence of this change.

- The emergence of the highway mode and the shifts in the composition and sources of railway traffic caused a large number of lines constructed prior to the 1930s to become uneconomic. The railways (from 1933 to 1967) and the federal government (from 1967 to 1996) absorbed the costs associated with the operation of uneconomic lines retained in the public interest. The withdrawal of the federal government from direct involvement in the railway sector has resulted in the current requirement for levels of government to acquire marginal and uneconomic lines if they wish the continuation of railway service to meet a broader social purpose.

- Under the *CTA*, municipal and provincial governments have become actively involved through the enactment of by-laws or legislation to influence the course of railway line discontinuances.

# IDENTIFYING BLACKSPOTS AT HIGHWAY-RAIL GRADE CROSSINGS IN CANADA

Congming Ren, Liping Fu and F.F. Saccomanno
Department of Civil Engineering
University of Waterloo, Waterloo, ON, Canada, N2L 3G1

**Summary**: This research provides a methodology for identifying high-risk grade crossings (or Blackspots) in Canada. Blackspots are crossings where the expected number of collisions and/or consequences exceeds some pre-set thresholds. The expected number of collisions and consequences are obtained from model output applied to individual crossings.

A variety of collision frequency and consequence models were attempted and evaluated. Statistical tests concluded that a Poisson model with separate expressions for different types of warning devices were the best to explain the relationship between the collision frequency at individual crossings and various crossing and collision characteristics, and a Negative Binomial model were the best for the total consequence resulting from a collision.

A two-dimensional graphical approach was adopted for comparing risk at individual crossings on the basis of their expected collision frequency and consequence scores. The risk graph was used to identify Blackspots based on a given percentage threshold value. For a threshold of predicted frequency and consequence exceeded 0.1% of the time, a total of 22 Blackspots were obtained for more than 10,000 grade crossings across Canada. Blackspots due to high frequency were found to cluster around urban areas in the Prairie Region, where road volumes were found to be highest. Blackspots resulting from high consequence were found to be more extensively distributed in rural and urban areas in Ontario and Quebec.

## INTRODUCTION

Highway-rail grade crossing collisions are a source of concern to railway authorities and the public-at-large. From 1992 to 2001, each year, an average of 47 people lose their lives as a direct result of grade-crossing collisions in Canada (Transportation Safety Board of Canada, 2001). In response to safety concerns at grade crossings, Transport Canada established a safety management program called "Direction 2006". The goal of Direction 2006 is to reduce collisions in Canada by at least 50% by the year 2006. The question that needs to be addressed is how this goal can best be achieved.

It would be prohibitively expensive and impractical to improve safety at all grade crossings to a uniform standard. A recent report prepared by the Transport Research Laboratory (TRL) for the World Bank concluded that a reduction in grade crossing collisions is best achieved by directing appropriate countermeasures to Black Spot (BS) locations. Blackspots refers to crossings with an unacceptably high collision risk. The TRL report suggests that when we attempt to allocate funds to all problem areas, lack of funds and poor maintenance capability often results in the most dangerous problems being left untreated. Targeting Blackspots ensures that this issue is less likely to be a problem.

In this paper, we assert that Blackspots cannot be established solely with reference to the historical collision experience for a given period of time. Collisions are rare random events that vary significantly over time and space. A longer term view of collision risk is needed to reflect potential risks involved over any period of time. Such estimates can only be obtained using accurate and reliable collision frequency and consequence models.

Furthermore, Blackspots identification based solely on collision potential fails to provide a complete view of the "collision risk" at grade crossings. Collision risk consists of two components: one is its frequency and another is its severity. Ignoring collision severity would lead to exclusion of some crossings that have low collision occurrence but high consequence in Blackspots list. When analyzing

the collision risk at grade crossings, we should not only consider collision frequency but also the related severity. A risk-based model is needed to identify blackspots at the grade crossings in Canada.

This paper is organized into three main sections: 1) development of a collision prediction model using the Canadian data, 2) development of a collision consequence model using the Canadian data, and 3) identification of Blackspots at highway-rail grade crossings in Canada based on the above models.

## DATA SOURCES

The study used the RODS/TSB database, provided by Transport Canada to calibrate the collision frequency and consequence models. This database contains an inventory of 29,507 grade crossings for all regions in Canada and includes information on highway and rail geometric characteristics, traffic volumes and selected train operating features. A second data table includes information on collision occurrence at these crossings for the period 1993-2001. The inventory and occurrence data share a common reference number that permits linkage of each collision occurrence to the specific crossing where it took place. A number of crossings were found to be poorly specified for our purposes, that is, they did not include variables needed in our models, and these were removed from the database in our analysis. As a result, the data set used in this study includes collision history and inventory information for 10, 381 crossings in Canada for the period of 1993 to 2001.

## COLLISION FREQUENCY MODEL

Before developing a new collision prediction model for the Canadian crossings, the RODS/ TSB data were split into two random samples, one consisting of 5,194 crossings for model calibration and the other consisting of 5,187 crossings for model validation.

A variety of collision prediction models were attempted based on different model structures (e.g. considering type of warning devices as a independent variable vs. different expressions for crossings with different types of warning devices) and different assumptions on the distribution of collision frequency (Poisson, Negative Binomial and Empirical Bayesian method). Three separate Poisson models, each for one of the three types of warning devices (Type S for crossings with signs, Type F for crossings with flashing lights and Type G for crossings with gates), were found the best to represent the observed pattern.

***1) Type S Crossings***

The Poisson model for crossings with signs only is:

$$E(m_i) = Exp(-11.6778 + 0.01 * \mathbf{train_speed} + 0.3973 * \mathbf{ln(exposure)}) \quad (1)$$

Where: *train_speed* = maximum train speed (mile/h)
*exposure* = a product of AADT and number of trains daily

A Chi-square goodness-of-fit test comparing observed and predicted collisions for different train speeds and traffic exposure was applied. The Chi-square (9.69) of the model is less than critical ($\chi^2_{0.05,\ 5}$ =11.07) at the 5% level of significance, suggesting the model is statistically significant at aggregate level.

***2) Type F Crossings***

The model for crossings with signs and flashing lights is of the form:

$$E(m_i) = Exp(-14.9060 + 0.0091 * \mathbf{train_speed} - 0.0077 * \mathbf{road_speed} + 0.0312 * \mathbf{surface_width} + 0.5161 * \mathbf{ln\ (exposure)}) \quad (2)$$

where: *surface_width* = road surface width (m)
*road_speed* = posted road speed (km/h)

This expression contains four statistically significant explanatory variables. The Chi-square value (16.09) was found to be slightly greater than critical (11.07), indicating a relatively good model fit for crossings with flashing lights.

*3) Type G Crossings*

A third collision prediction expression was obtained for crossings with signs, flashing lights and gates. The expression is of the form:

$$E(m_G) = Exp(-8.7407 - 0.1428 * \mathbf{track_no} + 0.258 * \mathbf{ln(exposure)}) \quad (3)$$

where: *track_no* = number of railway tracks (both directions)

The Chi-square goodness-of-fit test also yielded good results, when crossings were classified by train speed and traffic exposure. Chi-square value (2.82) is less than the critical at 5% level, indicating a good match to the observed data.

## COLLISION CONSEQUENCE MODELS

A collision may result in a variety of consequence, such as fatalities, serious injuries and property damage. In our research, we use a collision consequence score to combine the different types of consequence. Since fatalities, injuries, and property damage contribute disproportionately to collision severity, it was necessary to first weigh each of these consequences according to their reported costs. In this study, The weights assigned to fatality and person injuries were based on the WTP approach [2].

The weight for property damages (PD) was set to 1.0 and scaled accordingly for other consequences to yield a consequence score (CS) expression shown in Equation 4.

$$\mathbf{CS} = 44.0 * \mathbf{Number\ of\ Fatalities} + 1.0 * \mathbf{Number\ of\ Injuries} + 1.0 * \mathbf{PD} \quad (4)$$

This score reflects the severity of collisions at grade crossings based on the number of fatalities and injuries and property damage.

The final data set used to calibrated consequence model contains 826-collisions on 720 crossings Canada-wide for the period 1997 to 2001. The collision occurrence data were split into two samples, one to calibrate the consequence model (413 collisions) and the other to validate the model (413 collisions).

The consequence score was summed over all collisions at each crossing during the five-year period and then divided by the number of crossing collisions. This yielded a crossing consequence score per collision, which is served as the dependent variable in the collision consequence model. The explanatory risk factors in the data consisted of train speed, road speed, number of tracks, track angle, surface width, AADT, number of train daily, and number of persons involved in a given collision.

Again, several models were attempted and a Negative Binomial (NB) model was found to be the best to fit the data. The resultant NB consequence model is of the form:

$$E(\textit{Consequence Score/Collision}) = Exp(0.3426*\textbf{persons_involved} - 0.2262*\textbf{track_no} + 0.0069*\textbf{track_angle} + 0.0250*\textbf{train_speed}) \quad (5)$$

Where: *persons_involved* = number of persons involved in a collision
*track_angle* = the angle between track and road

## BLACKSPOTS IDENTIFICATION

With the collision frequency and consequence models, high risk crossings or Blackspots can be identified. Two Blackspot identification approaches were considered: 1) a two dimensional graphical approach, and 2) a combined risk-based approach. In the graphical approach, collision frequency and consequences are represented by separate axis in a two-dimensional plot. Crossings with unacceptably high frequencies and/or consequence scores as predicted by collision models are identified on the basis of either a critical frequency value or consequence value. The second approach is based directly on risk measure, that is, the product of collision frequency and consequences at specific crossings. The predicted risk at a crossing is then compared to pre-set threshold to determine whether or not this crossing should be designated as Blackspots and then considered for intervention.

The number of Blackspots targeted for intervention depends on the underlying thresholds applied to predicted frequency, consequence and risk. Obviously as these thresholds are reduced, an increased number of crossings come under the Blackspot designation. With an increased number of Blackspots the cost of intervention is expected to increase as well. Practicable thresholds can be established by considering the tradeoff between safety improvements and the associated intervention costs.

**Blackspots Identification- Graphical Method**

A total of 10,336 highway-rail grade crossings were considered for Blackspot identification in all regions of Canada. These include both crossings that have experienced collisions over the period 1997-2001 period and those that have not.

For each crossing, collision frequency and consequence/collision were predicted using the above models for different crossing characteristics, AADT and speed. Model prediction rather than historical collision observation was adopted in Blackspots identification, because models can provide long-term, stable and reliable estimations. Notwithstanding the estimation of a combined risk measure, a graphical collision frequency versus consequence approach was adopted for identifying Blackspots. There are essentially two reasons for this: 1) If we combine frequency and consequences into a single risk measure, crossings with high frequency and low consequence or crossings with high consequence and low frequency would might in low risk, and hence, be excluded from intervention. This could result in a possible misallocation of safety funds; and 2) If risk alone is used, it would be more difficult to tailor intervention strategies to the safety concerns at each crossing. Counter-measures that are tailored to reduce collision frequency could differ from countermeasures tailored to reduce their consequences.

Collision frequency and consequences at each crossing were plotted as shown in **Figure 1.** In this figure, the horizontal axis represents predicted consequence for all collisions at each crossing for the

period 1997-2001, while the vertical axis reflects the predicted collision frequency at these crossings for the same period. This approach is crossing specific in order to be in line with our study objective: identify the unsafe crossings in the nation railway network.

Three thresholds values were considered: 0.1%, 0.2%, and 0.5%. Here threshold 0.1% is defined as crossings whose predicted collision frequency and/or consequence score is exceeded only 0.1% of the time, and in a similar fashion for 0.2% and 0.5% threshold value.

**Figure 1** shows that crossings with high collision frequency differ from crossings with high consequence. This indicates that Backspots based solely on one criterion fails to provide an adequate representation of crossings that should be targeted for intervention. Clearly, we should not be using collision frequency or consequences in isolation to establish Blackspots. Rather both criteria should be considered to provide a more complete picture of the underlying risk.

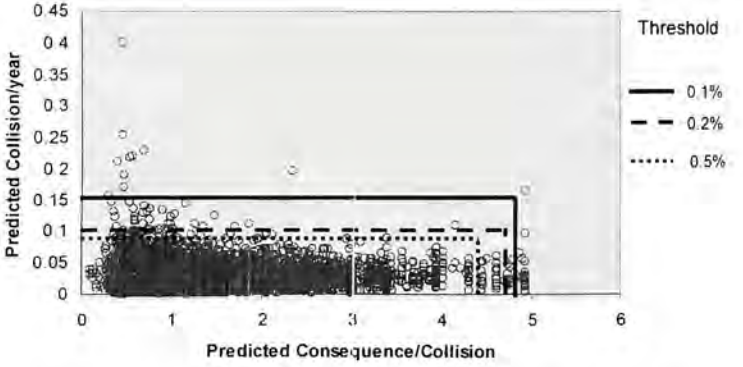



**Figure 1: Graphical Identification of Blackspots Based on Predicted Frequency & Consequence**

**Choice of Threshold**

In Blackspots identification, the basic question that needs to be addressed is: which threshold to choose, such that safety is enhanced at the lowest intervention cost.

An optimal threshold can be determined based on a thorough cost-benefit analysis of the intervention measures being considered. In the absence of this type of analysis, it was selected based on the relationship between number of Blackspots and potential reduction of collision risk. The more crossings identified as Blackspots the higher the cost. As more Blackspots are targeted, there is a greater possibility for risk reduction. In the absence of a more in-depth analysis of safety countermeasures and their benefits at individual crossings, it was assumed that benefits from countermeasures is equal to the total predicted frequency and consequences at Blackspot crossings.

**Figures 2 and 3** illustrate the relationship between total frequency and consequences respectively, for different thresholds. We note that from these Figures no "inflection" point exists where improvements in safety increase at a decreasing rate with higher thresholds. In the absence of such an inflection point the more crossings are identified as Blackspots, the safer is the system. This needs to be investigated further with respect to increases that would take place in the intervention budget. In this study, 0.1% was selected for further analysis.

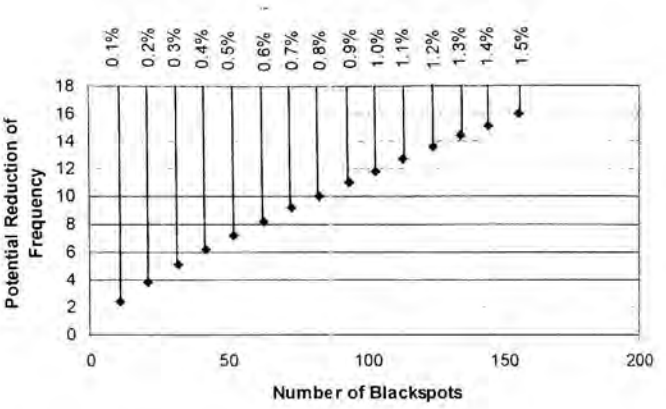



**Figure2:Potential Reduction of Collision Frequency vs. No. of Blackspots Treated**

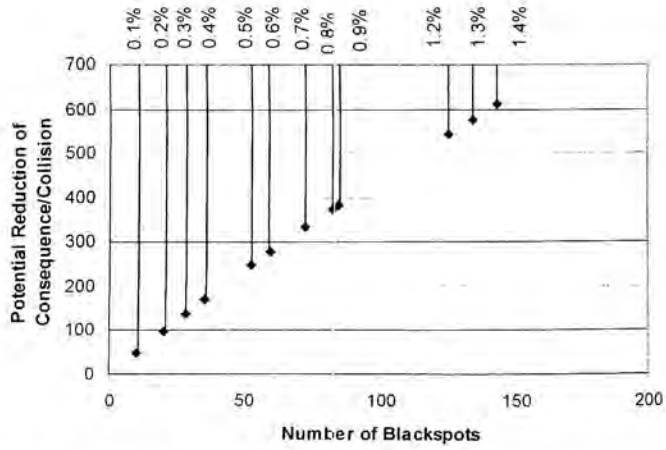



**Figure 3: Potential Reuction of Collision Consequence vs, No. of Blackspots Treated**

**Blackspots in Canada**

Based on the frequency and consequence thresholds of 0.10%, a list of 22 Blackspots was obtained across Canada. The location of these crossings is given in **Table 1 and 2** for collision frequency and consequences, respectively. The predicted Blackspot crossings are subsequently compared to the top 22 crossings with the highest historical collision frequency and consequence as reported in the data. The results are summarized in **Table 3** and **4.** Based on the models, the top five predicted frequency crossings are located in Saskatchewan and another three crossings at Saskatchewan are listed in the top eleven as well. Five out of eleven top crossings with highest consequence/collision are located in Ontario and four crossings are located in Quebec.

The top 11 predicted high frequency crossings differ from the top 11 predicted high consequence score crossings, suggesting that the two criteria yield significantly different results. This underscores the importance of a Blackspot model that accounts for both collision frequency and consequence prediction. The top 11 crossings with highest historical frequency and consequence tend to be widespread in Canada, while the top 11 crossings with highest predicted frequency and consequence tend to be more clustered in Ontario and Saskatchewan. This suggests that a reliance on the historical data to identify Blackspots would not yield an accurate representation of the potential risk involved. Potential risk can only be obtained through the application of the frequency and consequence models.

The Blackspots list (Table 1 and 2) shows that the top 11 crossings with highest frequency are mostly located in urban area, especially in Saskatchewan. The top 11 with highest consequence are mostly located in rural area, especially in Ontario. One possible explanation to this phenomenon is that crossings located in urban areas usually have more traffic volume than rural areas, which leads to potential for more collisions. While in rural areas there are less traffic volume. The speeds at which trains traverse the crossing are also high. Train speed is a major factor contributing to collision consequence. Hence, once collision occurs, the consequence at rural crossings is expected to be more sever than the urban area.

**Table 1: Blackspots List Based on Predicted Frequency**

| Frequency /year | Provi_ nce | Municipal | Street No |
|---|---|---|---|
| 0.401 | SK | Saskatoon | 22nd Street |
| 0.254 | SK | Saskatoon | 33rd Street |
| 0.230 | SK | Regina | Albert Street(Hwy 6) |
| 0.223 | SK | Saskatoon | 3rd Avenue North |
| 0.220 | SK | Prince Albert | 2nd Avenue West |
| 0.214 | NB | Saint John | Main Street (Highway100) |
| 0.197 | SK | Corman Park No. 344 | 21-22-36-6 |
| 0.191 | ON | Brockville | Perth Street |
| 0.172 | SK | Regina | Winnipeg Street |
| 0.165 | QC | St.-Cyrill-De-Wendover | Chemin Du 3e Rang |
| 0.157 | SK | Regina | Pasqua Street |

**Table2:Blackspots List Based on Predicted Consequence**

| Consequ /collision | Provi_ nce | Municipal | Street No |
|---|---|---|---|
| 4.93 | QC | Saint-cyrille-de-wendover | Chemin du 3e rang |
| 4.93 | QC | Saint-simon | Rang st-georges |
| 4.93 | QC | Sainte-helene-de-bagot | Chemin 2e rang est |
| 4.93 | ON | Wolford | County rd16 |
| 4.93 | ON | Maidstone | Rourke line |
| 4.93 | QC | Val-alain | Route du 3e |
| 4.93 | QC | Saint-germain-de-grantham | Chemin du 8e rang |
| 4.93 | QC | Sainte-helene-de-bagot | Rang st-augustin |
| 4.93 | ON | Belle river | Ducharme road |
| 4.93 | ON | Wolford | Kilmarnock rd |
| 4.93 | ON | Tilbury north | Couture road |

**Table 3: Blackspots List Based on Collision Frequency History (Number of Collisions) (1997-2001)**

| No of Collisions | Provi nce | Municipal | Street No |
|---|---|---|---|
| 6 | ON | Niagara Falls | Reg Rd #102-Clifton |
| 5 | SK | Saskatoon | 3rd Avenue North |
| 4 | QC | Saint-Jean-Sur-Richelieu | Grand Bernier Road |
| 4 | MB | Winnipeg | Kimberly Avenue |
| 3 | SK | Regina | Ross Avenue |
| 3 | SK | Senlac No. 411 | Grid Road 675 |
| 3 | ON | Brampton | Torbram Road. |
| 3 | MB | Portage La Prairie | Third Street |
| 3 | SK | Sherwood No. 159 | Municipal Road |
| 3 | MB | Winnipeg | Marion Street |
| 3 | QC | Montreal | Rue De Courcelles |

**Table 4: Blackspots List Based on Collision Consequence History (Consequence/Collision) (1997-2001)**

| Total Fatality | Total Serious Injuries | Provi_ nce | Municipal | Street No |
|---|---|---|---|---|
| 4 | 1 | ON | Halton Hills | 4th Line Road |
| 3 | 0 | ON | Ingersoll | Mckeand Ave. |
| 2 | 0 | ON | Halton Hills | Derry Road Reg. 25 |
| 2 | 0 | ON | Cambridge | Dolph St |
| 2 | 0 | ON | Elizabethtown | County #28 |
| 2 | 0 | AB | Mountain View County | Ns W15-33-1-5 |
| 2 | 1 | SK | Arlington No. 79 | Yellowhead Hwy |
| 2 | 0 | AB | Leduc County No. 25 | Rge Rd 245 |
| 2 | 1 | ON | Whitchurch-Stouffville | Slater Road |
| 2 | 2 | AB | Crowsnest Pass | 9th Ave. |
| 1 | 1 | QC | St.-Jean-Sur-Richelieu | Grand Bernier Road |

## CONCLUSIONS

This research presents a risk-based Blackspots identification model at highway-rail grade crossings in Canada. Two sets of models were developed to predict collision frequency and consequence at individual crossings. A two-dimensional graphic approach was adopted to combine these two models together to predict the risk at each crossing.

A list of Blackspots were obtained based on both predicted collision frequency and consequence in all the regions of Canada and compared to the list on the basis of collision history. It was found the Blackspots based on collision history tended to wide spread in Canada, while the list based on model prediction tended to cluster in Saskatchewan for frequency and Ontario and Quebec for consequence. Most Blackspots identified based on collision frequency are located in urban areas with high AADT, while the Blackspots by collision consequence are mostly located in rural areas with high train speed.

## ACKNOWLEDGEMENTS

The research project described in this paper was performed by the authors under a contract with the Transportation Development Centre of Transport Canada and funded by the Direction 2006 research KRA sponsors which included Transport Canada, Canadian National Railway, Railway Association Of Canada, Canadian Pacific Railway, via Rail Canada inc., Alberta Transportation, and the Quebec Ministry Of Transportation. The research KRA is one of six key result areas under Canada's Direction 2006 initiative that has the objective of reducing grade crossing and trespassing occurrences by 50 percent by 2006.

## REFERENCES

1. California Department of Transportation, "*California Life-cycle Benefit/Cost Analysis Model*", Booz Allen & Hamilton Inc. CA 1999

2. David W. Schoppert and Dan W. Hoyt " *Factors influencing Safety at Highway-rail Grade Crossings*" Highway Research Board, National Research Council, 1968.
3. Hauer, E. and Persaud, B.N. "How to estimate the safety of rail-highway grade crossing and the effects of warning devices". *Transportation Research Board 1114*, TRB, National Research Council, Washington DC, 1987, pp131-140.
4. Hitz, J.S. "Accident Severity Prediction Formula for Rail-highway Crossings". *Transportation Research Record 956*, TRB, National Research Council, Washington, D.C., 1984.
5. John S. Hitz " Accident Severity Prediction Formula for Rail-highway Crossings" *Transportation Research Record 956*, TRB, National Research Council, Washington, pp. 5-10, 1984.
6. McCullagh, P. and Nelder, J.A., "*Generalized Linear Models*", Longon, Chapman and Hall, 1989.
7. Miaou, S.P.. "The Relationship between Truck Accidents and Geometric Design of Road Sections: Poisson versus Negative Binomial Regressions". *Accident Analysis and Prevention*, Vol. 26, No.4, pp. 471-482, 1994.
8. Persaud, B.N. "*Blackspot Identification and Treatment Evaluation*". Research Report TDS-90-04, Research and Development Branch, Ministry of Transportation, Nov.1990.
9. Research and Special Programs Administration John A, Volpe National Transportation Systems Center *"Assessment of Risk for High-Speed Rail Grade Crossings on the Empire Corridor"* U.S. Department of Transportation. Federal Railroad Administration, Cambridge MA, 2000.
10. Saccomanno, F.F., R.Grossi, D.Greco, and A. Mehmood. "Identifying Black Spots along Highway SS107 in Southern Italy Using Two Models" *Journal of Transportation Engineering*. Volume 127, pp. 515-522, 2001
11. Saccomanno, F.F. "*Identifying Highway- Rail Grade Crossing Black Spots*" (Contract Proposal), University of Waterloo, 2001
12. SAS Institute *SAS/Insight User's Guide Version 6*, Gary, NC., 1995.

# Importance of Intermodal Connectivity and Bottleneck Elimination

Barry E. Prentice, Director, Transport Institute,
University of Manitoba

## Introduction

Intermodal transport refers to the shipment of goods that involves two, or more, modes of transport in a single journey. Ideally, each mode of transport is used for the length of haul that minimizes the line haul cost for the maximum distance moved. The best attributes of each mode of transport are combined in a system that yields the lowest cost of transportation for the supply chain.

Efficiency is the prime rationale for intermodal transport, but accessibility is a further reason for using two or more modes of transport. Most exports require trucks, or railcars, for pick-up and delivery at some point in the supply chain.

Intermodal transportation systems compete in terms of costs and time. A rail-barge intermodal system should be lower cost than an all rail movement, but normally it will be slower. Shippers of value-added goods regularly identify reliability and transit time as attributes equal to the importance of freight rates in modal choice decisions (Coyle, et al., 2003). Hence, potential time savings in intermodal are a key competitive issue.

The level of connectivity can affect reliability and transit time. Any impediment that slows or halts the flow of traffic is a bottleneck. The symptoms of bottlenecks are usually congestion slowdowns, queue formation or shipping delays. Maximum connectivity of intermodal transport demands an absence of bottlenecks.

Bottlenecks can have infrastructure or regulatory causes, and in some cases dysfunctions in the supply chain can also create bottlenecks. The purpose of this paper is to explore the causes of bottlenecks, and to illustrate how this conceptual framework might be used as a means of examining the competitiveness of intermodal systems. A taxonomy of bottleneck causes is set out in the next section. Subsequently, the framework is used to compare the intermodal handling of gain in bulk versus containers.

**Bottleneck Elimination**

The elimination of bottlenecks may appear to be futile. "Clearing up a single bottleneck only causes another bottleneck to appear." (Manheim, 1979) A system may never be free of bottlenecks, but the value of their elimination should not be underestimated. As bottlenecks are reduced or removed, the average velocity of the traffic increases. With greater utilization, average logistics costs fall and the supply chain network becomes more competitive.

Figure 1 presents an economic model of the impacts of bottlenecks on transport and logistic costs. Utilization has a direct impact on line-haul and terminal costs because transportation systems have large fixed costs. With greater utilization, the ratio of fixed to variable costs falls and average transportation costs decline.

Bottlenecks cause the average total costs (including logistics costs) to rise well before the economies of size are exhausted. As queues form and congestion begins to emerge the rate of throughput slows and rising indirect costs' offset the economies of size.

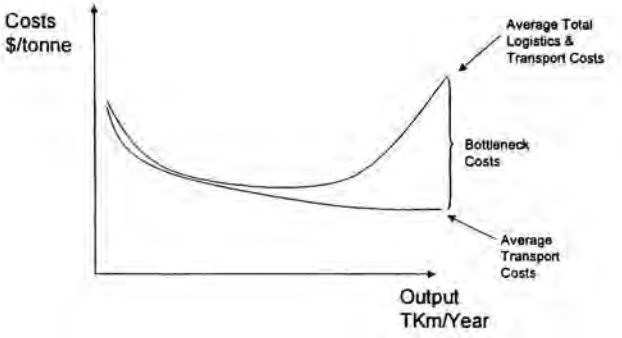



Figure 1 Economic Model of Bottleneck Costs

Figure 2 presents a framework for the analysis of bottleneck causes associated with infrastructure, regulations and supply chain conduct. Infrastructure bottlenecks are divided into temporary constraints, which last six months or less, and chronic constraints that can be present for years or decades. Regulatory bottlenecks are discussed in terms of direct and indirect effects. The supply chain dysfunctions are dealt with individually.

**Infrastructure Bottlenecks**

In Figure 3, climate and physical barriers are classified as chronic infrastructure problems. Climate limits the Port of Thunder Bay to about 10 months of operation, and the Port of Churchill to a 3 to 4 month shipping window. These bottlenecks might be avoided with ice breaking, and other measures, but this has not been shown to be economic. Mountain passes are an example of physical barriers that can cause bottlenecks that limit the number of train transits. Again,

investment can overcome this limitation as was demonstrated in the 1980s when the CP Railway built its new tunnel at Rogers Pass.

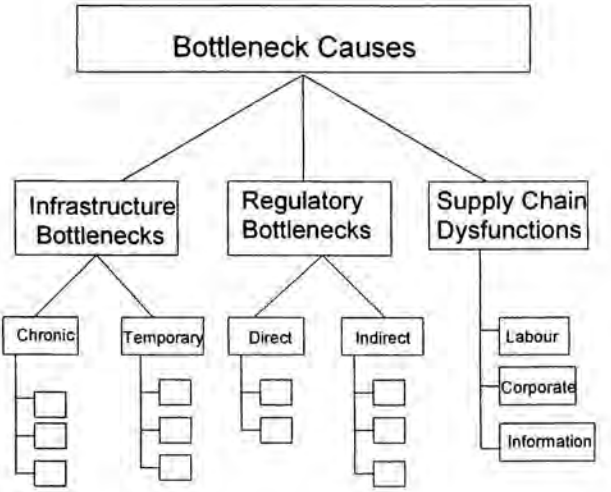



Figure 2 Taxonomy of Bottleneck Causes

Infrastructure under-investment is a third cause of chronic bottlenecks. Under-investment can occur when a system is growing very rapidly. Over the past decade intermodal container traffic has been expanding faster than the terminals of the railways have been able to accommodate. Although they have invested significantly in terminal expansion, some rail terminals remain a chronic bottleneck.

Weather disruptions, construction and accidents cause temporary bottlenecks and need no further explanation. These events are very difficult to predict or prepare for, but are not long-lived. A more regular form of bottleneck is caused by market perturbations. These are cases when the system is stressed by a temporary surge of demand. An example is a bumper harvest that leads to a shortage of

covered hopper cars. The railways cannot afford to supply enough cars to meet every eventuality, and hence, temporary bottlenecks arise whenever the demand is well above average. Peak-load pricing is a means of managing such bottlenecks, but is not necessarily popular with shippers. If the railways are in charge of determining the car supply and operating a peak-load pricing system, they could set the car supply at a level that always generates a shortage and maximizes their peak revenues (Prentice and Thomson, 2001).

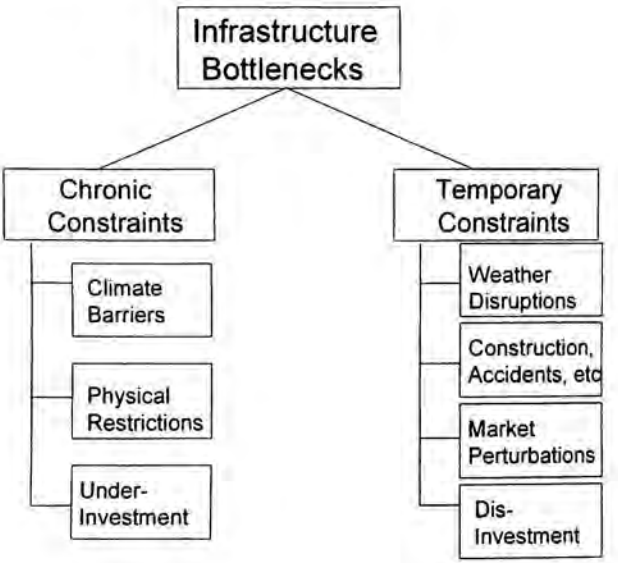



Figure 3 Forms of Infrastructure Bottleneck Causes

A shift in demand can also cause bottlenecks. After the mid-1970s, Asia became the principal market for Canadian grain exports. The terminals on the west coast became unable to handle the surge in

demand. This bottleneck became alleviated technically when additional capacity was added at Prince Rupert. The residual congestion at Vancouver illustrates that infrastructure alone may not eliminate bottlenecks.

Disinvestments occur when parts of infrastructure are abandoned, or maintained at a lower level of efficiency. Temporary bottlenecks can emerge as shippers search for alternative routes. An example of this occurred in Minnesota with the abandonment of local grain elevators. Instead of driving to the next closest elevator, many truckers decided to go all the way to the Minneapolis barge transfer sites. This has resulted in congestion of the suburban neighbourhood and longer truck queues at the transfer points[ii].

**Regulatory Bottlenecks**

Regulatory bottlenecks are usually the unintended consequences of some other policy objective. Government has a legitimate role in ensuring safety and guaranteeing security. Inspection protocols do not necessarily lead to bottlenecks, but if the authorities under-staff positions, or become over-zealous in enforcement, queues and delays are a typical result. In Figure 4, these inspection-related bottlenecks are classified as the direct effects of regulation. The other types of bottlenecks are associated with indirect effects of policy.

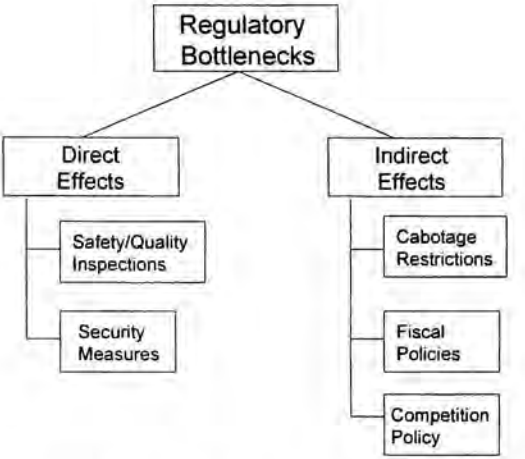



Figure 4 Forms of Regulatory Bottleneck Causes

The indirect effects are associated with policies that are imposed to protect a local industry, raise government revenues, or influence market conduct. Cabotage restrictions that limit foreign competition might not lead to bottlenecks directly, but bottlenecks in the domestic market might be alleviated if foreign carriers or ports were accessible.

Competition policy is seldom associated with bottlenecks per se, but the Canadian grain industry is rife with anecdotes of how the Canadian Wheat Board and the private grain trade congest and interfere with each other's shipments. In fairness, some bottlenecks could have occurred in any case, but the lack of coordination and differing agendas under this competitive arrangement makes bottlenecks more likely.

Fiscal policies can work indirectly through market forces. Prior to the end of the Statutory Freight Rates (1897-1982), the Canadian railways found the carriage of grain to be non-remunerative. As a result they ceased to invest in the system. Consequently, when

demand surged in the mid-1970s, bottlenecks appeared throughout their network. Like a price control, a tax system that takes more out of transportation, than the government puts back in spending, is likely to experience infrastructure gaps. These bottlenecks are not directly traceable to fiscal policy, but are clearly the result thereof.

**Dysfunctional Supply Chains**

Figure 5 presents the bottlenecks associated with the failure of participants in the supply chain to act in a common interest.

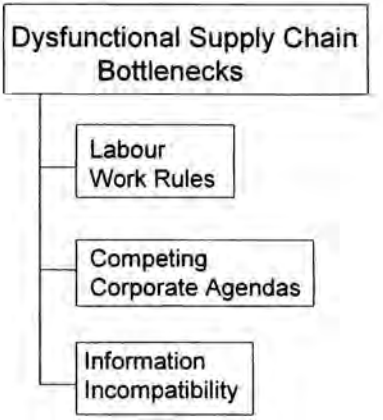



Figure 5 Bottlenecks Caused by Supply Chain Dysfunctions

Work stoppages were a constant source of grain shipping delays at the ports until the government finally forced these groups to adopt the same hours of operation. The recent strike on the US west coast is another example of job protection among a small group of unionized workers that makes the whole supply chain weaker. It is interesting to note that the unions actually gain their power from the bottleneck.

When such a bottleneck works in one group's favour, their incentive to remove it can also disappear.

Competing corporate agendas are not an obvious bottleneck source. An example is the operations of the two railways that deliver rail cars to the various grain terminals at Thunder Bay. The competing terminals refuse to dedicate their operations to single grains, so ships often call at more than one berth to load. In addition, the turn around time to Winnipeg on the railcars sent to Thunder Bay is worse than that of similar trains going all the way by rail to Montreal. If the grain terminals were to develop a common supply chain objective this bottleneck could be diminished.

Interoperability of communications systems requires all parties in the supply chain to adopt common information standards. International bulk ocean shipping has many partners to link with, and thus far no universal ship-to-shore communications system has been accepted. Paper-based information bottlenecks have been eliminated by electronic communication systems in container shipping where the industry is more vertically integrated.

**Application of Bottleneck Framework: Bulk versus Containers**

Two intermodal systems are serving the grain marketing supply chain. The bulk system is the over 150 years old and handles the majority of the grain exports. However, ISO container shipping is growing rapidly and threatens to take a much larger share of the grain market. The traditional bulk handling system has its strengths, but the introduction of genetically modified (GMO) grains and the demands for Identity Preservation (IP) are challenging the incumbent system. This section examines the competing intermodal systems for grain transportation through the lens of the bottleneck framework.

Bulk

The key advantages of bulk handling grain stems from its economies of size and specialized material handling systems. Every time a new

generation of facilities has been built, they have grown larger. At the same time, labour input has been maintained constant or reduced. Consequently, the labour cost per tonne of handling grain in bulk has fallen continuously.

The newest country elevators in Western Canada are giant terminals that can load multiple railcars simultaneously. For speed alone, the loading and unloading in the bulk system is impressive. This leads to faster car turns and associated savings in the use of railcars. The railways have also kept pace, moving from boxcars to 100 tonne hopper cars to newer "286" hopper cars that can carrying even larger volumes of grain.

With greater size and speed, the bulk handling system has managed to drive the unit costs of handling grain down to very economical levels. Of course, size can also have diseconomies. If the crop is short, or seasonal fluctuation in shipping lowers utilization, the unit costs of these systems can rise sharply. In addition, the system is designed for one way flows. The entire burden of handling costs and the round-trip of transportation is borne by the export commodity.

An appealing feature of bulk handling is the savings in packaging costs. No packages are required to hold the grain and the weight of the packaging does not add to the transport costs. Finally, the bulk handling system provides blending opportunities to the industry. Grades of lower quality grain can be raised to a higher standard through blending, while buyers receive a more consistent product than would be the case without blending[iii].

**ISO Containers**

Containerization is a specialized case of unitized intermodal transport in which a standardized box is lifted from one vehicle directly to another. Economies of scope are a key advantage of containerized shipping. Containers can be used to transport a wide array of manufactured and semi-processed goods as well as commodities like grain. As a result, the costs of equipment, ships, and terminals are

shared with these higher value goods. Typically, more valuable goods pay higher freight rates, and determine the traffic patterns. In the case of grain exports from North America, container shipping to Europe and Asia enjoys backhaul rates. Currently two full containers from Asia arrive at North America for every one that returns full.

Containerization also enjoys economies of size, and this has been particularly evident in the past decade. Trains that once carried single containers, now carry containers stacked two high. In 1990, a 3,000 TEU (twenty-foot equivalent unit) ship was common, this has doubled to 6,000 TEU ships, and 9,000+ TEU ships are in the shipyards (Kosior et al, 2002). Significant advances have also been made at the terminals, and the opportunity for more efficiency exists and will likely soon be implemented. These technical changes have led to a steady fall in the costs of container shipping.

The container is the storage medium as well as the unit of transport. This makes is very easy to track and trace shipments of products. It also enables a shipper to set up a Just In Time (JIT) inventory delivery system for his customer that lowers the in-transit inventories and reduces the customers inventory carrying cost.

Container supply chains have been designed to improve connectivity and eliminate transshipping bottlenecks by reducing material handling of the product. Minimum product handling is a significant advantage for delicate crops, like lentils, that could be destroyed in the bulk handling system. While this is still the mainstay of the industry, bulk grains are beginning to find a home in containers, and the requirements for IP grain shipments is providing further impetus. The contents of a container are only loaded and unloaded once during its intermodal movement. Consequently, contamination is impossible and the exact origin and route of the product can be traced if for any reason the quality or variety differs from the contract agreement.

Figure 6 presents a subjective scorecard of the advantages of bulk versus containers in regard to bottlenecks. Space does not permit an elaboration of this ranking, and readers may disagree with the

distribution of advantages. The containerization of grain appears to have more advantages than bulk, but it is not the number of bottlenecks alone that matters. The question is how binding or severe are the bottlenecks that remain.

| Sources of Intermodal Grain Transportation Bottlenecks | | Advantage Containers | Advantage Bulk |
|---|---|---|---|
| Infrastructure: Chronic - | Climate Barriers | — | — |
| | Physical Restrictions | ☆ | |
| | Under Investment | | ★ |
| Temporary - | Weather Disruptions | — | — |
| | Market Perturbations | ☆ | |
| | Accidents, Construction, etc. | — | — |
| | Dis-investment | ☆ | |
| Regulations: Direct - | Cabotage Restrictions | | ★ |
| | Pricing Policies | ☆ | |
| | Competition Policy | ☆ | |
| Indirect - | Safety/Quality Inspections | ☆ | |
| | Security | — | — |
| Supply Chain Dysfunction: | Labour Work Rules | — | — |
| | Corporate Agendas | ☆ | |
| | Information Incompatibility | ☆ | |

Figure 6 Bottleneck Scorecard for Bulk and Containerized Grain Handling

The most important bottlenecks affecting containers are cabotage restrictions and infrastructure under investment. These are not insurmountable issues. Cabotage restrictions would be relatively costless to government to change because no revenues would be given up, and no domestic industry would have any significant dislocation (Vido et al, 2001). Giving foreign containers better access to Canada would lower re-positioning charges and encourage loading inland. The under investment in terminals and handling equipment (e.g. chassis, loading facilities, etc) are really a function of

volume. As more grain moves in containers, the revenues to relieve these bottlenecks will be drawn forth from the private operators.

The most important bottlenecks affecting the bulk system are information incompatibility and safety/quality regulations. This has only recently become an issue as GMO crops have been introduced, and demands for IP grain has grown. The grain handlers have proposed a system of documentation and testing to maintain the identity of grain and to prevent accidental blending.

The testing method of maintaining IP grain quality is neither a proven, nor an inexpensive system. Kosior et al, (2002) discuss the costs of testing and the time required. In addition, each grain has to be binned separately. The attitude of the grain industry has been that if buyers want IP grain, they will have to pay higher prices. This view however, was countered by the observation that in other resource industries, failure to meet buyer specifications has led to discounts rather than premiums (Prentice et al, 2001).

In a normal year, the bulk handling system handles about 29 million tonnes, while about 1 million tonnes of grain are shipped in containers. The bulk handling system is covering its full costs (at least in a year of normal volumes), but the container system operates on the basis of backhaul rates. Consequently, the fixed costs of container shipping that are not presently covered. The total market operates at the costs determined by the marginal costs of the dominant bulk handling system.

The widespread introduction of IP grains and testing measures in the bulk system are going to create bottlenecks. The time delays for test results, testing costs and lower utilization of bin space will drives the marginal and average costs of the bulk handling system. This should encourage more grain to move in containers that the ability of containers to handle better the bottlenecks posed by IP grain.

Economic theory is unable to forecast the magnitudes of market share changes with accuracy, but is usually reliable in predict the direction

of change. This is all that is attempted here. The actual volume changes will depend on the cost relationships

**Observations**

Congestion and queues are symptoms of bottlenecks and should not be treated exclusively as an infrastructure problem. An expansion of the infrastructure will not cure a problem that is regulatory in nature.

Any infrastructure bottleneck can be relieved, at least temporarily, if enough money and time is invested. Just because a bottleneck exists however, removal may not be economically justified. In some cases, it may be more economic to manage a temporary bottleneck through peak-load pricing than to attempt to alleviate it permanently.

Removal of any bottleneck is likely to improve the efficiency of an intermodal supply chain. But some parties may benefit from bottlenecks, and not want them removed. Careful analysis of bottlenecks is necessary to ensure that infrastructure solutions are not proposed to solve "gatekeeper" problems.

Governments may not appreciate the costs of bottlenecks resulting from their policy and regulations. The new security measures at the ports to counter terrorist threats could provide a useful case to assess the economic impact of inspection-related bottlenecks.

The costs of bottlenecks caused by supply chain dysfunctions could be a fruitful area for research. It is frequently observed that supply chain members can join together to obtain mutual benefits, but more often they do not. It would be interesting to study the role that bottlenecks and gatekeepers play in dysfunctional supply chains.

**References**

Coyle, John, Edward Bardi and John Langley. *The Management of Business Logistics.* 7th Ed., Mason, OH: South-Western, 2003.

Kosior, Jake, Barry E, Prentice and Erica Vido. *A Mixed Logistics Strategy for Grain: The Competitiveness of Containers versus Bulk*. Winnipeg, MB: Report Prepared for PFRA, Agriculture and Agri-Food Canada, October 2002 www.umanitoba.ca/transport_institute/publications

Manheim, Marvin L. *Fundamentals of Transportation Systems Analysis*. Cambridge, MS: The MIT Press, 1979.

Prentice, Barry E. and Tamara Thomson. "An Electronic System for Railcar Market Access." *C.D. Howe Commentary*. No. 152 May, 2001.

Prentice, Barry E. Caroline Chapain, Jeff Browaty and Meyer Lapkin. "Getting Supply Chains Right", *6th Annual Fields on Wheels Proceedings*. Winnipeg, MB: Occasional Paper No. 20., November 2001. www.umanitoba.ca/transport_institute/publications

Vido, Erica, Barry Prentice and Jake Kosior. *An Assessment of North American Container Cabotage Regulations: The Impact on Canadian Operations*. Province of Manitoba, Transportation and Government Services, March 2001. www.umanitoba.ca/transport_institute/publications

---

[i] The carrying cost of inventory is an indirect cost that increases because bottlenecks increase the average inventories in transit.

[ii] Source: Dr. Richard Stewart, University of Wisconsin-Superior

[iii] Some farmers maintain that competition guarantees that the benefits of blending return to the farmers in higher selling prices. Others are skeptical. Mathematically, all farmers with above average grain quality must be subsidizing those with lower quality grain.

# INTERMODAL TRANSPORT IN CANADA

Joseph Monteiro and Gerald Robertson*

## Introduction

Intermodal transportation services[1] have attracted considerable attention since its dramatic growth in the 1970s. The National Transportation Act Review Commission called it "one of the most significant developments on the transportation scene in North America in recent years."[2] The most recent interest in it has resulted from new information technologies and the continued demand for door to door services.

In this paper, the development of intermodal services in Canada in Part I is examined. In Part II, the factors that the Competition Bureau will consider in assessing intermodal mergers, joint ventures and alliance under the *Competition Act* are examined. In Part III, intermodalism and the new technologies together with the resulting benefits are examined. Finally, a few concluding remarks are made.

## I. Intermodal Services in Canada

a) The Development of Intermodal Services in Canada

The development of intermodal services in Canada has largely followed two distinct paths. Those related to trailer on flat car (i.e, TOFC) and those related to container on flat car (i.e., COFC). The former is largely associated with trucking and railway and is domestic or transborder in nature, and the latter is largely associated with the liner shipping industry and the railways (or at times trucking) and is international in nature.

The development of both forms of intermodalism (i.e., TOFC and COFC) had its origins in the 1950s with TOFC taking the lead in the 1980s. There were a number of factors responsible for the subsequent advancement of COFC. The first was *containerization, liner shipping and container terminals.* Integrated service was initially started in 1969 by Dart Container Line and Manchester

Liners from Montreal to Europe. By the end of 1969 extensive liner services (using containers) had begun between Canada and Western Europe, and in 1970-71 several new container terminals or berths were established in Canada.[3] The second was *double stack train service and tunnel expansion.* This development arose due to the need for faster or more efficient services and was largely facilitated due to the amendments to s. 279 of the *Railway Act* which permitted confidential contracts. The third was the emergence of *mega-size carriers and gantry cranes.* After 1966, container ships carrying 600 TEUs increased ten fold or more. This was largely a result of economies resulting from the use of mega-size carriers. Finally, the latest impetus to the development of containerization came from advancements in *information technology and tracking.*

b) Growth of Intermodal Traffic in Canada

*Intermodal Traffic in Rail*: The growth in intermodal rail traffic in Canada is shown in table 1. It reveals the dramatic growth from the early 1970s. However, the overall figures conceal certain fundamental changes occurring in the composition of the traffic. While the COFC form of intermodal traffic has risen dramatically,

**Table 1 - Intermodal Traffic by Rail (COFC and TOFC) (metric tonnes)**

| Year | COFC | TOFC | Total |
|---|---|---|---|
| 1970 | 369, 429 | 1, 910, 749 | 2, 280, 178 |
| 1980 | 4, 345, 016 | 1,858, 268 | 6, 163, 284 |
| 1990 | 9, 094, 818 | 3, 916, 834 | 13, 011, 652 |
| 2000 | 20, 213, 528 | 1, 712, 833 | 21, 926, 361 |

Source: Railway Carloadings, Statistics Canada, Cat. No. 52-001-XPB.

the TOFC form of intermodal traffic has fallen. In percentage terms, COFC increased 5371 percent and TOFC decreased 10 percent over the period 1970-2000.

*Intermodal Marine Container Traffic*: The growth in intermodal traffic is also seen in the number of containers handled at the leading

Canadian Ports in international shipping. This is shown in table 2. The dramatic growth is particularly noticeable at the Port of Vancouver where the number of containers increased by 420 percent over the period 1985-1999.

**Table 2 - TEUs Handled at Leading Canadian Ports: International Shipping**

| Year | Halifax | Montreal | Vancouver | Other | Total |
|---|---|---|---|---|---|
| 1985 | 224, 000 | 439, 000 | 164, 000 | 123, 000 | 950, 000 |
| 1990 | 403, 000 | 487, 000 | 286, 000 | 46, 000 | 1, 222, 000 |
| 1999 | 325, 000 | 927, 000 | 853, 000 | 84, 000 | 2, 189, 000 |

The statistics include loaded and unloaded. Source: Shipping in Canada, Statistics Canada Cat. No. 54-205.

*Containerized Cargo*: The growth in intermodal traffic is also evident in the increase in the rate of containerisation of certain products such as machinery/equipment; other paper products; cement related products; newsprint and ores/base metals. The change for these products is shown in table 3.

**Table 3 - Rate of Containerized Goods and Changes 1986-1999**

| Year | Machinery/ Equipment | Other Paper Products | Cement/Related Products | Ores/Base metals | Newsprint |
|---|---|---|---|---|---|
| 1986 | 71.2 | 41.5 | 0.3 | 7.9 | 7.5 |
| 1990 | 76.8 | 49.4 | 20.1 | 13.2 | 9.8 |
| 1999 | 89.1 | 66.3 | 44.2 | 17.0 | 19.1 |
| **Change** | 17.9 | 24.8 | 43.9 | 9.1 | 11.6 |

The statistics include loaded and unloaded. Source: Shipping in Canada, Statistics Canada Cat. No. 54-205.

*Land-bridge Services*: The growth of land-bridge services (i.e., the overland portion of international intermodal movements) is also an indication of the growth of multimodal services. For the few years for which data are available, the growth has been spectacular rising from 14 to 48 from 1987 to 1994. This is shown in table 4 by type of service for conference and non-conference carriers.

**Table 4 - Number of Weekly Landbridge Services 1987-1994**

| Year | Eastern Canada to Far East | | Western Canada to U.K./Continent | |
|---|---|---|---|---|
| | Conference | Non-Conference | Conference | Non-Conference |
| 1987 | 9 | 3 | 2 | 0 |
| 1990 | 14 | 3 | 3 | 0 |
| 1994 | 24 | 13 | 8 | 3 |

Source: Annual Review of the National Agency of Canada 1994, p. 159.

c) Laws Affecting Intermodal Services

There is at present no specific law dealing with intermodal services, though there are two basic laws that have a bearing on intermodal services in Canada. These are: the *Shipping Conferences Exemption Act* (i.e., SCEA), and the *Canada Transportation Act* (i.e., CTA). The former explicitly refers to intermodal services in subsection 5(2)[4] in that the exemption from the *Competition Act* does not apply if the Conference establishes multi-modal rates in 'agreement' with another transport mode.

The above subsection of SCEA has been subject to criticism in the past as some bodies have claimed that it could have a detrimental effect on the development of intermodal traffic. However, the Competition Bureau has always maintained that this need not be so as this subsection does not prevent individual shipping lines from making an agreement with another transport mode. Further, providing intermodal exemption would have the effect of extending the scope of the exemption from ocean water to other forms of transportation which goes beyond the intent of SCEA.[5]

The CTA has three specific provisions dealing with intermodal services. These sections are: 159(1)(b), 131(3) and 115(4). The first section indicates that the final offer arbitration provisions (i.e., ss. 159-169) between shippers and carriers only apply to containers which arrive by water at a port in Canada, served by only one railway company for further movement by rail or arrive by rail at such a port in Canada for further movement by water. This excludes

other intermodal movements such as trailers or containers on flatcar. The second section also contains the above restriction for establishing a competitive line rate. The third section requires a railway company to provide facilities at the same rates and on the same terms and conditions to all for-hire truckers as those applicable to motor vehicles or trailers operated by a company under their control. The Agency may disallow any rate or tariff that does not comply with the above and may require a new rate or tariff.

Ownership of one mode of transportation by another mode of transportation is not prohibited. This however does not mean that mergers, joint ventures and alliances are not reviewed. Such review falls under sections 91-103 of the *Competition Act* though formerly they were also reviewed by the Agency.

d) Do intermodal services compete?

Competition between intermodal services can take various forms. First, there may be direct competition between intermodal services provided by different companies. Second, there may be competition between similar intermodal services (eg., intermodal service from Rotterdam to Chicago via Montreal or via New York) where the same modes of transport are used (ship and rail). Third, there may be competition where some components of the intermodal service are different (eg., intermodal service from Rotterdam to Toronto via Montreal first by ship to Montreal and then by rail or truck to Toronto). Fourth, there may be competition where all the major components of the intermodal service are different (eg., movement of grain to Mexico via the mid-continent using basically rail or barge or grain movement to Mexico via sea routes basically).

The third form indicated above has received a considerable degree of attention in the economics of intermodal transportation when part of an intermodal service can be substituted for another for example, where rail service can be substituted for truck. Here, distance is the principal determinant of costs. However, with the introduction of new intermodal rail technology such as double stacking, the roadrailer and the iron highway, the two modes that were competitive between 750-1600 miles are now competitive between

500-1600 miles. Generally, the alternative components of intermodal services are considered complementary to each other.

Information as to whether the other three forms of intermodal services can compete depends on the specificity of each situation. Perhaps, what one should be aware of are the 'major Ports' through which intermodal competition can occur and their rail links or the 'major routes' through which intermodal competition can occur. For example, regarding 'major Ports' on the West Coast, the Ports of Vancouver, Seattle and Tacoma could compete and the former has the rail links of CP, CN and BN and the latter two have the rail links of BN and UP. Similarly on the East Coast, the Ports of Halifax, Montreal, New York, Norfolk and Baltimore could compete. Halifax has rail links with CN, Montreal has the rail links of CN and CP, New York, Norfolk and Baltimore has rail links with CSX and NS. Regarding major routes, for example Dr. Prentice has mapped the intermodal sea routes vs. the mid-continent routes that can be used for the shipment of grain to Mexico. It is expected that as these alternatives develop, competition and the potential for competition will increase.

Overall, whether individual modes compete in the provision of part of the intermodal services or whether alternative intermodal services compete depends on a number of factors, some of the important considerations include the origin-destination, the cost of these services, the types of services and the quality of these services (i.e., speed of service, frequency of service, etc).

## II. Do Intermodal Mergers, Joint Ventures or Alliances Raise Competition Issues?

a) Definitions

The definition of a 'merger' is laid out in section 91 of the *Competition Act*. In general terms, a merger occurs when direct or indirect control over, or significant interest in the whole or part of a business of another person is acquired or established. A significant interest occurs when a person acquires or establishes the ability to materially influence the economic behaviour or the business of the

second person. A holding of less than ten percent voting interest in another entity is not considered a significant interest. Transactions that do not meet this requirement do not fall within the scope of section 91. The definition of a 'joint venture' is not specifically provided in section 95 of the *Competition Act*, though the section indicates the criteria needed to qualify for a joint venture. Finally, an alliance is not mentioned in this Act, though the Bureau has issued a publication to guide firms considering strategic alliances.

b) Factors that the Competition Bureau Would Consider in Examining Intermodal Mergers, Joint Ventures or Alliances

An intermodal merger, joint venture or alliance which provides joint intermodal service can usually be considered as a vertical form of integration. Examples of this are when a shipping line integrates with a railway or trucking company or when an airline company purchases a trucking company. These various intermodal forms of transport are complementary and do not generally compete (see earlier discussion) other than in a very broad sense. However, if they do compete then the matter would have to be considered as a horizontal merger since the service provided would be the same regardless of the mode of transport used.

Under the Canadian *Merger Enforcement Guidelines* vertical mergers only raise concerns in two circumstances: if it increases barriers to entry; and if it facilitates interdependence so that it prevents or lessens competition substantially. These two circumstances will be examined in greater detail.

*Increased barriers to entry*: An intermodal merger raises a concern where it leaves only a small amount of unintegrated service capability at either stage of the intermodal operations. This is because an entrant into one segment of the multimodal market would consider it necessary to simultaneously enter into the other segment of the multimodal market. In general, where such simultaneous entry into both segments of multimodal operations involves incurring greater sunk costs than would be required to enter into one segment, barriers to entry into either segment are effectively raised. However, this would only raise concern if the degree of actual competition that

would remain subsequent to the merger is so low that it would be impossible for a new entrant to exercise any important constraining influence on prices in the market.

It is unlikely that intermodal integration will prevent or lessen competition substantially unless: a) the merger results in rendering unlikely entry into one segment on a scale sufficient to eliminate a material price increase within two years due to a need to enter the other segment; and, b) the exercise of market power in one segment is likely to be facilitated by the merger in the absence of such entry.

*Interdependence facilitated*: Integration that results in or increases the existing degree of intermodal activity can facilitate interdependent behaviour by firms in any of the markets if it is easier to monitor prices by rivals. In general, this intermodal integration will not likely prevent or lessen competition unless: a) the prices at which transactions are actually made in one segment are more visible than the other segment; b) the conditions in one segment are conducive to the exercise of market power; and, c) the services available through unintegrated operations are so limited that sales by such operations will not likely prevent a material price increase from being imposed and maintained for two years.

If the above two circumstances are found to hold then the other criteria used in evaluating horizontal mergers will have to be considered.[6]

Joint ventures, unlike mergers, are much looser forms of integration which can provide benefits without having some of the detrimental effects of mergers. As a result, joint ventures are provided an exemption from the merger provisions of the *Competition Act* if they satisfy certain criteria.[7]

Alliances are not specially referred to in any provision of the *Competition Act*. This form of integration has grown in popularity as firms have attempted to improve their competitiveness with globalization and a decline in trade barriers. This has been recognized by the Competition Bureau and it is therefore of the view that most alliances do not raise an issue under the Act. In examining alliances, the Bureau will consider them under the conspiracy

provision when there is an agreement, if they do not result in economic integration. If economic integration results, the matter will be considered under the abuse of dominance provision if their conduct is questionable otherwise under the merger provision.[8]

c) Intermodal Cases Examined

There has only been one inquiry relating to intermodal transport to-date and it involved multimodal transportation rates. In May 1980, the Bureau received a section 7 application from six Canadian residents for an inquiry. The applicants alleged that the shipping lines were charging multi-modal rates that were lower than the sum of ocean, terminal and inland transportation rates in that the multi-modal rates were lower than that paid for cargo destined to the port. Further, it was alleged that the purpose of this pricing policy was to eliminate Canadian freight forwarders who handled the inland movement of traffic. The matter was considered under sections 34(1)(b) (i.e., geographic price discrimination), 34(1)(c) (i.e., predatory pricing) and 31.4 (i.e., market restriction) of the *Combines Investigation Act*.

Section 34(1)(b) was considered inapplicable as there was considerable doubt whether the product offered by shipping lines was the same product as the product offered by freight forwarders. Further, it was doubtful if it could be shown that the policy of shipping lines substantially lessened competition or eliminated a competitor, given the alternative routes open to shippers and since freight forwarders derived a substantial portion of their business from other services. Furthermore, there was no indication that the multi-modal rates were intended to eliminate freight forwarders as the rates were introduced due to intense competition on ocean routes. Section 34(1)(c) also could not be satisfied under existing jurisprudence as the multi-modal rates allowed the steamships to cover direct variable costs of providing the service and it was necessary to establish that they did not cover it to show that they were selling at unreasonably low prices. In addition, intent could not be found as indicated above. Finally, section 31.4 could not be met as it was difficult to establish what portion of the multi-modal rates was being offered at more favourable terms to shippers, since shipping lines did not offer inland

transport as a separate product to promote its sale. As a result, the inquiry was discontinued and the Minister of Consumer and Corporate Affairs was informed of the discontinuance.

Besides the above inquiry, there were five major inquiries and complaints related to shipping conferences. These were: a) The Port of Valleyfield Inquiry pertaining to rate discrimination; b) The Inquiry into the Container Shipping Services to the Port of Montreal concerning predatory pricing; c) The Inquiry into Container Shipping Services to the Port of Montreal pertaining to merger and conspiracy; d) The Inquiry into the services provided by a conference to Canadian meat importers; and, e) The complaint by the Canadian Shippers' Council on the TransPacific Stabilization Agreement. All these inquiries were discontinued.

## III. Intermodalism and New Technologies

Intermodal transport has in the last few years been affected by two major developments: 1. Information and Communication Technologies (ICT); and 2. New intermodal technologies. These developments together with the numerous resulting benefits will be briefly reviewed.

*ICT affecting intermodal transport:* The transport of freight from several sources (raw material producers, intermediate processors manufacturers), by several modes and over several countries has always required a substantial co-ordination and planning. The recent developments in ICT have tremendously increased the efficiency with which the above operations can be performed. These developments can be classified into: electronic data exchange (EDI); Internet services; logistics; and intelligent transport system (i.e., ICT related to road transport are referred to Intelligent Transport Systems (ITS)).

EDI: EDI is basically the transmission of data or information electronically. It is being used to enhance efficiency in several ways: to expedite smooth passage of goods through indication of arrival and departure of shipments to various individuals in the supply chain; to lower the need for larger inventories and to reduce the storage capacity for these inventories; to facilitate border crossing through

electronic release of invoices between importers or brokers and custom officials; and to enable vehicle and cargo identification and tracking through use of vehicle positioning systems, automatic equipment identification, transponders and satellite tracking.

Internet services: The Internet enables shippers and transportation providers to do business directly on the Internet. In addition, systems are being developed whereby shippers can indicate the precise nature of their shipments and schedule requirements, and transportation providers or individual companies can make bids. This can save shippers and companies time in providing cost estimates on the cargo to be shipped.

Logistics: The management of the entire supply-chain from sourcing of raw material to distribution of finished products is referred to as logistics. The more sophisticated logistics systems are increasingly using high-tech equipment like bar code scanners and computer logging and tracking systems which are more suitable for handling high volumes. In addition, third party logistics providers are being increasingly considered since they specialize in their function thereby reducing cost. This may facilitate the move towards intermodal shipping.

ITS: ITS in trucking brings together the road user, the vehicle and the road infrastructure in a single communications system that operates in four performance areas: location, identification, assessment and control. This enables better fleet management through automated vehicle location (AVL), route guidance to avoid congestion; rapid transit through weight inspection stations and border crossings as a result of automatic vehicle identification (AVI); etc. This ultimately leads to efficiency, lower costs and service improvement.

In rail, simpler tracking technologies are used (bar codes and transponders on cars with readers attached to infrastructure) due to concentration in this industry. It enables better monitoring of trains, provides information on delays, enables better sharing of tracks and better shipment management. ITS covers areas such: radio and signals, rail traffic dispatch and control, automatic equipment ID and

tracking, and interlining system with other railroads.

In marine transport, ITS is used by shipping companies and by marine infrastructure providers. The former uses global positioning satellites with electronic digital charts as well as ship to shore communication to track ships and calculate optimal routing and scheduling. The latter uses ITS to track movement of ships and cargo within a port or canal to optimize loading and unloading by allocating berths and cranes; storage and location of containers in yards (through spread spectrum technology); and cargo pick up and delivery by other modes.

In air transport (excluding passenger), the use and adoption of ICT technologies has been the first among the modes largely due to the nature of the overnight delivery transborder service industry. The need to keep track of packages from the time of pick-up, sorting at the overnight terminals, air movement and courier delivery has necessitated the need for use of technologies such as bar codes and courier communications. In addition, both navigation systems and cargo airlines use GPS-based satellite tracking, allow for ongoing consolidation of air traffic and control of the infrastructure.

*New technologies affecting intermodal transport:* New technologies affecting intermodal transport can be classified into: 1. Technologies related to a specific mode and infrastructure; and 2. Technologies related specifically to intermodal transport. Regarding the first, in the marine mode the most significant development is the mega-sized carrier. The size of the containership has evolved from about 600 TEUs in the 1960s to 4,000 TEUs in the late 1980s and 7,000+ TEUs in early 2000. China Shipping and Maersk Sealand intends to or has ordered ships of 9000 TEUs or more. In the rail mode, the most significant development is the development of the use double stack trains. There has also been significant investment in infrastructure: to build new container terminals, to dredge the Port of Montreal for larger ships, to complete tunnel clearance, to purchase railway lines in the US, to create innovative services (Iron Highway Road Railer) etc.

Regarding the second, the development of new intermodal

technologies has largely been for distance over which truck and rail compete or provide substitutable services. New shorter trains have been developed which simplify the loading and unloading process for trailers on trains. The new trains do not require the trailers to be lifted. This reduces the time and cost of mode-to-mode transfer. Other examples in this area are the modification of a trailer so that it can be attached to rail wheels and pulled by a locomotive, and a train that is a continuous platform on which trailers can be driven and parked.

*Benefits of the application of ICT to Intermodalism:* The basic benefits for intermodal transport from the above description are: i) reduced paper burden and operational costs associated with automated and electronic transactions; ii) new and increased market opportunities for suppliers and users; iii) improved monitoring and managements flows; iv) time savings and operational efficiencies; and, v) more reliable transportation. All of these benefits will undoubtedly have an effect on improving efficiency, reducing costs, and improving transportation services to users.

There are also numerous other benefits such as: increased safety, reduced accidents; reduced environmental impacts; reduced regulatory burden; and improved data collection for more effective policy planning. As indicated by Transport Canada "The potential benefits of ITS applications are considerable for all concerned including users and providers of services, the public sector and the public at large. ... The key benefits of ITS technologies are improved safety of the transportation system, reduced congestion and improved mobility, enhanced economic productivity, reduced travel time and government, traveller and operator costs, improved energy efficiency and reduced impacts on environment."[9]

In light of this, the CTA Review Panel recommended: a co-operative program with the national carrier associations in all modes to facilitate and encourage e-business and e-commerce skills and training in the application of the technologies; and the development of e-government initiatives to streamline the communication process.

**Concluding Remarks**

Intermodal transport services are one of the most important recent developments in transportation. Testimony of its importance is not only its significant growth but also investments in projects such as the recent launching of Montreal's $47m. intermodal facility and the completion of Vancouver's Deltaport facilities.

Surprisingly, there is no regulatory framework that specifically governs intermodal transport in Canada nor is there any specific law which encourages its development. This does not imply that it is not affected by other laws such as the *Competition Act*, a law of general application. However, intermodal mergers, joint ventures and alliances have rarely raised an issue under this Act.

Intermodal transport systems can provide competition often sought by policy makers when there are no competitive alternatives. The recent boost given to intermodal transport as a result of advancement in ICT should not only lead to increased efficiency and lower costs but also better service to customers. Encouraging the development of this form of transportation would therefore not only be beneficial shippers and carriers but could also lead to an increase in exports and imports.[10] This was also indicated by the Minister of Transport who stated at the CITT conference "...intermodalism is good for all of us. It is anti-congestion. Its about making the best possible use of all modes. It helps us move goods more efficiently."

**Bibliography**

1. **Transportation in Canada 1996**, Annual Report, Transport Canada, TP 13012E.
2. **Developments in Intermodal Transport in North America**, Oct. 1987, TC.
3. **The Canadian Trucking Industry's Stake in Intermodal Transport**, TC, 1994.
4. **Competition in Transportation**, Policy and Legislation in Review, Volume II, National Transportation Act Review Commission, 1993, pp. 123-133.
5. Prentice, Barry E., "Shipment of Grain to Mexico: Sea Routes vs. the Mid Continent Corridor," **CTRF**, May 25-27, 1997, pp. 370-383.
6. O'Keefe, Doug, "Canada's East Coast Container Ports, Do they Compete With or Complement One another in the Race for North American Container Traffic?", **CTRF**, May 23-28, 1998, pp. 154-169.
7. **Transportation in Canada 1998**, Annual Report, TP 13012E, pp. 147-166.
8. **Proceedings**, Transport Canada Seminars on the Impact of Information and Communications Technology on Transportation, Ottawa, Ontario, November, 1998.

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

## Endnotes

Intermodal transport is defined here as the movement of unitized freight, either in containers or highway trailers, on a single bill of lading or a single waybill, by two or more modes of transport in a continuous operation. Here the term intermodal transport will be used interchangeably with multimodal transport.

Competition in Transportation, Policy and Legislation in Review, Volume 11, 1993, p. 123.

Bryan I. A. and Y. Kotowitz, Shipping Conferences in Canada, Consumer and Corporate Affairs Canada, 1978, p. 17.

"Subsection 4(1) [exemption from the *Competition Act*] does not apply in respect of a conference agreement if the parties to the agreement enter jointly into any contract, agreement or arrangement with any carrier in Canada for the purpose of establishing the amount to be paid by any party to the agreement to any such carrier for the inland transportation of goods for which that party has charged a through rate for the transportation of those goods."

The EC Regulations on shipping conferences also do not provide intermodal exemptions. However, the US law (i.e., *The Shipping Ocean Reform Act of 1998*) does provide an exemption provided it does not violate the antitrust laws and is consistent with the purposes of this Act. (i.e., s. 10(c)(4)).

*Merger Enforcement Guidelines*, Director of Investigation and Research, Competition Act, pp. 41-42.

For the exemption, joint ventures must ensure that they are true joint ventures and ensure that it is not designed to prevent competition. The joint venture cannot be structured as a corporation and must be formed to undertake a specific project or research and development. In addition, it must be demonstrated that the project would not reasonably have taken place in the absence of the joint venture. It must also be shown that no change in control to any party to the combination resulted or would result from the joint venture. Further, all the persons who formed the combination must be parties to an agreement in writing, requiring some of them to contribute assets over which a continuing relationship exists. Furthermore, the agreement must restrict the range of activities that may be carried on and it must provide for termination on completion of the project. Finally, the combination should not prevent or lessen, or should not likely prevent or lessen competition except to the extent reasonably required to undertake and complete the project.

These alliances raise concern as it raises barriers to entry in that a potential entrant in order to gain a toehold in the market must be accepted as a member to these major international alliance. Thus, the potential to damage competition increases. Behaviour that is particularly injurious to competition are agreements in respect of prices, output, marketing strategies or other areas important to rivalry.

Canada's ITS Plan, Transport Canada, November 1999, p. 7.

On November 8, 1999, the Minister of Transport announced a funding of $7 million for ITS. Under SHIP $30m. are available for ITS projects. Other projects have also been funded eg. STRAIT PASS.

**Locating Warehousing And Logistics: Exploring The Link Between Transportation And Land Use In Calgary: 1963-2001**

Clarence Woudsma, Associate Professor, Department of Geography, University of Calgary cwoudsma@ucalgary.ca

John F. Jensen, Graduate Student, Department of Geography, University of Calgary, jfnjense@ucalgary.ca

Abstract

The importance of transportation-land use issues was highlighted in a recent news interview with the Federal Minister of the Environment where he commented with respect to the Kyoto Accord that, "Cities must examine their land use planning attitudes and goals and begin to plan for use that promotes decreased emissions." (CBC, Oct. 24th, 2002) This poses challenges for both government and industry since the interrelationships between transportation and land use remain contentious despite extensive research. In particular, the influence of transportation system performance (typically congestion or travel time) on land use development has yet to be fully understood. This paper describes the development of a novel historical spatial-temporal approach to answer this transportation-land use question. The approach is based on the creation, modification and analysis, within a Geographic Information Systems (GIS) framework, of extensive historical databases of transportation system performance (traffic volumes) and land use data (actual land parcel use type and year of development) for the City of Calgary. An example focus is on warehousing/logistics land uses, which are critically

important to Calgary's economy, and broadly under-examined within the field. The intensity of warehousing development in a given time period is related to a series of independent access oriented variables in an attempt to capture the strength and timing (lag) of this relationship. Early results indicate that at a system wide level, the timing and location of warehousing/logistics development is statistically shown to be associated with high congestion areas. However, focusing on a zonal scale, the relationship between developments and zone proximal congestion is less clear.

## INTRODUCTION

Globalization and the knowledge (technology) economy are viewed as the major forces shaping our economy and our cities. It has been argued that one key result is that distance no longer matters, and many transportation sectors are viewed as being "old economy" – definitely not cutting edge! It follows then that if distance no longer matters, neither does location. However, those in the industry and beyond would disagree, and in fact argue the converse (Hesse, 2003). Today, location more than ever is a critical consideration. The goal of this research is to explore the location of warehousing and logistics in the City of Calgary, with an eye to understanding the influence of the broader transportation system. How does, for example, increasing congestion influence the location decisions of firms within Calgary, and those coming to Calgary? These questions are not only important from a businesses efficiency standpoint, but also with respect to major environmental issues like air quality and greenhouse gas emissions. This link between the transportation system and land use decisions is therefore our focus.

There is an extensive body of research in this area, yet, a number of key gaps remain. First, the impact of land use (urban activity) in the form of traffic generated on the transportation system is extensively modelled using well-developed methodologies including the urban transportation

modeling system (UTMS) or four stage models, individual choice models and activity-based models (Meyer and Miller, 2002) however, there are questions about our understanding of the causal links between urban form (land use and transportation infrastructure) and travel behaviour (Boarnet and Crane, 2001). Second, transportation is considered to be an enabler of land use from the perspective of technological advances (e.g. invention of the automobile), and infrastructure development among others, but there is not a common view on how to model land use response to transportation system change or even what the significant relationships are ( Boarnet, 2000). Third, these gaps in empirical research are exacerbated by the fact that most research efforts have been directed towards the movement of people, not goods resulting in an even greater knowledge gap with respect to the non-residential transportation/land use relationship (Woudsma, 2001). The motivation for this research stems from these gaps in the literature.

The aim of this research is to explore and quantify the relationship between transportation system performance and land use development using a historical spatial-temporal approach based on thirty-four years of transportation and land use data. It is expected that this research will contribute to our understanding of the transportation/land use relationship and afford benefits related to 1) the application of a new approach to examining the influence of transportation system performance on land use based on the use of extensive historical data, 2) development of a spatial-temporal methodology that can be applied in other jurisdictions, and 3) development of a methodology that can be used in medium to long range city planning.

*Transportation and Land Use*

The influence of transportation on land use has generally been understood through the application of transportation costs in theoretical models of household and firm location decisions (for

an extensive review, Torrens, 2000). The two major theoretical paradigms with respect to these models are the: 1) economic-behavioural and 2) network equilibrium. Giuliano describes these approaches as being somewhat problematic for several reasons. 1) "They are static in that time is not incorporated", despite general acknowledgment that there is a lagged relationship between transport accessibilities and land use development . 2) They generally focus only on one part of the transportation/land use problem (e.g. residential land use). 3) They typically apply one or more simplifying assumptions (e.g. households locate at a point where commuting and housing costs balance within constraints imposed by income). These limitations result in a simplified approach to solving the problem, but a simpler approach may not be problematic since it tends to make the problem manageable.

*Integrated Models*

Integrated models simulate the interaction between the transportation and land use systems by means of feedback mechanisms generated by sub-models representing the various components of the two systems (for a thorough discussion and review see Hunt et. al, 1999). These models are useful in that they are able to reasonably replicate actual land use and transportation patterns; they provide a tool to forecast future urban patterns; and they facilitate controlled testing of theories and practices. However, although useful, these models have some limitations. For example, Hunt et al. (1999) found several limitations including:

1. Most models are static equilibrium models with large time steps. All models are zone-based, often with very large zones.
2. Goods movement only represented in MEPLAN/TRANUS.
3. All models use variations on conventional four-stage modelling systems, and so are susceptible to all the criticisms of these models.

Of particular relevance to the research presented here is the limitation related to the existence and characteristics of the lag between the influence of transportation on the land use system.

*Research Objectives*

We know there is a land use response to negative network externalities, such as congestion, but we do not fully understand how these externalities are internalized and ultimately manifest as urban form; nor is there a common view on how to model land use response to transportation system change. In order to address this aspect of the transportation/land use problem, this research poses the question: Does transportation system performance have a quantifiable, although temporally lagged, influence on the timing and spatial character of non-residential (commercial, industrial and retail) land use development? In this paper, the focus is on exploring this link as it relates to the warehousing and logistics sector in the city of Calgary.

## METHODOLOGY

*Study Area*

Calgary was selected as the study area for several important reasons. The key spatial data inputs required for this research are in place and include i) transportation system performance represented by average weekday traffic (AWDT) on Calgary's major streets and expressways for the period 1964-1998 incorporated in the 2001 *Roadnet* database and ii) land use in the form of approximately 270,000 individual land use parcels and attributes including actual use codes and building year of construction. Secondly, Calgary is a young, dynamic community that is experiencing considerable economic growth. Also, Calgary is strategically located as a major distribution hub for western Canadian markets and the logistics transportation sector represents one of the major growth areas with firms like WalMart and Sears establishing new logistics centres recently. Thirdly, Calgary has a well-developed urban planning process

that is facing significant challenges in the areas of transportation and land use planning. According to The City of Calgary 2001 Annual Report, transportation infrastructure falling behind the speed of growth was the number one issue for Calgarians in the 2001 Customer Satisfaction Survey. The report also stresses Calgary's intent to combine and use planning initiatives and transportation operations strategies. It is apparent from these points that research of this nature in Calgary is both appropriate (data is available) and timely (the city is experiencing transportation and land use challenges).

**Data Development**

Roadnet is a GIS (Geographical Information System) spatial database containing the City of Calgary street network along with key attributes including street name and address information, class code (e.g. expressway), direction of flow, and arc length. In addition to this baseline network information, the database was recently augmented to include traffic volume data as part of this research project. The City of Calgary Transportation Data Group has collected traffic volume information since 1959 through a variety of methods including: Automatic permanent count stations, portable automated pneumatic hose count stations, manual counts and other special counts.

The collected data are used to create hardcopy flow maps displaying AWDT (vehicles/weekday) for major streets in the City. Since collected traffic volume data is aggregated into general flows, it provides only a perception of volume on city streets rather than specific volumes across the network. It is assumed that this volume data fairly represents traffic flow on city streets. AWDT information from these flow maps for the years 1964 to 2000 has been input into a GIS database and merged with *Roadnet*. This process involved over 500 person hours of manually reading and inputting link volumes from hardcopy maps (for each year, a citywide, and city core map were created) into a GIS database.

Land use data is derived from the registered land parcel rolling database which is made up of 270,000 records including attributes such as zone (e.g. R1 – residential 1), type (e.g. single family dwelling), year of construction and geographic coordinates. The fact that these are rolling databases means that land use types and years only reflect the

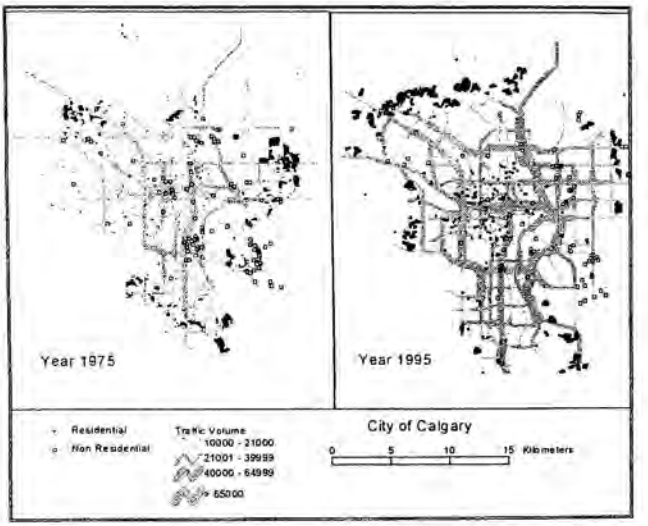



Figure1 Comparison of New Development and Traffic Volumes

most recent database updates and any changes are lost. Therefore, transportation influence on land use will be considered from the perspective of new growth as opposed to changes to existing land use. The parcel database contains polygons of all land parcels in Calgary and will be used to add an area attribute to land parcel point data. The building footprint database contributes a building polygon that can be merged with the point databases and the parcel polygons to

produce a comprehensive spatial representation of every land use parcel in Calgary.

## Analytical Methods

*Data Enhancements*

The first major data enhancement is converting the AADT volume data into a meaningful representation of congestion, or more general, system performance. This is accomplished through the development of a congestion index attached as an attribute to each link in the road network and then a travel time function has been calculated as a second step.

Development of the first congestion index first requires the calculation of link capacity. It is determined using capacity analysis methodologies readily available from the Highway Capacity Manual. First, lane information has been manually included at a general level based on knowledge of the City. Second, free flow speeds based on the HCM street classification are used in conjunction with Level Of Service (LOS) D to establish maximum capacity. LOS D was chosen since it represents approximately 40% of free flow speed and is associated with signalization and heavy volumes. In the City of Calgary, there is only 1 major length of unsignalized expressway so this was deemed appropriate. Next, the volume data, which is presently in the form of annual weekday averages, is converted to Annual Average Daily Traffic (AADT) using the prescribed conversion factor and is distributed throughout the day using typical traffic distribution K and D functions. K and D factors represent the proportion of total daily traffic that occurs in the peak hour. Finally, a volume capacity ratio is calculated to provide a basis for a congestion index. This is a relative index that is not tied to units of measurement, which permits comparison between links. Measures of this type are commonly used to represent traffic flow conditions. This first index is used to represent

transportation system performance and provides the basis for further analysis.

The second, link travel time measure is based on actual link information provided by the City of Calgary transportation engineering department. This link travel time measure is used to create a series of accessibility variables which play a role in explaining the pattern of warehouse locations over time. For example, access from a series of sample points within the city to various points of interest like the airport, intermodal yards, the core and a selection of random points is calculated based on least cost path determination. What results is a surface representing how accessible each point is in the city to a point of interest. These variables will play a role in the multivariate analysis.

For any given year, the parcels developed can be displayed and analyzed as individual points, or linked with their parcel and building footprint for a more two dimensional analysis. However, in order to capture the intensity of development in certain areas, it is necessary to establish a spatial unit e.g. zone. In the first case, the transportation zones established by the Calgary transportation department are utilized in order to calculate measures like the change in developed space between given years within a zone. In the second, multivariate phase, an intensity of warehousing development is calculated for a series of grid sample cells covering the city. This measure is the dependent variable and represents the amount of new warehousing per unit area in a given year.

*Investigating Relationships between Transportation and Land Use*

The challenge is to take the congestion index and relate it to the development patterns for warehousing. In this paper, we present two approaches. The first employs a buffering technique in a GIS environment to determine the average

system performance associated with a given warehousing zone. The system performance or congestion index is averaged within a 5 km radius of a given zone centroid and that value linked to each zone. This facilitates statistical comparison with rates of development within each zone. The 5 km distance is arbitrarily chosen to capture the influence of major roads in the network, however, this distance will be varied and sensitivity analysis conducted in order to establish the most appropriate influence range.

The second approach involves multivariate spatial autoregression to relate warehousing intensity in a given year to a series of independent variables related to access to various features in different time frames. Spatial autoregression is chosen over traditional regression because the pattern of warehouse development exhibits a distinct clustering, with the consequence being a lack of independence in the error terms.

## RESULTS AND DISCUSSION

The system performance or congestion index is based on HCM (TRB 2000) formulations and determined for each link in the AWDT based road network. Not surprisingly, Figure 2 illustrates recent steep increases in values for expressways and main roads, while collectors and streets exhibit less dramatic increases. Calgary is a rapidly growing city and traffic congestion is considered a major issue; a fact supported in this chart. The average for expressways were regressed against population ($R^2 = 0.98$) employment ($R^2 = 0.94$) and car ownership ($R^2 = 0.85$) over the study time frame as a means of simple verification. This suggests that despite the inability to truly verify the base AWDT data, the resulting index is a good proxy.

Linking the transportation and land use elements with a focus on the warehousing land use sector is presented in figure

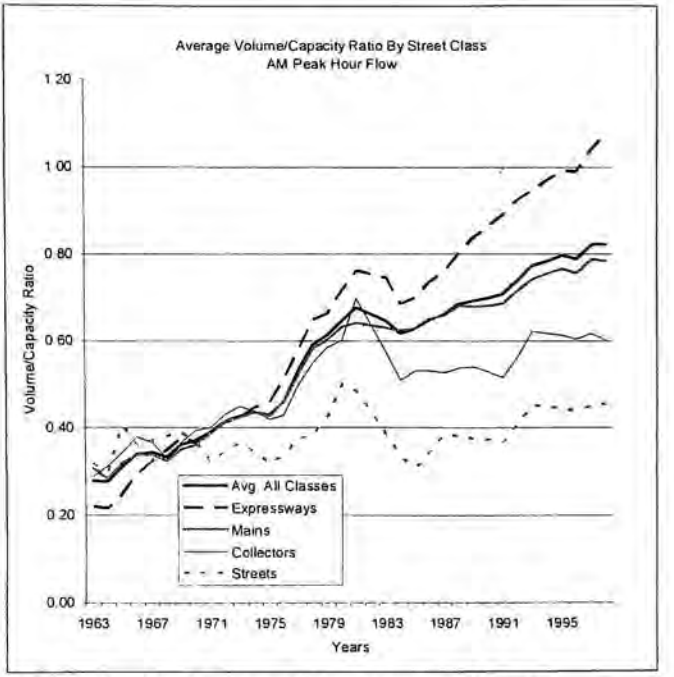



**Figure2. System Performance Change by Road Class**

3 and demonstrates the previously identified increasing trend as the growth in traffic outstrips the addition of capacity. The bars representing added warehousing land use in each year exhibits steady growth in the 70s followed by a sharp drop associated with the recession of the early 80s. The sharp spike in 2000 reflects the opening of major logistics centres for WalMart and Sears. Statistically, the relationship between these two variables is strongly positive ( Pearson's R = 0.754), a fact replicated with other change variables not presented here, but reflecting rates of change. This suggests that system

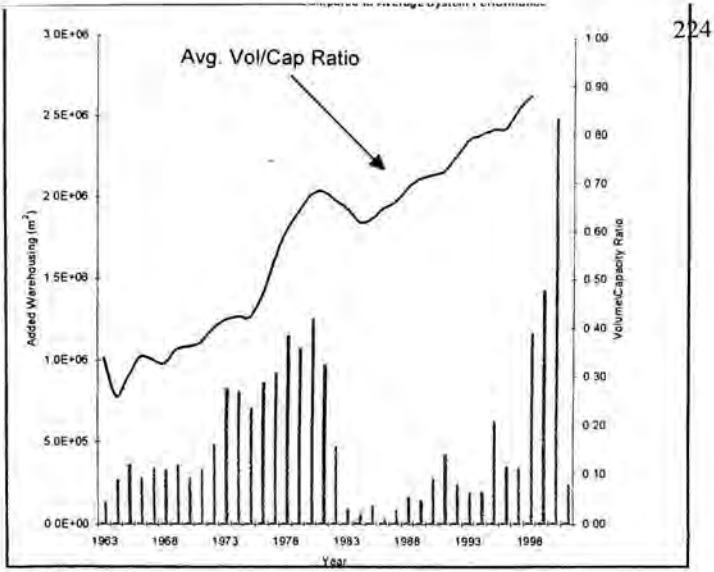



FIGURE 3 Aggregate Comparison of System Performance to Warehouse Development Through Time

wide, increasing warehousing land development is associated with increasing congestion, confirming an intuitive perspective. However, it is an aggregate view that does not fully exploit the potential within the databases created

The volume/capacity ratio (system performance or congestion index) is averaged for all links and weighted by lengths within the 5km zone. Examining development and the congestion index specifically within a single zone from 1964 to 1998 provides a more muddled view. A straightforward statistical comparison between the two variables reveals a weak correlation and this fact is true in most cases for the 56 zones examined. Visually, the periods of stable or low congestion in the early 70s and mid 80's tend to be followed by periods of increased warehousing development 5 years in the future. The second part of our methods aims to statistically verify these lags.

*Mulitvariate Results*

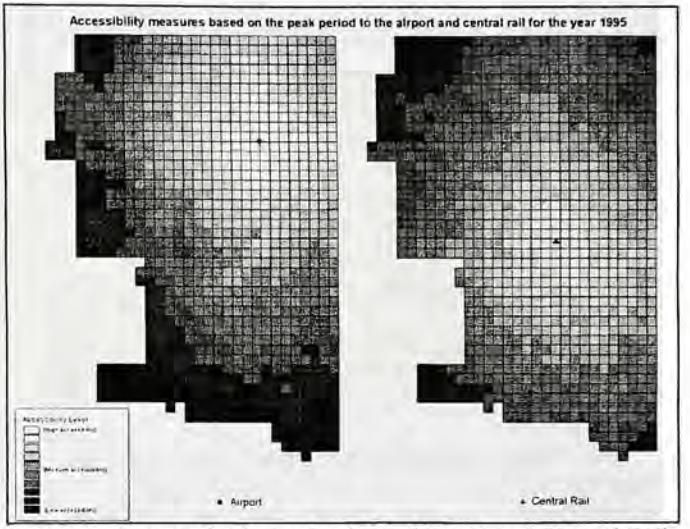



**Figure 4: Access Surfaces for 1995, Airport and Central Rail**

The above figure represents the accessibility of points within the city of Calgary to the airport (left) and central rail yard (right). Although this looks like a simple concentric pattern with decreasing access as you move away from each feature, there is actually considerably more to it. As indicated previously, each grid cell is connected to the road network and the least cost path from each cell to the feature is calculated, in this case based on am peak hour travel times on each link. It is therefore a more informed measure of access than simple distance.

In the model, intensity of warehousing in a given year (2001) is regressed (using spatial regression) against a range of accessibility variables. A typical result provides parameters as follows: access to north highway exit, -7.3599 (t-score 2.04), access to airport, 7.79 (t-score 2.2). The overall model fit is

acceptable, but there is clearly many considerations missing. The results here suggests that warehousing intensity is strongly related to airport access but less so to the northern city exit. This is perhaps reflecting the centrality and general business clustering around the airport. In future analyses, accessibility from different years will be included in order to specifically address the empirical nature of the hypothesized lagged relationship between transportation and land use.

## CONCLUSIONS

This paper has presented arguments which support the development of a simple approach to the continuing challenge of understanding the relationship between transportation and land use. This simple approach is based on the creation and use of historical databases which reflect the transportation system performance and micro-scale, parcel level data on land use, actual use, and year of development. The results have supported the appropriateness of the data development. At a system wide level, evidence supports the argument that increasing development of warehousing is associated with increasing congestion. This is an obvious result and is included for validation of our approach thus far. Focusing on individual zones, the relationship between development and congestion is less clear, although weak evidence for the existence of lagged effects is shown. The multivariate results providie further support for the statistical importance of the relationship between system performance and patterns of warehouse development. However, the key question of the empirical nature of the lagged relationship between transportation and land use remains to be resolved in future work.

## AKNOWLEDGEMENTS

The authors' would like to acknowledge the Data Collection Group, Planning and Transportation Policy, City of Calgary Land Use and Mobility who provided generous data and consultative support. Financially, we acknowledge the support of the Social Sciences and Humanities Research Council of

Canada and Canada's National Science and Engineering Research Council.

## REFERENCES

Boarnet, M., and R. Crane. The influence of land use on travel behavior: specification and estimation strategies. Transportation Research A, Vol.35, 2001, pp. 823-845.

Boarnet, M. G. Do highways matter? Evidence and policy implications of highways' influence on metropolitan development. A Discussion Paper Prepared for The Brookings Institution Center on Urban and Metrolitan Policy, 2000 pp. 1-37.

Hesse, M. (2003), Location Matters, Access vol 21, 22-27

Hunt, J., Kriger, D., and E. Miller. Current operational urban land-use transport modelling frameworks. in Proceedings of the 79th Annual Meeting of the Transportation Research Board (CD-ROM) TRB, National Research Council, Washington, DC. 1999.

Meyer, M. D., and E. J. Miller. Urban transportation planning: a decision-oriented approach. Second ed., McGraw Hill, Boston, 2001.

Torrens, P. M. How land use transportation models work. Centre for Advanced Spatial Analysis, University College, London, Working Paper Series, No. 20, 2000, pp. 1-75.

Transportation Research Board. Highway capacity manual - HCM 2000 (Metric Units). TRB, National Research Council, Washington, D.C., 2000.

Wilson, A. G. Land-use/transport interaction models: past and future. Journal of Transport Economics and Policy, Vol. 32, No.1, 1998, pp. 3.

Woudsma, C. Understanding the movement of goods, not people: issues, evidence and potential. Urban Studies, Vol. 38, No.13, 2001, pp. 2439-2455.

# Border-Related Costs Attributable To U.S.-Canadian Border Crossings

John C. Taylor, Grand Valley State University
Douglas R. Robideaux, Grand Valley State University
George C. Jackson, Wayne State University

## Abstract

The U.S. and Canada are the world's two largest trading partners and have experienced rapid growth in trade volumes over the last decade. However, this "longest undefended border in the world" has come under increased security scrutiny, especially since the September 11, 2001, terrorist attacks. The additional security procedures have added to the preexisting costs of border crossing, which were already considered burdensome. This research was undertaken to develop estimates of economic costs attributable to U.S. and Canadian border crossings. These cost estimates were derived from multiple secondary and primary research methodologies. The general cost of border crossings between the two countries is estimated at about $6.3 billion per year. The costs associated with border transit time and the uncertainty of border transit time are estimated at another $4.0 billion. Recommendations for reducing these border costs are discussed.

## Introduction

The U.S. and Canada are the world's two largest trading partners and have experienced rapid growth over the last decade. While the border is often referred to as the longest undefended boundary in the world, the customs processes that are used to manage the border are rooted in a system developed to collect customs duty and control the flow of peoples. These processes have had a significant economic

cost to the economies of the two countries. The cost has been exacerbated by the increased border transit times, and the uncertainty of transit times, since the terrorist attacks of September 11, 2001. This paper reports on the results of a research project aimed at estimating the impact of border related costs. Understanding these costs will be important in order to estimate benefits due to any future changes in the way the border is managed.

## Concerns of U.S.-Canada Trade Levels

In 2000, trade between the U.S. and Canada was the world's largest bilateral trading relationship, with total trade in goods, services and income of US$489 billion. For perspective, this was 52% greater than the trade with the U.S.'s number two trading partner, Japan (Canadian Embassy 2001). U.S.-Canada total trade has grown by 152%, or 13.8% per year since implementation of the U.S.-Canada Free Trade Agreement in 1989. U.S. exports of goods to Canada totaled US$178.9 billion in 2000, or some 23% of all U.S. exports. The U.S. market is even more important to Canada's economy, with exports to the U.S. in 2000 totaling US$230.8 billion and representing 87% of all Canadian exports. Trucks moved 72.6% of the value of exports from the U.S. to Canada, and 55.4% of the value of goods moving from Canada to the U.S. The U.S. and Canada are also major sources of foreign direct investment for each other, with US$227 billion invested in each other's countries at the end of 2000. For 2001, merchandise trade between the two countries totaled US$382 billion, with truck borne trade totaling US$235 billion. Personal travel between the two countries is also extensive, with 19.4 million person visits in the 2$^{nd}$ Qtr of 2002, and some US$2.83 billion in spending by these travelers.

Providing for proper anti-terrorism security checks on all the necessary vehicles, while facilitating the free flow of goods and people, was a daunting task pre 9/11 and has become all the more difficult since 9/11. One problem is the extreme concentration in traffic at several key crossings, and the extensive growth in traffic at

these crossings. For instance, out of 130 border crossings, the four Ontario-Michigan crossings accounted for 35.9% of the northern border's total bidirectional truck traffic in 2001, and the Peace Bridge and Lewiston-Queenston Bridges in the Buffalo-Niagara area accounted for another 17.2% of the total. Truck traffic at Windsor-Detroit has grown 133.2% since 1984, and by 446.5% at the Sarnia-Port Huron crossing. It is also important to note that the bulk of this truck traffic crosses the border at locations that turn out to be key points for auto traffic as well, further congesting these crossings and straining the capacity of the existing bridges and tunnels over the river way border between the U.S. and Canada in these regions. In 2001, the 15.3 million autos crossing at the two Detroit-Windsor crossings represented 22.4% of total border traffic, with an average daily flow over a 365 day year of 41,918 autos per day, or 2,619 autos per hour over a 16 hour per day year. The four crossings at the Niagara frontier generated an additional 14.2 million bidirectional crossings, or 20.8% of total northern border auto crossing activity. In total, these six crossings account for 43.2% of all auto crossings at the northern border's 130 ports of entry. This concentrated volume of truck traffic at equally congested auto crossings points out some of the problems in trying to increase border security without leading to major delays and uncertainty that could have the effect of reducing trade and transportation.

And indeed, while trade and truck traffic grew substantially over the 90's, there has been a dramatic slowdown in Canadian exports to the U.S. since 9/11 and a slight reduction in truck traffic. This fall-off in Canadian exports to the U.S. by land will be of considerable concern in Canada where a number of trade associations, such as the Canadian Association of Manufacturers and Exporters, have expressed fears that post 9/11 perceptions of border delays and uncertainty might have this effect (MacFarlane 2001, Dobson 2002, Lawson 2002,The Windsor Star 2002, ).

For the summer of 2002, border transit times were not dramatically longer than they were pre 9/11, but there has been considerable

publicity about border problems immediately after 9/11, and there is greater uncertainty today over the time it will take to cross the border. In addition, there has been considerable press about the need to "secure" the northern border, and this may have led to buyers having some qualms about using Canadian sources. Border crossing processes and procedures, and their costs, were coming under scrutiny pre-9/11 (Kenna 2001, National Post 2001, Tricky 2001) and have received much more attention in recent months. However, what are the cost impacts of the border on trade and personal travel? The objective of this paper is to identify border related costs for manufacturers, carriers, and personal travelers. Once these costs are identified it will be possible to estimate the benefits that might accrue from different border management strategies such as an "external perimeter," or "open border" approach.

## Methodology

In order to estimate overall border costs, funding was obtained from the U.S. Department of Transportation , and the Michigan and New York Departments of Transportation. Additional funding support was provided by the Canadian Embassy. The results of this work are under final review and the full report will be released shortly, however the information reported on here is final. In order to estimate border related costs to the economy, a combination of secondary source reviews and site visit/personal interviews were used. The information gathered in these reviews was then used, along with a variety of assumptions, to make cost estimates for each category of potential costs. Examples of specific cost impacts on each of these types of border users include primary booth transit time, secondary inspection yard processing time, reduced cycles for carriers, lost productivity from reduced trade, higher inventory carrying costs, etc.

The secondary source review included identification, analysis and categorization of cost impacts from a review of some 750 newspaper articles on border issues. These articles appeared in 25

Canadian and 18 U.S. newspapers that were reviewed. Other secondary sources included some 45 border management reports on the overall border crossing environment or on specific border crossings, and several previous studies on the extent of and costs of border transit times. Key reports that were used are summarized in the References. In addition several key secondary sources of data on trade, traffic, tourism, and transit time were used. These key sources included Bureau of Transportation Statistics reports on U.S.-Canada trade by year and month, U.S. Customs Service reports on monthly and annual traffic flows into the U.S., Statistics Canada reports on vehicle traffic entering Canada by year and month, and Canada Customs archives on border transit times for commercial and passenger vehicles entering Canada and the U.S. These specific reports are also summarized in the References.

In addition, in order to gain a better understanding of the nature of various border crossings and to better understand the extent of border costs, a series of site visits to key border crossings were conducted during the summer of 2002 in order to make observations and conduct interviews. The seven key border crossing frontiers at Champlain, NY-Lacolle, Ont (and Vermont crossings).; Niagara Falls, Ont.-Niagara Falls, NY (three crossings); Buffalo, NY-Fort Erie, Ont.; Windsor, Ont.-Detroit, MI (two crossings); Port Huron, MI-Sarnia, Ont.; Emerson, MT-Pembina, ND; and Douglas, BC-Blaine, WA (four crossings visited) were visited. Based on these site visits and other sources, a total of 173 personal and/or telephone interviews were conducted in order to assess the impact of border transit time and other border related costs. These interviews were conducted with manufacturer, carrier, broker, trade development, and trade association organizations.

In order to develop a detailed cost analysis we sought first to identify the types of cost impacts that are due to border costs, and then to develop high, medium and low estimates of those costs. We also developed estimates of general border costs due to carrier customs administration and cabotage costs, and manufacturer

related costs categories such as those related to customs administration, customs brokerage fees, and remaining duties.

Our interviews, site visits and review of numerous reports identified both macro indicators of border related impacts, and specific categories of actual costs. The following sections review these macro impacts with some detailed cost categories and actual estimates of costs that firms encounter.

**Macro Indicators of Border Impacts**

Several macro indicators of border related impacts have been identified. These macro indicators relate to the drop-off in traffic levels since 9/11, the relationship of cross-border freight rates to U.S. domestic rates of an equivalent nature, and the border crossing planning time being assumed by third parties and carriers.

One indicator of the impact the border has, which relates specifically to the events of 9/11, is the level of cross-border Canadian land based exports and traffic to the U.S. Cross-border Canadian land based exports to the U.S. in the nine months following 9/11, as compared to the same 9 months pre 9/11, were down 10.8%, despite U.S. industrial production remaining relatively flat and U.S. auto production actually increasing 4.2%. This decrease in imports to the U.S. may be due to several factors but it clearly is due at least in part to the perceived and actual transit times and uncertainty related to border crossings. This reduced level of Canadian exports to the U.S. has significant impacts not only in Canada, but also in the U.S., where companies are now forgoing productivity benefits that accrued from these imports. These losses in productivity benefits and their cost impact are estimated in the following section on detailed cost impacts.

Another indicator of a border impact from the 9/11 events relates to the reversal of the decade long trend in cross-border truck traffic growth rates since 9/11. Between 1984 and 2001, border-wide two way truck traffic grew at an annual rate of 7.2%. Truck traffic into

the U.S. alone grew at a similar rate. However, when the nine months post 9/11 are compared to the same 9 month period pre 9/11 we find a 2.2% decline in truck traffic into the U.S. border-wide. While traffic declines were at a slower rate than would be expected by the level of trade fall-off, this decline in truck numbers does represent a significant impact resulting from the border. Interestingly, auto traffic was down by some 14.5% for the same pre and post 9/11 nine month comparison period, mostly by same day travelers.

Several interviews resulted in information indicating that cross-border trucking freight rates are considerably higher than would be the case for similar domestic U.S. moves (Freight Carriers Association of Canada 2002, Overland 2002, Liberty 2002, Holland 2002, Yellow Freight 2002, Reimer Express 2002, and Con-Way 2002, Western Logistics 2002). While there are several reasons for these higher rates, including historical practice and the overall supply demand relationship, interviewees suggested that one of the key reasons relates to border crossing transit times, uncertainty about border crossing times and costs, and the costs of border related administration and information systems support. How much higher are cross-border rates? The Freight Carriers Association of Canada suggested cross-border rates are 10-15% higher than comparable domestic rates. However several carriers told us their cross-border rates are 20-35% higher than domestic U.S. rates, with the lowest suggested rate premium for cross-border freight being 10%. It is also important to note that several carriers charge a border crossing premium routinely, and/or wait time at the border. For instance, LTL and Roadway subsidiary Reimer Express charges a $20 per consignment fee for all cross-border freight (Reimer Express Interview 2002). Con-Way Transportation has an $8 surcharge (Schulz 2002). These two carriers alone estimate border crossing administration costs of US$25 million. The estimates of cross-border freight cost penalties and results in cost estimates ranging from US$.94 billion to US$2.35 billion with a midrange estimate of US$1.59 billion. These estimates start with the value of cross-border trade moving by truck, and assume typical domestic

freight rates as a percentage of these trade values equal to 4-5% depending on the scenario. These freight costs %'s are based on published data from Herbert W. Davis and Company (2002). Penalty costs of 10, 15, and 20% on top of these typical domestic freight estimates are then assumed for each of the respective scenarios.

Another major macro impact of border transit time and uncertainty relates to the time that shippers, 3PL's, and carriers assume that border crossings will take, regardless of how long it will actually take. Border crossing transit time uncertainty, and the penalties that consignees such as the auto companies and mass merchants charge for deliveries that miss delivery windows, have led both for-hire carriers and private fleet mangers to assume a generous amount of time for border crossing activities, regardless of actual experience. This assumed route time, at least for a significant percentage of truck movements is in effect lost time because the operator cannot effectively redeploy the truck if the border crossing time in fact ends up being far faster than assumed. Long before the actual move carriers have made route planning assumptions about the number of stops that can be made by one truck given the assumed border crossing time and have deployed assets and manpower accordingly.

In order to calculate the extent of this planned border crossing time we start with the number of trucks crossing the border per year, and assume, depending on the scenario, between 40-60% of these trucks are subject to route planning and are not able to recoup the assumed time even when actual crossings take less time then assumed. We then apply an assumed border crossing time to determine the total number of planned border crossing hours. This assumed time ranges from 1.5 to 2.0 hours based on the typical two hour assumed time that almost all third parties and carriers told us they assumed (Innovative Logistics 2002, Mercer Trucking 2002). While two hours was the most typical response, several shippers, such as Accucamps Manufacturing (2002) in Canada, and Lamko Plastics (2002), told us they assume 4-6 hours because of the extremely time sensitive nature of their deliveries. In order to

finalize the cost estimates, a cost per hour of US$150 was assumed. This hourly cost is based on the value used in a recent FHWA report that suggests fully allocated costs for planned transit time range from US$144-192 per hour (Maring and Lambert 2002 and ICF Consulting 2002). Based on US$150 hourly cost we estimate the cost of planned border crossing time at US$1.20 to 2.41 billion with a midrange estimate of US$2.00 billion.

**Detailed Border Costs**

While these macro indicators suggest the border has a significant impact on costs, the actual categories of detailed border transit time and uncertainty costs are not detailed here, but are shown in Table 1. The estimated cost of transit and uncertainty range from $2.5 to $5.3 billion, with a midrange estimate of $4.01 billion.

Table 1 — Transit Time and Uncertainty Costs (Millions of US$)

| Type of Cost | Minimum | Midrange | Maximum |
|---|---|---|---|
| Transit Time/Uncertainty Costs | | | |
| Carrier Related | | | |
| Primary Inspection Transit Time | 275.3 | 324.2 | 351.8 |
| Secondary Yard Processing | 602.5 | 755.4 | 908.3 |
| Excess Plan Time | 113.7 | 416.4 | 515.7 |
| Reduced Cycles/Other | 65.8 | 120.7 | 197.4 |
| Driver Documentation/Fax Time | 133.5 | 250.7 | 400.9 |
| Carrier Subtotal | 1190.8 | 1867.4 | 2374.1 |
| Manufacturer Related | | | |
| Manufacturer Sourcing Benefits | 1007.0 | 1530.0 | 2000.0 |
| Extra Inventory Carrying Cost | 229.0 | 458.0 | 686.0 |
| Manufacturer Subtotal | 1236.0 | 1988.0 | 2686.0 |
| Personal Traveler | 96.7 | 159.0 | 209.6 |
| Transit Time/Uncertainty Subtotal | 2523.5 | 4014.4 | 5269.7 |

The general border costs are in addition to the transit time and uncertainty discussed so far. The general border costs are derived from estimations of carrier customs administration and cabotage

costs, and manufacturer related cost categories such as those related to customs administration, customs brokerage fees, and remaining duties. These are detailed in Table 2. Also in Table 2 are the estimated minimum, maximum, and midrange totals for Transit Time, Uncertainty, and General Border Costs. The estimated total costs associated with the border range from $7.5 to $13.2 billion, with a midrange of $10.3 billion.

Table 2 — General Border Costs and Grand Total (Millions US$)

| Type of Cost | Minimum | Midrange | Maximum |
|---|---|---|---|
| General Border Costs | | | |
| Carrier Related | | | |
| General Border Administration | 100.0 | 200.0 | 250.0 |
| Cabotage | 100.0 | 150.0 | 333.3 |
| Carrier Subtotal | 200.0 | 350.0 | 583.3 |
| Manufacturer Related | | | |
| Brokerage Costs | 372.8 | 462.9 | 552.9 |
| Duties, Border Fines, and Fees | 1337.6 | 1605.1 | 1872.3 |
| Customs Administration | 2630.0 | 3290.0 | 3950.0 |
| Manufacturer Subtotal | 4340.4 | 5358.0 | 6375.2 |
| Federal Inspection Services Staff | 452.9 | 571.5 | 960.9 |
| General Border Subtotal | 4993.3 | 6279.5 | 7919.4 |
| Transit Time and Uncertainty Subtotal | 2523.5 | 4014.4 | 5269.7 |
| Total U.S.-Canada Border Costs | 7516.8 | 10293.9 | 13189.1 |

## Alternative Border Management Strategy

The key contribution of this research is the development of cost estimates for the impact of border transit times and uncertainty on the two economies. These cost estimates are crucial for any effective cost-benefits estimate of the current border management system, and are critical to any future assessment of the benefits that would accrue from changes in the current border management system. This research suggests that the transit time and uncertainty costs of the border range from a minimum of US$2.52 billion to a

maximum of US$5.27 billion, with a midrange estimate of US$4.01 billion. The midrange cost estimate of US$4.01 billion represents some 1.05% of total U.S.-Canada trade, and 1.71% of truck borne trade.

The border management system in place today results in periodic backups, and considerable uncertainty about the extent of transit times, but provides very modest levels of actual security given the wide expanses of border with unguarded dirt roads, trails and waterway crossings, and average screening times of just 30-75 seconds for cars and trucks at the high volume guarded crossings. Is their perhaps a better approach that would help to eliminate the cost impacts described above, while providing for similar or even better security than is provided by the current system?

One of the key options is an "external perimeter" strategy that would replace the current border management system with more effective external border checks at the perimeter while reducing controls at the U.S.-Canada border and replacing routine checks with random inspections. This strategy would place the emphasis on border security at the U.S. and Canada's external border, and reduce the emphasis on the U.S.-Canada border itself where levels of interaction and commerce make it almost impossible to provide effective security. Such a policy would require Canada and the U.S. to harmonize some immigration policies on the scrutiny and admissibility standards of immigrants, refugees, and foreign visitors. An external perimeter strategy would also require Canada and the U.S. to more closely cooperate on immigration and customs enforcement offshore and at our external borders – changes that are currently already in process to some degree. The key to being able to reduce scrutiny at the U.S.-Canada border is the ability to build a robust system of random inspections and post-audits of the companies that conduct the bulk of trade across the border, and a system of severe penalties for corporate or personal violators of each countries domestic laws.

An "external perimeter" strategy could have a long term goal of bringing the U.S.-Canada border to a level of "openness" similar to what is seen on European Union internal borders without the need for total harmonization of all policies. Such a system could be phased in with a ramping up of external border controls and post audit procedures, and a gradual loosening of the U.S.-Canada border with initially high random inspection rates and eventual reduction of inspections to an almost free flow state. The benefits of such a system would be significant. First, there is the potential to save the US$2.52 to US$5.27 billion per year in the transit time and uncertainty costs of the current system. In addition, there is an opportunity to save additional monies related to general border management that were not considered in detail in this paper. Our preliminary work on these costs, for brokerage services, various duties that are still collected, customs administration costs by manufacturers and carriers, and the cost of federal inspection services, suggests the potential to save an additional US$5-8 billion dollars. The total savings from changing the border management system would then reach some US$7.5-13.2 billion, with a midrange estimate of US$10.3 billion, or at the midrange, some 2.70% of total U.S.-Canada trade, or 4.38% of truck borne U.S.-Canada trade in 2001. Secondly, there is an opportunity to actually increase security be redeploying the money spent on U.S.-Canada border guards to the external border, to intelligence activities, and to post-audit inspections, where a more effective job perhaps can be done. While there has been little discussion of such changes in policy on the U.S. side of the border, there has been considerable discussion in Canada about the potential for an external perimeter strategy (Conference Board of Canada 2002, Hart and Dymond 2001, Dobson 2002). In fact one recent Windsor newspaper editorial suggested the Canadian government should seriously explore a European Union style border arrangement with the U.S. (Windsor Star 2002). Should the U.S. and Canada want to maintain or increase their current levels of integration, while enhancing security efforts against terrorism, it may be time to consider dramatic changes in the way we mange the border.

**References**

Broker Interviews with, among others, *Livingston, Tower Group, Del-Will Brokers, Centra Customs Brokers, PBB Global Logistics, Sander and Travis, Transborder Customs Services, Derringer, Norman G. Jenson Brokers, Danzas, J.L. Woods Brokers, GHY Customs Brokers, George H. Young Brokers, and Fed Ex Trade,* Summer, 2002.

Canadian Embassy, *United States-Canada: The World's Largest Trading Relationship,* August, 2001.

Canadian Manufacturers and Exporters Association, *The Value of Boundaries* [Canadian Manufacturers and Exporters Association estimate that border delays and customs regulations drive costs up 6%], The Toronto Star, August 11, 2001, P. HO6.

Carrier and 3PL Management and Driver Interviews with, among others, *Chrysler Transport, Reimer Express, Liberty Linehaul, CCX, Yellow Freight, Celadon, S and S Transport, Transfreight, Landstar, Canadian National, Canadian Pacific, Holland Motor Freight, Western Logistics Carriers, Roadway Express, Overland Express, UPS, Cavalier Transportation, Ludke Pacific Trucking, Mercer Trucking, Ryder Logistics,* Summer, 2002.

Conference Board of Canada, *Border Choices: Balancing the Need for Security and Trade, October*, 2001.

Crossing Operator Interviews with, among others, *Peace Bridge Authority, Niagara Falls Bridge Commission, Detroit International Bridge Company and Canadian Transit Company, Detroit and /Canada tunnel Corporation, Blue Water Bridge Authority, Michigan Department of Transportation Blue Water Bridge Unit,* Summer, 2002.

Dobson, *Shaping the Future of the North American Economic Space,* C.D. Howe Institute, April, 2002, 1-30.

Hart, Michael and William Dymond, *Common Borders, Shared Destinies: Canada, the United States and Deepening Integration*, November 20, 2001.

Herbert W. Davis and Company, *Davis Database*, Vol. 27, No. 1, June, 2002.

ICF Consulting, *Economic Effects of Transportation: The Freight Story*, January, 2002, 16.

Kenna, Kathleen, "Think Tank Urges Borderless NAFTA," *Toronto Star*, September 4, 2001.

Lawson, Brent, "Extra Security Should Speed U.S. Border Crossing," *The Hamilton Spectator*, March 25, 2002, A5.

Local Government and Chamber Interviews with, among others, *Plattsburgh North Chamber, Greater Niagara Buffalo Partnership, Niagara Falls, Ontario Chamber, Niagara Falls, Ontario Tourism Association, Fort Erie Economic Development Association, Detroit Chamber of Commerce, Windsor Chamber of Commerce, Windsor City Center Business Association, Windsor Traffic Commissioner, Windsor Mayor's Office, Winnipeg Economic Development Corporation, Manitoba Chamber, West Coast Border Coalition, Cascadia Institute, Bellingham-Whatcom Chamber, and Whatcom Council of Governments*, Summer, 2002.

MacFarlane, Stephen, "Border Delays Won't Jeopardize JIT But Tighter Security Essential to Reassure the U.S.," *Canadian Business and Current Affairs*, October 8, 2001.

Manufacturer and Retailer Interviews with, among others, *General Motors, Daimler-Chrysler, Toyota, Moen, Atlas Tube, Ontario Greenhouse Growers, Kodak Canada, American Axle, Delphi, Mastronardi Produce, Noranda, Lantic Sugar, Canadian Sugar, Family Traditions, Accucamps Industries, Lyndall Cedar Homes, Donnley, Lamko, Meijer, Cooper Standard*, Summer, 2002.

Maring, Gary and Bruce Lambert, *The Freight Analysis Framework: Status and Future Directions*, Federal Highway Administration, Office of Freight Management and Operations, October 3, 2002, 35.

*National Post*, "Open Borders" Editorial, September 3, 2001.

Schulz, John D., "Con-Way Takes $8 Security Surcharge," *Traffic World*, November 18, 2002, 45.

Statistics Canada, *Exports and Imports with U.S., Monthly Data*, April, 2000 – June, 2002, and other statistics.

Trade Association Interviews with, among others, *Canadian Chamber of Commerce, National Association of Manufacturers, American Trucking Association, Canadian Manufacturers and Exporters Association, Canadian Trucking Alliance, Ontario and British Columbia Trucking Associations, Washington Trucking Association, Canadian International Freight Forwarders Association, Freight Carriers Association of Canada, and the Canadian Society of Customs Brokers*, Summer, 2002.

Trickey, Mike, "The Undefended Border: Economic Concerns Spur Campaign to Erase Line Between Us and the U.S.," *The Montreal Gazette*, August 4, 2001, A12.

*Windsor Star*, "Perimeter Border for North America Editorial," December 11, 2002.

# Smart Borders and Safe Borders: Is there a Distinction?

Dr. Darren Prokop
Department of Logistics
College of Business & Public Policy
University of Alaska Anchorage

Business Education Building
3211 Providence Drive
Anchorage, Alaska
99508
tel. 907-786-1992
fax. 907-786-4115
e-mail: afdjp1@cbpp.uaa.alaska.edu
website: www.cbpp.uaa.alaska.edu

## Introduction

Both John Manley, Deputy Prime Minister of Canada, and Tom Ridge, United States Homeland Security Director, have gone on record promoting a "Smart Border for the 21st Century"--- a border that is "open for business but closed to terrorists". U.S. Customs Commissioner, Frank Bonner was quoted as saying: "[US] Customs is mindful of the need to heighten security without choking off the flow of trade that is so important to the U.S. economy. If business takes steps to secure its cargo against terrorism, we will give it the 'fast lane' through the border."[1]

This paper examines the trade-off implied by securing a border while promoting efficient trade and supply chain management. Both governments can promote a more secure set of supply chains that cross the Canada-U.S. border by either setting up incentives for firms to bring about that security; or simply require them by regulation. The former is a market-based mechanism while the latter is a political-based one. The currently-evolving border initiatives

appear to be seeded with both types of mechanism. This structure will be appraised in terms of the security-efficiency trade-off.

**Transportation and the Canada-U.S. Border**

The Canada-U.S. border, at 4000 miles, is the world's longest unguarded border. Both countries are each other's number-one trade partner in terms of value and volume. No two countries trade more goods and services than Canada and the United States.

Canada-U.S. trade in goods in 2001 totaled $(US) 345 billion, about 68% of which was moved by truck. About 13.2 million trucks crossed the Canada-U.S. border that year, or about 25 trucks per minute. Rail accounts for 17% of Canada-U.S. trade by value followed by air (6%) and marine (2%).

The Canada-U.S. border makes up 40% of the U.S. ports of entry. These ports are staffed with only 14% of the U.S. Customs Service's inspectors; and they handle about one-third of its total workload (**Coalition for Secure & Trade-Efficient Borders 2001; p. 6**). Thus, the border is understaffed given that Canada-U.S. merchandise trade has more than doubled over the 1990s while the number of U.S. inspectors has remained basically unchanged.

At the same time shippers are becoming more cautious about how, and who, is providing their transportation. For many years, shippers have been asking carriers to show them their insurance certification documents. In the wake of the September 11, 2001 tragedy (hereafter 9-11) the U.S. Federal Aviation Administration (FAA)[2] has, since October 8, 2002, enforced the "known-shipper" rule which prohibits an air cargo carrier and/or freight forwarder from accepting a shipment from an "infrequent user" unless the carrier takes the time to visit/inspect the shipper's premises to determine the legitimacy of his operation. The frequency criteria for the carrier/forwarder are: (1) at least 24 shipments since September 1, 1999; and (2) a record of doing business with the shipper *before* September 1, 1999.

**Efficiency and Safety**

Each day along the Canada-U.S. border people of all sorts pass: business people, students and tourists. Goods of all sorts pass in trailers on motor carriers, boxcars attached to locomotives and in containers[3] transported on the road, sea, rail and in the air. Is it possible for the efficient flow of Canada-U.S. trade to be maintained, or even enhanced, while providing for a reasonable level of security? Or is it an unavoidable trade-off?

In terms of this trade flow: are just-in-time (JIT) and lean-manufacturing models still workable?[4] Will the result of security compliance be an increase in safety stocks across the supply chain in order to compensate for a slowing in border clearance of goods?

In December of 2001, the Canada-U.S. "Smart Border" initiative was announced. The intent is to manage the trade-off implied by securing the Canada-U.S. border and yet promoting trade flows. Using a system known as "free and secure trade" (FAST), low-risk freight and vehicle operators are to be expeditiously granted access across the border while tougher scrutiny is reserved for the remaining.[5] In other words, the trade-off is to be managed by dividing shippers and carriers into two distinct cohorts.

In December of 2002, 6 of the 82 Canada-U.S. road-based, border crossing points implemented FAST. Motor carrier traffic figures for these points are listed in Table 1. It should be noted that these 6 points represent the busiest border crossing points for motor carriers and account for almost 75% of motor carrier-based, cross-border traffic. Dedicated lanes are to be used by trucks that have pre-cleared the customs process. Canada Customs and Revenue Agency and the U.S. Customs Service will pre-screen the freight before it has arrived at the border. Thus, shippers that use a JIT system of cross-border trade or simply make frequent border crossing have an incentive to integrate customs pre-screening into their supply chains. Regular and respectable shippers (e.g., the "Big 3" automakers) will be separated out from the shippers and carriers deserving of tougher

scrutiny--- those using rental vehicles and those hauling unmarked trailers or containers.

**Table 1**

**Top 6 Motor Carrier-Based, Canada-U.S. Border Crossing Points**

| | Number of Motor Carrier Crossings (2001) | Mean Growth Rate of Crossings (%) (1996-02) | Share of Canadian-Registered Motor Carriers (%) |
|---|---|---|---|
| Ambassador Bridge (*Windsor-Detroit*) | 3,274,754 | 1.5 | 55.8 |
| Blue Water Bridge (*ON 402 – I-94*) | 1,467,580 | 1.9 | 74.6 |
| Peace Bridge (*ON QEW – I-190*) | 1,351,672 | 0.7 | 80.1 |
| Lewiston-Queenston Bridge (*ON 405 – I-190*) | 1,004,178 | 1.1 | 67.8 |
| Douglas-Blaine (*BC 99 – I-5*) | 788,076 | -0.1 | 74.5 |
| Lacolle-Champlain (*QB 15 – I-87*) | 762,512 | 1.4 | 83.1 |
| **Source: Nix (2002). p. 20.** | | | |

In terms of rail crossings through the border both the Canadian Pacific Railway and Canadian National Railway have been electronically submitting manifests to U.S. Customs since 2000. By foregoing paper manifests delivered at the border, U.S. Customs' Automated Manifest System (AMS) has allowed train crossing times to be reduced from several hours to about 10 minutes. U.S. railroads: Burlington Northern Santa Fe, Union Pacific, and Wisconsin Central (a subsidiary of Canadian National) have all been using AMS on their

import runs out of Canada. AMS was introduced along the U.S.-Mexico border in 2001.

As a bi-national initiative, FAST will blend Canada's Customs Self Assessment (CSA) program with the U.S.'s Customs-Trade Partnership Against Terrorism (C-TPAT) program. In both cases, shippers who *volunteer* to join these programs and are deemed to be "low-risk" will accumulate data regarding their shipping transactions and report and pay any applicable customs duties on a monthly basis. Information on each shipment in transit, however, will have to be sent electronically to customs officials at the border in advance of the truck arriving at the primary inspection lane (PIL). Bar-codes will be presented to the customs official by the driver showing that, he, the carrier he works for, the shipper(s) of record, and the shipment(s) have all been pre-approved. After the bar-codes are scanned, the vehicle is simply waved through without the usual questions about the shipping manifest, the vendor, the consignee, and the contents of the vehicle. The actual proof of the transaction will be sent to customs officials as part of the monthly data reports.[6]

As FAST develops it appears that the United States will be requiring more information for pre-clearance than will Canada. Canada will carry on with three CSA identifiers: shipper of record (the importer or exporter), the carrier and the driver. The United States will require further elements: the goods' vendor (if different from the shipper of record), a description of the goods, and the route to be traveled. In any case, the Canadian and U.S. customs services will be integrating their computer systems into one harmonized database and clearance system.[7]

Two impediments remain: (1) infrastructure and manpower at several border crossings are not ready to handle the volume of vehicles expected to be expedited so quickly; and (2) the majority of trucks crossing the border are less-than-truckload (LTL) and haul freight consolidated from among several shippers. All that is needed is for one of the shippers to not be in the low-risk category for the truck to face tougher inspection. Or if a carrier sub-contracts the shipment to one of the thousands of owner-operators that are not part

of FAST, a compliant shipper's position within FAST is in effect voided. It would seem likely that shippers would require contracts with their carriers that guard against these possibilities. In the interim, FAST will by no means completely eliminate congestion at border crossings.

Beyond FAST is the issue of shipments not credited as low-risk. International couriers are worried that serving shippers that are not within the FAST framework will cut into their ability to provide 10 a.m.-noon, next-day service.[8] In Canada, shipments not eligible for CSA will be relegated, as of December 2002, to a customs program called Advance Commercial Information (ACI). While the details are not worked out as yet--- and the courier companies are discussing possible exemptions--- Canada Customs and Revenue Agency will require full and complete manifest data to be sent electronically and at least 12 hours in advance of arrival at a customs area (either the Canada-U.S. border itself or the customs clearance area of the courier's sorting warehouse at the shipment's destination).

In the United States the timing of electronic manifest submissions is broader though even less clear than in Canada. An omnibus trade bill was passed by the U.S. Congress in January, 2003. There is nothing in the bill that specifies the time frame for electronic submission to the U.S. Customs Service; however, the discretion will rest with Customs in that it must: (1) take into account the differences among transport modes in terms of speed, technology, etc.; and (2) limit data requirements to those which are "reasonably necessary to ensure transportation safety and security" (**Edmonson 2002; p. 24**). At this point, only the timing for ocean vessel containers has been made clear (**q.v., *supra*-note 3**).

**Container Security**

In January 2002, U.S. Customs Service implemented the Container Security Initiative (CSI). The first step is to set up CSI at the top 20 *foreign* ocean vessel ports (which account for about 68% of the 5.7 million foreign containers entering the United States each year). Currently, U.S. Customs physically inspects about 2% of

containers entering the 301 ports of entry to the United States. All countries that are ports-of-origin for the containers will be required to sign a bilateral agreement with the United States so that U.S. Customs inspectors might pre-clear these containers at the foreign ports themselves.

As of February 1, 2003, detailed vessel cargo manifests related to the containers and their contents have to be submitted by carriers or forwarders to U.S. Customs at least 24 hours before the vessel leaves any non-U.S. port. Under the *Trade Act* (2002) U.S. Customs will be required to devise similar submission time requirements for trucks, rail and air by October 1, 2003. With respect to ocean carriers fourteen points must be specified on the manifest as indicated in the customs regulations (**paragraph 4.7a; Title 19 Code of Federal Regulations**). These are as listed below:

1. Foreign Port of Departure
2. Standard Carrier Alpha Code (SCAC)
3. Voyage Number of the Vessel
4. Date of Scheduled Arrival in the First U.S. Port
5. Number and Quantity of Packages based on the Bill of Lading (i.e., the contract between the shipper and the carrier or forwarder)
6. First Port of Receipt by the Carrier
7. Cargo Description: Detailed Shipper Description or a 6-digit Harmonized Tariff Schedule Number; and the Cargo's Weight
8. Shipper(s) Name(s) and Address(es) or I.D. Numbers Assigned by U.S. Customs
9. Consignee(s) Names(s) and Address(es) or I.D. Numbers Assigned by U.S. Customs (i.e., these are the party or parties that will accept delivery of the cargo in the United States. The shipper is the consignor)
10. Name of the Vessel, National Flag, and Vessel Number
11. Names of Foreign Ports Visited Beyond (6)
12. International Hazardous Goods Code if Applicable
13. Container Number
14. Numbers on all Seals Affixed to the Container

Vague descriptions such as "freight all kinds" (FAK), "said to contain..." (STC), "chemicals", and "foodstuffs" are no longer acceptable. Electronically, submission may be handled through U.S. Customs' Automated Manifest System (AMS). Of course, those carriers and forwarders (i.e., non-vessel operating common carriers, NVOCCs) that are not hooked into AMS will have longer waits before Customs receives the documentation. Of course, carriers and NVOCCs will have to impose their own discretionary deadlines on shippers over and above the 24-hour cut-off so that they may collect, process, and transmit the data to U.S. Customs on time. Unfortunately, electronic or not, this means that a container will be sitting idle at a port for at least one extra day beyond the average 2-3 day wait. Also perishables such as food are often at the farm-gate 24 hours prior to being loaded into a container and put on a ship--- the quick turn-over from farm to vessel being done to ensure freshness. Containerized cargo that is simply passing through the United States (i.e., foreign "freight remaining on board" (FROB)) also falls under the 24-hour rule. For example, a Canadian vessel with only some U.S.-bound containers on board would have to provide manifests for *all* containers on board if vessel entry to a U.S. port is to be granted. Note that bulk shipments (e.g., coal, grain, oil, lumber, steel beams, etc.) and palletized shipments are exempt from the 24-hour rule because these are not containerized. However, manifests must reach U.S. Customs 24 hours before the ship reaches a U.S. port. Even empty containers being hauled as part of repositioning plans may require notice to U.S. Customs 48 hours prior to arrival. On June 2, 2003, U.S. Customs and selected carriers will embark on a pilot project to test the efficacy of that proposal. According to U.S. Customs about 600,000 empty containers entered the United States in 2001.

To date the 18 ports that have agreed to accept U.S. Customs inspectors as part of CSI are: Vancouver, Montreal, and Halifax, in Canada; Algeciras, Antwerp, Bremerhaven, Felixstowe, Genoa, Hamburg, La Spezia, Le Havre, and Rotterdam, in Europe; Hong Kong, Kobe, Nagoya, Tokyo, Yokohama and Singapore, in Asia. It should be noted that the European Commission is taking legal action

against the European Union (EU) countries that signed the bilateral CSI agreement with the United States because, as with bilateral air agreements, the Commission feels that only a multilateral approach is legal within the EU. Currently, U.S. Customs inspectors are on-site at 7 of the 18 ports: all three Canadian ports, Le Havre, Rotterdam, Antwerp and Singapore.

In the spirit of reciprocity, Canada Customs inspectors are now being stationed at the U.S. ports of Seattle, Tacoma and Newark. However, there is a question as to whether U.S. Customs is physically able to process and screen the flood of information that CSI is requiring. Their estimation is that the pre-screening through AMS will flag 5-10% of inbound containers that will need to be physically inspected on arrival. Unlike FAST (**q.v., *supra*-note 5**) which separates shippers/carriers into cohorts, CSI requires *all* manifests to be expeditiously delivered to AMS. It is also curious that a straight 24-hour rule has been established across all commodity-types irrespective of their different logistical requirements.

What is clear is that the choke points will be at the foreign ports. What is also clear is that shippers, carriers and NVOCCs all have incentives to acquire or maintain electronic submission capabilities and be certain that their data is accurate. Certainly, shippers may wish to jump-start the process by electronically submitting the cargo data to the carrier or NVOCC for processing *before* the container is actually filled and transferred to the carrier or NVOCC. Indeed, those NVOCCs which are not electronically hooked into AMS--- and needing to expedite their forwarding activities--- will have to provide the manifests directly to the carriers. This reveals their shipper-customers to the carriers and creates opportunities for them to "back-sell" directly to the shipper. Before October 2002 NVOCCs did not have access to AMS, and their manifests passed along by the carriers to U.S. Customs of their behalf, did not have to reveal the name of the originating shipper. But carriers too face problems: loading a container before the documents arrive (and facing a customs fine) or holding the container over until the next vessel (and facing a port storage charge). In any case, such charges are likely to be passed back to the shipper.

**A North American Transportation Network?**

It is not often understood that neither the Canada-U.S. Trade Agreement (CUSTA) nor the North American Free Trade Agreement (NAFTA) addressed the transportation sector explicitly. Despite the spirit of free trade that permeates these agreements, and the lowering of tariff barriers among Canada, the United States and Mexico, cross-border transportation remains a significant non-tariff barrier to trade.

The best example of transportation as a non-tariff barrier comes in the form of *cabotage* regulations.[9] Examples of these include: restricting commercial ocean vessel travel along U.S. coasts to only U.S.-flagged, U.S.-built vessels; and no point-to-point domestic haulage of U.S. (Canadian) freight by a Canadian (U.S.) driver and vehicle.

The effects of *cabotage* regulations within the Canada-U.S. transportation network are: a prevalence of excess capacity on backhauls; a limiting of foreign competition; and higher freight rates for both fronthaul and backhaul shippers (**Prokop 1997**). While deregulation of transportation has been occurring domestically in both Canada and the United States, continental regulations remain largely unchanged.

The North American free trade area has fallen behind the European Union on the issue of building a truly continental transportation network and fleet. And it is certainly the case that U.S. security concerns will slow this process down significantly.[10] Given a truly North American fleet, customs and immigration services on both sides of the border could concentrate on the shipment itself and not be burdened with enforcing regulations on foreign conveyances and operators in the areas of: driver and vehicle origin and destination; vehicle routing; value and volume of "allowable" *cabotage* freight, etc.

**Economic Analysis of U.S. Security Policy**

What FAST, Nexus and CSI have in common is that the point of compliance is moved away from U.S. territory. Where the difference lies in is terms of where the bottlenecks may occur. FAST (Nexus) merely fast-tracks cargo (people) through the border provided that the shipper's outbound logistics are compliant. If it is not, a simple delay at the U.S. border is possible. CSI results in the bottleneck occurring at the foreign port if the shipper's outbound logistics are not compliant. Of course, the ocean carrier is also the repository of all the compliance information. Non-compliance results in fines and the possibility that the containerized-shipment, and indeed the entire ocean vessel, will be denied entry. Finally, CSI is a compulsory program whereas FAST and Nexus are optional.

As far as U.S. Customs is concerned, a shipper's outbound logistics require both the shipper and the carrier to be compliant. Do both the shipper and the carrier enjoy the same compliance incentives? This section will examine that question using a game-theoretic model.

The game matrix in Table 2 shows a shipper and a for-hire carrier that both independently choose one of two levels of security compliance: tough (T) and weak (W). Security compliance takes the form of allocating money toward the technology and protocols necessary to satisfy U.S. Customs. This allocation leads to payoffs as shown in the table (both in numeric and symbolic terms). The numeric values are not important; just there relative values are. It is also important to note that when the shipper uses the carrier for its outbound logistics the total level of security compliance provided becomes a two-party public good. Both parties want a level of security even if they paid for it alone. The danger in this arrangement is that if one chooses to be compliance-tough the other could simply free-ride on that decision by choosing to be compliance-weak.

**Table 2**

**Security Compliance as a "Game of Chicken"**

| | | Carrier: T | Carrier: W |
|---|---|---|---|
| Shipper | T | (3, 3)<br>(c, c) | (2, 3.5)<br>(p, f) |
| | W | (3.5, 2)<br>(f, p) | (1, 1)<br>(u, u) |

**Payoffs: (Shipper, Carrier)**

**Payoff types: f>c>p>u and**
**2c > f + p**

The payoff types may be defined as: c=coordinated security; f=free-rider security; p=paternalistic security; and u=uncoordinated security. The other point is that the summed payoffs of coordinated security (2c) outweigh the summed payoffs when a free rider is present. Thus, the shipper-carrier supply chain is more secure when each player coordinates than when one chooses to free-ride

The provision of a public good is characterized as a "game of chicken" (**Mueller 1989; pp. 15-17**). There are two Nash equilibria, given by the shaded cells, whereby one player chooses W and the other chooses T. This means that in the short-run there is no incentive for one player to change his mind so long as the other one does not change his mind either. There is also a first-mover advantage in that the choice of W necessarily means that the other player must choose T in order to provide Pareto-improving security.

With CSI, the shipper literally makes the first move (i.e., sending a container and contents to the ocean carrier's port). Since the onus of compliance related to AMS rests with the carrier it has little choice but to be compliance-tough; therefore, the shipper has an incentive to be compliance-weak. The shipper's pre-commitment strategy is to choose W knowing that it will not be dealing directly with U.S. Customs. With the specifics outlined in U.S. Customs' 24-hour rule its protocols must be treated as a state of nature in this game. FAST, by contrast, does not have an explicit rule for compliance and nor does the onus rest with the shipper or carrier exclusively. The program is voluntary and the incentive structure facing the shipper and carrier need not be symmetric as it was presented in Table 2. FAST is being used for the most part by shippers operating in a JIT environment. Operating within FAST means, by necessity, choosing T because U.S. Customs directly interfaces with both the shipper and the carrier. There is no first-mover advantage; both the shipper and the carrier are regulated so that both choose T and the game above converges to the (T,T) cell. Any other combination would not be workable under FAST and it is, therefore, the case that only FAST-compliant carriers would be used to handle the outbound logistics of FAST-compliant shippers. It should also be noted that CSI could, in the long run, promote a (T,T) result so long as the shipper and carrier deal with each other long enough to form a cooperative relationship. The carrier could devise "punishments" to make the shipper adopt T over time; e.g., passing demurrage charges back to the shipper when containers do not arrive on time for the contracted vessel.

Now consider an LTL-trucker that is FAST-compliant but simultaneously handles the freight of shippers that are FAST-compliant along with those that are not. This is presumably done as a means to fill excess capacity. Effectively, the carrier is making a pre-commitment to W to the extent that some freight on board is not eligible for FAST. The FAST-compliant shipper faces a potential trade-off: higher TL freight rates for exclusive carriage in order to guarantee a FAST clearance versus lower LTL freight rates along with the possibility of a delay at the U.S. border even when the carrier itself is part of the FAST program. Of course, if the shipper persuades

the LTL carrier to provide JIT-style service, the LTL carrier has less of an incentive to haul freight that might jeopardize speedy border clearance.

**Conclusions**

In June, 2002 the U.S. Administration proposed creating a *bone fide* Department of Homeland Security which would bring together border security and inspection functions that were spread over 80 federal agencies (e.g., Customs, Immigration & Naturalization, the Border Patrol, the Coast Guard, the Transportation Security Administration, the Federal Emergency Management Agency, the Secret Service, etc.). The workforce is expected to be around 170,000 personnel. Congress passed the legislation in November, 2002.

At the Canada-U.S. border there is no agency better equipped to handle trade-related security issues than is the U.S. Customs Service. Of course, that service used to be under the U.S. Department of the Treasury because of its role in trade compliance and revenue gathering. Now, because of its security role, the U.S. Customs Service has been put under the Department of Homeland Security. Given this dual role, will shippers be subject to two rather than one set of regulations and inspection procedures? In any case, how will the roles of security and trade-compliance stay balanced as a matter of government policy? There is a danger that this new Department of Homeland security--- top-heavy in security functions--- could, by synergy, tip the Customs' balance even further toward security at the expense of trade-compliance.

The effects of tightening times for electronic submission of manifests and for enhancing security at ports of entry (or pre-screening at foreign ports of exit) are that the burden will be shifted back to the shipper. The sooner that customs officials require information before actual transit takes place the likelier it is that manufacturers will not be able to ship the last day's production. Inventory carrying costs will therefore be higher if they cannot meet

the time frame. This will be a problem for JIT shippers and shippers with freight subject to spoilage.

It is useful to note, however, that FAST is designed to look at cargo on a shipper-by-shipper basis as opposed to a cargo-by-cargo basis. Once a shipper has been deemed to be low-risk, customs officials can focus their energies elsewhere. But this paper has noted that customs compliance procedures are in a state of flux and focus is less than clear since in some cases the procedures are evolving transport mode-by-transport mode and in others it is evolving shipper-by-shipper.

Customs services are merely the enforcers of security measures. True security comes from a securing of the entire cross-border supply chain. This further encompasses: shippers and carriers at all stages of production; warehouse operators; and intermediaries such as freight forwarders and customs brokers.

The role of technology cannot be overstated. Despite current discussions that lead in this direction, manual inspection of every vehicle and every container is impossible if trade flows are to remain at anything better than a stand-still. The cost in terms of inventory build-up and productivity loss is too large to contemplate; therefore, new technologies such as "scanning in motion", "weighing in motion", and electronic documentation must be more rapidly deployed. Radio tags attached to containers, trailers and boxcars at the point of shipping can essentially make these conveyances "smart" by having wireless readers deployed at strategic points along the supply chain to feed real-time information on the status and location into a database that may be used for "track-and-trace" and for security as well. Microchips with fiber optic cables can be placed by the locks on conveyance doors. The microchip creates a magnetic field around the lock that can detect tampering and transmit such outcomes in real-time to the carrier.

There is no doubt that the cost of all such technologies will be passed along to the consumer. This is to be expected since security compliance is a costly issue. However, securing the supply chain is a

collaborative effort as noted in this paper and it is through that effort that costs will be minimized and a reasonable mix of efficient and safe trade between Canada and the United States can be maintained.

**Endnotes**

[1] Quoted in **Harrington (2002; p. 66)**.

[2] The newly created U.S. Transportation Security Administration (TSA) has since taken over the FAA's jurisdiction over security matters. The TSA was created through the *Aviation and Transportation Security Act* (Nov. 19, 2001). Currently, U.S. passenger airlines have been restricted to carrying pieces of mail weighing no more than one-pound. The resulting drop in cargo volumes has had a negative effect of passenger airline revenues. Heavier packages have been relegated to air cargo freighters operated by the commercial airlines. About 10-25% of their revenue flows derive from cargo transport. Needless to say, the main beneficiaries have been Federal Express and United Parcel Service. On November 19, 2002 all security screeners at airports became federal employees; and on December 31, 2002 all U.S. airports were required to have explosive detection systems installed in order to examine all luggage/parcels. It should be noted that the TSA has been mandated to handle security issues over all modes of transportation into the United States.

[3] The security issues surrounding containers on ocean vessels have been developing relatively quickly. These will be explored ahead in a separate section.

[4] In the wake of 9-11, DaimlerChrysler, General Motors, Ford, Toyota and Honda shut down U.S. plants for a time because they did not maintain enough safety stock to wait out the shutdown of U.S. and Canadian airspaces nor the bottleneck of trucks at the Canada-U.S. border. Manufactured vehicles represent the largest share of export and import trade by value carried by road and rail along the Canada-U.S. border. The figures are:

**Canada's Merchandise Trade with the United States (1996)**
(millions of current U.S. dollars)

| | Mode of *Vehicles-Only* Merchandise Exports* | | |
|---|---|---|---|
| **Total Exports to the U.S.** | **Road** | **Rail** | **Total** |
| 163,682 | 22,969 | 17,778 | 40,747 (25%) |
| | **Mode of *Vehicles-Only* Merchandise Imports*** | | |
| **Total Imports from the U.S.** | **Road** | **Rail** | **Total** |
| 115,188 | 20,034 | 5,700 | 25,734 (22%) |

* Road and rail only. Parentheses indicate vehicle-trade's share of total export or import trade where appropriate.

**Source: *North American Transportation in Figures*. (2000); tabs. 6-1a, 6-1b & 6-6b.**

As can be seen, Canada ran a large merchandise trade surplus with the United States both overall and on a vehicle-trade basis.

[5] FAST is preceded by a program used to expedite tourist passage through the Canada-U.S. border. The NEXUS system is currently in use at the Blue Water Bridge and Douglas-Blaine border crossings. The goal of both governments is to implement NEXUS at all major border crossings.

[6] Needless to say, shippers and carriers using FAST must have electronic goods-tracking, accounting and reporting systems in place that are connected to customs officials. DaimlerChrysler, for example, is well-positioned to take advantage of FAST. It sends about 1,500 truck loads per day through the Windsor-Detroit border crossing (with about a 50-50 split of northbound and southbound traffic). Currently, about 50% of its northbound traffic is cleared into Canada through the CSA (**Tower 2002; p. 22**). Other automakers

using CSA are Ford, General Motors and CAMI Automotive (the Canada-based, GM-Suzuki assembly partnership).

[7] At the Group of Eight (G8) meetings in Kananaskis, Alberta (June 25-26, 2002) it was decided that the Brussels-based World Customs Organization (WCO) would be charged with developing a Customs Data Model which would allow a shipper to submit required electronic information to the applicable customs service in the G8. The information would subsequently be shared in customs-to-customs exchanges among the G8. A preliminary assessment of the WCO's model is expected by June, 2003.

[8] Canada-U.S. courier service is dominated by Federal Express (with 10 Canada-U.S. flights/day) and United Parcel Service (with 16 Canada-U.S. flights/day).

[9] For an overview of *cabotage* regulations across several modes, see: **Prokop (1999)**; and **Prokop and Dean (1999)**.

[10] However, there has been one exception to date. In June of 2002, the U.S. Administration ceased blockage of a NAFTA requirement that Mexican motor carriers be allowed full export-import access to U.S. territory. While this provision was to be implemented by 2000, the previous Administration followed a line of argument promoted by the Teamsters Union that Mexican trucks are unfit and unsafe for U.S. highways. Through June 2002, Mexican trucks could only proceed within 20 miles north of the U.S.-Mexico border and would have to interline its freight with a U.S. motor carrier.

## Bibliography

Coalition for Secure & Trade-Efficient Borders. (2001). *Rethinking our Borders: A Plan for Action*. Position Paper.

Edmonson, R. (2002). "What's in the Box?" *JoC Week*. Aug. 5-11. pp. 23-4.

Harrington, L. (2002). "Sourcing Globally now that the Rules have Changed." *Inbound Logistics*. October. pp. 62-9.

Mueller, D. (1989). *Public Choice II*. Cambridge: Cambridge University Press.

Nix, F. (2002). "Making the Best of It." *Motor Truck*. April. pp. 18-20.

*North American Transportation in Figures*. (2000). Washington: Bureau of Transportation Statistics.

Prokop, D. (1997). "The Welfare Gain from Trucking Deregulation: Transborder Trucking and Cabotage." *Canadian Transportation Research Forum*. Proceedings of the 32nd Annual Conference. pp. 555-73.

Prokop, D. (1999). "In 1988 We Freed Trade. Now Let's Free Transport." *Policy Options*. June. vol. 20. no. 5. pp. 37-40.

Prokop, D. and J. Dean. (1999). "The Goods and Services Tax and the US Federal Excise Tax: Barriers to Trucking Cabotage Reform in Canada." *Canadian Tax Journal*. vol. 47. no. 5. pp. 1180-93.

Tower, C. (2002). "On the FAST Track." *JoC Week*. July 15-21. pp. 21-3.

# THE RAPID INFILTRATION OF THE CANADIAN AND UNITED STATES HIGHWAY TRANSPORTATION MARKETPLACE BY ROUNDABOUTS AS A TRANSPORTATION REVOLUTION FOR URBAN AREAS


## Abstract

Recent developments add momentum to modern roundabout growth in Canada and the United States (US). Through a comparison to France, the Canada and US roundabout market potential is estimated at 104,000 and valued at $104.0 billion (US). Both separate and integrated transportation and land use models now emerging respond to the needs to deal with the interdependence of land use and transportation. Roundabouts impact positively both land use and transportation but modeling does not now incorporate the short term and long roundabout beneficial effects. Higher development density and more energy efficient modes use as well as associated reduction in non-renewable energy consumption and healthier air–all are associated with roundabouts deployment.

Roundabouts recently pursued as part or all of alternatives to actual traditional highway projects leads to the proposition of roundabout centered transportation designs as the yardstick for measuring project performance for transportation service as well as for environmental and land use benefit. Policy options ensuring fair consideration of roundabouts in transportation are presented.


## Introduction

In 2001-2002 the escalation of modern roundabout construction throughout Canada and US continued. A number of roundabout related developments–in research, technology transfer, the environment, energy, law, and politics--signal a further infiltration and popular acceptance of roundabouts. This policy paper outlines the recent evidence of the pervasive nature of Canadian and US

roundabout growth, notes important related trends, and relates the importance of roundabouts to the subjects of sustainability, sprawl, smart growth, and the land use-transportation relationship. The dimensions of the market potential arise by simply applying pro rata on population the French built and annual production numbers to Canada and the US. French urban transportation research estimates approximately 1,000 roundabouts built there annually 1994-2002 and an estimated total of 20,000 roundabouts in place at the end of 2002 (Novellas, 2002). A current traffic circulation and management studies review finds them limited mostly to motor vehicle mobility.

A report of a project in litigation involving roundabouts in a corridor with moderate traffic levels versus the traditional highway expansion suggests the roundabout as a measure of performance. An expanded definition of "benefit" elevates highway project alternatives employing roundabouts as a baseline yardstick because of better performance in the areas of air quality, life-cycle cost, induced traffic (transit, pedestrian and bicyclist), and facilitation of higher development densities. Policy options for roundabouts are presented.

**Recent Developments and Trends**

Roundabout developments in 2002 include:

1. Landmark research reporting a five-lane typical 0.9 km US commercial strip development with two signals converted to four lanes and four roundabouts not only resulted in far lower speeds but also lower through travel times based on signal coordination model runs calibrated to serve through traffic (Sargeant, 2002).
2. An empirical Swedish study confirmed past research of reduced fuel consumption by converting a signal to a roundabout, in this case an annual savings of 18,800 gallons of fuel at an intersection with 23,500 entering cars daily (Varhelyi, 2002).
3. Passage of the first legislative endorsement of roundabouts by a US state (Vermont, 2002), issuance of the first Canadian roundabout design guide (Quebec Ministry of Transport, 2002), and construction of the first general traffic service roundabout in Ontario at Hamilton.

4. Phase one construction, including three roundabouts, in the Capital of Mississippi, Jackson--the Jackson Metro Parkway, revamping a four-lane divided highway to install five roundabouts overall which access the adjacent Jackson State University and residential areas.
5. A 2002 State Court determination requiring roundabouts be given full consideration as an alternative to a major bypass expansion project (NH Merrimack Superior Court, 2002).

Practitioners estimate the number roundabouts in place in Canada and the US at the end of 2002 at 600 to 800. Several features of the roundabout contribute to its role as a transportation change agent. First, without question roundabouts move significantly more traffic with less delay than signals. A single lane roundabout operating near capacity had less than a fifth of the peak hour vehicle delay of a signal when calculated using either Australian or United Kingdom (UK) modeling software (Central Vermont Regional Planning Commission, pp. 50-51). Second, studies document roundabouts reduce serious injury for vehicle occupants and pedestrians at intersections by up to 90% (Elvik, 2003; Persuad, Retting, Garder, and Lord, 2000).

A historic change in traffic growth deserves note. US vehicle miles of travel growth began to stall during the 1990s, and growth rates can be expected to moderate, stagnate or even decline in the future. For example, the six New England States grew at perhaps the lowest rate of the last century, 16.3%, during 1990-2000, less than half that of the 1980-1990 decade (FHWA, Series, Table VM-3). The growth stagnation follows a historic pattern of older transportation modes (Garder, 2000, pp. 2-3). Stable traffic levels enable circulation investments promising improvement over current conditions. The roundabout can key community center areas renewal where solutions are sought in "mixed transportation" context.

Canada ratified the international treaty on global warming while US efforts are confined to a number of states and localities. Global




**Grand Union Roundabout, VT 7A, Manchester, built 1997**

warming policies inevitably will dampen car travel and encourage less polluting modes. Roundabouts represent a "no regrets" investment at busy intersections, assuring immediate decreases global warming gases (GHGs).

**The Transportation-Land Use and Roundabout Connection**

The equation of land use and transportation is commonly known: the relative potential travel ("attraction") between two locations depends primarily on time–a substitute for cost–to that location versus an alternative destination. Urban traffic models evaluate "traffic analysis zones"and employ techniques to describe current and future trips between the zones. Except where significant public transit facilities exist, models reflect mostly motor vehicle oriented travel and rely on current and planned land uses derived from existing land use regulations and plans. Integrated land use and transportation modeling emerging now allows a realistic approach to transportation and land use investments and policies which further community goals.

The Portland, OR, integrated land use and transportation study (1000 Friends of Oregon, 1997) pioneered regional design, which provided options for reducing public investments while also lowering car travel and increasing transit, walking, and bicycling.

A major thrust for coordinated land use and transportation planning arose from 2001 US Environmental Protection Administration guidance recognizing land use practices as integral to reqired states air quality plans and implementation. The EPA allows benefits of land use activities in attaining air quality goals, including those related to transportation (Liu, 2003). A promising areawide multi-modal level-of-service analysis approach to traffic management which is environmentally sensitive arose from congestion management policies in Florida (Guttenplan, Davis, Steiner and Miller, 2003).

Walking demonstrates past constraints encountered in transportation design. Locations with high levels of pedestrian activity require four elements–sidewalks, a connected system of pedestrian sidewalks and paths, level geography, and easy to negotiate intersections. Changing geography remains an obstacle but pedestrian delay and discomfort at signalized intersections can be overcome with a roundabout.

Recent urban transportation policy material and research concentrates on managing the transportation land use interrelationship with focus on accessibility, sustainability, induced development from new roads, sprawl, and smart growth (Newman and Kenworthy, 1999; Waddell and Nourzad, 2002; Kitamura et al, 2001; and Liu, 2003). The roundabout directly addresses or keys approaches to at least three of five suggested techniques for overcoming automobile dependence--traffic calming, bicycling and walking modes, and provision of urban density (Newman and Kenworthy, p. 144). Improved aesthetics come at no extra cost. The roundabout facilitates in the short term bicycling and walking as well as more efficient public transit. Roundabouts induce multi-modal traffic and within the existing road system greater

densities, a more sustainable condition. Public policy and investments in transportation can include roundabouts and related investments to facilitate induced positive types of traffic and land uses. Roundabouts represent the ideal "no regrets" transportation investment. Developing an appreciation of roundabout influence on transportation and land use becomes essential for those engaged any aspect of urban development, renewal, and environmental betterment.

**Canada and US Roundabout Potential Market–The French Dimension**

Roundabout construction began in North America with two in 1990 reaching 24 in 1995 and totaling an estimated 600 to 800 in 2002. To define what the economists call the "market" for roundabouts, a relative comparison of the estimated yearly 1,000 roundabout built in France and 2002 total of 20,000 in place is presented in Table 1.

The 104,000 roundabouts for Canada and the US total and a production level of 5,100 per year in Table 1 demonstrates clearly the relative flood of roundabouts into the French transportation marketplace where roundabout installations began in the early 1970s. Taking a small state like Vermont, the French roundabout numbers equate to about 200 in place and a production rate of ten yearly. In Vermont the signalized intersection population totals about 300, so 200 roundabouts certainly is a realistic number. At the end of 2002 actual Vermont roundabouts totaled four, recent production level averaged about 0.5 per year, and roundabouts in development, 17. As significant as the potential installation numbers are the dollars attached to 104,000 roundabouts: $104 billion (US) for 104,000 roundabouts, and continued annual production of $5.1 billion (US). The US federal FY 2002 federal highway program apportionments to the states total $29.5 billion (US) amounts to a third of the potential roundabout market (FHWA, 2001, Table FA-4). The Vermont federal FY 2002 allocation was $136 million (US).

TABLE 1: FRANCE 2002 ROUNDABOUT POPULATION AND ANNUAL PRODUCTION EQUIVALENT FOR CANADA AND THE US THROUGH PRO RATING BY RESIDENT POPULATIONS

| Nation | Roundabouts Pro Rata to France, 2002 Population | Roundabout Estimated Value ($ US) Installed (000,000) | Annual Estimated Production | Annual Estimated Value ($ US) Installed (000,000) |
|---|---|---|---|---|
| France (Actual) | 20,000 | 20,000 | 1,000 | 1,000 |
| United States | 93,000 | 93,000 | 4,600 | 4,400 |
| Canada | 11,000 | 11,000 | 500 | 500 |
| Total Canada/US | 104,000 | 104,000 | 5,100 | 5,100 |

**NOTES:** 1. National 2002 populations: Canada, 31.3 million; France 59.3 million; and US 275.6 million (Statistical Abstract of the United States:2000, Table 1352).
2. France 20,000 roundabout population represents 337.3 roundabouts per million population, French annual 1,000 roundabout production for the period 1994-2002 represents 17.76 roundabouts per year per million population.
3. Roundabouts costs vary widely from a few thousand dollars to several million dollars. For analysis purposes, an average of $1 million per roundabout is assumed.

**Urban Traffic Circulation and Traffic Management**

The fields of urban traffic circulation and traffic management studies mostly center on attempts to move more cars or moving them with greater efficiency. Ogden provides a definition of highway traffic management that reflects maximizing without substantial capital investment various attributes of the transportation system ranging

from sustainability and efficiency to safety and accessibility (Ogden, 1996, pp. 309-310). For purposes of this paper, traffic circulation deals with the needs and betterment at the higher level of corridor or area traffic movement, which encompass traffic management and moderate capital investments. Typical capital investments for better circulation include roundabouts, traffic signals and signal coordination, new road capacity, pedestrian and bicycle facilities, improved mass transit services in larger metropolitan areas, etc.

Traffic circulation studies center on analyses for a given downtown or other defined area through a review of current problems, trends, and community concerns. An action plan then follows, mostly a set of signal and traffic management tools to better the existing system. Computer simulation software employed defines before and after performance for an area, corridors and intersections. None of three typical traffic circulation research reports recognized the roundabout (Sharp and Albeck, 1999; Liu, 1999; Schwinger et al, 1999). These small area and regional circulation models generally do not address the bicycling and walking function. Circulation plans that suggest signs and signals often do so at the expense bicycling and walking modes. Roundabouts impact circulation (Redington, 1999).

There remains a larger question, that is, how to attain maximum accessibility and mobility at the least cost and carried out so as to assure a high standard of environmental quality, the twin goals being affordability and sustainability (Akinyemi, 1997)? Induced travel as a result of accessibility increase from new roadways is well documented through application of integrated models (Rodier, Abraham, Johnston and Hunt, 2001; Newman and Kenworthy, pp. 139-141; 1000 Friends of Oregon). In summary, current techniques and models except for the most complex integrated land use and transportation models cannot adequately compare the performance of small area or regional areas employing roundabouts versus traditional signalized and sign treatments.

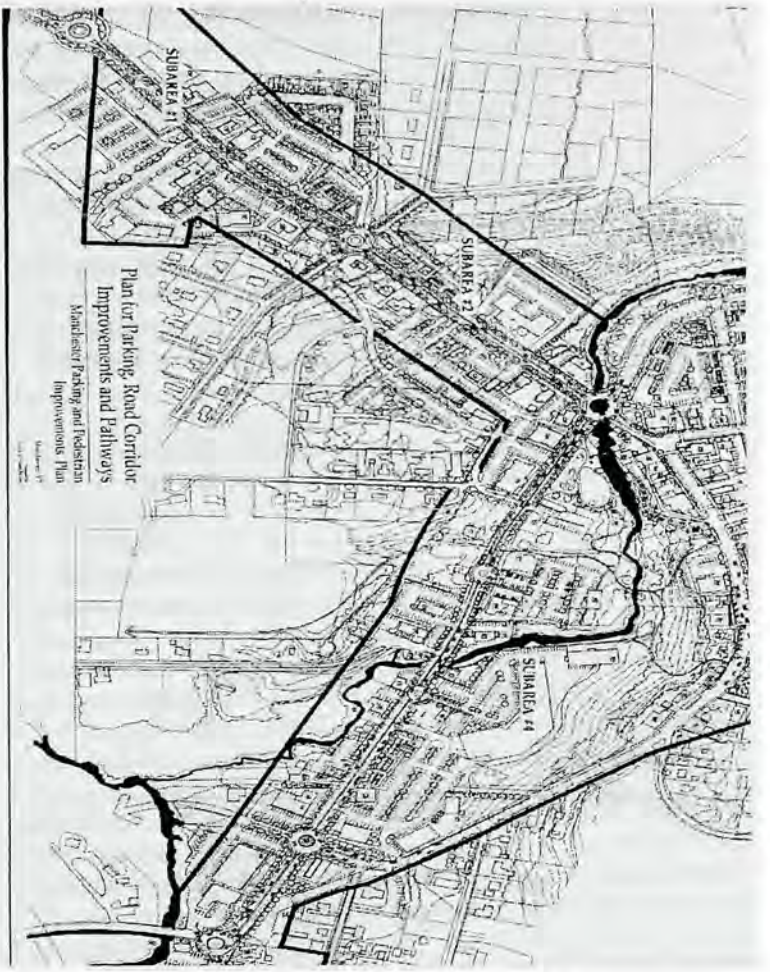



Figure 1: 1995 Manchester plan for "park and walk" features seven roundabouts.

**The Keene Bypass Expansion**

An apparently routine April, 1998 public hearing in Keene, N.H., on the $60 million Keene Bypass Expansion marked the start of a period of organized community opposition. A citizens group, Concerned Cheshire Citizens (CCC), formed and undertook a substantial community education and inquiry. In fall 1999, the first northeastern US two-lane roundabout opened about 20 miles away on the same east-west route. The Keene-turn roundabout in Brattleboro, VT, quickly became a popular success and bolstered the CCC cause. The question became whether four key intersections on the east-west axis, Figure 2, would be better served by roundabouts or an overpass, two signals and a large T-intersection grade separation, the "Trumpet" (NH Merrimack Superior Court, 2002).

A CCC legal appeal focused on loss of more than 20 acres of wetlands. The CCC also asserted roundabouts would not only protect the wetlands and reduce pollution but also provide superior transportation service at a fraction of the cost. The Court 2002 decision supported three CCC key contentions: (1) State wetlands laws were violated; (2) the DOT did not undertake a professional examination of the roundabout alternative; and (3) the traffic projections were inflated. Latest numbers on east-west segment and intersections traffic fall below those of 1990. The Bypass segments currently carry no more than 10,000 to 22,000 vehicles per day on 35-45 mph speed limit controlled access, mostly two-lane highway.

The Keene project experience may be paralleled by a quarter-century old Burlington, VT, area highway project, the Chittenden County Circumferential Highway (CCCH), undergoing re-evaluation phase of environmental documents in 2002. The overall 25.4 km initially two-lane roadway has one 7.2 km segment in place and a 6.1 km segment to cost $44.5 million (US) under review. The EPA comments pointed to the "modest improvements" in performance from the 6.1 km segment and noted the lack of evaluation of

alternatives including Transportation System Management (EPA, 2002). EPA raised concern over the induced traffic from increased regional accessibility, an evaluation left out of earlier environmental analyses in 1986 because, as the EPA stated, an evolution in thinking occurred about highway induced traffic from access created sprawl. The common thread in the Keene and the Burlington area projects appears to be the roundabout as a measure of performance.

## The Roundabout Revolution--a Yardstick for Performance and Policy Options

A confluence of trends and changes affect surface transportation both in theory and practice. The historic slowing of motor vehicle travel and appreciation of the importance of land use as well as transportation in solving community development both play a role. Roundabouts enable improved traffic circulation for all modes leading to healthier air, safety, and improved mobility as well as accessibility.

The roundabout option needs to be incorporated at the planning stage when projects can be measured against alternatives. Better transportation service to all modes and safety is practically a given with a roundabout.. It is becoming practical to expand alternatives analysis to encompass life cycle costs, air quality benefits, energy use, and both primary and secondary land use impacts. The Keene and Burlington area cases reflect what happens when expanded analyses do not enter public discussion now the roundabout treatments are available.

**Policy Options**

Suggestions for roundabout related policies include:

1. Require study of the roundabout alternative whenever an intersection improvement is considered. The Maryland State Highway Administration has such a policy.
2. Establish in each state DOT or provincial MOT a lead roundabout liaison or coordinator to provide information and technical expertise

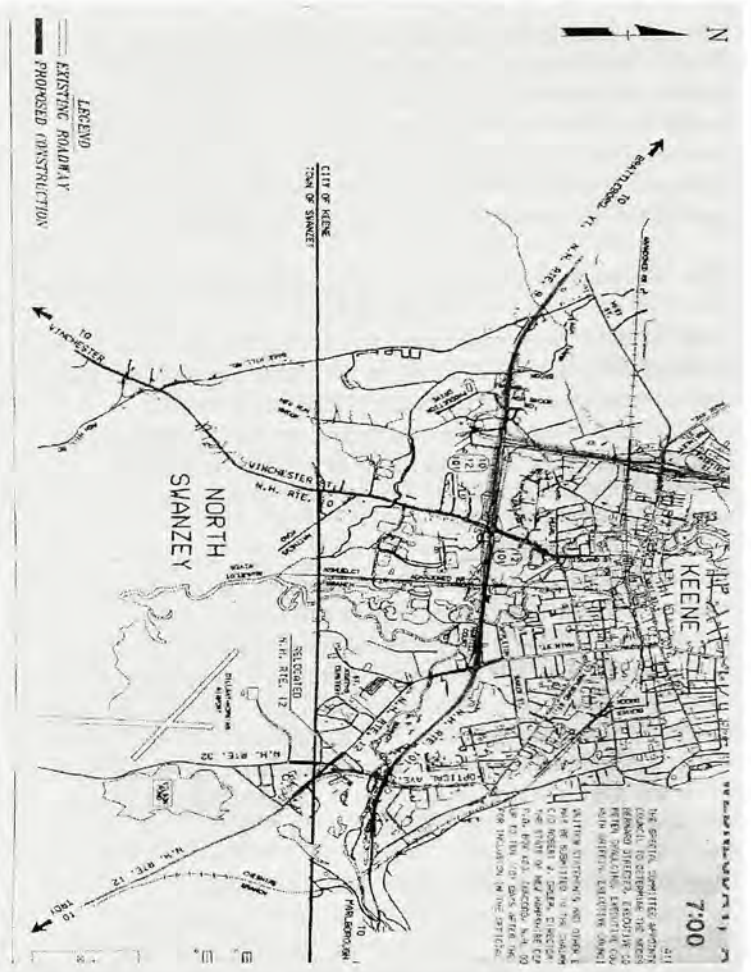



Figure 2: Keene Bypass Expansion. East (NH 9 to Brattleboro)-west (NH 101 to Marlborough)

inside and outside the agency. Michigan, New York and Washington state DOTs do possess central office coordinators who provide technical assistance, arrange training, and provide technological transfer roles in a fast changing roundabout marketplace.
3. Passage of legislation, such as Vermont's, directing transportation agencies to employ roundabouts at unsafe intersections. Language could further address land use, healthy air, GHGs generation, pedestrian service or other aspects of the roundabout.
4. Addition to US federal transportation law a provision allowing 100% funding of roundabouts, now allowed for certain other safety project types. Transport Canada could play a coordinating role in the areas of design guidelines, research, and technology transfer.
5. Take stronger measures, such as a direct roundabout program, a moratorium on signal projects until roundabout alternatives are examined, review of all highway projects against a roundabout-based alternatives, etc.
6. Strengthen and expand transportation and land use models to incorporate short and long term effects of roundabout deployment.

**References:**

Akinyemi, E O (1997) A total performance approach to traffic management for sustainable development of communities in third world cities. *1997 Institute of Traffic Engineers International Conference* pp. 191-209 (ITE, Washington, DC).

Bureau of the Census (US) (2000) *Statistical Abstract of the United States: 2000.* Table 1352 (US Government Printing Office, Washington, DC).

Central Vermont Regional Planning Commission (2000) City of Montpelier U.S. 2/302 intersection improvements. 55 p. (CVRPC, Montpelier, VT).

Elvik R (2003) Effects on road safety of converting intersections to roundabouts: a review of evidence from non-US studies.

*Proceedings of the 82nd Annual Meeting of the Transportation Research Board* 27 p. (TRB, Washington, DC).

Environmental Protection Administration (2002) Comments on Environmental Assessment Chittenden County Circumferential Highway Reevaluation of 1986 FEIS Segments A-F, September 6, 2002. (EPA Region 1, Boston).

Federal Highway Administration *Highway Statistics* Series, *2001, 2000, 1990, 1980* (FHWA, Washington, DC).
Federal Highway Administration (2000) *Roundabouts: An Informational Guide.* 268 p. (FHWA, Washingtron, DC).

Garder P (2000) Calculations of capacity for Keene, N.H. 18 p. (Concerned Cheshire Citizens, Keene, NH)

Guttenplan M, Davis D, Steiner R and Miller D (2003) Planning level areawide multi-modal Level of Service: performance measures for congestion management. *Proceedings of the 82nd Annual Meeting of the Transportation Research Board* 27 p. (TRB, Washington, DC).

Kitamura R, Akiyama T, Yamamoto T and Golub T (2001) Accessibility in a metropolis: toward a better understanding of land use and travel. *Proceedings of the 81st Annual Meeting of the Transportation Research Board* 24 p (TRB, Washington, DC).

Liu F (2003) Quantifying travel and air quality benefits of Smart Growth in state implementation plan. *Proceedings of the 82nd Annual Meeting of the Transportation Research Board.* 17 p. (TRB, Washington, DC).

Liu QX (1999) Consideration and approaches for a downtown access and circulation study. *69th Annual Meeting of the Institute of Traffic Engineers* (ITE, Washington, DC).

Manchester Town (1995) Manchester commercial district parking and pedestrian plan. 124 p. (Town of Manchester, Manchester, VT).

New Hampshire Department of Transportation (1998) Project information brochure Keene/Swanzey NH Routes 9/10/12/101 upgrade project. 9 p. (NHDOT, Concord, NH).

New Hampshire Merrimack Superior Court (2002) *Order: Conservation Law Foundation v. New Hampshire Wetlands Council, et al. No. 01-E-286, March 18, 2002.*

Newman N and Kenworthy J (1999) Sustainability and Cities: Overcoming Automobile Dependence. 442 p. (Island Press, Washington, DC).

Novellas F (2002) of the French Centre d'études sur les réseaux, les transports, l'urbanisme, presentation, "Les Giratoires en France," *Proceedings of "Des Carrefours Giratoires Pour Le Quebec," October 7, 2002.* (Association Quebecoise du Transport et des Routes, Inc., Montreal).

Ogden KW (1996) *Safer Roads: A Guide to Road Safety Engineering.* 516 p. (Avebury Technical, Brookfield, VT).

1000 Friends of Oregon (1997) Making the connections: a summary of the LUTRAC project. 11 technical reports, 1991-1997 (1000 Friends of Oregon, Portland, OR).

Persaud BN, Retting RA, Garder PE, and Lord D (2000) Crash reductions following the installation of roundabouts in the United States (Insurance Institute for Highway Safety, Arlington, Virginia). Quebec Ministry of Transport (2002) *Les Carrefour Giratoire un mode de gestion different.* 145 p. (MOT, Quebec, Quebec).

Redington T (1999) Impacts of the modern roundabout on North American traffic circulation, modal choice, sustainable development and land use. *34th Annual Conference of the Canadian Transportation Research Forum* (CTRF, Saskatoon, Saskatchewan).

Rodier CJ, Abraham JE, Johnston RA and Hunt, JD (2001) Anatomy of induced travel using an integrated lane use and transportation model in the Sacramento region. *Proceedings of the 80nd Annual Meeting of the Transportation Research Board* 34 p. (TRB, Washington, DC).

Sargeant SC and Christie JS (2002) Performance evaluation of modern roundabouts on South Golden Road. *Proceedings of the 37th Annual Conference of the Canadian Transportation Research Forum*. pp 194-209 (CTRF, Saskatoon, Saskatchewan).

Schwinger CM, O'Leary S, Fulton TH and Graham GS (1999) Central business district traffic circulation improvement a case study: Salina, Kansas. *69th Annual Meeting of the Institute of Traffic Engineers* (ITE, Washington, DC).

Sharp W and Albeck J (1999) Utilizing comuter simulaation models to optimize urban arterial traffic operations and identify capacity improvements. *69th Annual Meeting of the Institute of Traffic Engineers* (ITE, Washington, DC).

Varhelyi A (2002) The effects of small roundabouts on emissions. *Transportation Research Part D 7*. pp. 65-71 (Elsevier Science, Oxford, UK).

Vermont Laws (2002) Act 141, Sec. 37 Legislative support for roundabouts. (Vermont Legislature, Montpelier, VT).

# ITS and GPS Based Demand Responsive Public Transit

Sarah J. Taylor
Carleton University

Ata M. Khan
Carleton University

## ABSTRACT

This paper describes the progression of demand responsive transit (DRT) and identifies potential improvements through the use of ITS and GPS technologies. The objective of developing DRT in 1970s was to establish a shared-ride service providing a level of service better than conventional fixed-route transit. This system would have achieved widespread acceptance had it not been for cost, technologies with limited capability, and the disappointing ridership. The new era of interest has led to the concept of "smart" DRT. The new technologies have the potential for improved management strategies to better meet the needs of society, provided that these are integrated in a well researched DRT design.

## INTRODUCTION

The objective of this paper is to describe the application of Intelligent Transportation Systems (ITS) and Geographic Information Systems (GIS) for re-engineering the demand responsive transit (DRT) so that it becomes 'smarter' than its current versions. An overview of the computer automation involved and hence the development of algorithms is given. As well, indications of ITS technology applications are provided along with their resulting benefits. The paper concludes with a brief coverage of future prospects and research requirements.

## DEVELOPMENT OF DEMAND RESPONSIVE TRANSIT

DRT was first introduced in the early 1970s. It represented a departure from fixed route service and the first major transit service innovation in many decades (Teal, 1993). DRT was also the first transit innovation premised explicitly on computer technology. Computers and other electronic technologies were used to collect and store customer trip information, schedule vehicles for passenger pickups and deliveries, and dispatch trip orders to vehicles.

The vision for DRT (Figure 1) was to accept telephone requests for both immediate and advance reservation service, develop a continually changing set of vehicle schedules, serve passengers within a fairly small window of desired pickup and drop-off times, hold riding time in the vehicle below a reasonable maximum, and do all this with as few vehicles as possible (Lave et al, 1996). Overall, it was established to provide a level of service better than conventional fixed-route transit (Teal, 1993).

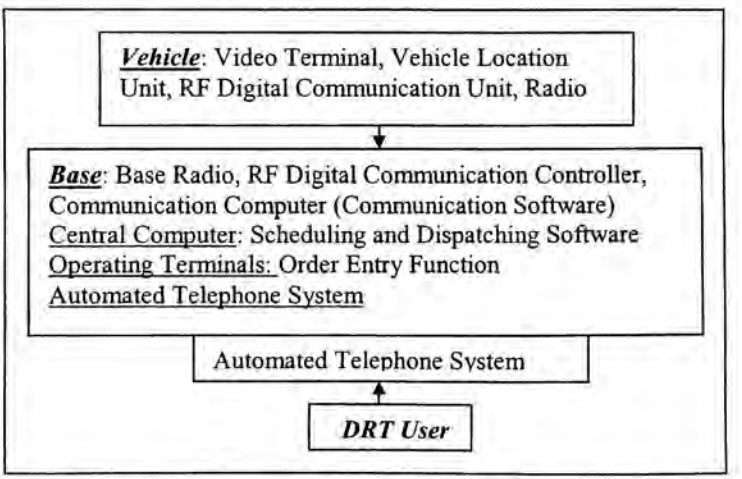



Figure 1: DRT Concept in 1970s (Adapted from Teal 1993)

This system would have achieved widespread acceptance had it not been for three primary reasons. First, it proved much more difficult and expensive to develop the system than anticipated since the computer technology of the 1970s was simple and far more costly than today. Second, experience with implemented DRT systems quickly demonstrated that they did not require complex technologies of limited capability. Third, the disappointing ridership of actual DRT systems made the technology both unnecessary and cost-ineffective in most cases (Hendrickson, 1979; Lave and Mathias, 2000).

Due to the almost complete failure of DRT, in the late 1970s and early 1980s, the service underwent a complete overhaul. Promoted in part as a method for simplifying the scheduling and dispatching tasks of a DRT operation, most systems turned to software solutions because it was much less expensive and the algorithms encoded in computer software could handle the control problem. Albeit algorithms helped, but many systems did not require the complex nature of immediate response so systems began serving one-day advance reservation service only as compared to the original concept of immediate response service (Teal, 1993).

Although many operators anticipated that advance reservation systems would have major advantages over immediate-response DRT systems, in practice, this mode of operation has been associated with much lower service productivity and with more problematic software requirements. Despite these problems, advance reservation systems became commonplace because they allowed DRT operations to ration capacity easily, and they avoided at least some of the complexity of real-time scheduling and dispatching (Lave et al, 1996).

## NEW BEGINNINGS

In the 1990s, DRT became more prominent when the Americans with Disabilities Act (ADA) was introduced in the United States followed with Canada's Transportation Act. This resulted in stipulating every transit agency provide some sort of service for the disabled and those

not able to use the provided fixed-route services. For individuals who lack the ability to use fixed-route transportation, access to DRT services was critical for meeting their mobility needs. Therefore, the issue of high cost was set aside for policy, which deemed that accessible transit, is a civil right (Lave et al, 1996; Transport Canada, 1996).

These imposed demands forced new requirements on many DRT systems. Consequently, new developments in hardware and software created potential for another technological change in DRT (Rahimi and Dessouky, 2000). Many DRT systems purchased computer software to automate their control systems and other aspects of their operations. This involved incorporating Geographic Information Systems (GIS) where it could be used to allow for the integration of data from a variety of sources to perform a number of planning tasks and/or analyses that were traditionally completed manually and were quite time-consuming (Smith et al 1999).

In addition, other technologies such as mobile data terminals, automatic vehicle location devices, in-vehicle computers, and map-based software systems entered the commercial marketplace and have been the focus of interest by DRT systems. Hence, new ways of incorporating DRT software and related electronic technologies into operations, as well as software with cost-effectiveness potential in central day-to-day operational control needs are being continually reviewed and tested. This potential to change DRT once again is using what is essentially off-the-shelf hardware combined with incremental improvements in software. This is stimulating renewed interest in DRT technologies. (Lave et al, 1996)

Consequently, the new technology has enabled a return to real-time assignment of vehicles to trip requests and real-time data communication between the control center and the vehicle (Figure 2). In general, the non-scheduling aspects of DRT operations have been fully automated. However, the scheduling aspects of dispatching are not easily automated. Most DRT service providers are using semi-

automated or computer-assisted scheduling (Rahimi and Dessouky, 2000).

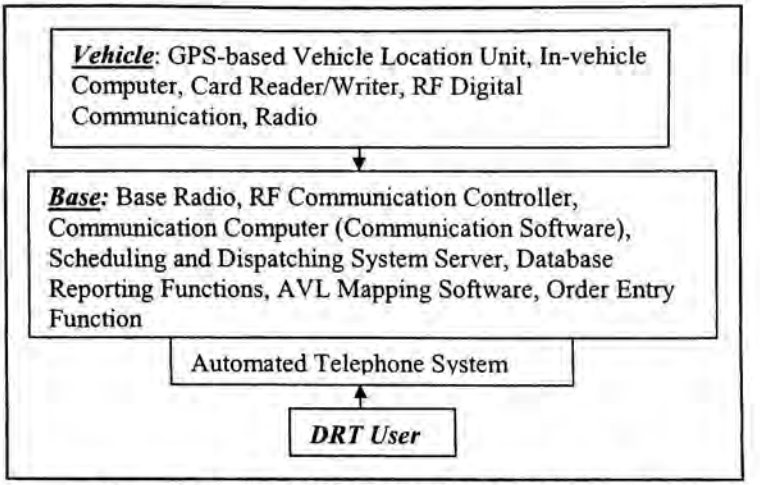



Figure 2: Changes to DRT (Adapted from Teal, 1993)

## 'SMART' DEMAND RESPONSIVE TRANSIT

### Serving the General Public

A new area of interest in DRT is the development of 'smart' DRT. This new approach is being developed to serve not only the disabled and elderly but to now include the general public. It responds to the transportation dilemma posed by suburban development patterns and the growing need to serve the rural communities (Salon et al, 2000).

The introduction of communications-based technologies is making DRT services 'smarter' in providing services in rural and suburban areas where fixed-route transit is not or scarcely available. It offers access to healthcare, enables opportunities to get to work, school and shopping. The technology assists management strategies to better

meet the needs of society by building upon the earlier design initiatives.

**Services**

Service planning will continue to move toward incorporating appropriate roles for a range of modes instead of a single approach. These systems should deploy a range of services in different geographic areas, by different times of day or day of week, and even within the same area but at premium fares to make public transit more attractive while increasing overall system efficiency. This will enable DRT to provide the appropriate service to different markets. Modal shift will be encouraged by the current interest in smart growth, which is based, in part, on providing many alternatives to automobile travel (Lave and Mathias, 2000).

The range of DRT options can be diverse. Options comprise a mix of service types and configurations, passenger-carrying levels, market orientations, and levels of regulatory control. (Cervero, 1997). Table 1 shows two examples of existing services. New forms of transit can be designed that behave more like the automobile but provide the benefits of shared-ride transportation.

The introduction of ITS and GPS technologies is moving DRT to 'smart' DRT where all of the capabilities are now in place to create intelligent forms of DRT that closely mimic the service features of the private automobile.

**Technology Enhancements**

There are a number of dimensions of DRT services that bear on high technology applications. Cervero (1997) maps out 8 features and the options available that are most open to technological enhancements. These are summarized in Table 2.

Table 1: Examples of Existing Dial-a-ride Services

| | Service Types | Service Configuration | Typical Passenger Loads | Current Primary Markets |
|---|---|---|---|---|
| Dial -a- Ride: Specialized | On demand phone request | Many-to-many | 6-10 | Elderly, handi-capped |
| Airport Shuttles | On demand phone & hail request | Few-to-one | 6-10 | Air travel-ers |

Note: Adapted from Cervero 1997

## SOCIO-TECHNICAL ADVANCES

### Automation

So far, only small attempts have been made in the field of 'smart' DRT. Steps have been taken to apply automated technologies in ways that begin to resemble what 'smart' DRT systems should look like. The challenge of implementing 'smart' DRT has more to do with institutions, politics, and money than with technology. Applicable technologies are already in place to launch. What is still missing is an effective integration of individual parts into a workable system, along with a conducive institutional, political, and economic environment.

Research has mainly focused on the improvements in level of service that the technologies can offer. The next step is to look at the broader picture. Agencies interested in applying the different technologies will have to weigh the tradeoffs between effectiveness and costs of implementation and operation. By knowing ridership or potential ridership response to different technologies, the best applications can be implemented (Ben-Akiva et al, 1996).

Table 2: DRT Features Relevant to Advanced Technologies

| Features | Options |
|---|---|
| Scheduling | . Fixed schedule<br>. Demand-responsive<br>. Unscheduled |
| Routing | . Fixed Route<br>. Route-deviation<br>. Flexible-route |
| Clientele | . Specialized<br>. General Public |
| Continuity | . Transfers<br>. No Transfers/Continuous |
| Occupancy | . Shared-ride<br>. Exclusive-ride |
| Connectivity | . Door-to-door<br>. Checkpoint |
| Geography | . One-to-one<br>. One-to-many/One-to-few<br>. Many-to-many/Few-to-few |
| Information | . Real Time<br>. Delayed |

Drivers, schedulers and dispatchers contribute a great deal to the success and quality of DRT programs. There is also a role for automation (e.g. GIS-based AVL technology for providing accurate information on where a vehicle is located at a particular time, automatic passenger counters for checks on seat availability, on-line information on traffic conditions and hence expected travel times, etc.). There is clearly a major role for new communication technologies.

**Algorithms**

An issue essential to the smart DRT system development is the effectiveness of automation in improving the process of dispatching

and scheduling of DRT. The question is whether or not ITS technologies have been implemented efficiently and productively for this level of user complexity. Along with improving technology for automation there is a need to improve the algorithms for the complex nature of demand responsive transit.

Since travel times between individual locations in urban traffic environments are often subject to factors like changes in traffic volumes and unpredictable occurrences of traffic incidents, DRT systems must find ways to confront this issue in order to adhere their service to pre-established schedules (Fu, 1999).

This is especially true when schedules are calculated on the basis of models that assume time-unvarying and/or deterministic travel times. It can be expected that in situations of high uncertainty the service vehicles may not be able to follow the schedules generated from these models and thus a reliable service may not be guaranteed.

For example, based on the assumption of deterministic travel time it would be feasible to schedule a vehicle to drop off a passenger at his/her destination at his/her appointment time. However, there is a certain amount of uncertainty that the passenger may be dropped off after his appointment time because of the randomness of travel time. Therefore stochastic nature of travel time should be treated in algorithms (Fu, 2002)

This scheduling problem has been the focus of research since the beginning of the DRT service concept. In solving the scheduling problem, traffic congestion has to be taken into account and should be assisted with real-time information. Fu (2002) argues that travel time in urban routing environments is inherently time-varying and stochastic due to temporal and spatial variation of traffic congestion and therefore should be explicitly modeled as such in formulating the DRT scheduling problem in order to produce more reliable and efficient schedules.

Hence, he successfully developed a model and algorithm that has been successfully integrated into an interactive scheduling tool and was able to solve problems of realistic size on personal computers. But, a further attempt is being made to extend the proposed methodology to the dynamic DRT scheduling problems where real-time information on vehicle service status and traffic congestion may be available via advanced information technologies and randomness in system states (Fu, 2002).

Another issue that has to be dealt with is waiting time at consecutive stops at the same location (picking more than one person up at the same location). Limiting the waiting per location rather than per stop can be handled in the algorithm by appropriately changing the update of the latest possible departure time. (Hunsaker and Savelsbergh, 2002)

## FUTURE DRT SYSTEM

If other industry experience is a reliable guide, technology within DRT functions will only lead to higher levels of automation in the coming years. The products that exist today can be used with limited technological risk and adapted. Control centers could provide automated telephone call-backs to passengers with vehicle status information. When vehicles are running late, patrons can be informed, and when they are within a certain distance of the pickup point, patrons can be notified.

In more ambitious systems, reservations can be made on-line using a computer (Lave et al, 1996). As the Internet and World Wide Web expand in both presence and performance over the next several years, this access to reservations systems may become quite common. Such automation would need to have fully computerized reservations and scheduling capability and a GIS capability. While this would seem to have significant potential for cost saving, it is a use of technology that involves the passenger to a greater degree than other systems and may therefore cause resistance to acceptance. Since many users of DRT

service have functional difficulties, the interaction with a known voice may be a desirable part of the service. Therefore, although it is not likely that on-line reservations will ever totally replace the person-to-person reservations process, a substantial percentage of reservations activity might be handled in this fashion.

The impact of the new spatial data technologies will be profound. These technologies will change completely the way transportation professionals view their roles and responsibilities. The technologies will not only be inexpensive, but also easy to use and ever present.

Making such applications a reality, however, will require substantial advances in technical knowledge; in understanding of human–computer interactions; and in the development of appropriate models of environmental, physical, and social processes that shape our geographic world. Major investments in information infrastructure will be required (Turner and Bespalko, 2000).

Today's most pressing and troubling transportation-related problems demand that bold and creative approaches to reducing reliance on the private automobile and improving efficiency in urban travel be introduced. The automobile is the primary means of transportation because it is best suited to serving contemporary travel patterns. Public transit's increasing operating costs, declining market shares, and diminishing productivity stem from the fact that traditional fixed-route, fixed-schedule, large vehicle transportation is unable to effectively compete with the private car given today's settlement and travel patterns.

DRT represents an entirely different ideal for coping with rural and suburban development systems. It more or less accepts low-density lifestyle preferences of most people and tries to effectively adapt to the suburban and rural landscape. Thus, DRT is a transportation response to established land-use patterns and preferences (Sayed and Ho, 2000). It remains the closest thing within public transportation to a supply side strategy that begins to mimic the operating characteristics of the private automobile.

For DRT system design, hardware as well as software are to be studied carefully. Establishing vehicle size for a given market niche is important for level of service as well as cost considerations. The ITS and GPS are of-course the driving force behind the future DRT system. Likewise, the DRT software is also very important for a successful design. DRT's software plays a role in service make-up and is therefore a key component of the system design.

As a hybrid of bus transit and the private car, DRT offers a wide spectrum of service features that agree with the shifting nature of urban travel (Sayed and Ho, 2000). DRT can never match the service features of private automobiles, like continuous availability and personal privacy. Accordingly, DRT will never have the extent of applications of a private vehicle. Therefore, DRT will always be a niche market service between private cars and conventional transit. An understanding of this niche market is worthy of further research.

## CONCLUDING REMARKS

1. Continuing research is required on DRT market potential and system design. The role of ITS and other innovations has to be defined and economic factors should be a part of system design.

2. Further research is required in the following subjects.

   (a) What is the most cost-effective use of technology in DRT?

   (b) In the system design, the advantages and disadvantages of various communications systems should be studied.

   (c) Development of algorithms for intelligent control.

   (d) In system optimization, the vehicle size should be treated as a variable.

(e) Market niches require further investigation, especially trip volumes and features to be served.

## ACKNOWLEDGEMENTS

This paper is based on research sponsored by the Natural Sciences and Engineering Research Council (NSERC).

## REFERENCES

Ben-Akiva, Moshe, Julian Benjamin, Geoffrey J. Lauprete, and Amalia Polydoropoulou. (1996) *Impact of Advanced Public Transportation Systems on Travel by Dial-a-Ride.* Transportation Research Record, No. 1557.

Cervero, R. (1997) *Paratransit in America: Redefining Mass Transportation.* Westport, Connecticut: Praeger.

Fu, Liping (1999). *Improving Paratransit Scheduling by Advancing for Dynamic and Stochastic Variations in Travel Time.* Transportation Research Record 1666, Transportation Research Board, national Research Council, Washington, D.C.

Fu, Liping. (2002). *Scheduling dial-a-ride paratransit under time-varying, stochastic congestion.* Transportation Research - Part B Methodological, V. 36, No. 6.

Hendrickson, C. (1979) Evaluation of Automated Dispatching for Flexibly Routed Paratransit Services. *Special Report 186: Paratransit: 1979,* Transportation Research Board, National Research Council, Washington, D.C.

Hunsaker, Brady and Martin Savelsbergh. (2002) *Efficient feasibility testing for dial-a-ride problems.* Operations Research Letters, Vol. 30, No. 3.

Lave, Roy E., Roger Teal, Patrisha Piras (1996) *TCRP Report 18 A Handbook for Acquiring Demand-Responsive Transit Software.* Transportation Research Board National Research Council Transportation Cooperative Research Program, Washington: National Academy Press.
http://nationalacademies.org/trb/publications/tcrp/tcrp_rpt_18.pdf

Lave, Roy, Rosemary Mathias. (2000) *State of the Art Paratransit.* Transportation Research Board.
http://nas.edu/trb/publications/millennium/00107.pdf

Rahimi, Mansour, Maged Dessouky (2000*) A Hierarchical Task Model for Dispatching in Computer-Assisted Demand-Responsive Paratransit Operation* Publication: ITS Journal - Intelligent Transportation Systems Journal. v. 6, n. 3, p. 199.

Salon, Deborah, Daniel Sperling, Susan Shaheen, Daniel Sturges. (2000) *New Mobility: Using Technology and Partnerships To Create More Efficient, Equitable, and Environmentally Sound Transportation.* Transportation Research Board.
http://www.nas.edu/trb/publications/millennium/00078.pdf

Sayed, T. and G. Ho. (2000) *Intelligent Transportation Systems: An Overview of The Potential Safety Benefits,* CITE 2000, Canadian Institute of Transportation Engineering, Niagara Falls, Ont., May 6-10. http://www.eng.ucalgary.ca/Civil/C-TEP/ITS_seminar/ICBC%20ITS%20Research%20Paper.pdf

Smith, Brian L., Priya K. Durvasula, and Stephen C. Brich. (1999) *GIS-Based Support System for On-Demand Flexroute Transit Service.* Journal of Public Transportation Vol.2, No.4.

Teal, Roger F. (1993) *Implications of Technological Developments for Demand Responsive Transit* Transportation Research Record Number 1390, Transportation Research Board, National Research Council, Washington, D.C., p.33.

Transport Canada. (1996) *Canadian Transportation Act.* http://www.tc.gc.ca/Actsregs/ct-ltc/ct_a.html

Turner, A Keith, Stephen J. Bespalko. (2000) *Spatial Data Technologies.* Transportation Research Board. http://nas.edu/trb/publications/millennium/00104

# Development of A Public Transit Information System: Use of GIS and ITS Technologies

Sarah J. Taylor
Carleton University

Ata M. Khan
Carleton University

## ABSTRACT

This paper describes the development of a transit information system, which enables the identification of an optimal route and provides the corresponding travel time estimate while accounting for the uncertainty in schedule adherence. Data from the Ottawa-Carleton Regional Transit Commission (OC Transpo) and the City of Ottawa were used to develop the transit information system. The algorithm for route planning takes into account transit vehicle operational characteristics. Bayesian statistical methodology and a link to the transit agency's on-line data file are used to address the uncertainty in schedule adherence. A Geographic Information System (GIS) software is used to implement the system. Trip planning is the main feature of the transit information system.

## INTRODUCTION

One of the important initiatives that a public transit agency can undertake for improving ridership is to provide up to date and reliable travel information. This includes optimal route and arrival time (Syed and Khan 2000). Traditional customer information systems provide users with route maps, printed transit schedules, and telephone/email assistance with itinerary trip planning. In all cases, a customer service representative supplements standard route and schedule brochures (Smith 2000). However, neither customer service agents nor users

know whether the planned route is the optimal one. Manual trip planning is a tedious, time-consuming, and often error-prone process, and information is sometimes inconsistent from one operator to another (Peng and Oliver 1999). Furthermore, there is uncertainty in travel time estimates provided to transit users (Abdelfattah and Khan 1998).

Literature sources show that existing and planned information systems have highly diverse capabilities (U.S. Department of Transportation 2002, Tayyaran and Khan 2001, NextBus 2002). There is a need to overcome the following deficiencies of the existing transit information systems by (1) taking into account all the complexities of transit operation, both spatially and temporally, (2) developing the ability to search and display the optimal route, (3) addressing the uncertainty in schedule adherence or arriving at a designated stop/station according to projected time.

This paper reports the development of an advanced transit information system that overcomes the deficiencies of existing information systems in terms of providing route and travel time information while accounting for the uncertainty in schedule adherence.

## METHODOLOGICAL FRAMEWORK

The transit information system design process involves answering four major questions:

- Where is the nearest bus stop? (Location)
- When does the next bus leave or for travel at a certain time, which is the most appropriate departure? (Scheduling)
- How do I get from where I am to where I want to go? (Route Optimization)
- When will I arrive at my destination? (Travel Time)

In order to formulate these questions, the system has to enable geocoding of trip origin and destination points and link them to bus stops and routes. The respective bus routes are to be selected and an optimum route should be found. The result has to be illustrated as the

preferred route and trip itinerary. Hence the system has the following four major attributes: list of trip locations and the capacity to enter addresses, location of the transit stops, schedule information, improvement in estimating travel time, and route optimization.

Major elements of the transit information system development process are shown in Figure 1.

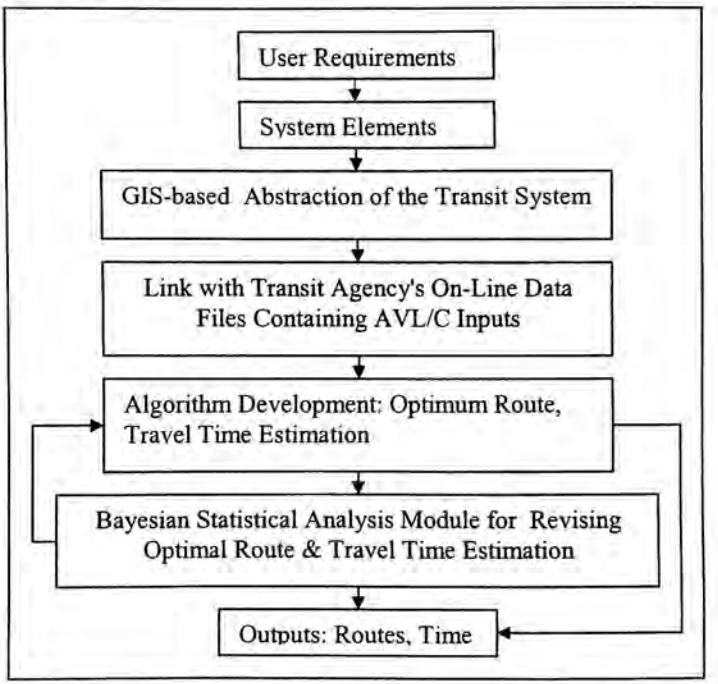



**Figure 1 System design methodological framework**

Although the generic aspects of the system design form an important part of the methodology, the application reported here is based on OC Transpo data consisting of 23 selected routes and almost 2000 bus stops. These routes were selected from each service time period,

namely regular, rush hour, express, and early morning. The school and shuttle services were excluded.

ArcView3.2a GIS software was selected due to its many favourable features, including optimal route finding capability. The transit, road system and other data were coded according to the requirements of the software. A small sample of landmark addresses was gathered from the phone book. All of these point locations were individually digitized into ArcView3.2a.

The design process starts with defining a GIS data structure to represent a logical relationship among individual elements of the transit data. Next, a functional structure is defined including the control relationships among functions. Further, the design focuses on the interface by showing how the application communicates within itself and with users. Finally, the transit information system was designed utilizing ArcView 3.2a, Avenue (the object-oriented programming language), and the extensions Dialog Designer and Network Analyst. The final product of the system consists of 75 scripts (algorithm), and 7 dialogs.

Seventeen themes were defined (i.e. the street network, the transit route network, geocoded locations, namely, cinemas, churches, emergency, hospitals, hotels-motels, libraries, museums, tourist attractions, schools, shopping malls, grocery stores, recreation centers, bus stops, an empty theme for input information, and a hotlink). The geocoded addresses were created from a list of digitized points. The empty theme is used when the user enters a location by an address and to join multiple locations through landmark selection. This theme is then geocoded for use in finding the optimum route. The hotlink theme is used to link the user to OC Transpo's website.

Rules of the network were coded (e.g. roads that were closed, one-way streets, speed limits), including traffic control. The schedule information is considered as relational databases made up of multiple linked tables rather than a single table. These are the schedule tables, the bus route table, and the bus stop table.

In the transit information system design, a provision was made for a link with the transit agency's on-line data files containing Automatic Vehicle Location and Control (AVL/C) system data. This on-line file provides advisories regarding the status of bus movement on a route.

An algorithm was developed for finding the optimal route and the corresponding travel time. This methodology interacts with the Bayesian statistical analysis module, described later in this paper, which in turn is intended for revising optimal route and travel time estimates. For the analyst, flexibility is provided in checking outputs without statistical analysis. The end result is the developed user-friendly transit information system, which determines an optimal trip itinerary based on the traveller's origin and destination at a specific time and day.

## BAYESIAN STATISTICAL ANALYSIS MODULE

### Rationale

Only when a public transit journey from an origin to a destination is complete, the actual travel time becomes known. The actual time can be different from the estimated time, given a large number of sources of uncertainty (e.g., weather, lane blockage due to snow clearing or fire fighting activities, accidents or incidents). Recurring traffic congestion on mixed traffic links can cause unexpected delays unless its effects are accounted for in schedule development. Passenger cars or other vehicles can adversely affect the operation of bus-only lanes on city streets. Passenger loading/unloading and other processes on the Transitway (a limited access busway) can cause deviations from the schedule. In spite of these sources of uncertainty, it is common practice in transit information system development to treat travel time estimates as if these are certain to become true.

A major thrust of this research was to formally model the uncertain nature of travel time as a part of the development of the transit information system. This required the incorporation of a method in the

design of the system for dealing with the uncertainties in travel time estimates.

The Bayesian statistical methodology treats a future event, such as travel time from an origin to a destination, as uncertain. Initially, prior probabilities are assigned to travel time values. As new data become available, these probabilities are changed to posterior probabilities by using the Bayes Theorem (McGrew and Monroe 1993). In turn, these are then used to find the expected travel time. Although Bayesian methods are attracting increasing attention in high technology and other areas of research, there have been relatively few applications in transportation ( CSHRP 2000). In public transit operation, by applying the Bayesian methodology, travel time information can be continually updated based on the availability of new data. This transit information system uses the latest available schedule information as the starting point. The system then checks to see if OC Transpo has given any revised information based on travel conditions.

To begin the analysis, the system was assigned three states-of-nature (T1, T2, T3), which are uncertain origin-destination travel times. T1, T2, and T3 correspond to early, on time, and late arrival, respectively. As defined by OC Transpo, "the allowance for 'early' is tight but the 'late' allows a few minutes". As explained further, a bus was categorized as early if it was one to two minutes earlier than scheduled. A bus was considered late if it arrived 3 to 4 minutes after the scheduled time. For the purpose of calculating travel time, on the basis of OC Transpo's information, T1, T2, and T3 were assigned travel times as follows:
T1: Scheduled travel time minus 1minute or more
T2: Scheduled travel time (if arrival is less than 1 minute early or less than 3 minutes late)
T3: Scheduled travel time plus 3minutes or more

**Prior Probabilities and Expected Time**
The prior probabilities were estimated on the basis of frequency analysis of OC Transpo data. These show low probability of early arrival at destination, high probability of on-time arrival at destination,

and moderate probability of late arrival. The sum of probabilities is equal to one, given that the model is based on three states of arrival time.

The prior probabilities of the Ts, P'(T) were defined for off peak periods (18:31 – 6:30 & 9:31 – 15:30), peak periods (6:31 – 9:30 & 15:31 – 18:30), and peak hours (7:31 – 8:30 & 15:31 – 16:30). As an overall summary of all day performance, these were also compiled. To represent the sample routes within the application, probabilities were estimated for both Transitway (95, 97) and non-Transitway (3, 118) routes. Examples of prior probabilities are presented in Table 1.

The initial expected travel time is obtained by weighting times with prior probabilities.
Expected travel time = P(T1)(T1)+P(T2)(T2)+P(T3)(T3)

**TABLE 1 Prior Probabilities Based on OC Transpo Data (Example Travel Periods)**

| Routes | 07:31-08:30 | | | 15:31-18:30 | | |
|---|---|---|---|---|---|---|
| *Weekday* | Early | On Time | Late | Early | On Time | Late |
| 95 | 0.130 | 0.700 | 0.170 | 0.230 | 0.640 | 0.130 |
| 97 | 0.200 | 0.710 | 0.090 | 0.270 | 0.630 | 0.100 |
| Average | 0.165 | 0.705 | 0.130 | 0.250 | 0.635 | 0.115 |
| 3 | 0.110 | 0.580 | 0.310 | 0.360 | 0.530 | 0.110 |
| 118 | 0.280 | 0.530 | 0.190 | 0.450 | 0.450 | 0.100 |
| Average | 0.195 | 0.555 | 0.250 | 0.405 | 0.490 | 0.105 |

**On-line Updates & Reliability of Information**

The intelligent transportation system (ITS) installations including the automatic vehicle location and control system (AVL/C) enable the public transit agency to make frequent checks on schedule adherence. Within the transit information system, the transit agency must specify their perception of how the buses are running. A code is entered into the transit route table corresponding to early, on time or late status; R1, R2, and R3, respectively.

The reliability of on-line information updates is expressed in the form of conditional probabilities. For example, P(R1|T1), is the probability of getting the indication of 'early arrival', given that the actual state is T1 (early arrival). In other words, if it turns out that the traveller will arrive early, what is the probability that the information obtained on-line suggests the same. Likewise P(R2|T1) defines the probability of getting the on-time indication, given that the true state is early arrival.

The basis for estimating conditional probabilities is the OC Transpo's AVL/C system data. The conditional probabilities are shown in Figure 2 and an explanation is provided here. If the actual travel time turns out to be 'early', the probabilities of getting the advisory as early, on time or late are 0.70, 0.25, and 0.05, respectively. The probabilities of receiving advisory as early, on time, or late given that the true travel time will be 'on time' are 0.15, 0.70, and 0.15, respectively. The probabilities of receiving advisory as early, on time, or late given that the true travel will be 'late' are 0.05, 0.25, and 0.70.

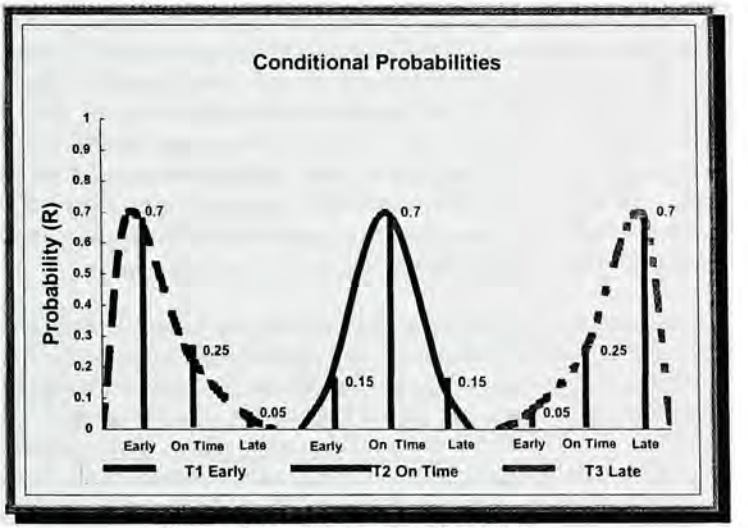



**Figure 2 Conditional probabilities**

As noted above, these conditional probabilities can be regarded as the reliability of information. As more data are obtained on a seasonal or yearly basis, modifications can be made.

**Posterior Probabilities and Expected Time**

These are revised probabilities of states of nature (i.e. travel time), found by combining old information with new information. Bayes' Theorem is used to calculate posterior probabilities. Due to space limitations, the logic diagram for the Bayesian analysis of travel time and equations for posterior probabilities cannot be shown here.

## OPTIMAL ROUTE

In solving the optimum path problem, many standard algorithms do not apply. The transit network is much more complex than the road network because it is strongly time-dependent and highly dynamic. Travel time on transit networks is constrained by a schedule and arrival times are uncertain. The availability and the level of transit service vary by time of day and day of week because many transit routes have express and limited services at different times. To plan a trip, the trip planning system needs service information for specific times and locations. A trip planning system that is based only on transit route configuration and assumes ever-present availability of service on every route and at all stops will generate erroneous trip plans. Therefore, the most important database requirement of the transit information system design is the incorporation of transit routes and the relevant transit services.

The analysis of transportation networks is one of many application areas in which the computation of the optimal path is one of the most fundamental problems. Several algorithms and data structures for algorithms have been put forward since the classic shortest path algorithm by Dijkstra was published in 1959. Most computer applications, including ArcView, use a modified version of this model to find the optimal route. The modified Dijkstra's algorithm included in ArcView 3.2a was used in the transit information system to find the shortest path tree.

## SYSTEM STRUCTURE

In developing the structure of the transit information system, an attempt was made to simulate the communication that takes place when the telephone service is utilized. Like telephone service interaction, the structure of the transit information system has three components: input of users' information, calculation of the optimal route and expected travel time, and display of the result. The following steps provide a description of the process used by the algorithm.

- Obtain information from user and step through user interface
- Geocode the origin and destination stops
- Search for bus arrival times at the origin point closest to the user's input
- Search all bus routes containing the origin or the destination point
- Obtain the closest bus stop to the origin and destination
- Obtain the nearest bus stop with a time point for linear interpolation
- Calculate the arrival time at the bus stop closest to the origin and destination
- Using the applied costs, calculate the travel time from the origin to destination
- Apply Bayesian statistics to the travel time
- Output the results graphically and with a written itinerary

Within the transit information system, the database plays an important role. It organizes data describing the transit system, and provides a mechanism to store and manage user preferences as they interact with the system. Considerable effort was required in designing the structure of the database tables.

The transit information system was developed as a user-interface. In the user-interface, there are three parts: setting the user's preference, inputting the user's desired origin and destination or schedule

information, and displaying the results. Figure 3 outlines the process. First, according to the set user preferences the application generates the subsequent pages, for selecting the origin and destination points. From these pages, the user's origin and destination data flow into the application for locating the points and their respective bus stops. Once it finds the origin and destination, and bus stops, the application displays these points and calculates the optimum path. The result is displayed to users to print. Sample itineraries and route illustrations are shown in Figures 4 and 5, respectively.

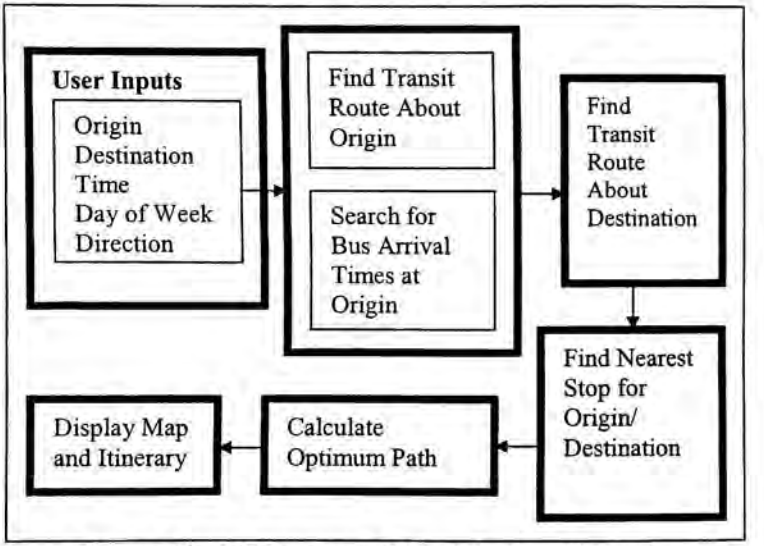



**Figure 3 Overall structure of transit information system**

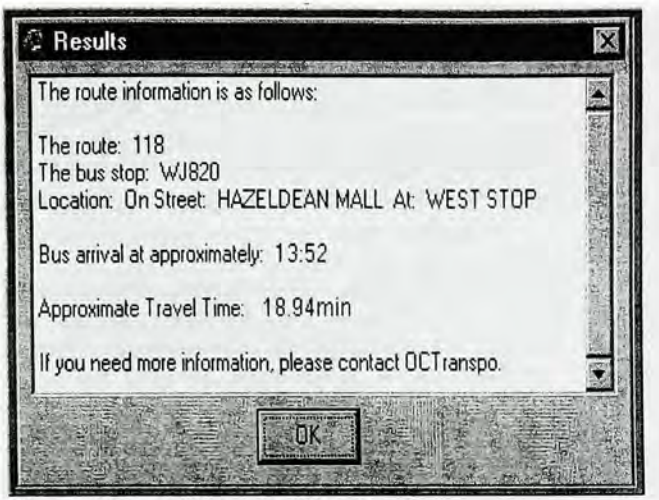



**Figure 4 Report box reporting results**

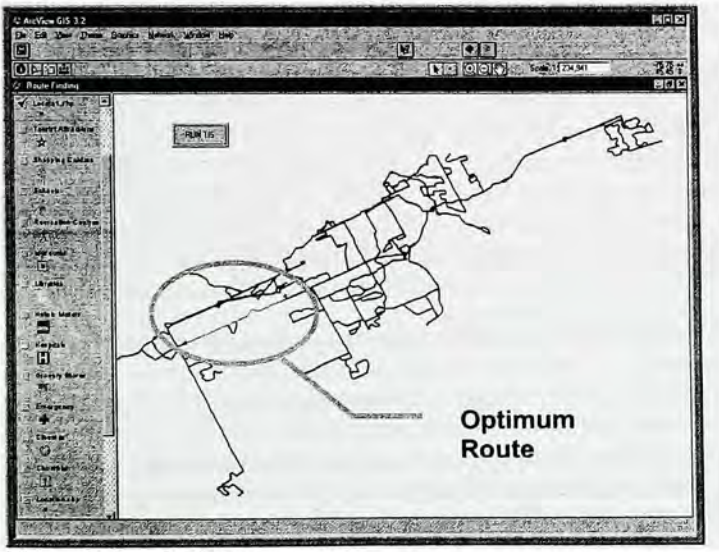



**Figure 5 Results image**

## SYSTEM VALIDATION

Once an application like this has been created, it needs to be tested. For this step, the key is to find all possible errors in the algorithm that a user might encounter. For this step several trial runs of the system were conducted in an attempt to simulate possible user inputs. To date this has been successful and any errors encountered have been eliminated.

Based on the results of the algorithm, trial runs were executed given each condition of early, on time, or late. Bayesian analysis was applied for both weekday and weekend trips to visualize the different travel conditions instituted by the probabilities. Selected results are shown in Table 2.

**TABLE 2 Selected Results: Weekday Trips: Route 97 Kanata Town Center to Airport (Scheduled Travel Time 64 minutes)**

| No Statistical Analysis | Use of Prior Probabilities | Use of Posterior Probabilities | | |
|---|---|---|---|---|
| Algorithm Calculated Time (min) | Expected Time (min) | Result With Early Arrival Advisory (min) | Result With On Time Arrival Advisory (min) | Result With Late Arrival Advisory (min) |
| 65.41 | 66.54 | 62.85 | 65.85 | 72.21 |

The results obtained from the Bayesian analysis clearly show how the uncertainty of transit travel can be minimized. There is an obvious difference in travel time given the scenarios of being early, on time, or late. Depending on the applied probabilities to the corresponding time period, the bus arrival can vary up to 10-15% representing early to late at a particular bus stop. This percentage demonstrates how a bus could arrive between 3 to 8 minutes early or late as compared to the actual scheduled time.

## CONCLUSIONS

The development work, analyses carried out and results achieved suggest the following conclusions.

1. A state-of-the-art transit information system is developed by using ITS and GIS technologies and the Bayesian statistical analysis methodology. The Bayesian method is useful for incorporating new travel time information (i.e. transit advisories regarding bus movements), thus making the best use of AVL/C information obtainable from transit agency's on-line file.
2. This transit information system is unique in the field in terms of formally accounting for the uncertainty of schedule adherence.
3. The object-oriented data model design simplifies data management and maintenance as well as increases the efficiency of network analysis, including spatial search, query, and shortest path finding. The use of ArcView GIS software was found to be very helpful because many functions are integrated into the software and require a minimal amount of new programming software code for any specific routine, with the exception of the transit route-planning and statistical analysis algorithm.
4. The transit information system has been validated and is operational. Results obtained suggest that this system will be useful in terms of providing trip itinerary, optimal route and corresponding travel time. Sample runs indicate the ease of use.
5. It can be used by the OC Transpo with minor further development work. The system can potentially be accessed wherever web capability is available (e.g. desk top computers, kiosks, and hand-held devices such as a cellular phone).
6. The generic nature of the system deign enables its application by public transit agencies other than OC Transpo.

## ACKNOWLEDGEMENTS

Financial support for this research by the Natural Sciences and Engineering Research Council of Canada (NSERC) is acknowledged. Professional staff of the OC Transpo and the City of Ottawa helped in data acquisition. Their help is gratefully recognized.

## REFERENCES

Abdelfattah, A. and A.M. Khan (1998). Models for Predicting Bus Delays. *Transportation Research Record 1623*, Transportation Research Board, pp.8-15.

Canadian Strategic Highway Research Program (CSHRP) (2000). Bayesian Modelling: A User's Guide. 2000

McGrew, J. and C.B. Monroe (1993). *An Introduction to Statistical Problem Solving in Geography*. Dubuque, Iowa: Wm. C. Brown Publishers Inc.

NextBus (2002). Websire http://www.nextbus.com

Peng, Z-R. and J. Oliver (1999). Assessing Means of Transit Information Delivery for Advanced Public Transportation Systems. *Transportation Research Record 1666*, Transportation Research Board.

Smith, B.L (2000). Using Geographic Information Systems and the World Wide Web for Interactive Transit Trip Itinerary Planning. *Journal of Public Transportation*. Vol.3, No.2.

Syed, S.J. and A.M. Khan (2000). Factor Analysis for the Study of Determinants of Public Transit Ridership. *Journal of Public Transportation*. Vol.3, No.3, pp1-18.

Tayyaran, M.R. and A.M. Khan (2001). Transit Operations within the Context of Intelligent Transportation Systems. Canadian Institute of Transportation Engineers (CITE) Annual Meeting, Calgary.

U.S. Department of Transport (2002). Transit website: Top Transit Web Sites Recognized. 2002/02/08 Web address: http://www.transitweb.its.dot.gov/Documents/PressRelease.htm

# The Lower Mainland (Vancouver) Truck Freight Study

D. Bickel, Vancouver Port Authority; G. Chow, University of British Columbia*; B. Clement, TransLink, J. Mills, Transport Canada, J. Wang, TransLink
*corresponding author garland.chow@commerce.ubc.ca

## INTRODUCTION

Trucks are the dominant mode of transport for the movement of urban freight in the Vancouver Lower Mainland, accounting for over $1 billion in revenue per year and representing approximately 8% of the Lower Mainland economy. Quantifying and estimating truck movements are a valuable planning tool for transport planners to develop policies and regulations and implement road strategies. Many jurisdictions accomplish this through a commercial vehicle survey (*1,2*). Vancouver transport planners had been relying on a truck forecasting model developed in 1990, calibrated on 1988 data (*3*). However significant changes have occurred, including:

- a significant increase in cross-border truck movements due to Canada-United States free trade agreements,
- growth of container traffic and air cargo movement as Vancouver grew in importance as a gateway into and out of North America,
- expansion and diversification of the economic base of the Lower Mainland and redistribution of the employment,
- significant additions to the region's infrastructure over the last decade that have affected the demand for truck movement,

- changes to the storage and handling of commodities that has altered the nature of demand for trucking, such as the use of containers and just-in-time delivery.

It is evident that trucking plays a significant role in the regional economy, and has the potential to continue to grow rapidly. However, with this growth are concerns that the road network will be unable to efficiently accommodate this demand; and more localized concerns from residents who wish to relieve their roads of truck movements. In response to these issues, the TransLink Strategic Transportation Plan expresses the desire to facilitate truck demand on the regional transportation system through selective implementation of road improvements that will benefit goods movement, road priority measures and implementation of ITS technology. Efficient goods movement is also a stated priority of Transport Canada and the Ministry of Transportation and Highways. Hence, the analysis of truck movements is a priority of all agencies involved in providing transportation services.

In order to provide a more relevant and current basis for addressing truck movement issues and investment priorities, a consortium of regional transportation agencies commissioned the Lower Mainland Truck Freight Study (LMTFS). The consortium included the Greater Vancouver Transportation Authority (TransLink) which acted as project manager, Transport Canada, British Columbia Transportation Financing Authority, British Columbia Ministry of Transportation and Highways (MoTH), Insurance Corporation of British Columbia (ICBC), Vancouver Port Authority, Vancouver International Airport Authority, and Fraser River Port Authority. Numerous stakeholders including the the BC Trucking Association, terminal operators and trucking carriers, provided useful advice, resources, and information and were consulted throughout the study. Steering and technical committees, comprised of representatives of the consortium partners, stakeholders and academia, guided the project. A consortium of consultants undertook the study with the final report produced by a project team consisting of Technical Committee members from TransLink and the Ministry of Transportation and Highways, and staff from Reid Crowther and Partners Ltd. the lead project consultant. This study

reflected the current trend within the Lower Mainland toward stronger inter-agency co-operation on a wide range of transportation issues, and involved sustained constructive effort from a large team of individuals that represented goods movement stakeholders

The study objectives were to:

- develop a 'snapshot' of trucking movements for a typical day during October/November 1999;
- quantify the changes in truck movements since 1988; and
- develop a computer model that can be used to forecast future truck demand.

The deliverables from this study are being used by a range of organizations and professionals in the field. Specific applications of the deliverables include major infrastructure planning, traffic monitoring, traffic impact assessments of major developments, cross border freight movement, inter-modal freight planning, pavement management systems, and air quality modelling.

## METHODOLOGY

The LMTFS investigated trucking movements in the geographic area bounded by the U.S. border to the south, the Straight of Georgia to the west, the Coast Range mountains to the north of the Fraser Valley, and the town of Hope.

The study was divided into three main components:

- origin/destination surveys;
- vehicle volumes and classification survey; and
- development of truck demand forecasting model.

### Origin/Destination Surveys

The objective of the regional truck activity surveys was to obtain quantitative information regarding demand for light and heavy truck trips in the Lower Mainland. The type of information collected included the number of trips made in a day, origins and destinations of these trips, and land use at the trip end.

Light and heavy trucks display distinctly different operating characteristics. As a result, they were considered separately for the purposes of this study. Truck classification for this survey was based upon gross vehicle weight (GVW), where trucks under a GVW of

20,000 kg were considered to be light, and trucks over a GVW of 20,000 kg were considered to be heavy. As gross vehicle weight can be difficult to visually observe in the field during the vehicle volume and classification survey, the number of axles on a truck was also used to distinguish between light and heavy trucks. Trucks with only two axles, such as cube vans or panel vans, were considered to be light trucks. Trucks that had three or more axles were considered to be heavy trucks. This includes single unit trucks and combination vehicles.

In order to produce an understanding of truck demand, regional truck activity surveys of three types of truck trips were conducted: Internal Trips, External Trips and Special Generator Trips.

*Internal Trips*

Internal trips are truck trips originating and terminating at points within the study area. Trip diary surveys were mailed out to fleet managers of 13,600 trucks in the Lower Mainland, based on a random sample of heavy and light trucks generated from the ICBC vehicle registry database. A total of 1,740 surveys were completed and these surveys described a total of 8,100 truck trips. This 13% response rate is considered high when compared to similar efforts elsewhere. Typically response rates of 1% to 10% have been achieved in U.S. jurisdictions for similar surveys (*4*).

*Special Generator Trips*

Special generator trips are truck trips originating or terminating at facilities that are major discrete truck traffic generators and possess truck trip generation characteristics that are distinct from other types of trip generators in the Lower Mainland. Demand for these types of truck trips is related to economic forces within and outside of the Lower Mainland, as well as trends within industry regarding containerization of goods. As such, truck trips from special generators are considered to be a distinct sub-set of all truck trips. They include port terminals, the airport, and inter-modal rail facilities. Truck demand information for these facilities was gathered

using roadside interviews at six sites and supplemented by input from facility operators.

*External Trips*
External truck trips are those that originate or terminate outside of the Lower Mainland such as the British Columbia Interior, Vancouver Island and the United States. This survey also captured 'through trips', or truck trips that originate outside the Lower Mainland and then pass through the region without making freight stops. Because demand for external trips is partly driven by economic forces outside the region, external truck trips bear different trip making characteristics from trips internal to the region. Furthermore, many of the trucks using external gateways were not registered in British Columbia and were therefore not eligible for the mailout survey. Data on truck movements for external trips were assembled from a variety of sources including roadside interviews and co-ordination with the National Roadside Survey (NRS). Roadside interviews were conducted at seven entry/exit points.

**Vehicle Volumes and Classification Survey**
A major vehicle classification count program was undertaken throughout the region, incorporating 266 separate traffic counting/classification activities. Vehicles were classified into 10 different categories including light and heavy trucks at 75 of these locations. Many of the stations follow physical barriers (rivers), municipal boundaries and/or major roads. These artificial boundaries are called screenlines, and the object is to count all movements crossing the screenline such that the quantity of trips from these sub-areas can be monitored. This survey built on the screenlines initially established in 1985, and now includes screenlines that capture some intra-municipal travel as well as special trucking movements throughout the region. This count program also served as an update to the last major survey of traffic volumes, carried out in 1996. This element of the Lower Mainland Truck Freight Study:

- Completed the 'snapshot' of truck activity on a typical day in autumn 1999;

- Established a reference point for comparison to historic counts, and to support monitoring truck movements in the future;
- Presented insight into route selection and identification of major truck routes; and
- Provided a basis for calibration and validation of the truck demand forecasting model and provided the vital link between the estimated (model) and observed truck traffic.

**Truck Demand Forecasting Model**

A computer model that is able to forecast truck demand was developed using the surveys and vehicle classification counts. By specifically addressing major traffic sources as discrete "special generators", and by linking truck demand to demographic variables which will change over time, a flexible, state-of-the-art tool was created. The truck demand forecasting model was integrated into the regional EMME/2 travel demand forecasting model, and is able to forecast truck demand for future horizon years such as 2006, 2011 and 2021.

A vehicle based model was chosen due to data availability issues and the planned applications of the model. This approach is similar to the 1988 Truck Model that estimates travel demand starting with the vehicle as the unit of demand. The new Lower Mainland Truck Model provides several major improvements over the model that it replaces and provides a platform for continuing evolution of freight analysis capabilities in the region. Some of the more significant improvements achieved in this model development program include the development of separate internal and external models, the incorporation of explicit special generator models, and behavior-based trip distribution in the internal model.

*Separate Internal and External Models*

Intra-regional and inter-regional truck trips have very different characteristics in terms of the economic activities which generate trips, the trip lengths and origin-destination patterns, and the types of trucks that take these trips. By developing separate internal and external models, the new truck model allows for the incorporation of

these distinct behavioral characteristics and this provides greater accuracy. It also provides the opportunity to build future model enhancements in each of these areas independently. For example, work is currently underway to collect new data on truck trips across the regional border crossings with the United States. In the future, these data can be used to build better models of cross-border traffic that can be easily integrated into the new truck model structure.

*Special Generator Models*
Major special generators such as the ports, rail-intermodal yards, and air cargo facilities clearly have different trip generation and distribution characteristics than do other industrial and transportation facilities. The new special generator models capture these differences. These facilities are also significant elements of the regional economy and the ability to independently analyze their relationship to the rest of the transportation system is a clear benefit of having separate special generator models. As in the case of the separate internal and external models, separate special generator models also provide the opportunity for continual enhancement of the truck model through improvements to these modules independent of the rest of the model.

*Behavior-Based Trip Distribution*
In the previous version of the Lower Mainland truck model, trip distribution was based on a factored origin-destination matrix and was not actually modelled. In the new model, gravity models were developed that calibrated well with respect to trip length distributions and link impedances. This means that future trip tables will show shifts as regional traffic conditions impact future link impedances. Over time, these changes may also prove important in determining future land use patterns.

**Final Model Design**
The model was developed using the standard three-step urban travel demand model design (mode choice is not applicable to a truck model).

*Trip Generation*

Trip generation is accomplished separately for internal, external, and special generator models. In each case, trip generation is estimated for light trucks and heavy trucks separately. The internal trip generation model estimates trip ends in each zone (productions and attractions assumed to be equal) as a function of employment by land use category. The model uses trip generation rates estimated from survey data. Trip generation results are then adjusted using sub-area factors in order to achieve better calibration results as compared to critical screenlines.

Trip generation in the external model is based on classification counts at the external stations. Trips are assumed to be produced at the external station and the attraction trip end is allocated to internal zones. Trip generation at each external station is done separately, making it possible to use exogenous forecasts of border trade to drive future trip generation along the international border. Alternatively, growth in attractiveness variables can then be used to forecast external trips in the future.

Trip generation for each of the special generator models is accomplished in slightly different fashion. In general, trip generation rates are a function of specialized activity variables that are forecast by each special generator. Trip rates are developed based on relationships between trucks counted at special generator sites and these other activity variables.

*Trip Distribution*

Trip distribution is also calculated separately for internal, external, and special generator models. The internal distribution models are gravity-based models calibrated to match a trip length distribution obtained from survey data. Three sub-area gravity models were developed in order to more accurately account for variations in average trip lengths between the urban core of the region and outlying suburban areas. Gravity models were developed using travel time as the measure of link impedance.

Trip distribution for the external models was developed in a two stage process. In the first stage the distribution of trips to super-zones is based on an origin-destination matrix computed from survey

data. Within super-zones these trips are allocated to traffic analysis zones (TAZs) based on employment variables. Distribution for most external stations is handled separately, recognizing the difference in trip characteristics for different external routes.

Trip distribution for special generators is generally based on factored origin-destination matrices developed from the survey data. One exception is trip distribution for integrated air cargo carriers where survey data was not sufficient to develop origin-destination matrices and trips were therefore allocated to zones based on employment distribution.

*Network Assignment*

At the assignment stage, internal, external, and special generator trip tables are summed to produce trip tables for two distinct truck classes – light and heavy trucks. These two trip tables are assigned to the network along with passenger trips based on a multi-class, simultaneous assignment procedure. Assignment is based on generalized cost algorithms with separate values of time for heavy trucks and light trucks. The truck network is modified to take into account weight restricted routes.

## PRINCIPAL FINDINGS

### Regional Trucking Characteristics

Information on truck trips obtained from the surveys was expanded to represent the entire truck population as well as observations of trucks obtained during the vehicle classification counts. For the purposes of this report all population values presented are from the expanded survey data. These values represent the expanded estimates produced during calibration of the EMME/2 truck demand forecasting model.

There were approximately 187,000 truck trips made in the Lower Mainland on a typical day in November, 1999. Approximately 68% of these trips are made using light trucks and 32% using heavy trucks. Light truck trips are mostly (96%) composed of internal trips, or in other words trips that have an origin and destination within the Lower Mainland. The majority of the light truck trips attributed to special generators (2%) are related to integrators and food service providers in the area of Vancouver

International Airport. Internal trips also constitute the majority of heavy truck trips (79%). However, external and special generator trips are also significant components of heavy truck trips. Approximately 7,700 heavy truck trips (13%) have an origin or destination outside of the Lower Mainland. Approximately 8% of heavy truck trips are related to special generators.

Approximately 60% of the trucks registered in the Lower Mainland are active on any given day. Approximately 10% of heavy trucks operated outside of the region. Of the trucks that were active on the survey day, light and heavy trucks were used for, on average, 10 and 8 trips per day, respectively. For example, close to 15% of light trucks were used for between three and four trips per day. Approximately 40% of light trucks were used for more than 10 trips per day. Generally, heavy trucks were used for fewer trips per day than light trucks. Approximately 25% of heavy trucks were used for more than 10 trips per day.

The length of trips was derived from the stated origins and destinations in the internal survey. The average trip length for light and heavy trucks is 8.5 and 15.8 kilometres, respectively. The number of truck trips decreases with distance much more rapidly for light trucks than for heavy indicating that light trucks predominately make more short trips, and fewer longer haul trips than heavy trucks. This trip length does not include truck trips to and from external gateways.

A profile that describes when truck trips were made throughout the day was developed from the reported arrival time for the trip diary surveys. This profile was validated with observations of trucks obtained during the vehicle classification counts. For the purposes of comparison, a typical profile for total traffic including trucks is also provided. The time of day profile for light and heavy truck trips are very similar, with both peaking during the midday period, and decreasing prior to the afternoon rush period. The only notable difference appears that heavy truck trips start approximately one hour earlier (6-7 a.m.) than light truck trips (7-8 a.m.). Approximately 70% of trucks arrive at their destination during the period of 9:00 AM – 4:00 PM. The time of day profile for trucks is notably different from total traffic which experiences peaks during the AM and PM peak periods.

To an extent, light and heavy trucks serve different purposes and different sectors of the economy. For the purpose of this study, this distinction was made through identification of the type of land use where truck trips terminated. Land uses where light trucks were used more than heavy trucks included retail, residential and office/ professional services. Land uses where heavy trucks were used more than light trucks included manufacturing, transportation/communication/utilities, construction sites and agriculture/mining/forestry.

**Origin-Destination Information**

The Lower Mainland region is divided into eleven sub-areas that are generally aggregations of municipalities. Origin-Destination trip tables were produced from the LMTFS. Estimated origins and destinations of light and heavy truck trips by sub-area were produced. For example, the total number of light trucks generated in Vancouver was 36,711, 36,707 light trucks were destined to Vancouver and 972 light truck trips from Vancouver destined to Richmond. Figure 1 shows the total number of light and heavy trucks generated from each of these sub-areas. The grey and black parts of the bar represent light and heavy trucks respectively. Over 40% of truck trips in the Lower Mainland are generated on the Burrard Peninsula. The City of Vancouver generates the largest amount of truck trips with over 46,000. Burnaby/ New Westminster /NE Sector generates over 34,000. North Delta/North Surrey and Richmond generate close to 25,000 truck trips every day. Most other sub-areas generate between 5,000–12,000 truck trips every day. Approximately 5,000 truck trips generated in the Lower Mainland leave the region via external gateways. Using a geographic information system, the trip tables can be illustrated on a map. Figure 2 displays the truck destinations by one geographic sub-area and include a commentary on some of the notable truck trip characteristics for each region.

**Special Generators**

There were approximately 7,200 truck trips attributed to special generators on a typical day in November, 1999. This constituted approximately 4% of all truck trips in the Lower Mainland. Special

generators account for 2% of all light truck trips and 8% of all heavy truck trips.

The total truck trips produced by each of the eight special generators are shown in Figure 3. With the exception of Vancouver International Airport (YVR), special generators produce almost entirely heavy truck trips. The significant number of light truck trips at the airport is largely due to integrators and food service providers located on Sea Island.

It is important to remember that the information presented in this section is the product of surveys conducted in November, 1999. The level of activity, commodity being handled, and the origins and destinations of truck trips can be expected to vary due to a number of factors including the shipping lines being serviced at the ports and seasonal variation in activity and commodity. The information presented in this section provides valuable context regarding the contribution of special generators to total truck movements in the Lower Mainland, but should not be considered a comprehensive analysis that accounts for variation throughout the year.

*External Gateways*

External trips constitute approximately 5% of the total truck trips in the Lower Mainland. External truck trips account for approximately 2% of total light truck trips and 13% of total heavy truck trips. Approximately 6% of external trips are through trips, or in other words, trips that pass through the region without making a freight stop. Approximately 50% of external trips cross the Canada-United States border. The British Columbia interior accounts for a further 40% of external truck trips. The Vancouver/Gulf Islands and Highway 99 each account for 5% of external trips.

The magnitude of truck trips at each external gateway as the sum of both directions is shown in Figure 3. Two gateways dominate in terms of total truck traffic. Highway 15 is the primary border crossing connecting the Lower Mainland to the United States. Specifically, it connects to Interstate 5, the major north-south highway that serves the American west coast. Highway 1 is the primary highway connection between the Lower Mainland and the rest of Canada, including the British Columbia Interior. Combined,

these two gateways constitute 65% of all external truck trips. Light and heavy trucks account for approximately 20% and 80% of trips using external gateways, respectively.

*Through Trips*

Through trips are trips that enter the region at one gateway and leave the region at another gateway on the same trip. They are a subset of external trips because the trip origins and destinations are outside the region. Of the 9,900 total external truck trips, 670 trips, or 6.8%, are through trips. The majority of through trips (89%) are made using heavy trucks.

Figure 4 shows the origin destination patterns of the through trips. The most pronounced demand line for through trips is between the United States border and the British Columbia Interior / rest of Canada, accounting for 72% of all through trips. Trucks trips from the US border to the Tsawwassen Ferry Terminal is the second most popular demand line at 21%. Six percent of all through trips are between the Vancouver/Gulf Islands and the British Columbia Interior gateways. Approximately 1% of through trips was between Highway 99 north and the US border. Through trips were not observed between Highway 99 North to the British Columbia interior, or from Highway 99 North to the Vancouver/Gulf Islands.

**Truck Demand Forecasting Model**

The regional EMME/2 Travel Demand Forecasting Model is typically used to produce forecasts of single occupant and high occupant vehicles and transit users for system, corridor and project level studies, and for focus on specific issues within municipalities. This tool has been enhanced with development of the truck demand forecasting model that operates as a sub-model of the regional EMME/2. The new truck demand forecasting model is able to forecast the quantity of light and heavy truck trips, the origins and destinations of these truck trips, and the most likely route taken between these origins and destinations. The truck demand forecasting model can also be used for explicit analysis of special generators such as ports and external gateways.

The ability to forecast truck trip demand requires definition of the future years under consideration, and certain assumptions about those future years. In order to be consistent with the regional EMME/2 Travel Demand Forecasting Model, the truck demand forecasting model was developed to estimate truck trips for the AM peak hour or a full 24 hour period for the years 2006, 2011 and 2021 and is based upon assumptions regarding:

- Forecasts of population and employment and their distribution throughout the Lower Mainland.
- Forecasts of containers at port terminals and rail inter-modal yards.
- Estimates of future air cargo tonnes for both integrators and non-integrators at Vancouver International Airport.
- Forecasts of employment by industrial sector for external gateways.
- Configuration of the future road network.
- Economic charges such as tolling.

Various scenarios regarding the future can be tested by altering the assumptions listed above i.e. the benefits of changing the future road network to include a proposed major truck route can be assessed. The truck demand forecasting model can be used to support the following types of initiatives:

- Corridor/route analysis and major infrastructure planning, including economic analyses.
- Truck route planning such as truck priority lanes, definition of Major Commercial Road Network (MCRN), traffic management during road construction.
- Tolling analysis and revenue forecasting.
- Cross-border studies.
- Examining the transportation impact of industrial development.
- Inter-modal freight planning including rail, seaport and airports.
- Pavement deterioration and management analysis.
- Air quality modelling and analysis.

- Weigh scale planning including strategic planning of locations and enforcement/compliance.
- General transportation planning.

An example of a typical model forecast is shown in Figure 5 which illustrates the forecast of 2021 origins and destinations of truck trips that use the Highway 15 (Pacific Highway) border crossing, and the routes that they can be expected to take between these points. The volumes represent a full 24 hour period. This forecast was produced assuming that:

- the Growth Management Strategy forecast for 2021 has been realized;
- a crossing between Maple Ridge / Pitt Meadows and Surrey/Langley has been constructed following the 200th Street alignment, and a $1 toll applied for each trip across the bridge;
- an additional EB HOV lane has been added to Port Mann Bridge (for a total of 5 lanes);
- George Massey Tunnel has been widened to accommodate counter-flow HOV lanes.

It is important to note that none of these assumptions presuppose provincial, TransLink or municipal policy. These assumptions were selected solely to demonstrate an example application of the truck demand forecasting model for the horizon year 2021.

The forecast is compared to 1999 observed truck movements using the Highway 15 border crossing was approximately 1,800 per day in each direction, or 3,600 per day in total. The 2021 estimate is approximately 5,000 per day in each direction, or 10,000 per day, total. Many of the forecast trucks follow similar paths to the 1999 pattern, with the following exceptions:

- a number of trucks can be expected to use the crossing between Maple Ridge/Pitt Meadows and Surrey/Langley.
- the number of trips that use the Highway 15 (Pacific) border crossing and have either an origin or destination in Richmond or Burrard Peninsula has increased, thereby increasing the volume of traffic on the Port Mann, Alex Fraser and George Massey water crossings. However, the

George Massey Tunnel captured the approximately 60% of this growth.

## CONCLUSIONS

### Baseline Data

The Lower Mainland Truck Freight Study has provided reliable and comprehensive data that establishes a 1999 baseline of truck movements in the Lower Mainland. The data collected will be useful for the detailed analysis of truck movements, and provides an indication of the extent that external gateways and special generators contribute to the total truck demand in the Lower Mainland. Observations of total vehicles as well as light and heavy truck movements at main screenlines will assist in the monitoring of regional truck movements in the future. This information will also be useful in providing a context for addressing localized truck and truck route issues. Examples of the baseline truck movements and characteristics of trucks movements were amply illustrated in the paper.

As a result of the study, a new truck demand forecasting model will enable the estimation of future truck demand and activities. The truck forecasting model has been integrated into the regional EMME/2 travel demand forecasting model, and is being used to forecast truck demand for future horizon years such as 2006, 2011 and 2021. As a result, the regional travel demand forecasting model has the capability to integrate multi-modal attributes into the transportation planning process. Specific applications of the truck demand forecasting model include major infrastructure planning, traffic monitoring, traffic impact assessments of major developments, cross border freight movement, inter-modal freight planning, pavement management systems, and air quality modelling.

### Further Studies

The Lower Mainland Truck Freight Study provides valuable insight into trucking movements for a typical day in November, 1999. In addition, the development of the truck demand forecasting model will enhance the region's ability to effectively address goods movements and trucking related issues. However, this understanding can be

improved through additional studies that focus on detailed goods movement activities.

*Future Comprehensive Truck Studies*
The current study has established a baseline understanding of truck movements for November, 1999. As the trucking industry can be expected to continue to undergo significant changes, it is recommended that a similar study be undertaken every five years. This will ensure that the data being used for trucking analysis is up to date, and to monitor changes in trucking movements.

*Commodity Flow Analysis*
The current study was unable to effectively collect commodity information. Hence, other methodologies for collecting this information require examination. For example, waybill analysis or customs import/export data may provide some better information. The refinement to the model and the ability to more accurately reflect truck impacts based on future economic projections would be enhanced through commodity based analysis.

*Province-Wide Truck/Freight Model*
Consideration could be given to the development of a province wide truck freight study and development of a demand forecasting model that would incorporate modes such as rail, ferry, air cargo and truck freight with advanced techniques such as commodity flow analysis.

*Detailed Analysis of External Gateways*
With respect to types of truck trips and commodities, the information in this study regarding entry/exit points into the region represents a few days of data collection in November, 1999. However, the types of truck trips and commodities using entry/exit points into the Lower Mainland can be expected to vary throughout the year. Further study of the variation at external locations is recommended.

*Detailed Analysis of Special Generators*
Similar to external locations, the types of truck trips and commodities accessing the special generators can be expected to vary throughout

the year. Further study of each special generator is recommended. In addition, the type of special generators perhaps needs to be expanded to account for the large warehouse /distribution centres and other major truck trip generators.

**Lessons for Methodology**

A number of lessons from the Lower Mainland Truck Freight Study can be applied to future truck studies suggested or studies of a similar nature in the future.

*Timing of Future Studies*

Due to the complexity of the study and multi-agency involvement, sufficient lead time is required to establish the study scope and assign the required funding within the budget of each agency. It is recommended that preparation for a similar study (magnitude and scope) begin two years prior to the anticipated commencement of the study.

*ICBC Vehicle Registration Database*

Access to the ICBC vehicle registration database proved to be a valuable source for determination of the truck population in the Lower Mainland. However, because of the emerging share of leased truck fleets it was difficult to track the ultimate operating entity for the distribution of the survey questionnaires. Future studies need to take this change in ownership / vehicle registration into consideration.

*Harmonization of Data Sources*

Significant effort was made in this study to obtain data from a number of sources such that efforts were not duplicated. This presented a number of difficulties regarding differing data collection periods, resolutions of data being collected and data formats. It is recommended that such harmonization be investigated in the future. However, it is important to note that the integration of various sources of data is an important consideration in preliminary study design. Also, where possible, collection of data by one study team should be considered. This can be expected to be more efficient and result in improved data integrity.

*Special Generator Sub-Models*
The truck study sampled a number of special generator locations and applied the results to the broader universe of special generators, including Abbotsford Airport. It is suggested that roadside interviews be conducted at all special generators in future studies. The collaboration of special generator operators has greatly enhanced the explanatory power of the data and truck demand forecasting model compared to a similar truck study in 1988. Due consideration should be given to different forecasting variables when incorporating special generator truck sub-models within the EMME/2 travel demand forecasting model.

*Expanded Coverage Area*
Understanding of trucking movements in the Lower Mainland was enhanced through expansion of the study area to include a large portion of the Fraser Valley Regional District. Future studies should at minimum maintain the expanded study area, or perhaps consider further expansion in Squamish-Lilloet Regional District.

*Validation of Data*
The immediate validation of the data collected to ensure integrity is a critical element of the study. The quality assurance aspect of data collection needs to be an integral component of the project management process.

*Inter-Agency Collaboration*
The study was funded by eight agencies ranging from the federal government to port authorities. A trademark of this study was the successful inter-agency collaboration throughout the project, funding negotiations to project delivery. Useful input was also obtained from non-funding stakeholders such as the British Columbia Trucking Association. This can serve as an example for future large scale transportation studies.

## REFERENCES

1. M. L. Schlappi, R.G. Marshall, and I. T. Itamura. Truck Travel in the San Francisco Bay Area. *Transportation Research Record 1383*, TRB, National Research Council, Washington, D.C., 1993, pp. 85-94.
2. D. O. Stephens, J. M. L. Gorys, and D. S. Kriger. Canada's National Capital Region Goods Movement Study. *Transportation Research Record 1383*, TRB, National Research Council, Washington, D.C., 1993, pp. 77-84.
3. Vancouver City Engineering Department and GVRD. Truck Study, 1990.
4. G. Chow. Review of North American Commercial Transport Data Collection and Modelling Experience. Transport Data Centre, New South Wales Department of Transport, Sydney, Aust.,1997.

**FIGURE 1 24 Hour light and heavy truck trip generation by sub-area.**

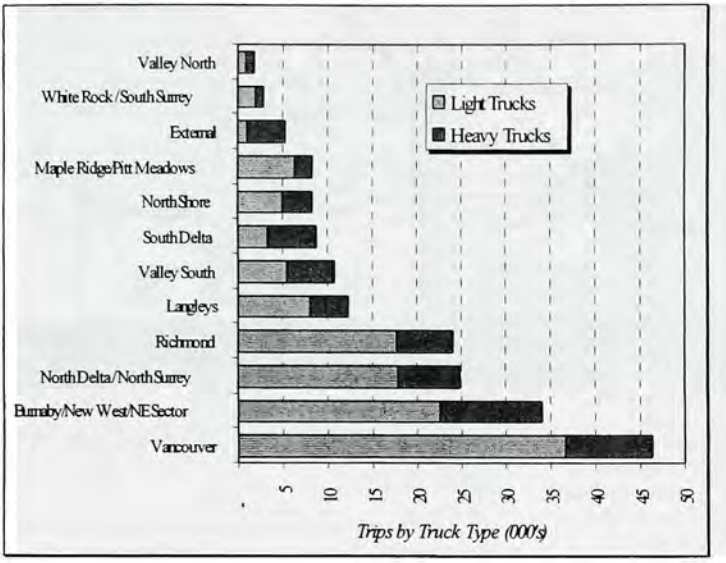
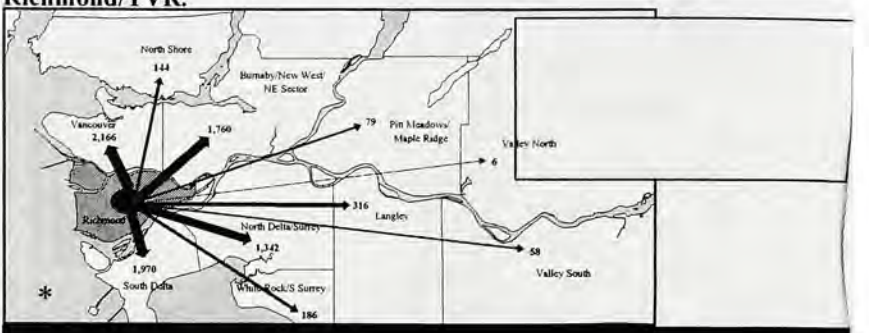


**FIGURE 2 24 Hour total truck trips generated from Richmond/YVR.**

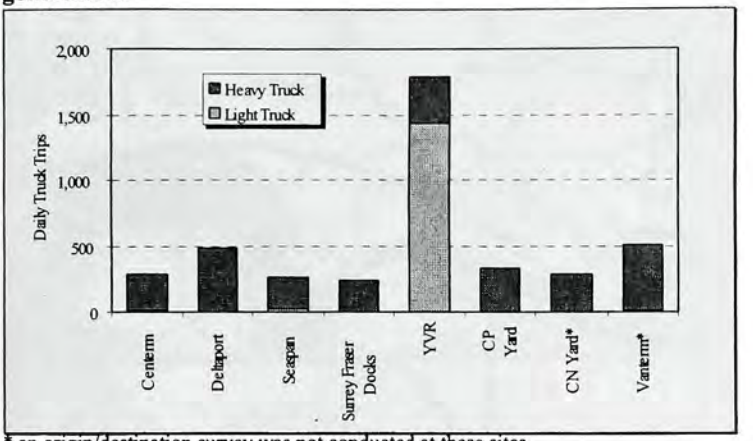



The Richmond/ Vancouver International Airport sub-area generates approximately 24,000 truck trips. This contribution is approximately 13% of all light and heavy truck trips in the Lower Mainland. Truck routes in this sub-region are also used for trips between other sub-areas. Highways 91 and 99, Knight Street and Russ Baker Way are major truck corridors in the sub-area and also carry the majority of through traffic.

| Destined to: | | Light | Heavy | Total | Perce |
|---|---|---|---|---|---|
| *Within sub-area* | | *13,146* | *2,331* | *15,477* | *64* |
| *Other sub-areas* | | *4,471* | *3,556* | *8,027* | *33* |
| *Outside the region* | | *101* | *426* | *527* | *3* |
| *Total* | | ***17,718*** | ***6,313*** | ***24,031*** | ***100*** |

The Vancouver International Airport and associated integrators produce approximately 8% of the total truck traffic and 6% of the light truck traffic this sub-area. Of the trips going to the other sub-areas, most are destined to Vancouver and South Delta.

**FIGURE 3 Total daily truck trips originating from special generators.**




* an origin/destination survey was not conducted at these sites

**FIGURE 4 Through trip origin destination patterns.**

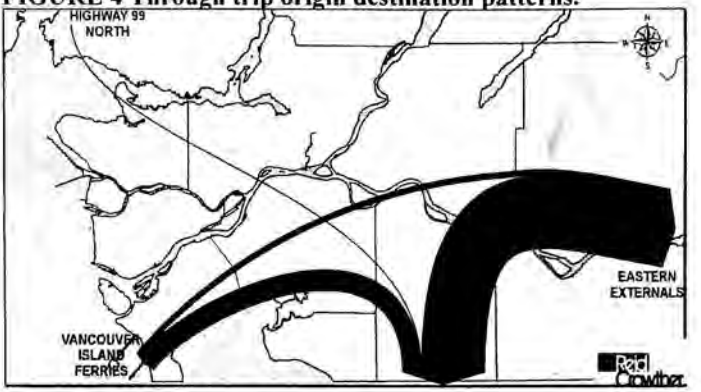
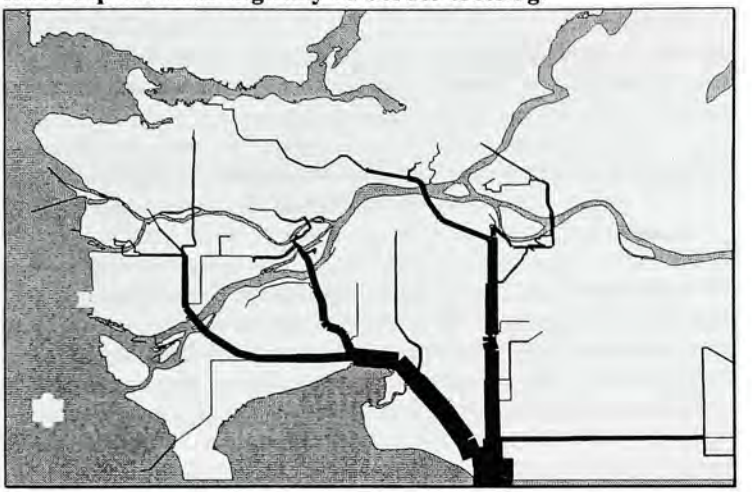


**FIGURE 5 Forecast of 2021 origins and destinations of 24 hour truck trips that use Highway 15 border crossing.**



# Emerging Security Shifts and Trends in U.S. Trade and Border Crossings

*Lisa Randall, M.A.*
*International Program Manager*
*Bureau of Transportation Statistics*

*Felix Ammah-Tagoe, Ph.D.*
*Senior Research Analyst*
*MacroSys Research and Technology*

*Paper submitted for presentation at the 2003 Annual Canadian TRF Conference. Ottawa, Ontario, May 2003.*[1]

**Abstract**

The terrorist attacks of September 11, 2001 on the United States impacted the U.S. transportation system in many ways. Not only did the attacks immediately affect merchandise exports and imports as freight passing through the nation's seaports, airports, and land borders slowed, but they also changed the way the transportation community views and handles transportation security. This paper discusses the plethora of security strategies and initiatives that have become a major focus of the U.S. government and private sector. We discuss the possible effects of these initiatives on the flow of goods in and out of the United States. Since relatively little is known about the direct empirical impacts of the strategies on trade flows, we analyze recent data on trade and border crossings to uncover any possible emerging trends.

**Executive Summary**

The September 11, 2001, terrorist attacks exacerbated an economic slowdown already in progress in the United States, resulting in a marked decline in U.S. international trade and freight activity. Overall U.S. merchandise trade fell 6.2 percent in 2001, with most of the decline occurring after the attacks. Compared with the same period in 2000, the value of overall U.S. merchandise trade dropped 1.7 percent from January through August 2001, but dropped by 14.7 percent between September and December. While all modes were affected by September

[1] This paper is based on U.S. Department of Transportation, Bureau of Transportation Statistics, *U.S. International Trade and Freight Transportation Trends*, March 2003, written by the authors.

11, air cargo saw the largest decline in freight activity (13 percent by value), followed by trucking (8 percent), maritime (3 percent), and rail (2 percent). Pipeline activity increased by 12 percent.

Following the attacks, transportation security concerns have focused on the vulnerability of the U.S. transportation system. Because large volumes of traded merchandise from all over the world enter the United States daily on ships and airplanes, and on trucks and trains from Canada and Mexico, transportation security has become a top priority, with growing attention focused on international import traffic. For example, in 2001, about 19 million containers were used to transport imports into the United States, one-third by ocean vessel and two-thirds by truck and rail from Canada and Mexico. The attacks changed how government and industry view cargo security and both are seeking ways to enhance security for traded goods from their foreign points of origin to final destinations within the United States. A fundamental objective of all the initiatives is to improve security while ensuring an efficient flow of goods.

This paper examines the immediate impacts of the attacks on U.S. international merchandise trade flows and looks at some of the new security challenges facing the U.S. freight transportation system as the nation implements transportation security measures. It concludes that while security issues have come to the forefront and new as well as heightened security initiatives are being implemented, the long-term implications of these measures for freight throughput are not yet known.

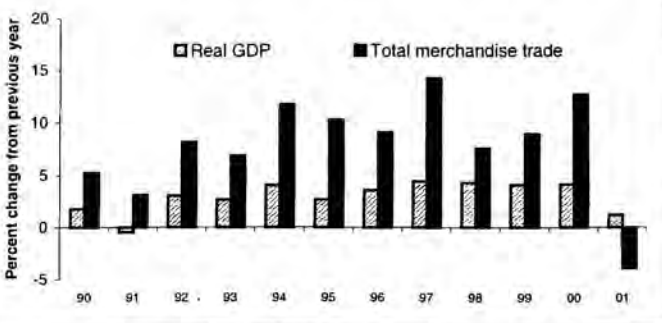
**Introduction**

Americans are buying more imported merchandise today than ever before and more of the goods produced in U.S. factories are bound for export. Much of the imported merchandise is transported in containers from around the world, raising the need for heightened cargo security measures from the foreign points-of-origin to the final destinations in the United States. In 2001, the U.S. transportation system carried merchandise exports worth $731 billion and merchandise imports valued at $1.1 trillion in current dollars. Transporting this merchandise requires a significant amount of equipment. For example, in 2001, there

were over 936,000 aircraft, 215,000 maritime vessels, and 19 million vessel, truck, and rail container entries into the United States. From a national security perspective, the large amount of transportation equipment involved in U.S. international trade highlights the possible threat of using freight vessels and vehicles for terrorist activity. This vulnerability underscores the importance of national measures aimed at improving security while maintaining quick and efficient freight flows.

**Overall Trade:** In 2001, the value of total U.S. international merchandise trade declined nearly 4 percent from the record $2.2 trillion reached in 2000 (in inflation-adjusted terms), the largest annual decrease since 1990 (figure 1). In 2000, both trade and GDP grew at high positive rates. The decline in 2001 was due, in part, to the weakness of global economic activity and the effect of the September 11 terrorist attacks. Exports were particularly affected, falling by 6 percent in 2001, while imports fell 3 percent. Between 1990 and 2001, merchandise trade saw greater year-to-year fluctuations than U.S. GDP due to its dependence on global economic activity.

**Figure 1. U.S. International Merchandise Trade and Real GDP: 1990-2001**



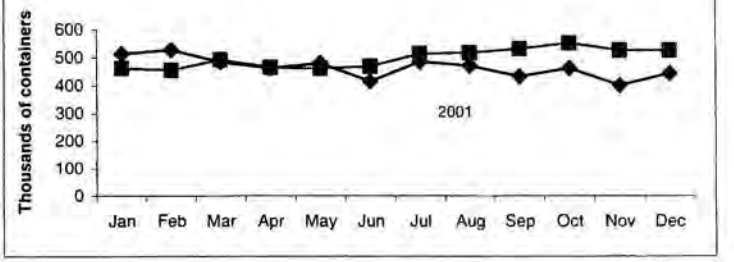

NOTE: Real GDP and total merchandise trade are in chained 1996 inflation adjusted dollars.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, based on data from the Bureau of Economic Analysis, National Income and Products Accounts, available at http://www.bea.doc.gov/bea/dn1.htm as of March, 2002.

The 2001 decline in trade levels affected U.S. trade partners differently. Trade with many of the United States' top trading partners declined sharply in 2001 compared with 2000. Among the top 10 trading partners, trade with Taiwan declined the most (21 percent), followed by South Korea (16 percent) and Japan (13 percent). Trade with the Asian countries was hit the hardest, in part because of sluggish demand in those countries and the global decline in the information technology industry.

**Maritime Trade:** In 2001, over $718 billion of maritime trade weighing 1.6 billion tons moved between United States and foreign seaports. Containerized cargo represents a large proportion of this trade. In 2001, there were 5.6 million maritime container entries into the United States, down 6 percent from nearly 6 million in 2000 (figure 2).

**Figure 2. Maritime Container Entries into the United States: 2000 and 2001**




NOTE: The above figures represent containers of various capacities not TEUs.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, special tabulation, April 2002; based on U.S. Department of Treasury, U.S. Customs Service, Mission Support Services, Office of Field Operations, Operations Management Database CD December 2002.

While the number of vessel containers entering the United States had been declining even in the months before September 11, when compared with the same months in 2000, there were 19 percent fewer such containers in September 2001 than in September 2000. The

declines continued in October, November, and December 2001 compared with the corresponding months in 2000.

**Air Trade:** U.S. airports handled over $519 billion of international merchandise trade, down from $593 billion in 2000. This drop represented the largest decline by any mode of transportation, between 2000 and 2001, and was primarily due to closure of the U.S. airspace following September 11 and the continuing effects of the attacks on the airfreight industry, as well as the slowing U.S. economy. Despite the 2001 decline, during the past two decades, growth in U.S. international air cargo revenues closely mirrored the increases in overall U.S. air freight revenue ton-miles. In 2001, while international revenue ton-miles by U.S. carriers declined, international air cargo operating revenues by U.S. carriers held steady, due in part to changes made immediately after the September 11 attacks.

The leading U.S. gateway for international airfreight is JFK International Airport. Two of the top five U.S. air cargo airports by trade value are located on the West Coast: Los Angeles ($63 billion) and San Francisco ($62 billion). Almost all U.S. air gateways experienced declines in international air freight in 2001. However, this trend was more pronounced for the West Coast airports where trade levels also continued to be affected by the Asian economic crisis of the late 1990s, along with the general economic slowdown and the effects of September 11.

**NAFTA Trade:** In 2001, merchandise trade with Canada and Mexico represented one-third of the value of all U.S. international trade, or $614 billion, with Canada accounting for about 20 percent and Mexico about 13 percent. Surface modes transported the majority of the value of U.S.-NAFTA trade, over 89 percent in 2001, nearly the same proportion as in 1994.

U.S. surface trade with Canada and Mexico fell in 2001 for the first time since the inception of NAFTA in 1994, with the greatest decline occurring after September 11. Overall, surface trade fell by 5 percent in 2001 (table 1). Surface trade was lower for most of 2001, showing a 1.5 percent drop between January and August, compared with the same

period in 2000, and a decline of 11.6 percent between September and December 2001. Surface exports declined more steeply (7 percent) than imports (3 percent) for the year.

The terrorist attacks caused immediate drops in overall U.S.-NAFTA trade, particularly for the truck and air sectors. Trade by truck fell over 15 percent in September 2001, compared with 2000, and continued drops over the remainder of 2001 resulted in the first annual decline in U.S. truck trade since NAFTA's inception.

**Table 1. Value of U.S. Merchandise Trade with NAFTA Partners by Mode: 2000–2001**
(Billions of dollars)

| | 2000 | 2001 | % change 2001–2000 |
|---|---|---|---|
| Truck | 429 | 395 | –7.8 |
| Rail | 94 | 93 | –1.7 |
| Air | 45 | 37 | –17.7 |
| Water | 33 | 29 | –10.1 |
| Pipeline | 24 | 26 | 12.0 |
| Other | 29 | 33 | 12.4 |
| **Total trade** | 653 | 614 | –6.1 |
| **Subtotal, land** | **576** | **547** | **–4.9** |
| **Land, % of total** | **88.1** | **89.2** | |

NOTE: Shipments that neither originate nor terminate in the United States (i.e., in transit or in-bond shipments) are not included here, although they use the U.S. transportation system.

SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, special tabulation, May 2002.

Of all the modes, air freight experienced the steepest fall in 2001—nearly 18 percent—due largely to the immediate impact of September 11 on the North American aviation services and system. Although the overall value of rail trade fell slightly in 2001, it was less dramatically affected than other modes, due partly to the fact that immediately after September 11, railroads continued moving freight across borders because the industry already had an effective cargo preclearance system in place for major shippers engaged in NAFTA trade.

The top U.S.-NAFTA land gateways handle thousands of truck crossings each day. In 2001, there were almost 11.1 million commercial truck crossings into the United States from Canada and Mexico, translating to 30,000 daily truck crossings. This was up 44 percent from 1994, but down 4.3 percent from 2000. The majority of these crossings occur on the U.S.-Canada border (61 percent), although the growth rate in truck crossings, as with trade, has been more rapid on the U.S.-Mexico border. As with trade levels, truck crossings are concentrated among a few ports. In 2001, the top three ports (Detroit, Laredo, and Buffalo-Niagara Falls) handled nearly 40 percent of all truck crossings.

Trade flows and vehicle and equipment crossings at key land gateways have fluctuated since the inception of NAFTA, generally characterized by a steady rise through 2000, followed by modest downturns in 2001, due to economic slowdowns throughout North America, the September 11 terrorist attacks on the United States, and the accompanying fall in trade between the United States, Canada, and Mexico. During the 1990s, traffic and flows at these gateways were influenced by notable differences in the geography and direction of trade flows, as U.S. trade expanded more rapidly with Mexico than Canada and import flows from Canada and Mexico grew more quickly than U.S.-NAFTA exports. In addition, key gateways are affected by the mix of commodities passing through these ports as well as changes in carrier efficiencies.

**Some Emerging Questions**

Given the changes that are occurring in U.S. international merchandise trade, improved cargo security will remain a daunting challenge as government and industry work together for solutions that will prevent terrorist attacks while maintaining an efficient flow of goods. Policy- and decisionmakers face several questions as they implement freight transportation security measures. For example, how will the new and evolving security requirements affect U.S. carriers and business supply chain management? What short-term impacts will industry adjustment to just-in-time and inventory management strategies have on freight volumes and flows? To what extent will industry be willing to provide the government with cargo and crew information far in advance to

enhance security in this new environment? How will these measures affect demand and planning of transportation services? While the answers to these questions remain uncertain, they are likely to have major implications for U.S. international freight transportation in the short and long term.

**New Security Environment**

Immediately following the terrorist attacks, tightened security necessarily slowed traffic at U.S. borders, seaports, and airports. Trade flows at key transportation gateways and corridors were affected. Many private sector businesses relying on just-in-time delivery of traded goods were impacted. For example, U.S. automakers temporarily halted production at some facilities when delivery delays from Canada and Mexico disrupted their supply-chain system of maintaining low inventories (*Wall Street Journal* 2001).

The attacks also highlighted how major transportation disruptions could affect manufacturers and the broader U.S. economy. During 2002, trade and freight activity levels started to recover. However, enhancing security and safety without hindering the efficient and cost-effective movement of goods and people into and out of the United States is still a challenge. Government and industry are now seeking to build on existing efforts and to develop new approaches to transportation and cargo security. A key component of this effort will be expanded information on crews and traded goods, such as the provision of advance and near real-time data.

**Initial Responses to September 11, 2001**

Immediately following the 2001 terrorist attacks, the many agencies with security missions implemented new and stricter procedures at U.S. ports and borders. Increased scrutiny of cargo and people entering and exiting the United States was a top focus. The U.S. Customs Service implemented intensive anti-terrorism operations under its highest alert level, particularly, providing a greater level of examination of cargo, conveyances, and passengers entering the United States. To support these efforts, additional personnel were deployed across the country and at major ports of entry. Customs also temporarily transferred about 100

inspectors from the southwestern border to the northern border (U.S Department of Treasury 2001).

Complementing Customs' focus on cargo security, was the U.S. Coast Guard's focus on port and vessel security. The Coast Guard called up over 2,200 reservists to help patrol over 360 seaports and reoriented a majority of its resources to security, a focus that will remain high (USDOT USCG 2001a). Coast Guard sea marshals began boarding vessels more frequently, and Port Security Units were deployed at four critical domestic ports to augment security forces. To improve information and risk analyses of vessels entering the United States, the Coast Guard started to require a 96-hour advance notice of vessel arrivals rather than just 24 hours, as well as crew and passenger lists in advance (USDOT USCG 2001b).

Air freight security was also an immediate focus. To better ensure the security of air cargo movements, the Federal Aviation Administration issued Emergency Amendment EA 109-01-01A, or the "known shipper" rule, on October 8, 2001. Under the new rule, the freight forwarder must verify the legitimacy of the shipper unless it had done business with the shipper prior to September 1, 1999, and had booked at least 24 shipments with them (BDP 2001).

The Transportation Security Administration (TSA), with security responsibility for all modes of transportation, was created through the Aviation and Transportation Security Act (Public Law 107-71), which President George W. Bush signed into law on November 19, 2001. Much of TSA's initial focus was on air security, particularly for passenger travel, as multiple deadlines were established in the Act for passenger and checked baggage screening. In addition, the Act established new provisions for air cargo, including the screening of all cargo that is not from a known shipper and the development of systems by integrated express carriers (e.g., Federal Express or United Parcel Service) for some level of screening and inspection of cargo that is transported in all-cargo aircraft. TSA also began working on enhanced cargo security initiatives for all modes of transportation.

On November 25, 2002, President George W. Bush signed into law the Homeland Security Act of 2002, creating a cabinet-level Department of Homeland Security that integrated the government's border and security responsibilities. The new department, which came into being in January 2003, consolidates components of the following agencies: the Coast Guard, TSA, Secret Service, Immigration and Naturalization Service, Border Patrol, U.S. Customs Service, Federal Emergency Management Agency, Animal and Plant Health Inspection Service, among others. The main missions of the new department are: border and transportation security; emergency preparedness and response; chemical, biological, radiological, and nuclear countermeasures; and information analysis and infrastructure protection. One of the goals of the new department is to consolidate, coordinate, and share otherwise fragmented information, in order to better target and respond to any potential terrorist threats.

**Longer Term Transportation Security Initiatives**

While the September 11 terrorist attacks on the United States elicited immediate responses by the U.S. government, they also underscored the need for multifaceted strategies and initiatives in transportation security. In the area of cargo security, many of these are long-term efforts that will build on activities that were already underway prior to September 11. Others are new approaches. All will require government resources and partnerships with industry. Some of these efforts will focus on one piece of the security picture while others have broader objectives covering cargo, conveyance, and crew security. Underlying all of the initiatives, however, is the recognition that enhancements and new measures are needed to improve cargo and conveyance "visibility" (i.e., availability of information), equipment and infrastructure monitoring, and crew and staff access to secure areas.

**Cargo and Conveyance Visibility**. Improving the visibility of cargo and conveyances is a critical component of improved transportation security. Visibility refers to secure access to information on goods, equipment, conveyances, and crews throughout an entire supply chain (e.g., for imports into the United States, having information about a shipment from the point of origin in a foreign country; through its loading and transport via a vessel, plane, truck, or train; to the U.S port

of entry and unlading; and finally to the U.S. point of destination). To achieve this objective, information would be required well before the foreign vessel or carrier and its goods have access to the U.S. domestic transportation system.

Several current security initiatives aim to improve cargo and conveyance visibility. Two major U.S. Customs Service programs are the Container Security Initiative (CSI) and the Customs-Trade Partnership Against Terrorism (C-TPAT). These two programs are private-public partnerships designed to secure goods from their origin at a foreign manufacturing facility through transit, until the goods arrive at U.S. ports.

The aim of the CSI plan is to establish strict screening standards at designated foreign ports for U.S.-bound shipments. Launched by the U.S. Customs Service in January 2002, one of the CSI goals is to provide U.S. authorities with more information on low-risk, prescreened cargo. One element in achieving this will be the deployment of U.S. Customs personnel at key foreign seaports to identify and prescreen U.S.-bound cargo before it is shipped to the United States. Another CSI element is to provide advance cargo information for Customs' risk analysis. To support this ability, Customs issued new regulations on October 30, 2002, requiring sea carriers to provide cargo manifests 24 hours prior to the loading of the cargo in foreign ports for shipment to the United States[5] (U.S. Department of Treasury 2002c). In January 2003, Customs began holding public meetings with the trade community to discuss options for advance manifest filings for truck, rail, and air modes.

Under the C-TPAT, manufacturers, shippers, carriers, import brokers, and freight forwarders that implement secure practices can apply to U.S. Customs for fast-track cargo processing. The C-TPAT is a certification process for use in business supply chains. Once the supply chain is certified, a company's low-risk cargo could move through U.S. Customs more easily[6] (U.S Department of Treasury 2002a).

Both the CSI and C-TPAT programs underscore the need for accurate and near real-time information on internationally traded goods in order to secure a supply chain. For example, with real-time information

gathered on an inbound container, including shipper, owner, origin, destination, transshipment points, carrier performance history, weight, value, commodity, and insurance, security staff will be better able to preselect shipments for physical inspection before the cargo arrives at a U.S. port. If the network from shipper to consignee is secure and Customs receives information about the inbound cargo far in advance, then less time could be spent inspecting these shipments and more time could be focused on higher risk freight.

An initiative on the U.S.-Canadian border, Free and Secure Trade (FAST), is also intended to improve cargo and conveyance visibility to security officials so that low-risk goods transported by truck can move efficiently between the United States and Canada. FAST is part of the Smart Border initiative between Canada and the United States begun in December 2001. Under the FAST program, motor carriers, importers, and truck drivers in both countries register with their governments and provide advance notice of the goods they intend to transport. Once Customs agents in each country have determined the safety of each shipment, the trucks can cross the border in special lanes, thereby reducing delay times at the major land ports.

A key component of security efforts focused on cargo and conveyance visibility is information. Currently, there are several limitations, including quality, coverage, and timeliness for the information the U.S. government collects about the cargo, crew, and conveyances that are part of an international trade transaction. To remedy these deficiencies and to respond to new security requirements, U.S. Customs has accelerated the modernization of its data collection system for international trade and transportation. With funding of $1 billion over multiple years, the new systems, known as the Automated Commercial Environment and International Trade Data System (ACE/ITDS) are intended to improve data collection and focus efforts on effective risk analysis. Unlike previous systems, ACE/ITDS will collect data from both shippers and carriers for all international trade transactions, linked by a unique shipment identifier.

**Equipment and Infrastructure Monitoring.** A primary focus of many security initiatives is enhanced equipment and infrastructure monitoring.

Since a great deal of U.S. international trade is transported in containers, much attention is focused on the implementation of electronic, real-time tracking of containers and the creation of tamper-resistant seals. In addition, the deployment of sensors to detect potentially toxic and/or explosive cargo is another focus. Another objective in this area is to further develop and implement technologies to facilitate improved security during the container loading process. For example, a range of new software is available with the potential to aid in the development of a secure loading plan or to check the hazardous materials compatibility of various cargoes.

One initiative focused on equipment and cargo monitoring is Operation Safe Commerce (OSC), a partnership between multiple federal agencies and the private sector. Its purpose is to explore commercially viable options that support cargo management systems that keep pace with expanding trade while protecting international shipments from a variety of threats. One of the objectives of the project is to develop procedures, practices, and technologies that help secure and monitor containers and cargo from point of origin to final destination. The project plans to implement a supply chain grant program for the ports of Los Angeles, Long Beach, Seattle, Tacoma, and New York-New Jersey. The focus of the grant program is to develop approaches and technologies that will demonstrate a secure supply chain for international trade transactions (USDOT TSA 2002).

**Crew and Staff Access.** A major component of new security enhancement plans is limiting access to cargo and conveyances to qualified and authorized personnel. This includes the development of standards for personnel for all system participants ranging from customs officials to crewmembers and third-party forwarders, both in the United States and abroad. Information and data would again play a central role, facilitating detailed background checks and providing officials with data points for risk analyses. Once staff members and crew are screened, their access to sensitive cargo could be further controlled through identification technologies such as biometric retinal and iris scans, hand geometry, facial recognition, voice recognition, or dynamic signatures.

TSA is implementing a new Ports Security Grants Program to finance security enhancements at major seaports in the United States. The bulk of the over $195 million in grants (FY2002-2003) will go to 77 seaports for increasing operational security, including facility access control and crew security. The grants also cover the development of security assessments and mitigation strategies for port and terminal security (USDOT OST 2002).

**Future Security and Trade Flows**

Balancing security requirements with the need for efficient and effective international freight flows will be a continuing challenge for the country as a whole and for the U.S. transportation system. The United States shares a 5,525-mile border with Canada, a 1,989-mile border with Mexico, and has 95,000 miles of open shoreline and navigable waterways. The task of fully securing this physical boundary is compounded by the millions of people, hundreds of thousands of vehicles, aircraft, and vessels, and millions of containers carrying freight that enter the United States annually.

The U.S. domestic transportation network is changing in response to these evolving security and trade requirements. The exact implications of these changes for freight are, as yet, unknown. For example, if delivery times are delayed, will globally sourced companies rely more on domestic suppliers? Will companies begin to hold more inventories, thereby affecting the demand for transportation services? It is clear that initiatives focused on improved technology and information will be essential in this new trade and security environment. However, the exact balance between the flow of international goods and necessary security requirements will continue to evolve and new strategies seeking to improve this balance will continue to be sought.

**Acknowledgement:** The authors are grateful for reviews, comments, and assistance received from several staff at the USDOT Bureau of Transportation Statistics, in particular from the International Program Team.

## References

BDP International. 2001. BDP Advisory: FAA Issues New Guidelines for Known Shippers. Available at http://www.bdpint.com/news_events/ad_air33.html, as of October 2001.

U.S. Department of Transportation (USDOT), Bureau of Transportation Statistics (BTS). 2003. *U.S. International Trade and Freight Transportation Trends.* March. Washington, DC.

U.S. Department of Transportation (USDOT), Office of the Secretary (OST). 2002. U.S. Department of Transportation Establishes Port Security Grants for Critical National Seaports. Available at http://www.dot.gov/affairs/061702sp.htm, as of Sept. 16, 2002.

U.S. Department of Transportation (USDOT), Transportation Security Administration (TSA), Maritime and Land Security. 2002. Personal communication. October.

U.S. Department of Transportation (USDOT), U.S. Coast Guard (USCG). 2001a. Media Advisory: New Reporting Requirements for Ships Entering, Leaving U.S. Available at http://www.uscg.mil/news/Headquarters/Reporting_requirements.htm, as of Sept. 16, 2002.

_____. 2001b. Statement by USCG Commandant on Port and Maritime Security, December 2001. Available at http://www.uscg.mil/overview/article_statementloy.htm, as of Sept. 6, 2002.

U.S. Department of the Treasury, U.S. Customs Service. 2001. Testimony of Commissioner Robert C. Bonner. Northern Border Security: Hearing Before the U.S. Senate Committee on Appropriations, October 3. Available at http://www.customs.ustreas.gov/news/news.htm, as of Oct. 28, 2002.

_____. 2002a. Customs-Trade Partnership Against Terrorism (C-TPAT). Available at http://www.customs.ustreas.gov/enforcem/tpat_fact.htm, as of Aug. 12, 2002.

_____. 2002b. Japan Joins Container Security Initiative. Available at http://www.customs.treas.gov/hot-new/pressrel/2002/0926-00.htm, as of Oct. 24, 2002.

_____. 2002c. U.S. Customs Publishes Final Regulations To Require Advance Shipping Information. Available at http://www.customs. treas.gov/hot-new/pressrel/2002/1030-00.htm, as of Oct. 30, 2002.

Wall Street Journal. 2001. As Security Worries Intensify, Companies See Efficiencies Erode. Sept. 24, 2001. p. 1.

# NOT ENOUGH HOURS IN A DAY

**By A. James Park**

*When the Interstate Commerce Commission (ICC) adopted the first Hours of Service (HOS) rules in 1938, long-haul truckers could average only 25 mph – the top speed was 40 mph – and the best daily run was about 250 miles. The rules haven't changed fundamentally since then. But almost everything else has.*

## INTRODUCTION

In their original form, conceived in 1935 and brought into effect in the U.S. in 1938, the HOS regulations were as much a labor issue as a safety issue. The need for adequate rest was recognized even then, along with the need to make a distinction between driving and non-driving time in order to prevent drivers from spending too many hours behind the wheel. Transport Canada first introduced a Canadian version of the rules in 1984.

While similar to the American rules in spirit and purpose, the Canadian law offers more latitude with respect to duty cycles, and longer hours behind the wheel. Both countries require drivers to log certain activities as on-duty time, but over the years much of that prescribed time has slipped off the pay ledger. For reasons unknown, drivers never objected too strenuously to this, and as a result, it's now common practice for carriers not to pay drivers for this time. But drivers today are feeling the pinch of all that unpaid time.

Record-breaking delays at our major border crossings are causing considerable stress for drivers who once made up that 'lost time' by hiding the wasted hours in the logbook, and running a few extra miles to make up the difference. The situation will only worsen until regulators agree to re-examine our HOS laws from both a labour and an economic perspective, rather than from solely a safety perspective.

Border security has become one of the pre-eminent concerns of American legislators in the post 9-11 era. On top of the increasingly

rigorous cargo inspections, officials at the U.S. Immigration and Naturalization Service have also stepped-up the frequency and intensity of the personal background checks they conduct. The resulting delays at the ports of entry cost truck drivers a fortune, but worse, they force drivers to choose between compliance with HOS and making the scheduled delivery. Missed deliveries can result in additional costly and unproductive delays further downstream.

The delays are generally beyond anyone's control or ability to predict, yet drivers are often called upon to 'take up the slack' resulting from the delay, or risk the possible loss of the carrier's client, or worse, their own jobs as a result of a service failure.

But the worst possible outcome for a driver would be an accident following a decision to 'hide' the delay time and proceed with the delivery. Where non-compliance with HOS might be a factor in the outcome of any civil or criminal court action, a driver who appears to be operating outside the rules will almost always be held at least partially accountable, even if he or she is technically not at-fault.

This paper will examine the human cost resulting from border delays in a context I believe often goes unconsidered in discussions of equipment utilization, supply chain efficiency, and competitiveness.

## THE PRESENT CIRCUMSTANCES

Over 13 million trucks crossed the Canada-U.S. border in 2001, or about one truck every 2.5 seconds. Sixty percent of that volume crossed into the U.S. from four ports of entry located in southern Ontario.[1] The problem is not unique to Ontario, but a great deal of the product exported from that province is of a highly time-sensitive nature. That's where the truckers' problems begin.

Just-In-Time supply chain management leaves the driver with few options – the load simply has to be delivered on time. Pick-up and delivery appointments are carved in stone, with literally no margin for error. Schedules are tight but manageable, under normal conditions, but a service failure can cost a trucking company dearly. It's not rare for the carrier to be held accountable for the cost of an emergency delivery to maintain production, or to pick up the tab for a stalled production line resulting from the shortage of inventory.

**Time and Distance Calculations**

Carriers use a variety of mileage and routing software programs to schedule deliveries. The routing can be determined by selecting from a menu of options, including practical route, shortest route, or truck-specific route (toll road or alternate) which provide the user with a defined route, and an estimated travel time. Time and distance estimates vary across the brand of program, and by the route chosen. The best time may not be the most practical route, and vice versa. Once the schedule has been set, it's up to the driver to make good on the promise regardless of the practicality of the routing, or the additional cost that may be incurred by using tolled highways.

These examples illustrate the time and distance variations, using two popular mapping and routing providers: Pro-Miles and Mapquest.

| Mileage | Time | Avg. speed | Route designation | Provider |
|---|---|---|---|---|
| From Belfield Rd in Toronto to E 50th St. New York City | | | | |
| 466.8 | 7:34 | 62 | Practical | Pro-Miles |
| 445.7 | 9:59 | 45 | Shortest | Pro-Miles |
| 492.4 | 8:02 | 62 | Toll road | Mapquest |
| From Belfield Rd. in Toronto to the Louisville Fairgrounds in Louisville, KY. | | | | |
| 602.5 | 10:31 | 57 | Practical | Pro-Miles |
| 573.3 | 11:45 | 49 | Shortest | Pro-Miles |
| 587.4 | 9:35 | 62 | Alternate | Mapquest |

The variations in estimated time and distance are not extreme, but a conflict arises for the driver if the company bases its pay structure on the shortest distance, but bases the delivery schedule on best time.

Drivers usually base their own routing decisions of a number of factors. Many may opt for a particular route out of familiarity, or because of the availability of services along the way. Others may favor a route because of traffic or road conditions, or even the type of terrain involved. Usually it boils down to a matter of reasonable distance, comfortable driving conditions, and total travel time.

As a matter of industry custom and practice, carriers tend to set the rate for a given destination, regardless of the actual route chosen by the driver. In the New York City example, the shortest route is also the most popular among drivers. That's not the case in the Louisville example. The preferred routing doesn't even appear as an option.

All the Louisville options involve crossing at Windsor/Detroit, which is the busiest and most congested port of entry in the *world*. For that reason, many drivers prefer the Sarnia/Port Huron crossing because the time saving vastly outweighs the additional distance involved – approximately 18 miles. Since carriers tend to pay a flat rate for the trip, the driver chooses to absorb the extra cost, while saving several hours in avoiding the massive delays at Detroit.

Underlying all of this are the HOS regulations. Estimating driving time is one thing, but adding allowable driving shifts and mandatory rest breaks into the estimate can increase the travel time considerably.

The Toronto to New York City trip can normally be completed in a single driving shift. The American HOS rules permit 10 hours of driving in a single shift, which places a driver at the outer edge of the envelope upon arrival at destination (the shortest route is 445.7 miles in 9 hours, 59 minutes). Any delays experienced en route could compromise the arrival estimates dramatically.

On the Toronto to Louisville trip, an eight-hour break would be required to maintain compliance with the regulations. The average speed estimates shown are somewhat higher than could be achieved under normal circumstances, and they are more than the U.S. DOT allows in a logbook audit. The practical routing of 602.5 miles is the more accurate measurement, but at a reasonable average speed of between 45 and 50 mph, the trip actually takes about 12 hours. Add to that, an eight-hour rest break and you've got a transit time of 20 hours – twice the time required for the New York trip, yet the trip is only 150 miles longer.

The Louisville example presents an interesting dilemma for drivers, the carrier, and the shipper. The best-case scenario shows a driving time of 10.5 hours – only slightly longer than the maximum allowed

by HOS. All parties have strong incentives to make the trip without the mandatory break: the carrier and the driver see better equipment utilization, and the shipper gets the freight 10 hours sooner.

It is useful to know that this scenario occurs far more often than not. In the textbook world of regulation and compliance, it's too easy to draw arbitrary lines in the sand. In the real world, market pressure has a far greater influence over how business is done. The carrier who can deliver on a promise usually gets the business. For better or worse that is the way it works.

I have deliberately chosen these two trip scenarios to illustrate the 'wiggle' room drivers have in logging the time over a given distance. Both examples contain circumstances where the trip would be either impossible, achievable, or comfortably compliant under the present regulatory framework. Given another dimension to the problem, such as a delay of several hours at the border, the driver could still make the trip appear to be compliant with the HOS rules, but doing so could have catastrophic implications further down the road.

**THE DRIVER'S POSITION**

"Like anyone else, truck drivers are moulded by their job requirements," writes Sesto Vespa, Executive Director of Transport Canada's Transportation Development Centre. "Understanding their driving behavior requires that we understand their working world."[2]

While it may seem incongruous to the layperson that truck drivers willingly violate the law in the course of fulfilling their duties, or seem only too happy to work numbers of hours far in excess of what many consider reasonable, their motives are justifiable, if not defensible, under the circumstances. Their priorities may, at times, seem out of sync with conventional views, but the rationale behind what they do is understandable in the larger context.

To understand what motivates a truck driver, one needs to understand how they are paid, and how that affects their priorities. Their devil-may-care attitude and apparent disregard for authority may be the public perception of truck drivers, but in fact, most of them take their jobs and their responsibilities quite seriously.

Truck drivers are an intriguing group of people. They often say one thing in theory, but contradict themselves in practice, which can make research and fact-gathering difficult. As someone who has worked shoulder to shoulder with these people for over two decades, I understand their ways and means. As a former long-haul trucker, I can relate to the driver's psyche.

Most drivers running cross-border medium- to long-haul freight are paid according to the distance they travel. Period. Some receive a fee for tasks such as crossing the border or loading and unloading, but it seldom mirrors the actual time required to complete the task.

By flat-rating drivers' pay, carriers can predict operating costs with a great degree of accuracy. They know, for example, that a trip to New York City may pay the driver 445 miles @ .40/mile, and perhaps $20.00 to load the truck, $20.00 to unload it, and another $20.00 to clear customs, for a total of $238.00. Drivers also know exactly what they will earn even before they leave, regardless of how long it takes, or what might be required of them by customs, the shipper, or the receiver. To that end, the driver will take steps to minimize the time, but usually not the effort, involved in completing the task.

Recent research suggests that there is a close relationship between levels of pay and truck driver safety. While safety enters into this discussion in a broad sense, I am more concerned with the economic impact of the delays and the implications of the steps drivers take to mitigate their losses.

Two aspects of the driver's work life dominate the hierarchy of priorities: maximizing their earning potential, and minimizing their time away. That means they are always mindful of scheduling difficulties that might arise from delays encountered en-route, and they will always take steps to minimize the risk of the plans collapsing. For example, a delay in unloading might mean another delay in being reloaded for the trip home – perhaps as much as 24 hours or more (missed appointments may carry a heavy penalty). When there's no compensation for the waiting time, the prospect of being delayed for any significant length of time becomes a strong motivator in ensuring the plans are not disrupted by some event beyond their control, such as a delay at the border.

Being kept away from home unnecessarily is not only irritating; it's costly. As I've stated, idle time is uncompensated time for most drivers. Consequently, they'll do whatever may be necessary to keep the plan on the rails – even if it means a breach of the regulations.

HOS rules are perhaps the easiest for the driver to justify breaking because they are seen to be arbitrary, and can be broken with seeming impunity. In their minds, allowing a technical line in the sand to stand between a decent paycheque, or perhaps an extended tour of duty, isn't quite enough keep them on the right side of the law. In the driver's mind, those who 'bend' the rules for the sake of expediency, aren't in quite the same league as those who flagrantly break the law and reap considerable rewards for doing so. The authorities, however, do not make a similar distinction.

**Hours of Service vs. Earning Potential**

It is difficult for laypersons to comprehend the economic impact HOS have on a driver. While the safety debate garners most of the public attention, other more subtle aspects of the law can have a devastating impact on driver earnings.

As I've stated, drivers are typically paid only for the miles they run, meaning if they are not running, they are not earning.[3] Conversely, since they are required to account for all of their on-duty time in the logbook, including delays at customs, the hours logged in that fashion further reduce the hours they have available to drive. This constant eroding of their earning potential is, in a nutshell, why we see such a low compliance rate with the HOS regulations.

Here's how it works, using the American regulations (I use the U.S. rules simply because they're easier to understand): a driver is permitted to drive for up to 10 hours in a single shift, before being required to take an eight-hour rest break. In addition, the driver is also permitted to work up to five hours before or during the 10-hour driving shift in some non-driving capacity, such as loading or unloading. This makes it possible for a driver to work up to 15 hours in a day before being required to book eight hours off-duty.

The American regulations permit a driver to work up to 60 hours in a

seven-day period or 70 hours in eight-days, at the driver's discretion. Within their workweek, drivers will attempt to preserve as many hours as possible for driving by hiding as many non-revenue-producing hours as possible. They accomplish this by logging what should be considered on-duty time as off-duty or sleeper time.[4]

What tends to happen is this: as the driver's workweek progresses, their hours accumulate. If the driver reaches the 60-hour mark in, say, four days, he or she will not be permitted to drive again until they comply with the 60-hours-in-seven-days rule.

The magnitude of this unpaid delay time is enormous. Studies conducted in 1998 and 1999 by the Truckload Carriers Association revealed that drivers spend between 33 and 43 hours per week waiting – unpaid – while technically on duty.[5] I needn't remind you, but this is the equivalent of a full week's work for many Canadians. This excessive waiting time represents a US$1.5 billion productivity loss.

The official interpretations of on-duty time found in both the Canadian and American HOS regulations are identical, in spirit.[6] Both countries also require that time spent engaged in those activities be logged accordingly. Drivers who log their on-duty hours in any other fashion are in violation.

In essence, 'on-duty' means any time when the driver is performing tasks directly related to the operation of the truck, such as loading, unloading, fueling, completing paperwork, repairing, and attending or occupying a truck – except while resting in a sleeper berth, or driving. 'On-duty' also includes time spent at customs, a shipper's facility, a weigh scale, the motor carrier's terminal, or waiting at an en-route point because of an accident or other unplanned occurrence.

'On-duty' time begins when a driver begins work or is required by the motor carrier to be available to work, and ends when the driver stops work or is relieved of responsibility by the motor carrier.

Given the scope of the definition of 'on-duty,' how does a driver avoid forfeiting a huge number of revenue-producing (driving) hours – out of the 60 or 70 hours available in a week – to non-revenue-producing time, such as loading, unloading, or waiting at customs?

**THE PROBLEM**

For the purpose of this discussion, I'll focus on the difficulties posed by the extraordinary delays at various American ports of entry. A similar situation exists when entering Canada, but the delays reported by drivers aren't nearly as dramatic.

Depending on the location, the time of day, and a myriad of other circumstances, delays ranging from 30 to 90 minutes are routine at most southern Ontario border crossings. The Ambassador Bridge in Detroit routinely reports delays ranging from four to six hours. Delays of 10 hours are not unheard of.[7]

Faced with the immediate prospect of a border delay causing late delivery, or the long-term prospect of an HOS violation for not properly reporting the delay at the border (on-duty time), truckers will usually place the delivery requirements first. Under some circumstances, extended delays could compromise the driver's allowable work time to the point where an eight-hour break could be required in a situation where that demand wouldn't ordinarily exist.

And, given the forced reduction in available working hours (owing to the unpaid time logged as on-duty) for the balance of the week, most drivers opt to make the delays disappear from the record by simply logging the time as off-duty. Later in the trip, the drivers can absorb the delay time back into the log by using the lost hours to provide extended break times or logging it as part of the loading or unloading time experienced later in the day or the week.

Falsification is illegal of course, but drivers feel the practice is warranted by the appalling loss in earning potential caused by unforeseen delays. It is worth mentioning that this has been going on since the industry decided that drivers need only be paid for their driving time. A handful take the practice to extremes in order to increase profits, but most are forced into the practice by the necessity of having to be somewhere at a specific time, regardless of what might happen in the interim.

Border delays pose difficulties for truckers, not because they are difficult to disguise, but because they are easy for authorities to trace.

**The Paper Trail**

Facility audits, or compliance reviews, are an essential component of the enforcement strategy. Auditors from U.S. DOT and provincial ministries of transportation conduct random visits to carrier terminals to inspect records. These audits usually include, among other things, an examination of drivers' hours of service records (logbooks). The log sheets are examined for clerical errors and obvious attempts to deceive authorities by under-representing the actual amount of time spent on a task. Among the most obvious clues are distances between two points traveled in an unrealistically short period of time.

For auditing purposes, the U.S. DOT uses a benchmark of 42 mph in areas where the posted speed limit is 55 mph for trucks, to compare driving time versus distance. The 42-mph DOT estimate may seem conservative, but given the traffic density and the number of urban centres a driver may pass through in areas where truck speeds are limited to 55 mph (mostly on the Eastern Seaboard), the allowance is reasonable. Auditors can easily spot bogus log entries, and frankly, they needn't look hard to find them. For more concrete verification of inappropriate logging practices, auditors compare change of duty status entries to time markers, such as bridge or highway tolls, fuel receipts, and other time-stamped documents.

Drivers using electronic logs are at even greater disadvantage in a border delay because of the traffic jams that ensue when the borders get busy. Electronic data recorders display these hours as 'driving time,' and the American definition of driving time includes all time spent at the controls of a truck. In inching forward through a lengthy back-up, the driver could see a significant portion of the work shift evaporate (along with the earning potential) in stalled traffic.

Each year, U.S. Federal Motor Carrier Safety Administration (FMCSA) auditors uncover more than 14,000 HOS and logbook violations. Roadside inspections result in more than 130,000 drivers being placed out of service for similar violations. This represents about 80 percent of all driver out-of-service violations and represents about six percent of drivers inspected annually. Usually, such cases result in fines or other civil penalties.

One such case concerned a fatal crash involving a gasoline tanker on Interstate 95 in Chester, Pa., that left two people dead and badly damaged the highway and a bridge on May 23, 1998.

Witnesses said a gasoline tanker, owned by Samuel Coraluzzo Oil Transportation Co., Vineland, N.J., and driven by Keith Thomas, sideswiped a bus, hit a pickup truck, smashed into the concrete divider, and exploded.

FMCSA auditors conducting the investigation determined that in the previous six months, Coraluzzo's drivers had exceeded HOS nine times. The agency also said Mr. Thomas, who was killed in the crash, had just begun his day's work, but had gone over the 70-hour limit by five hours the day before.

Evidence presented during the investigation did not suggest that fatigue was a causal factor, but because of the history of HOS violations, the company and the driver were held jointly responsible for the damage to the infrastructure. Coraluzzo still faces a lawsuit on behalf of the crash's other victim, the pickup truck driver.[8]

In another example, Edmonton-based trucker, Albert Labelle, was fined $6000 for HOS violations following a fatal crash in August 1998, despite the authorities' conclusion that fatigue was not a factor in the incident.

It was reported that Labelle had returned home on a Friday from his week's work, and was on his way to the yard the following morning when traffic ahead of him suddenly came to a halt. Labelle claimed the traffic stopped so suddenly that he was unable stop his truck in time. Labelle chose to swerve into the median rather than smash into the cluster of braking cars. He crossed through the median and collided with an on-coming vehicle.

What hours of service had to do with the accident was never made clear. A source close to the investigation told *highwaySTAR Magazine* that police had wanted to charge Labelle with careless or dangerous driving, or something worse, but didn't think they could make the charge hold up in court. After investigating his records, police found that Labelle had a pattern of running longer hours than

the law permitted, and falsifying his logbooks. Prosecutors were unable to produce evidence that there had been any attempt by Labelle to falsify his logbook on the day of the crash, but they laid the charge anyway. Labelle pleaded guilty to several counts of not maintaining a proper log and falsifying his log.[9]

The significance of this illustration is that where there is evidence of falsification, there's an implication of responsibility.

The obvious difficulty for drivers caught between operational realities and the need to earn a living, is that they leave behind a highly damaging paper trail, where violations are extremely easy to uncover after the fact. Any driver involved in an incident will be subject to the same sort of scrutiny as drivers Thomas and Labelle.

The U.S. is a highly litigious land, where the victims of an accident will usually sue everyone involved. This exposes the driver to the added threat of civil litigation. The driver's past actions leave a paper trail revealing what the plaintiff's attorneys like to call 'a pattern of violation and disregard for the law.'

As you can see, the act of banking the delay time in order to meet the delivery obligations, and to maintain an adequate number of available revenue-producing hours, can come at a very steep price for otherwise law-abiding truck drivers.

To quote Mr. Vespa once again, "Myriad job-related factors affect truck driver behavior on the road, altering it (for better or for worse) from the norms accepted by most of the population. An incomplete list of these factors includes . . . company monitoring of drivers, official company intolerance of unsafe practices and associated penalties, incentives for safe practices, tolerance or intolerance of delays by the trucking company, fatigue-inducing work practices, the level of government enforcement, and fines."

Mr. Vespa seems to understand the challenge.

The trucking industry faces huge challenges in resolving this issue, but it must struggle to accommodate several sets of priorities, not the least of which is the current reality of Just-In-Time delivery.

The other side of the coin is drivers' growing disenchantment with having to endure these delays. For all the reasons already mentioned, and others, drivers are less willing to work under these conditions. The unpaid time-on-task is certainly a factor, as are the repercussions of the delays with respect to scheduling and trip planning. Were the industry to come up with an appropriate formula to compensate drivers for their time, it would place Canadian carriers at a considerable competitive disadvantage compared to U.S. carriers, unless the Americans, too, adopted a pay-for-duty-time stance.

In his analysis of the effect of driver compensation on truck safety, Michael H. Belzer of Wayne State University, reports that drivers log 18.3 percent of their total hours under the on-duty heading.[10] Given the arguments I've just made, we can assume that a great deal more on-duty time goes unreported. The question is: what would it cost to compensate drivers for all that 'invisible' time? Given current market conditions, it is doubtful that the carriers would ever be able to convince shippers to absorb a rate increase of this magnitude.

**CONCLUSIONS & RECOMMENDATIONS**

While I'd be the last to suggest that a driver's work/sleep cycles have no bearing on highway or on-the-job safety, I'd go right to the wall with my assertion that safety should not be the sole component of a well-conceived HOS regime. But Transport Canada and FMCSA refuse to accept that there is a dimension other than safety to HOS.

On October 22, 1938, the U.S. Department of Labor (DOL) handed responsibility for drivers' time and earning records to the ICC (now FMCSA) under the provisions of the HOS regulations, exempting drivers from the U.S. Fair Labor Standards Act. Since then, drivers' concerns with respect to the work they do have fallen through the regulatory cracks. Where the DOL might have had something to say about drivers not being paid for time they were required to account for, DOT viewed that time only in terms of a measurable change in the number of hours they spend driving or on-duty.

Belzer and others have studied highway safety through the HOS lens, and Belzer makes a compelling case for higher driver pay in his *Paying for Safety* report. Unfortunately, the impact of the HOS

regulations, in the context of current industry custom and practice of not paying for on-duty time, hasn't been thoroughly examined in Canada. That examination is long overdue.

As we inch forward in the post 9-11 era, we can't be at all sure what difficulties and challenges face the industry. Security will certainly play a greater role in our everyday lives, and that will mean delays for those in security-sensitive positions. The costs associated with those delays are already becoming apparent, and they shouldn't be exacerbated by compliance with HOS regulations.

As the rules are currently applied, they discourage compliance by restricting driver earnings, but that needn't be the case. Here are a few first steps toward establishing an environment where all the players share the costs and the benefits of a safe and efficient transportation system and unfettered access to our largest trading partner.

- Enforcement agencies should quantify the difference between administrative violations and genuine safety violations in HOS.
- HOS regulations should be filtered through a labor-law model to reveal their impact on drivers' earning potential.
- Carriers, drivers, and shippers should be equally accountable for HOS violations.
- The motor carrier industry and the private motor carrier sector should be required to pay for all the time a driver is required to be on-duty, regardless of the circumstance.
- All parties in the supply chain should be held accountable for unrealistic delivery schedules.

## Endnotes & References

[1] For statistics on truck traffic at Canada/U.S. border crossings, see *Transport Canada, Transportation in Canada 2001: Annual Report*, p. 55, <http://www.tc.gc.ca/pol/en/anre2001/tc2001ae.pdf>.

[2] Sesto Vespa, "Human Conditions," *Recovery* (Summer 1997): Volume 8, Number 2, <www.icbc.com/Library/recovery/volume8/Number2/HumanConditions/index.html>.

[3] A survey conducted in 1997 by the Owner-Operators and Independent Drivers Association (OOIDA) in preparing a submission for FMCSA's Advance Notice of Proposed Rulemaking on revisions to HOS, revealed that 80 percent of drivers are not paid for time waiting while delayed by shippers or receivers. See Federal Register, p. 14 at <www.aamva.org/Documents/legRegulatoryIssues5200HOSNPRM.pdf>.

[4] The OOIDA study also showed that 73 percent of drivers log these duties as off-duty time; 66 percent said they would log the time as on-duty if they were paid. See Federal Register, p. 14 at <www.aamva.org/Documents/legRegulatoryIssues5200HOS NPRM.pdf>.

[5] Truckload Carriers Association, "Dry Van Drivers Survey" (1999) and "National Refrigerated Driver Survey" (1998), <www.truckload.org/pressroom/pr06_22_99.htm>.

[6] Canada's proposed changes to HOS regulations can be viewed on the Canadian Council of Motor Transport Administrators' website, under National Safety Code, "Final Draft Hours of Service Standard - August 13, 2002" at <www.ccmta.ca/english/publicationandreports/publicationandreports-reportcentre.html>. Current American regulations are available on FMCSA's website at <www.fmcsa.dot.gov/rulesregs/fmcsr/regs/395.htm>.

[7] Border wait times can be viewed on the Canada Customs and Revenue Agency website at <www.ccra-adrc.gc.ca/customs/general/times/menu-e.html>.

[8] Jeff Johnson, "Carrier Fined After Tanker Crash," *Transport Topics*, August 31, 1998, <www.ttnews.com/members/printEdition/weekly.archive/08.31.98.tw.html>.

[9] Jim Park, "Due Diligence," *HighwaySTAR Magazine*, July 2002, Volume 4, Number 7, p. 27.

[10] Michael H. Belzer, Daniel Rodriguez, and Stanley A. Sedo, *Paying for Safety: An Economic Analysis of the Effect of Compensation on Truck Driver Safety*, September 10, 2002, p. 13, <www.culma.wayne.edu/pubs/PayAndSafety_Report_020910.pdf>.

# Terrorism and Containers: Impact to Canadian Agriculture Importers and Exporters

**By: Shelley Thompson,**
**President,**
**SJT Solutions and**
**David Spearin,**
**President,**
**Logistic Marketing Services, Inc**
**Saskatchewan**

## INTRODUCTION

In the post-September 11th world, **security at borders has become a critical issue**. While it appears that the movement of people between borders is now much safer the same can not be said about the movement of goods, particularly goods moving in containers. In October of 2001, Italian port officials discovered a suspected terrorist hiding in a container bound for Canada. The **use of containers as a terrorist Trojan horse** was identified as a threat prior to the September 11th attacks. *"Customs Commissioner Bonner has stated that "the shipping of sea containers would stop" if a nuclear device were detonated in a container. One can only agree with his comment that this would be "devastating", would cause "massive layoffs" in the economy, and that "we must do everything in our power to*

*establish a means to protect the global sea container trade, and we must do it now."* [1]

It is difficult to guarantee the security of containers because of the many jurisdictions and entities involved in a shipment, the lack of a standardized and coordinated information system, and the lack of global capacity to inspect containers before they are loaded onto ships. Prior to the new security initiatives, the US Customs Service augmented the physical inspection of less than 2% of containers arriving in the US with computer analysis of cargo documents to search for suspicious containers while Canada inspected 3% of containers arriving at its ports.

**Smooth and efficient container movement is essential** to Canadian agri-food sectors such as special crops. The Canadian Special Crops survey in 1998-99 found that 22% (about 0.5 M tones) of **pulse exports** were by container in that year. The acreage of pulse crops in Canada increased three-fold over the 1991 to 2000 period and growth is projected to remain strong in the future. Export growth of pulses to food markets (as opposed to feed markets) is also forecast to increase. This growth will increase the demand for containers. Also increasing the demand for containers is the growth in the exports of **organic products and red meat. While the current supply of containers appears to be adequate[2], security measures may impact global container traffic and consequently affect the supply of containers available to Canadian exporters.**

**The purpose of this paper is to examine how greater security measures could impact global container traffic and thus effect the availability and cost of containers in Canada.** More specifically, our paper

---

[1] C Koch, "Meeting the Homeland Security Challenge: Maritime and Other Critical Dimensions", Presented to the House Transportation and Infrastructure Committee, March 13, 2002.

[2] Logistics Marketing Service, "Feasibility of a Saskatchewan Container Pilot Project", Report prepared for Saskatchewan Agrivision Corporation, 2001.

- Provides information on **global, North American, and Canadian container traffic.**
- Discusses what is being done with respect to increasing the security of containers.
- Analyzes the impact of various security requirements on **container availability, transit time, and cost for Canadian container users.**
- Provides **recommendations** for Canadian firms and policy makers.

**Global Container Traffic**

The volume of seaborne trade is closely related to global economic activity as measured by GDP.[3] About 45% of world port traffic is made up of liquid bulk commodities (i.e. oil, oil products, and chemicals), while dry bulk commodities (i.e. grain, coal, and iron ore) and general cargo account for about 23% and 32%, respectively. [4]

Today most ships can carry between 6,000 and 8,000 of the 20 foot containers. Containerization has increased the speed of ocean service by reducing the amount of time loading and unloading ships. This effectively increased the capacity of the shipping industry and resulted in improved service at lower cost. It has also increased the type of goods that can be transported long distances (i.e. like fruits, vegetables, and meat). [5]

Over the last two decades the **containerization of general cargo has significantly increased** although the Asian economic crisis did slow its growth during 1998. UNCTAD estimates that global container port throughput was 225.3 M TEU's in 2000, an increase of almost

---

[3] Nigel Gardiner, Drewry Shipping Consultants, "The International Shipping Markets as we enter the New Millennium", MessPierson 3rd Annual Shipping Conference, December 9, 1999, Rotterdam.
[4] World Bank, "Ports and Logistics Overview".
[5] W Hall, "Innovations in Shipping Food Products, Past and Future", in ERS, "Technological Changes in the Transportation Sector – Effects on US Food and Agricultural Trade", 1999.

16% from 1999. [6] According to de Langen the growth in container traffic from 1980 to 1995 occurred because of factors such as the growth in GDP, greater openness in the world economy, changes in the direction of trade, and changes in the composition of trade (i.e. what could be put in a container). [7]

**The ports of Hong Kong and Singapore are the leading container facilities in the world.** In 2001, the throughput at these ports was just over 33 M TEU's. [8]According to the World Bank, the Far East and Europe with 45% and 23%, respectively of container traffic dominate other regions of the globe. North America, Near and Middle East, Central and South America and Africa account for 16%, 6%, 4%, and 3% of world container traffic, respectively. [9] Developing countries are involved in container traffic, with 48 of these countries having facilities that handled at least 100,000 TEU's in 1999. [10]

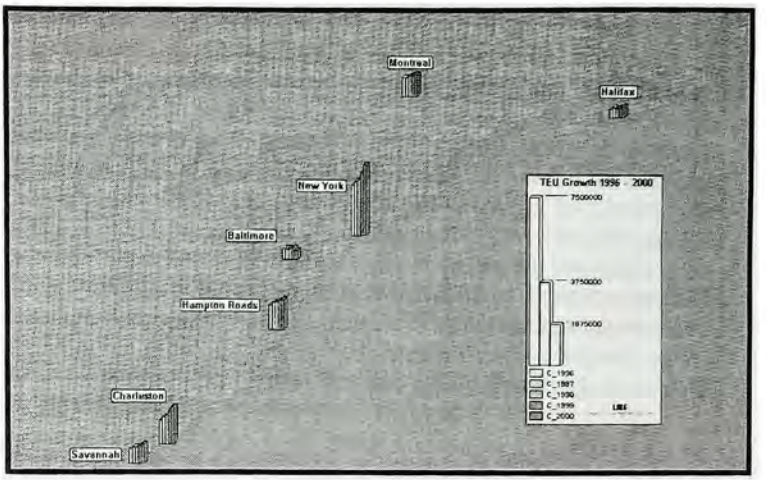
**North American Container Traffic**

In 2000, ports in Canada and the US handled 33.3 M TEU's, an 8% increase from 1999. Ports along the US West coast handled 47% of this traffic while US East coast ports handled 39%. Canadian ports handled 9% of the container traffic in 2000. The West Coast of Canada has experienced the fastest growth in containerized traffic during the 1990's while the Canadian East coast has seen the smallest growth. Overall, Canada – US container traffic grew by a compound annual rate of 7% over the decade.[11]

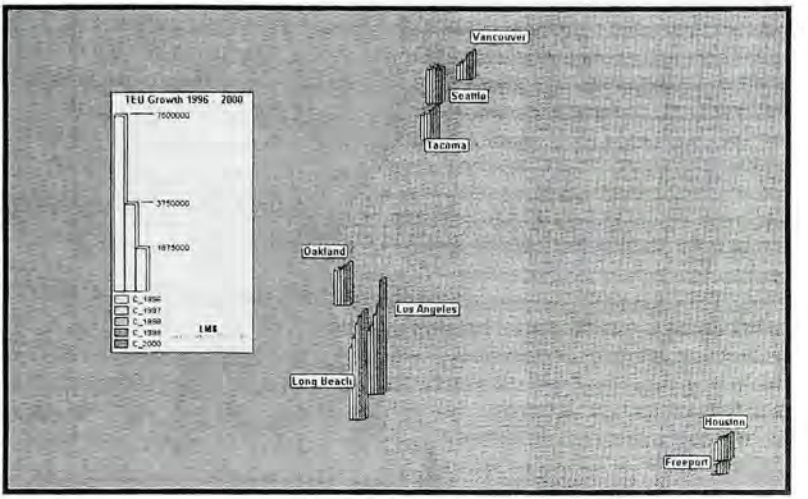
The ports of New York and New Jersey handled 3.1 M TEU's in 2000, about 24% of total US East Coast traffic. The growth in container traffic for significant East Coast ports is shown below.

---

[6] UNCTAD, "Review of Maritime Transport 2002", 2002.
[7] PW de Langen, "Growth Prospects for Port-Services: A Qualitative Model and Implications for Ports".
[8] UNCTAD, "Review of Maritime Transport 2002", 2002.
[9] World Bank, "Ports and Logistics Overview".
[10] UNCTAD, "Review of Maritime Transport 2001", 2001.
[11] American Association of Port Authorities




Along the West Coast, the ports of Los Angles and Long Beach are the major container ports. In 2000, Los Angeles handled 4.9 M TEU's while Long Beach handled 4.6 M TEU's. Along the US Gulf Coast, Houston is the major container port, handling 1.1 M TEU's in 2000. The growth in container traffic for significant West Coast and Gulf ports is shown below.




Container traffic at west coast ports is expected to continue to grow rapidly, although efficiency improvements will be necessary in order to keep up with demand. Growth is occurring because of strong import demand for Asian products. With China's acceptance into the World Trade Organization, eastbound container traffic will increase significantly. Container traffic at east coast ports in the US is also expected to occur. However, the port of New York/New Jersey cannot accommodate the new larger container ships.[12]
Chilled, refrigerated and processed food now accounts for approximately 63% of the total value of US agricultural exports compared to only 27% in 1975. The value of high value agricultural product exports is expected to reach $46 B US by 2009.[13] Pre September 11th, container traffic at Canadian ports was also expected to experience growth from economic growth, the continuing trend to containerization, and congestion at US ports.

---

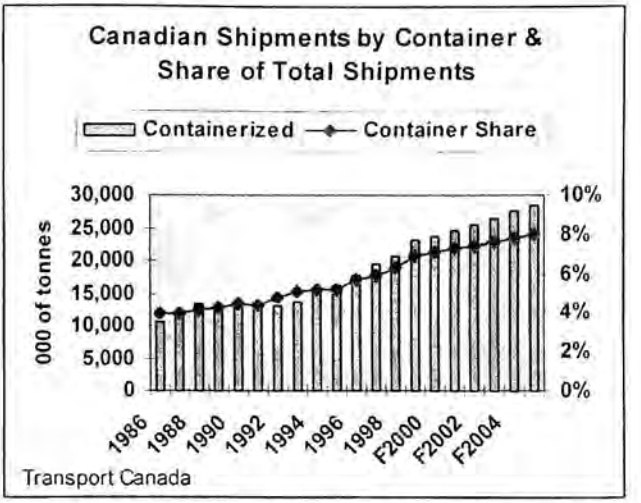
[12] Standards & Poor's, "International Port Trends are Positive", April 2000.
[13] USDOT, "An Assessment of the US Marine Transportation System", September 1999.

**Canadian Container Traffic**

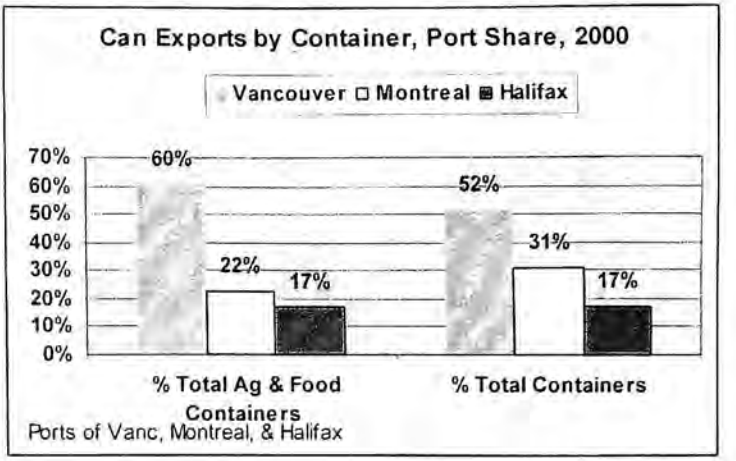
In 2001, the value of Canadian exports of goods was $412.5 B while the value imported was $35 B. Agricultural and fishing exports in 2001 were $30.8 B, representing 7.5% of total goods exported. Imports of agricultural and fishing products were valued at $20.4 B, representing 5.8% of total goods imported. Based on 1997 data, agriculture, with exports representing 83.3% of GDP from agriculture is one of the most export dependent sectors. [14]

Transport Canada provides data on the volume of goods shipped in containers (domestic, exports, and imports). The volume of containerized goods grew at an annual rate of 6% from 1986 to 1999 and reached 22.9 M tonnes in 1999. Transport Canada expects that this growth will slow to 4% annually during 2000 to 2005. Transport Canada forecasts that the volume of goods in containers will reach 28.4 M tonnes In 2005. Containers have grown in popularity over time. In 1999, containers accounted for 6.9% of the total volume of shipments in Canada (domestic, exports, and imports) compared to just 4% in 1986. By 2005, containers are expected to be used in the movement of 8% of the total volume. [15]

[14] DFAIT, "Third Annual Report on Canada's State of Trade", May 2002.
[15] Transport Canada, "Commodity Flows by Sector – Canada – Marine".




In 2000, Canada utilized an estimated 1.1 M containers (TEU's) to export goods, of which 0.347 M containers contained agricultural and food products. The following chart shows the breakdown by port. The Port of Vancouver handled more than 50% of total containers and 60% of all agriculture and food containers. While the Port of Montreal handled 34% of all Canadian exports by container, it handled only 22% of Canadian agriculture and food container exports by container. The Port of Halifax was responsible for only 17% of both total container exports and agriculture and food container exports.



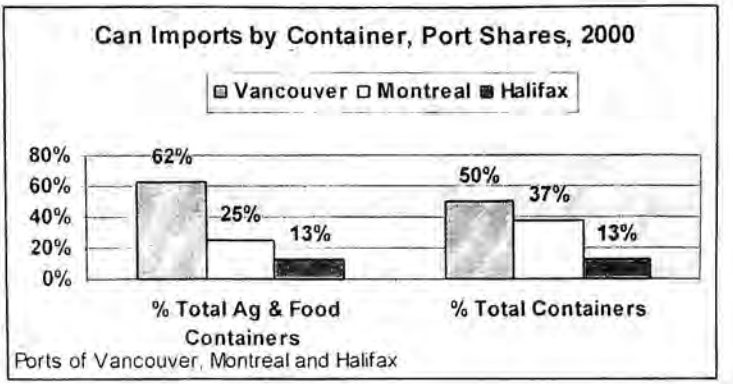

The breakdowns of Canadian agriculture and food products exported in containers are shown below for the year 2000. At the Port of Vancouver, the major agricultural and food commodity exported by containers were fodder and feed, meat and fish, and fruits, vegetables and food products. Unfortunately, each port categorizes pulse crops in a different way. The Port of Vancouver counts them in the fodder and feed category while the other two ports include them in the fruit, vegetables, and food products category.

At the Port of Montreal, the major commodities exported in containers were fruits, vegetables, and food products, other cereal, and meat and fish. Meat and fish and fruits, vegetables, and food products were the major agriculture commodities exported in containers through the Port of Halifax.

The following table provides more explicit information on Canadian containerized exports of pulse crops, cereals, and meat products. At the Port of Vancouver, the meat and fish containers include 7,994 TEU's of beef and 30,327 TEU's of pork.

| Selected Container Exports, 2000, TEU's | | |
|---|---|---|
| | Vancouver | Montreal |
| Dry Peas | 13,434 | 2,141 |
| Lentils | 6,103 | 5,507 |
| Dried Beans | 1,974 | 2,588 |
| Wheat | 944 | 261 |
| Barley | 2,704 | 1 |
| Corn | | 1,696 |
| Sunflower | | 1,716 |
| Meat & Fish | 56,442 | 12,099 |
| Ports of Vancouver & Montreal | | |

In 2000, Canada utilized an estimated 1.1 M containers (TEU's) to import goods, of which 0.156 M containers contained agricultural and food products. The following chart shows the breakdown by port. The Port of Vancouver handled 50% of total containers and 62% of all agriculture and food containers. While the Port of Montreal handled 37% of all Canadian imports by container, it handled only 25% of Canadian agriculture and food container imports by container. The Port of Halifax was responsible for only 13% of both total container imports and agriculture and food container imports.




**Enhanced Security Requirements**

In **Canada, the Standing Senate Committee on National Security and Defense held** hearings on various aspects of Canada's national defense and security. The committee found that Port Authorities are primarily focused on port viability and have little responsibility for port security. Also, there are hundreds of Canadian harbours and ports with little or no security. **The committee concluded that the lack of control over criminal activity provides a basis for terrorist activity** such as covert immigration and the shipment of terrorist weapons. Security lapses at the port were determined to constitute a threat to national security. It was also recognized that if the US determined that Canadian ports were not secure and restricted traffic that the economic consequences would be devastating. **Port security can provide a competitive advantage.** [16]

**The Canadian Government recently announced that it will allocate $172.5 M over five years to enhance Canada's marine security**. Projects include better surveillance and tracking of marine traffic, passenger and crew screening processes, new detection

[16] The Standing Senate Committee on National Security and Defense, "Canadian Security and Military Preparedness", February 2002.

equipment (gamma ray technology) to screen containers, and establishing restricted areas and personnel background checks at ports. [17]

**Under the US Port and Maritime Security Act of 2001, the following actions are mandated:** [18]

- Establishes a National Security Task Force to develop and implement standards for port security.
- Requires that all ports undergo a vulnerability assessment (beginning with the top 50 US ports).
- Establishes new processes for documents – shippers must now provide documentation to customs prior to leaving customs. Additional information such as the consigner, consignee, country of origin and the harmonized element numbers are now required on documents.
- Encourages the Coast Guard to persuade foreign ports to adapt the new US regulations and establishes a program to help foreign ports conduct assessments and implement security standards.
- Provides $80 M US to $120 M US per year for four years to assist ports to purchase improved screening and detection equipment.

Currently **it is difficult to guarantee the security of containers** because of the **many jurisdictions and entities involved** in a shipment, the **lack of a standardized and coordinated information system**, and the **lack of global capacity to inspect containers** before they are loaded onto ships. The US is **pushing out its borders** by placing custom inspectors at three Canadian ports (Vancouver, Montreal, and Halifax) and 10 overseas ports (such as Hong Kong,

---

[17] Transport Canada, "Canadian Government Announced Port Security Funding", January 22, 2003.

[18] A Grimes, "Transportation Security Issues" presented at Transportation Needs in Today's Global Economy", University of Minnesota, March 2002 and World Trade, "Port Security Tightens", February 2002.

Singapore, and Shanghai) to pre-screen containers bound for the US prior to loading. Canada, in return, will place its inspectors at three US ports (Newark and Seattle-Tacoma) to prescreen containers bound for Canada. The US Customs Service also uses computerized "profiling" to identify suspicious containers and wants foreign ports to adopt this process. [19]

**Impact of Greater Security Requirements**

Heightened security requirements will increase the cost of transporting products by containers. This will lower the volume traded of these goods. The import price will increase and the price received by exporters will fall. Canadian exporters of products such as pulse crops, organic commodities/products and meat which are significant users of containers will feel the following impacts:

- Inspection surcharges on containers. Assuming a cost of $100 to $150 per TEU, the aggregate cost to Canadian agri-food exporters would be $34.7 M to $52.1 M based on 2000 data.
- A slower supply chain (by 4 to 7 days). The reduction in velocity will have the following effects:
    - Reduce the global container capacity resulting in lower availability.
    - Increase inventories and the cost of carrying inventories.
    - Increase the carrying cost of product in transit.
    - Increase working capital requirements.
    - Increase the importance of the smooth and timely flow of product from the producer/processor to the port.

[19] National Post, "US Customs to Begin Canadian Port Inspections", March 12, 2002 and World Trade, "US, Canada Announce Border Plan", May 1, 2002.

Importers of containerized products will feel many of the same effects.

The impact of greater security requirements will grow over time. It is useful to **picture security requirements on the following continuum.** Currently countries are putting in place pre-screening procedures and investing in better technology to reduce the threat of containers being used as a terrorist tool. In the medium term, countries will work individually to develop and implement national standards for port and container security. This will include credentialing and tighter controls on documentation. **In the longer term, the entire supply global chain will become standardized, harmonized and digitized.** Moving along the continuum the risk of a breach of container security will decrease while the cost of moving product will increase. Information technology requirements may drive some exporters and ports out of business. To minimize higher trade transaction costs new governance structures must also emerge.

**Some Recommendations for Canadian Exporters and Importers**

- View port, trade, and business security as a source of competitive advantage and support initiatives that aim to enhance security.
- Determine what the Canadian port's action plans for security is and how they will affect your business.
- Evaluate the actions of the US government for port and container security because these actions will affect you.
- Evaluate the actions of major offshore ports for port and container security. Their actions will also affect you.
- Conduct a trade-risk-cost assessment of your business.
- Audit your present supply chain for exposure to risk. Where are the key risk areas? How much product (value and volume) is typically at risk during a given time period? What is your risk using your current routings
- Evaluate your logistics chain and identify added costs because of higher security requirements, including inventory

costs, shipping and delivery delays, surcharges, and insurance.

- Re-examine your terms of sale to identify items that could be passed on to customers.
- Re-evaluate your market options. Some markets may become "out of the money" or may carry too high a risk (i.e. is there another available market close by in case the port your product will use becomes blocked).
- Develop a better relationship with the participants in your supply chain better – your business depends on them.
- Develop and implement risk management strategies in the following areas.
    - Collaboration
    - Communication
    - Employee awareness, credentials, and training
    - Carriers
    - Customers
    - Mode/route selection
    - Crisis management

The preparation of security risk reviews may become standard for all exporters and importers of containerized products. The evaluation of risk security and its relation to supply chain management will provide secondary benefits as new standards and new accountabilities will enhance the efficiency of the current systems.

[15] Transport Canada, Government of Canada Compensation Program For Airlines And Specialty Air Operators Final Program Results . May 17, 2002, http://www.tc.gc.ca/pol/en/airpolicy/compensation/program_results.htm

[16] Transport Canada, Op Cit.

[17] U.S. Department of Transportation, Bureau of Transportation Statistics, Ibid, http://www.bts.gov/transtu/indicators/Mobility/excel/Enplanements_on_Domestic_Flights.xls

[18] Statistics Canada, Aviation Statistics Centre tabulation based on Canadian commercial air carriers in reporting levels I-IV inclusive.

[19] Statistics Canada, Aviation Statistics Centre tabulation based on Canadian commercial air carriers in reporting levels I-II inclusive.

[20] Air Canada Annual Report 2001, page 11

[21] WestJet Annual Report 2001

[22] U.S. Department of Transportation, Bureau of Transportation Statistics, Press Release April 23, 2002, *Airport Employment Dropped 11 per cent in 2001, BTS Reports.* Major airlines have operating revenues of $1 billion or greater.

[23] U.S. Department of Transportation, Bureau of Transportation Statistics, both full and part time employees of Form 41 carriers, http://www.bts.gov/oai/employees

# Commercial Aviation —A Canada-United States Post-September 11th Comparison

Gordon Baldwin, Lisa Di Piétro and Robert Masse
Transportation Division, Statistics Canada, Ottawa K1A 0T6

This paper examines the trends in commercial aviation in the United States and Canada before and after the terrorist attacks of September 11, 2001. The examination will cover the immediate or short-term impacts on the airline and airport sectors. The examination is made on both operational aspects (flights, traffic, and employment) and on the financial aspects. It is apparent that while the immediate effect was quite pronounced, in many cases, declines that were evident before September 11th have continued. As there is a very seasonal nature to air travel, the examination will primarily be done by examining year-over-year percentage changes, by comparing various indicators for a month or quarter to the same month or quarter of the previous year.

## Immediate Impacts of September 11th

At 9:45 a.m., September 11, 2001, the U.S. Federal Aviation Administration (FAA) ordered all aircraft in U.S, airspace to land and closed American airspace to incoming international flights. Canadian airports accepted 224 passenger flights with 33,000 passengers and 10 diverted cargo flights. At 11:00 a.m. flights at Canadian airports also were grounded.[1] Flights resumed in Canada on September 12th and in the United States on September 13th.

The news media can leave the impression that the problems in the aviation industry are largely due to the events of September 11th but there were signs of concern before then. In explaining the decline in

revenue passenger-miles in May 2001, the United States Air Transport Association stated that "The U.S. airline industry, like most other industries, has felt the impact of a weakened economy".[2] The United States House Subcommittee on Aviation summarized the situation as "Prior to September 11, 2001, the U.S. commercial airline industry was already in a weakened condition due to a combination of reduced passenger demand and rising labor costs. Business travel in particular had dropped significantly by January, 2001 in response to a rapid slow-down in the U.S. economy. The September 11th attacks were a major shock that further weakened the industry".[3] A similar situation seemed to exist in Canada. Air Canada press release February 7, 2002 quotes Air Canada President and Chief Executive Officer Robert Milton "Like the rest of the international airline industry, we experienced an unprecedented decline in business travel due to the economic downturn along with high fuel prices. Then came the devastating impact of September 11."[4]

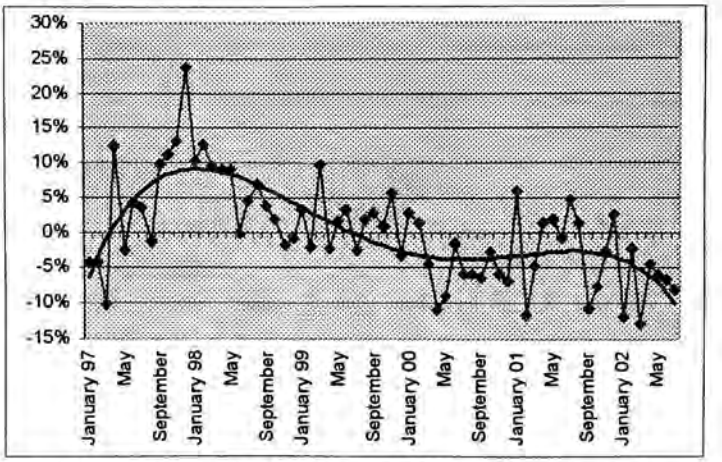
**Total Aircraft Movements and Flight Departures**

Aircraft movements can be used as a measure of aviation activity. An aircraft movement is a landing or take-off at an airport. There is a very seasonal pattern to the aviation industry. For this reason, Graph 1 shows the year-over-year percentage change in total itinerant aircraft movements at Canadian airports for the period January 1997 to July 2002. With the trend line one can see:

- Positive growth peaking in January 1998 ending in mid-1999;
- Movements show year-over-year declines from July 1999 on, slowly improving in January 2001;
- Declines from February 2001 on, with the decline becoming more pronounced after September 11th, 2001.[5]

It appears from Graph 1 that while there was a negative impact on aircraft movements in Canada as a result of the events of September 11th, this was an exacerbation of a downward trend that had actually started in mid-1999.

**Graph 1: Total Itinerant Aircraft Movements, Canadian Airports, Year-Over-Year Percentage Changes, January 1997-July 2002**

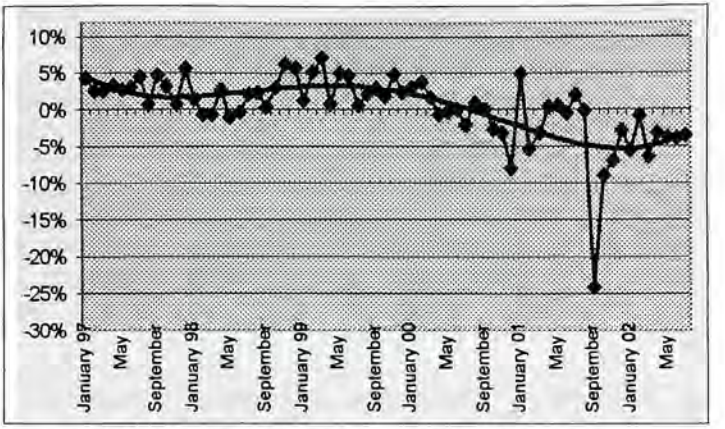



Source: Statistics Canada, Catalogue no. 51F0009XIE, Graph 2

Graph 2 shows the year-over-year percentage change in total itinerant aircraft movements at United States airports for the period January 1997 to July 2002. With the trend line[6] one can see:

- Slow growth peaking in May 1999;
- Movements show year-over-year declines from May 1999 until January 2002;
- While there was a large decline in movements in September 2001 in the United States, the trend actually appears more positive in 2002 than in Canada.

**Graph 2: Total Itinerant Aircraft Movements, United States Airports, Year-Over-Year Percentage Changes, January 1997-July 2002**




Source: Air Traffic Activity Data System (ATADS), FAA
http://www.apo.data.faa.gov/faaatadsall.HTM

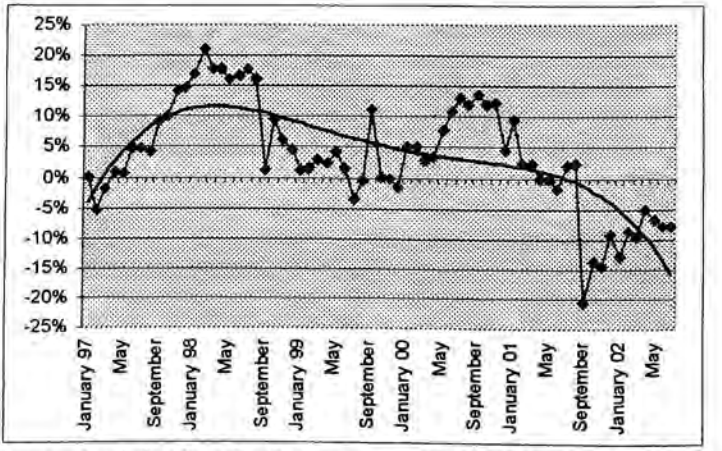
In the absence of geographic sector splits in the U.S. Federal Aviation Administration (FAA) aircraft movements data, flight departures were used from the U.S. Department of Transportation's Air Carrier Traffic Statistics.[7] In the United States, the year-over-year percentage change was positive for domestic flight departures for 32 straight months from October 1998 through May 2001. While March, April and May 2001 had year-over-year increases in domestic aircraft departures, these were smaller, however, than in 2000.[8] June 2001 showed a decline of 0.3%. July 2001 over 2000 growth was 1.8% versus the 4.3% growth of the previous year. August 2001 over 2000 growth was 2.2% versus 5.2% of the previous year. There was a huge decrease in September 2001 with declines in the next 6 months of 19.8%, 13.6%, 13.2%, 9.8%, 12.9% and 10.9%.

For international aircraft departures in the United States, the year-over-year percentage change was positive for 27 straight months from

June 1999 through August 2001. There was a similar pattern [9] to domestic departures in that while there was year-over-year growth during the period May-August 2001, it was much weaker than the previous year. As happened with domestic departures, there was a huge decline come September 2001 with declines in the next six months of 17.1%, 8.9%, 14.1%, 9.5%, 8.9% and 11.5%.

It was possible to examine the Canadian aircraft movements data on a geographic sector basis. The domestic commercial civil itinerant aircraft movements trend was very similar to that of all movements in Graph 1 since domestic movements account for 80% of civil itinerant movements. Transborder flights to/from the United States, (see Graph 3), showed a different trend. The trend in year-over-year percentage changes was positive from January 1997 through 2000. A negative phase started in September 2001 and the trend has continued.

**Graph 3: Transborder Commercial Civil Itinerant Aircraft Movements, Canadian Airports, Year-Over-Year Percentage Changes, January 1997-July 2002**




Source: Statistics Canada, Catalogue no. 51F0009XIE, Graph 9

**Financial Impacts**

Canadian commercial air carriers had a net income of $C68.7 million in 1999 which declined to a loss of $C84.5 million in 2000. This ballooned to a net loss of $C828.3 million in 2001.[10] Air Canada and Air Canada Regional reported declines of 15.2% in domestic revenue, 17.8% in international revenues and 29% in Canada-United States transborder revenue in the fourth quarter 2001 relative to the fourth quarter 2000.[11]

In the United States, the airline industry net income of US$ 5 billion in 1999 declined to US$ 2.6 billion in 2000. This dropped to a loss of US$ 7.9 billion in 2001.[12] This loss includes after tax compensation from the United States federal government under the Stabilization Act.[13]

Financial support was provided to air carriers by the federal government in both the United States and Canada. In the United States, the *Air Transportation Safety and System Stabilization Act*

> "provided a total of [US]$5 billion in compensation to air carriers for direct losses incurred as a result of Federal ground stop orders and for incremental losses incurred between September 11, 2001 and December 31, 2001, as a direct result of the terrorist attacks. In addition, the Stabilization Act provided for up to [US]$10 billion in airline loan guarantees....As of September 18, 2002, [US]$4.55 billion of the [US]$5 billion in direct compensation provided by the Stabilization Act had been paid to a total of 396 passenger and cargo air carriers."[14]

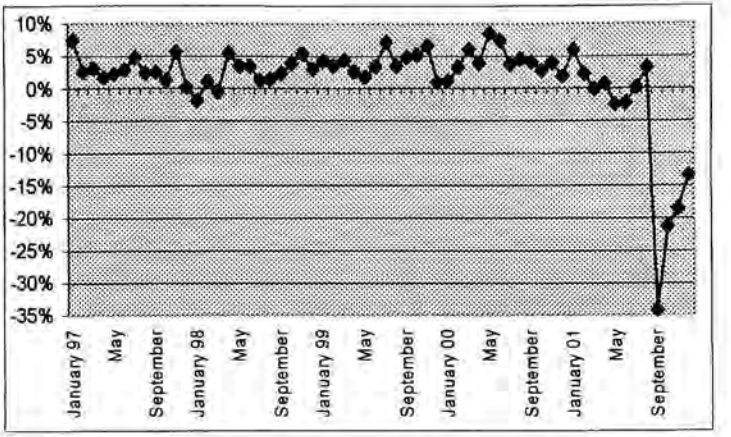
In Canada, compensation was provided under the "Government of Canada Compensation Program for Airlines and Specialty Air Operators". This program covered losses "incurred in the period September 11-16, 2001 inclusive...in or outside of Canada, and resulting from the ground stop order issued by the Minister of Transport, less any amount of loss for which the claimant has an

indemnity or insurance coverage".[15] There were 361 claims processed which resulted in compensation payouts of C$99 million.[16]

**Revenue Passenger Enplanements**

While the aircraft movements and flight departures are commonly used indicators of aviation activity, passenger counts are more important as flights departing with small loads are not viable in the long run. In the United States, during the four-year period January 1997 through December 2000, (Graph 4), domestic revenue enplanements showed positive year-over-year percentage changes during 46 of 48 months (modest declines of 1.8% and 0.5% were experienced in January and March 1998). This pattern changed in February 2001. The previous two Februarys had experienced year-over-year growth of 3.5 % and 3.3%. This slowed to a more modest 2.3%. March, May and June 2001 showed declines in year over year enplanements. While the first six months of 2000 had averaged 5.5% growth, the first six months of 2001 averaged a decline of 0.2%. This shows that the market was cooling prior to September 11th. The terrorist attack did have a pronounced effect, however, as the remaining months of 2001 showed year-over-year declines of 34.2%, 21.2%, 18.5% and 13.4%.[17]

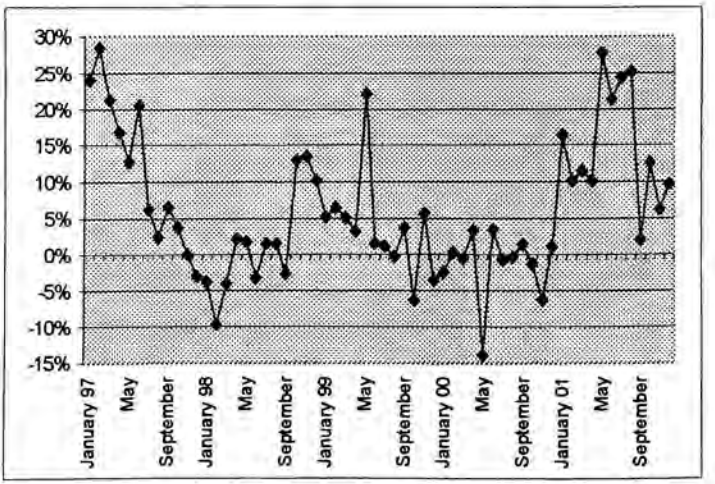
**Graph 4: United States Domestic Enplanements, Year-Over-Year Percentage Changes, January 1997-December 2001**




Source:
http://www.bts.gov/transtu/indicators/Mobility/excel/Enplanements_on_Domestic_Flights.xls

In Canada, the picture was more complex (Graph 5). While there had been almost continuous growth during the period 1997 through 2000 in the United States, in Canada 17 of 48 months showed declines. Year-over-year growth was very strong through the first half of 1997 then substantially cooled to a slight decline by year-end. From January through March 1998, enplanements continued to decline. Strong growth returned in October but this weakened again by June 1999. The next year and a half had alternating periods of growth and decline. Domestic enplanements showed very strong growth in 2001 until September but every month, even September showed positive growth—very different from the experience in the United States.

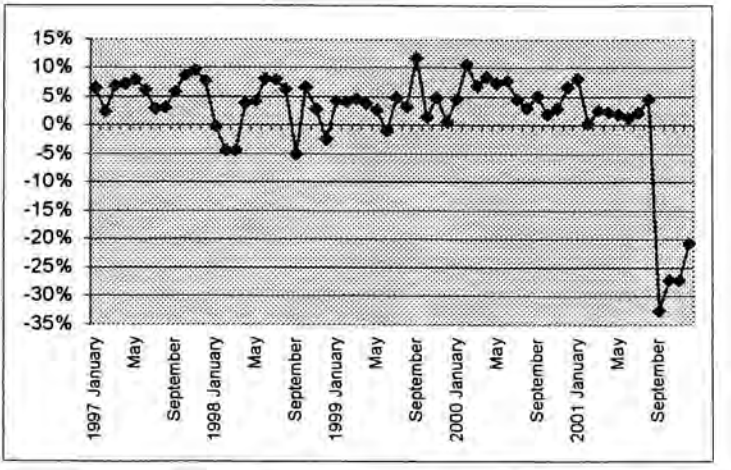
**Graph 5: Canada Domestic Enplanements, Year-Over-Year Percentage Changes, January 1997-December 2001**




Source: Aviation Statistics Centre, Statistics Canada, Statements 2 and 6

Where the Canadian experience appeared to mirror that of the United States was with the enplanements on flights destined for the United States (Graph 6). These transborder flights showed positive year-over-year growth in 50 of the 56 months from January 1997 through August 2001. While the first six months of 2000 had averaged 7.6% growth, the first six months of 2001 averaged growth of only 2.7%. This shows that the market was cooling prior to September 11th. As in the United States domestic market, after September 11th there were declines of 32.5% in September 2001, 27.1% in October, 27.3% in November and 20.8% in December.

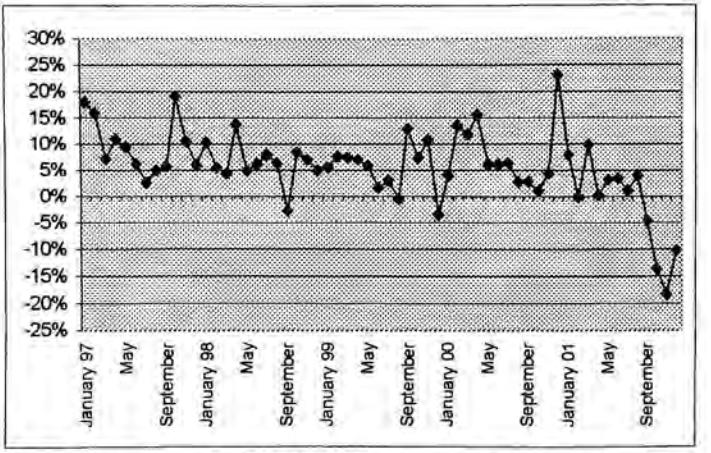
**Graph 6: Canada-United States Transborder Enplanements, Year-Over-Year Percentage Changes, January 1997-December 2001**




Source: Aviation Statistics Centre, Statistics Canada, Statements 2 and 6

Canadians enplaning to fly internationally other than the United States also showed the now familiar pattern (Graph 7). Much slower but positive growth in the first half of 2001 was followed by large declines after September 11th.

**Graph 7: Canada-Other International Enplanements, Year-Over-Year Percentage Changes, January 1997-December 2001**



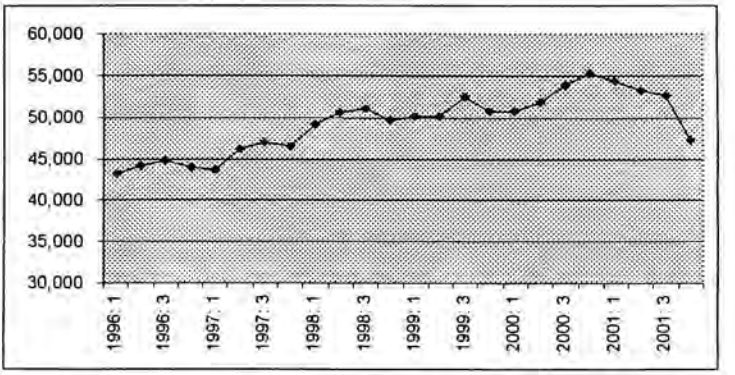

Source: Aviation Statistics Centre, Statistics Canada, Statements 2 and 6

**Employment**

In Canada from 2000 to 2001, Canadian commercial air carriers reported a loss of -1.7% in employment with employment dropping from 58,800 to 57,800 (Graph 8). The previous four years had recorded increases in annual employment of 3.2% (1997 over 1996), 8.4% (1998 over 1997), 0.7% (1999 over 1998) and 1.2% (2000 over 1999).[18] While the annual decline in 2001 appears to be moderate, these decreases are masked by the differences in each quarter. For the largest air carriers in Canada, there was employment growth of 7.2% in the first quarter 2001, 2.7% in the second quarter, and

declines of 2.6% in the third quarter and 14.5% in the fourth quarter.[19] Air Canada reported a decline in employment of approximately 13% in full time employment in the fourth quarter 2001 versus fourth quarter 2000 but on an annual basis they reported employment was down only 924 or 2.1% when compared to the combined Air Canada and Canadian Airlines operation.[20] WestJet reported adding 552 full time equivalent employees in 2001.[21]

**Graph 8: Employment, Canadian Commercial Air Carriers, Levels I and II, by Quarter, 1996-2001**




Source: Aviation Statistics Centre, Statistics Canada, Statement 21

In the United States, the airline industry reported a decline in employment of 10.7% from 2000 to 2001. Employment declined from 732,000 to 653,000 with 64,000 of the 79,000 jobs lost occurring at the major airlines.[22] The previous four years had recorded increases in annual employment of 13.5% (1997 over 1996), 6.1% (1998 over 1997), 4.6% (1999 over 1998) and 0.5% (2000 over 1999).[23]

## Conclusion

It is apparent that the terrorist activity of September 11th, 2001, involving commercial aircraft in the United States had a major impact on aviation in the United States and Canada. The declines in domestic aviation traffic in the United States echoed in the declines of aviation activity between Canada and the United States. Domestic Canadian aviation was less affected. International aviation involving Canada and countries other than the United States was negatively affected but not to the same degree as Canada-United States air travel.

It also appears that the terrorist activity made worse an aviation environment that was already slowing, with the suggestion made earlier in this paper that the decline was due to lessening demand, especially from higher yield business travellers. At the same time the carriers were facing increased labour costs, increased fuel costs and security costs.

## Note

The views and opinions expressed in this paper are those of the authors and do not necessarily reflect those of Statistics Canada. We would like to thank Rolf Hakka, Tim Davis and Ed Robinson for their valuable comments, corrections, and criticisms while retaining all responsibility for any remaining errors.

**Endnotes**

[1] Transport Canada, "Transport Canada's Immediate Response to the September 11, 2001 Terrorist Attacks on the United States: A detailed Chronology of the First Four Days"
[2] Air Transport Association press release, June 19, 2001
[3] Subcommittee on Aviation Hearing on Financial Condition Of The Airline Industry, February 24, 2002, http://www.house.gov/transportation/aviation/09-24-02/09-24-02memo.html
[4] Air Canada press release February 7, 2002
[5] Statistics Canada, Catalogue no. 51F0009XIE, Research Paper *How much did the airline industry recover since September 11, 2001*
[6] All trendlines in this paper were derived using a polynomial equation of order 4 to calculate the best least squares fit through the data series.
[7] In the Air Carrier Traffic Statistics data, scheduled flights between the United States and Canada are considered domestic flights for reporting purposes. Non-scheduled flights between the United States and Canada are reported as international.
[8] U.S. Department of Transportation, Bureau of Transportation Statistics, Air Carrier Traffic Statistics, monthly, TranStats
[9] U.S. Department of Transportation, Bureau of Transportation Statistics, Air Carrier Traffic Statistics, monthly, TranStats
[10] Statistics Canada, Aviation Statistics Centre tabulation
[11] Air Canada News Release February 7, 2002
[12] U.S. Department of Transportation, Bureau of Transportation Statistics, Press Release July 11, 2002, *Airline Industry Reported Steep Losses in 2001, BTS Year-end Financial Report Shows*
[13] House Subcommittee on Aviation Hearing on Financial Condition Of The Airline Industry, February 24, 2002, http://www.house.gov/transportation/aviation/09-24-02/09-24-02memo.html
[14] House Subcommittee on Aviation, Hearing on Financial Condition Of The Airline Industry, Ibid.

[15] Transport Canada, Government of Canada Compensation Program For Airlines And Specialty Air Operators Final Program Results , May 17, 2002, http://www.tc.gc.ca/pol/en/airpolicy/compensation/program_results.htm

[16] Transport Canada, Op Cit.

[17] U.S. Department of Transportation, Bureau of Transportation Statistics, Ibid, http://www.bts.gov/transtu/indicators/Mobility/excel/Enplanements_on_Domestic_Flights.xls

[18] Statistics Canada, Aviation Statistics Centre tabulation based on Canadian commercial air carriers in reporting levels I-IV inclusive.

[19] Statistics Canada, Aviation Statistics Centre tabulation based on Canadian commercial air carriers in reporting levels I-II inclusive.

[20] Air Canada Annual Report 2001, page 11

[21] WestJet Annual Report 2001

[22] U.S. Department of Transportation, Bureau of Transportation Statistics, Press Release April 23, 2002, *Airport Employment Dropped 11 per cent in 2001, BTS Reports.* Major airlines have operating revenues of $1 billion or greater.

[23] U.S. Department of Transportation, Bureau of Transportation Statistics, both full and part time employees of Form 41 carriers, http://www.bts.gov/oai/employees

# The Contribution of Commercial Aviation to the Economy of Manitoba: An Economic Impact Assessment

J. Jurgens Bekker, Senior Research Associate
Barry E. Prentice, Director, Transport Institute,
Asper School of Business, University of Manitoba

## 1.0 Introduction

In December 1903, the Wright brothers achieved the first manned, controlled, powered airplane flight. The ensuing development of aviation contributed outstandingly to overcoming the limitations presented by temporal, spatial and topographical barriers. It is fitting in the centennial year of the airplane that this conference examines the impact on our society of this momentous addition to transportation.

In Manitoba, aviation provides a critical link in the transportation network. The air mode provides vital connections between remote northern areas and larger provincial centres. It also connects all Manitobans to international destinations via Winnipeg International Airport.

The contribution by the air mode to facilitating the general economy is widely acknowledged. However, the contribution of commercial aviation to the economy of Manitoba is unquantified. This paper reports on the economic impact of commercial aviation within the Province of Manitoba for the year 2001. The next section outlines the structure of the industry and introduces the methodology. For

convenience, the detailed methodology is presented in an appendix. The body of the paper reports the quantification of the aviation industry in Manitoba in terms of direct, indirect and induced economic impacts.

## 2.0 Industry Structure

Political administrations derive guidance for economic policy formulation from a better understanding of the economic structure of industry. Economic impact studies are a means to facilitate conceptualisation of the often-elusive and complex economic interactions. Economic profiling of a total sector becomes feasible in conjunction with a systematic economic impact assessment (EIA) of cumulative industries. This is made possible by a comparative assessment of economic impacts for industries that constitute the sector (Link, 1996).

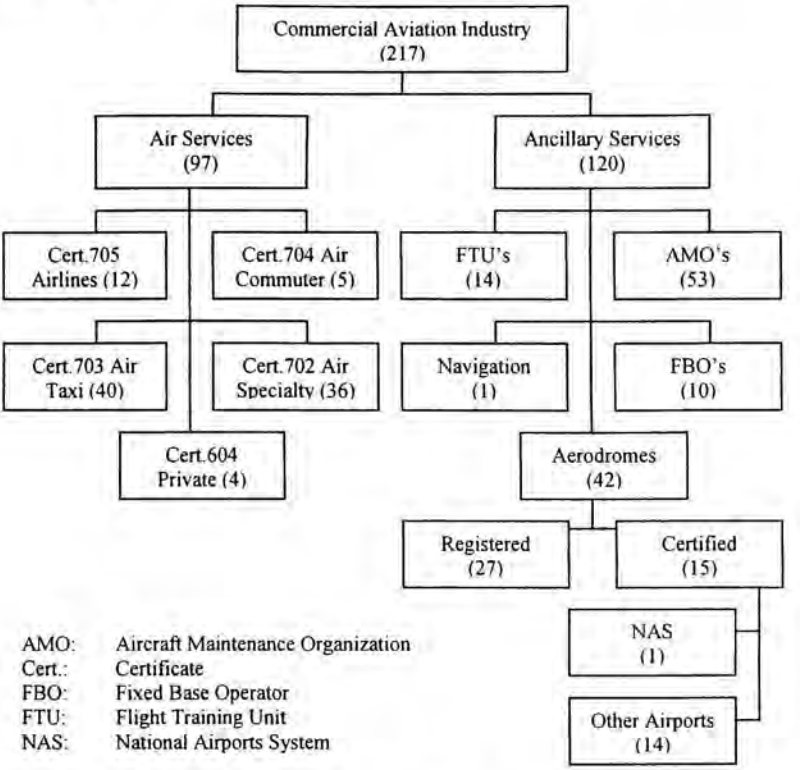
Figure 1 provides a schematic representation of the industry structure of commercial aviation in Manitoba. Commercial aviation, as defined for the purposes of this paper, is comprised of certified and specified non-certified aviation related operations.

Certified operations include carriers (airlines, commuters, taxi, specialty, private), airports, air navigation services, flight training units, fixed base operators and those approved maintenance organizations that are part of commercial air services companies. Non-certified operations are registered aerodromes.

The number of operations involved in commercial aviation (217) has a 45/55 percentage split between air services (97) and ancillary services (120).

It is important to note that the numbers of operators for a specific category do not imply size or contribution on total economic impact. For instance, the 12 airlines (certificate 705 operators) make a greater contribution to economic impact than the combined impact of all 85 remaining air services operators.

**Figure 1: Structure of the Manitoba Commercial Aviation Industry (number of elements in parentheses).**




This paper does not include the structure of secondary aviation activity. Ground transportation, indirect aviation activity around the airport, and the aerospace industry, which is engaged in manufacturing and overhaul, are excluded from results. The economic impact of secondary activities is captured in the output of the carriers. The export of the aerospace industry output would not constitute "double-counting", but it is considered to lie more in the realm of manufacturing than aviation.

## 3.0 Methodology

The contemporary economic environment within which Canadian commercial aviation operates justifies some caveats with the interpretation of economic impact results. Economic impact assessments investigate benefits to society from a specific activity, but do not address economic efficiency or financial viability. Economic efficiency falls within the ambit of benefit-cost analysis and financial viability is the focus of profitability analysis.

An EIA can be visualized as either an ongoing flow in economic activity (commercial aviation regular activity), or a surge in the flow of economic activity (contribution to stock of commercial aviation infrastructure such as aircraft or airport real estate). Assessments of commercial aviation general operations represent the first type of EIA. When considering general operations, the EIA allows for only the resources needed to perform ordinary operating activities (Prentice and Bekker, 2002).

The geographical scope of this paper is limited to the Province of Manitoba. Hence, expenses incurred in Manitoba of both Manitoba based as well as non-Manitoba based companies in 2001 are included in results. However, expenses incurred outside of Manitoba, also of Manitoba based companies, are excluded from results.

The economic impact of the much publicized airline terror event in September 2001 was minimal in Manitoba. According to Horner and Prentice (2002) aviation activity in the Prairie & Northern Region (PNR) was less affected by these events than national aviation. Aviation activity tracked previous months consistent with an economic slowdown only two months later in November. To the extent that there was any impact, the results would tend to under-estimate rather than inflate the economic impact of aviation in Manitoba.

A detailed discussion on methodology is presented in the appendix.

## 4.0 Results

### 4.1 Response Rate

The response rates to the survey are presented in Table 1. The participation of dominant companies is critical to the reliability of results. The 69 respondents include all the dominant companies that are mentioned in the various categories.

**Table 1: Response Rate of Commercial Aviation in Manitoba**

| Category | Respondents/ Population | Estimated Expenses Captured | Estimated Employment Captured |
|---|---|---|---|
| Commercial Air Services | 38/97 | 85% | 84% |
| Commercial Aviation Ancillary Services | 31/67 | 87% | 90% |
| **Total Commercial Aviation** | **69/164** | **85%** | **85%** |

The positive effect of participation by dominant companies is evident from the high proportion of respondents' captured values to the population estimated total value. Altogether, 85% of both estimated total operating expenses and estimated total employment were captured from respondents.

### 4.2 Monetary Impact

Table 2 shows operating expenses and revenues for commercial air services and aviation ancillary services. Total operating revenues of commercial aviation companies in Manitoba are estimated at $551 million in 2001.

| Table 2: Operating Expenses and Revenues | | | |
|---|---|---|---|
| Category | Commercial Aviation | | |
| | Air Services | Ancillary Services | Total [1] |
| | ($ Million) | | |
| Operating Expenses | 405 | 123 | 528 |
| Operating Revenues [2] | 410 | 141 | 551 |

(1) Totals may not add due to rounding.
(2) Operating Revenue = Operating Expense x (1/Operating Ratio) where Operating Ratio = Operating Expense / Operating Revenue.

The monetary impact of commercial aviation to the economy of Manitoba is presented in Table 3.

| Table 3: Monetary Impact on Manitoba Economy | | | |
|---|---|---|---|
| Category | Commercial Aviation | | |
| | Air Services | Ancillary Services | Total [1] |
| | ($ Million) | | |
| **GDP at Market Prices** | **435** | **150** | **584** |
| Direct Impact | 216 | 74 | 290 |
| Indirect Impact | 95 | 33 | 127 |
| Induced Impact | 124 | 43 | 167 |

(1) Totals may not add due to rounding.

In total, commercial aviation contributed $584 million to the Manitoba GDP at market prices in 2001. Air services contributed $435 million and ancillary services contributed $150 million to the total impact. The direct impact to the Manitoba economy from commercial aviation was $290 million, the indirect impact was $127 million and the induced impact was $167 million.

## 4.3 Employment Impact and Labour Income

The impact of commercial aviation on employment in Manitoba is presented in Table 4.

| Table 4: Employment Impact on Manitoba Economy | | | |
|---|---|---|---|
| Category | Commercial Aviation | | |
| | Air Services | Ancillary Services | Total [1] |
| | FTE PY [2] | | |
| **Total Employment** | **6,889** | **2,368** | **9,257** |
| Direct | 4,314 | 914 | 5,228 |
| Indirect and Induced | 2,575 | 1,454 | 4,029 |
| | ($ Million) | | |
| **Labour Income** | **277** | **95** | **372** |

(1) Totals may not add due to rounding.
(2) Full-Time Equivalent Person Years.

Manitoba direct employment from commercial aviation activity was 5,228 full-time equivalent person years in 2001. A total of 4,314 and 914 full-time equivalent person years resided with direct air services and direct aviation ancillary services respectively.

In addition to the direct employment, air services and commercial aviation ancillary services contributed to an additional 2,575 and 1,454 indirect and induced full-time equivalent person years respectively.

This means that in 2001 a total of 9,257 full-time equivalent person years of employment in Manitoba were consequential to the commercial aviation industry. The total labour income from commercial aviation activities in Manitoba was $372 million.

Figure 2 presents the total direct commercial aviation employment of 5,228 full-time equivalents which was, for the purpose of this study, divided into flight duty workers, flight support workers and administrative workers.

Flight support activities provided most of the direct employment at 2,790 full-time equivalent workers, followed by administration at 1,434 full-time equivalent workers and flight duties at 1,004 full-time equivalent workers.

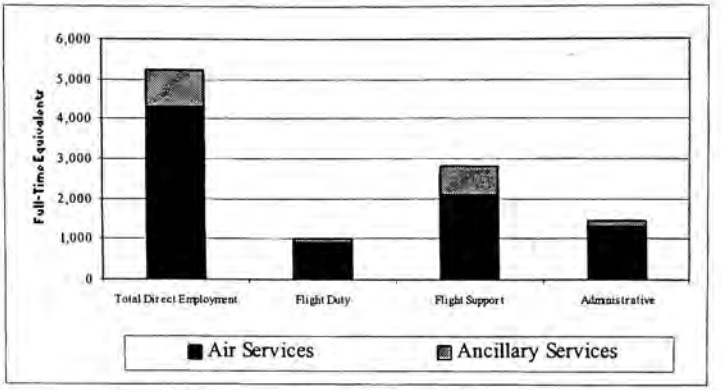



**Figure 2: Total Direct Employment by Activity Category.**

The largest single direct employment category within Manitoba commercial aviation in 2001 was flight support workers in commercial air services at 2,097 full-time equivalent workers.

Figure 3 shows total direct employment of commercial aviation in Manitoba on the basis of full-time, part-time and seasonal workers.

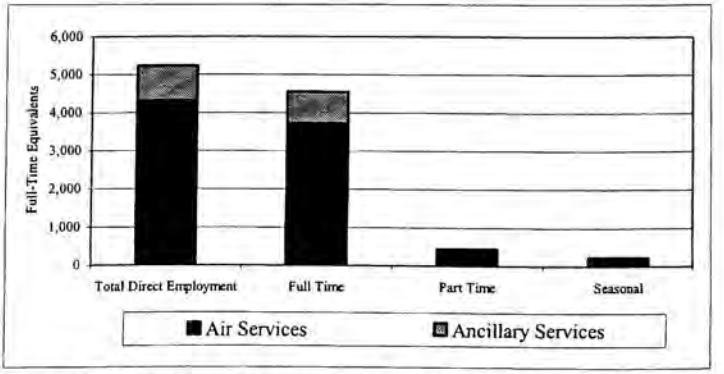



**Figure 3: Total Direct Employment by Time Category.**

By far the majority of workers directly employed in Manitoba commercial aviation were employed on a full-time basis. Full-time employment for commercial air services and aviation ancillary services sum to 4,546 full-time equivalents. Part-time and seasonal employment was 448 and 234 full-time equivalents respectively.

## 5.0 Conclusion

The advent of powered flight a century ago changed forever the way we travel and trade, and the frequency with which we now cross borders so readily. The ease with which modern transportation overcomes previous severe limitations often induces an underestimation of transportation activity, or leads to the assumption that it is the domain of a few large firms. While it is true that it is an industry of extremes, the multitude of small firms sum to provide a significant output. Another easy assumption is that the firms are self-contained. The reality is that a large and diverse support industry exists.

The 217 Manitoba commercial aviation entities that were included in this study had a continued effect in direct economic activity combined with the indirect and induced effects of over $580 million, or 1.67% of Manitoba's GDP in 2001 (Statistics Canada, 2003a and Statistics Canada, 2003b).

The continued effect of direct economic activity combined with the indirect and induced effect was total employment of 9,257 person years, or 1.66% of Manitoba's total employment in 2001 (Statistics Canada, 2003c).

Commercial aviation in Manitoba contributed $372 million, or 2.09% to total Manitoba labour income (Statistics Canada, 2003d) and 31.1% to Manitoba transportation and storage labour income (Statistics Canada, 2003e).

## Appendix: Methodology: Topics for Special Consideration

(i) Linkages

Fundamental to an understanding of economic impact is the concept of interdependence between businesses. This interdependence may be in the format of intra-industry, inter-industry and inter-sectoral linkages.

Total economic impact derives from direct, indirect and induced effects. The model of various interdependently configured links between businesses fundamentally underlies conceptualisation of these effects.

Economic multipliers are used to estimate total, direct, indirect and induced impacts form these effects.

(ii) Multipliers

Multipliers are derived from an input-output analysis of economic structural interdependence in the defined geographical jurisdiction. Multipliers are quantitative representations of economic interdependencies that are endogenous to the linkage system (Krumme, 2002).

Strong industry and sectoral linkages in an economy contribute to greater direct, indirect and induced effects and consequently to larger multipliers. Generally, territories with small economies, functioning with a market driven foreign trade regime, have less intra-territorial industry and sectoral linkages and hence have lower multipliers than territories with larger economies. The magnitude of the multiplier is a function of the local value added by the activity. Although general operating expenses may be high, if the amount of value added from that activity is small, then the multiplier will be small. The converse also applies (Prentice and Bekker, 2002).

Economic multipliers for Manitoba were obtained from the Manitoba Bureau of Statistics (MBS) (Manitoba Bureau of Statistics, 1999a).

(iii) Study Design

(a) Target Population

Non-duplicated economic production is achieved by capturing the value of final transactions. In so far as commercial aviation refers to air services only, the relevant final transactions almost exclusively implicate air carriers. However, within the defined economic scope of this study commercial aviation extends beyond the exclusive relationships with only air carriers.

From an economic impact point of view, the challenge is to capture the effect of these activities without at the same time generating "double-counting" of economic value in the economic impact calculation of "downstream" activities. To this end, certain expenses were "backed-out" of calculations. This allowed inclusion of an estimate of the non-duplicated economic activity of fixed base operators, aerodromes and flight training units under the commercial aviation ancillary services category, while still correcting for "double-counting" by excluding economic activity directly with carriers.

Notwithstanding best efforts to avoid "double-counting" there is a risk that some "double-counting" of economic impact remains between Manitoba based operating certificate holders. However, given the strict definition of the industry for this study it is unlikely that any remaining "double-counting" would exceed commercial aviation activity that was excluded. For example, AMO's not associated with an air carrier were excluded, due in part, to avoid "double-counting" their sales to Manitoba air service operators. However, many of these are specialty shops, which also perform services for operators outside Manitoba. This economic activity that is exported from Manitoba qualifies as commercial aviation ancillary services that impacts the economy of Manitoba, but, by definition, is not included in results. Therefore, the reported results for economic impact of commercial aviation in Manitoba are regarded as conservative estimates.

(b) Multiplier Limitations

MBS multipliers are derived from Statistics Canada Inter-Provincial Input-Output Tables (Manitoba Bureau of Statistics, 1999b). This methodology implies certain limitations.

A major limitation is that multipliers are static. Empirically derived multipliers represent structural relationships between variables in the economic input-output matrix at a given point in time. Therefore, it follows that multipliers pertain to the period for which the underlying relationships were quantified (Krumme, 2002).

The stability of input-output models are affected by a number of factors such as technological change, relative price changes, input substitutions, variations in product mix and changing scales of production (Conway, 1977 as referenced by Krumme, 2002).

Navigation charges were introduced since the last update of multipliers and these charges are now recorded in the expenses of carriers. Previously, the federal government recovered the air navigation system costs from the Air Transportation Tax. Air carriers collected and remitted these funds to the federal government, but it was not part of carriers' direct expenses. Therefore, a shift probably occurred in the underlying relationships of multipliers, but remains unrecorded.

It is beyond the scope of this study to update multipliers, but the change in navigation charges could be addressed by incorporating those costs as another support structure cost. It could be argued that inclusion of navigation charges would not constitute "double-counting" because the current input-output models do not incorporate these costs and, therefore, inclusion of navigation charges probably results in a lesser error than its omission. Accordingly, Nav Canada charges were included with the commercial aviation ancillary services category.

Given the imprecise reflection of the current nature of industry and sectoral relationships in existing input-output models, this hybrid design has been adopted to adjust for these limitations.

(iv) Survey Procedures and Data Analyses

An important consideration of this study is the concentrated nature of economic activity in aviation. Carrier activity in Manitoba is dominated by Air Canada. Winnipeg International Airport is the only National Airports System (NAS) airport in Manitoba and dominates airport activity. Nav Canada is the sole provider of navigation services. In short, while the methodology was based upon established sampling theory principles, in the case of these three organizations the methodology essentially required a census rather than a sample.

For missing values within partially completed surveys, as well as for complete survey values for non-respondents, data points were estimated by stratified mean-substitution. Where this technique proved impractical best estimates were based on interpolation of data from most similar available substitutes.

(v) Economic Impact Metrics

Intensity ratios were used to determine the total economic impact in terms of Gross Domestic Product (GDP), labour income (both measured in 2001 Canadian dollars), and Manitoba employment (measured in full-time equivalent person-years (FTE PY)). The impact on GDP at market prices represents the net monetary benefit to the provincial economy.

This study uses total operating expenses information and estimates industrial output by applying the inverse of the operating ratio of these expenses. Note that in the case of an operating loss the operating ratio was limited to a maximum value of one.

Operating losses of any company or companies do not diminish the economic impact below that which is incurred from expenses. An operating ratio of one represents an operating breakeven situation

where all economic impact originates from incurred expenses and no operating profit remains for distribution and its re-spending.

Operating ratios for specific companies were obtained from annual financial statements where possible. In other cases industry operating ratios were obtained from Statistics Canada (Table 5).

**Table 5: Commercial Aviation Industry Operating Ratios**

| | Operating Ratio | Applied Ratio |
|---|---|---|
| Air Canada | 1.0761[1] | 1.0000 |
| Levels IB-IV Carriers and Other Operators | 0.9708[2] | 0.9708 |
| Winnipeg International Airport | 0.9508[3] | 0.9508 |
| Other Airports and Aerodromes | 1.0000[4] | 1.0000 |
| Nav Canada | 0.7832[5] | 0.7832 |
| Maintenance and Support Operations | 0.6377[6] | 0.6377 |

[1] Calculated from *Air Canada Annual Report 2001*;
[2] Five year average 1995-1999 calculated from Statistics Canada report *Canadian Civil Aviation 1999 Cat. No. 51-206-XIB* Table 3.5;
[3] Calculated from *Winnipeg Airports Authority Inc. Annual Report 2001*;
[4] Operated on the basis of cost recoveries only, for example Northern Airports;
[5] Calculated from *Nav Canada Annual Report 2001*;
[6] Calculated from Statistics Canada report *Manufacturing Industries of Canada: National and Provincial Areas Cat. No. 31-203-XPB* Table 25.

*Acknowledgements*
*The authors acknowledge the financial assistance of the Manitoba Department of Transportation and Government Services towards this study. The views expressed in this paper do not necessarily represent those of the Department and they provide no warranties as to the validity or accuracy of the information presented herein.*
*We also express our gratitude to Mr. Al Philips and Mr. Fred Petrie for the valuable contributions they provided in their respective fields of expertise.*

## Bibliography

Conway, R.S., 1977. The Stability of Regional Input-Output Multipliers, *Environment and Planning A*, vol. 9, pp. 197-214 as referenced by Krumme, G., 2002, Analysis of

Interdependence Structures: Input-Output, University of Washington, Seattle, http://faculty.washington.edu/krumme/systems/multp.html

Horner, G. and Prentice, B.E., 2002. A Survey of Aviation Trends in the Prairie and Northern Region, *Proceedings of the 37th Annual Conference of the Canadian Transportation Research Forum*, p. 59.

Krumme, G., 2002, *Analysis of Interdependence Structures: Input-Output*, University of Washington, Seattle, USA, http://faculty.washington.edu/krumme/systems/multp.html

Link, A.N., 1996. *Economic Impact Assessments: Guidelines for Conducting and Interpreting Assessment Studies*, National Institute of Standards and Technology, Gaithersburg, MD, USA, p. 3-5.

Manitoba Bureau of Statistics, 1999a. *Manitoba Economic Multipliers 1998*, MBS 98-4, pp. 21-27.

Manitoba Bureau of Statistics, 1999b. *Manitoba Economic Multipliers 1998*, MBS 98-4, Preface.

Prentice, B.E. and Bekker, J.J., 2002. Economic Impact of a New Airport Terminal Building: An Ex Ante Assessment, *Proceedings of the 37th Annual Conference of the Canadian Transportation Research Forum*, pp. 1-15.

Statistics Canada, 2003a. Canadian Socio-economic Information and Management Database, *Manitoba GDP Income-Based / Gross Domestic Product at Market Prices, CANSIM Matrix 09007, Label D24094.*

Statistics Canada, 2003b. Canadian Socio-economic Information and Management Database, *Manitoba – Selected Economic Indicators / Gross Domestic Product, CANSIM Matrix 09226, Label D28755.*

Statistics Canada, 2003c. Canadian Socio-economic Information and Management Database, *Manitoba – Selected Economic Indicators / Total Employment, CANSIM Matrix 09226, Label D28745.*

Statistics Canada, 2003d. Canadian Socio-economic Information and Management Database, *Manitoba GDP Income-Based / Wages, Salaries and Supplementary Labour Income, CANSIM Matrix 09007, Label D24084.*

Statistics Canada, 2003e. Canadian Socio-economic Information and Management Database, *Wages and Salaries Manitoba / Transportation and Storage Wages and Salaries and Supplementary labour Income, CANSIM Matrix 10549, Label D139355.*

***

# ECONOMICS AND FINANCE APPLIED TO THE LIFE CYCLE OF TRANSPORTATION INFRASTRUCTURE

Michael E. Kieran
Transportation Consulting Principal
IBI Group

## Introduction

The transportation system is taken for granted and generally receives attention only when movement of people, goods and services are impeded. At the present time it could be argued that we are approaching a crossroads. There are serious impedances in the transportation system. Safety and efficiency issues result from inadequate capacity on critical links, and environmental emissions from transportation are becoming a concern for the public at large. In the past 50 years, expansion of the road system has provided the main response to traffic congestion; however, this course is losing its appeal because of high costs and other impacts that are becoming unacceptable to the voting population.

Congestion delays arising from capacity limitations coupled with commitments to significantly reduce greenhouse gas emissions are inciting governments to provide more infrastructure. Increasing population and concentration of development in large urban centers is placing even more stress on bottlenecks in the system. In this situation, the notion of private public partnerships and user-pay schemes emerges as an attractive way for governments to find the necessary capital while also injecting private sector initiative into the provision of transportation facilities. There are some success stories with respect to this model (for example, the initial privatization of Highway 407 in Ontario).

So, why aren't private financing initiatives pervasive? What are the impediments hindering wide application of this approach?

**Basic Concepts Infrastructure Value**

The scope of these questions is huge. Investors look at risk, reward, process and time frames (which are inevitably protracted - more easily measured in decades than in months), involved in reaching agreements to proceed. Public accountability and responsibility are difficult for private investors and infrastructure operators to decipher in many situations. Leadership is at the heart of the matter because of the number of jurisdictions involved in projects of significant scale, with each jurisdiction having its own constituent interests and intent to maintain control.

This paper focuses on just one aspect of the challenge: financial risk versus reward for infrastructure investments.

Public and private sector parties have completely different perceptions, and this difference can be an obstacle to reaching agreement. Exhibit 1 below is a generalized representation of the main value components of transportation infrastructure; its scale is relative (as opposed to absolute), and is intended to be indicative of market-based rates of return over a typical infrastructure life of 40 – 50 years, with moderate to high density of traffic.

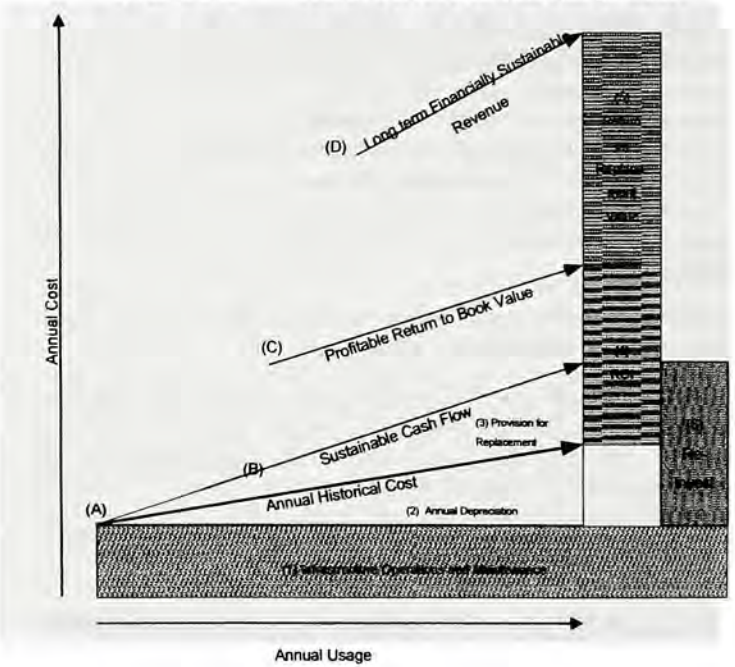
Exhibit 1 represents only infrastructure; references to financial return imply residual surpluses after all other operating inputs are covered. The main cost components are labeled from 1 to 6, and are described below.

(1) *Infrastructure Operations And Maintenance* represents annual costs to keep the infrastructure accessible, including routine maintenance such as snow clearing, regular inspection, traffic control and repairs.

(2) *Asset Depreciation* is accounted for in private sector infrastructure such as railways, and represents the estimated loss of capital value attributable to either natural aging or accumulation of traffic volumes; in the case of moderate to

high density of traffic it is reasonable to assume linear depreciation, as shown here.

**Exhibit 1: Infrastructure Value Components**




(3) *Provision for Replacement* represents an annualized accrual for eventual renewal of physical plant; normally this accrual is only partly covered by depreciation, because depreciation is based on historical costs, while prudent policy to provide for renewal should be based on current (i.e. inflated) values; it is a notional cost, difficult to estimate for any specific asset, and rarely reported in financial statements by way of explanatory notes. It is, however, a very important

consideration in determining the value of an infrastructure-owning transportation enterprise.

(4) *ROI* represents the rate of return on net book value of assets -- that is, historical gross investment less accumulated depreciation; the concept should apply to both private and public sectors, but the expected returns should be much higher in the private sector because the market price of equity incorporates a risk premium after taxes; ROI is exclusive of depreciation. It can be determined by analyzing financial statements.

(5) *Return On Replacement Value* represents a range of income that would be required for continuing investments to be competitive in capital markets. An asset would attract investors if it could produce market competitive returns to replacement value under reasonable business risk factors.

(6) *Reinvest* represents an average annual requirement to replace worn components and to maintain safety and efficiency; in theory, annual capital replacement programs would be spread evenly over the life of the asset, performing about the same amount of replacement each year (usually at a level close to that shown in (3) Provision for Replacement, described above); in practice, this annual pattern of reinvestment works best to optimize the deployment of project resources in a big system. Smaller companies would carry out the work in spurts, to try to obtain economies of scale.

**Value Perceived Differently by Public and Private Sector Investors**

The breakpoints in this structure of costs are labeled (A) to (D). The simplifying assumptions made to facilitate the illustration of these concepts continue to apply (i.e. forty-year design, moderate to high density, linear cost relationships and low-risk market-based capital costs).

(A) *Annual Historical Cost* includes the regular expenses of infrastructure operations and maintenance plus annual depreciation; in the case of a private sector company, this is the cost that would be reflected in financial statements; it would include labour, equipment and materials for crews assigned to specific links and nodes.

(B) *Sustainable Cash Flow* is notional (i.e. it is difficult to measure and report for public accountability purposes); it is helpful to explain cash flow needed to reinvest in infrastructure to maintain standards of efficiency and safety on a long-term continuing operation; failure to achieve these levels of reinvestment over an extended time period (often not visibly apparent for years) could force services to be curtailed and eventually discontinued.

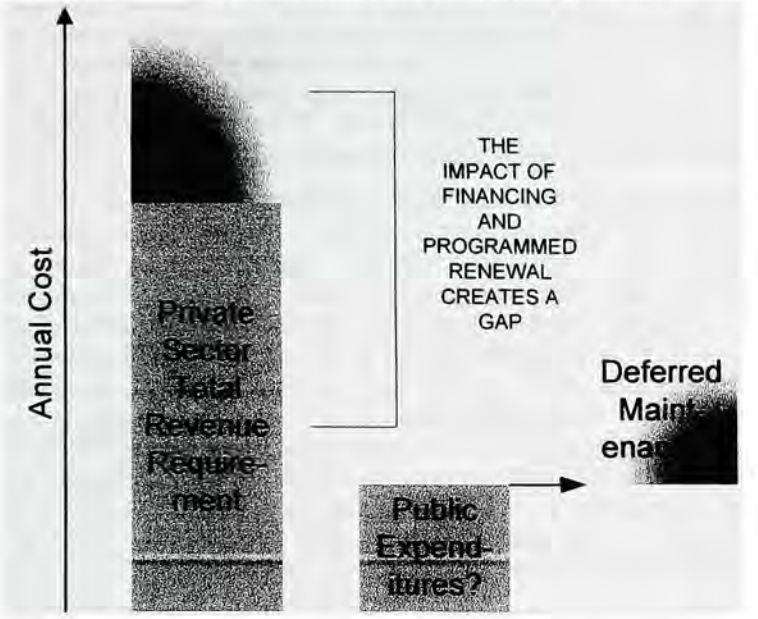
(C) *Profitable Return To Book Value* represents the relationship of income to usage whereby return on historical book value is in line with low-risk market rates of return after covering annual operations, maintenance and depreciation; for example, if a road or rail line were designed for a life of 40 years without replacement, this type of analysis would be appropriate (e.g. access to a mineral extraction area).

(D) *Long-Term Financially Sustainable Revenue* represents an income level competitive in the capital markets on an asset base equivalent to the cost of infrastructure renewal; at the upper end, it would represent full replacement cost; there are many circumstances in which returns that do not quite achieve this level could still be competitive; the cost of capital in transportation is a major subject unto itself with a substantial regulatory basis; the relationship indicated here reflects an upper limit beyond that prescribed by existing Canadian regulations.

In Canada, public infrastructure is funded through annual appropriations of capital and operating expenditures. Capital is not accounted for in the sense of a corporate balance sheet. Depreciation

as a concept is not applied to public infrastructure in any statement of public accountability. Further, as was pointed out in the Canada Transportation Act Review Final Report, annual expenditures have fallen considerably short of annual needs to sustain infrastructure for some time.

**Exhibit 2: Private versus Public Ownership: Sticker Shock!**




This suggests a crisis exists not only in terms of need for new infrastructure (or new ways of getting more from the existing plant) but also because each year the average condition of existing public infrastructure is deteriorating. Meanwhile, public perception of cost is based on a portion of the total economic and financial cost of transportation infrastructure. When confronted with private sector pricing and income models there can be sticker shock!

Exhibit 2 depicts Private versus public sector perceptions, based on the relative relationships indicated previously in Exhibit 1.

The difference in perceived annual cost of transportation "way" can be dramatic in some circumstances. The private-ownership model could be representative of railway infrastructure with average freight density. Public expenditures represent a public perception of the cost of rail infrastructure. Usually, in the case of private investors providing public services (e.g. railways accommodating passenger trains), investment risk would be shared between the parties and both operating and capital incremental values would be incorporated in agreements. However, the attribution of cost and risk to the pre-existing infrastructure is usually a bone of contention.

With respect to roadways, there is not yet a large body of private sector experience to supply insights. The difference between privatization of existing infrastructure versus new-build projects is a general and fundamental policy issue that transcends modal considerations. New-build projects consume large amounts capital over many years in the face of great uncertainty; political/social, environmental and economic; risk is considerable, and reward expectations must be high enough to see the project through. In the case of existing infrastructure the risks associated getting approval for designs, and building, had already been taken, so would risk tend to be lower than a new-build; and, the concern of the public would be on mitigating costs, while the private sector entrepreneur would be attempting to maximize reward for having taken a risk.

**Case Illustrations**

Two hypothetical cases are illustrated below to indicate significant differences between future-looking, risk-oriented commercial orientation and an historical, bookkeeping, public administration approach to transportation infrastructure.

Case 1 is representative of a two-lane highway with average traffic conditions. Cost estimates are based on "The Roadway Infrastructure Study" of the Transportation Association of Canada, published in 1987. Currency values are updated to 2001 using the Canadian

Consumer Price Index (CPI). These are meant to the national averages based on approximations and rules-of-thumb consistent with the intent of the working group that compiled the initial tables.

Case 2 is representative of a signaled single-track of railway, with traffic density about equal to the national average for Class I railways. The base year for financial estimates is 2001, and similar to Case 1, individual estimates are approximations and rules-of-thumb taken from analysis of "Railways in Canada" by Statistics Canada and past experience of the author.

The principal inputs are provided in Exhibit 3, below.

**Exhibit 3: Input Parameters**

**$, 000 (2001)**

| Description | Units | Case 1 Highway | Case 2 Railway |
|---|---|---|---|
| Program Cost | | | |
| Roadway | $/km | 700 | 800 |
| Bridges | $/km | 15 | 150 |
| Annual O&M | $/km | 13 | 14 |
| Service Cycle | Years | 45 | 40 |
| New Construction | $/km | 1,400 | 1,900 |

Program Cost represents the periodic renewal reconstruction programs of the roadway or railway.

Bridges are kept separate from Roadway because this is particularly difficult area for generalizations. Bridges and tunnels can represent the most significant cost and risk in some sections of infrastructure. Bridge factors are typical for the Canadian highway and road system

in accordance with the TAC assumptions. The author estimated the rail bridge factors. These are kept separate because the results are sensitive to significant variations in bridges and tunnels.

The cost for new construction is presumed to be double the program cost as a first approximation. Surveying, engineering, route alignment and site preparation are all elements of new construction that do not necessarily reappear in reconstruction programs. In all cases, the cost of land acquisition and ownership is excluded.

All of these parameters can be varied as inputs to the abbreviated version of a proprietary mathematical model that was originally developed to evaluate the effects of traffic on capacity and costs in a railway environment. The abbreviated version, which bypasses capacity and interference considerations, was used to develop annual costs per kilometer for both Cases.

*The Highway Case*

Case 1, the highway example is illustrated in Exhibit 4., using a waterfall-diagram approach.

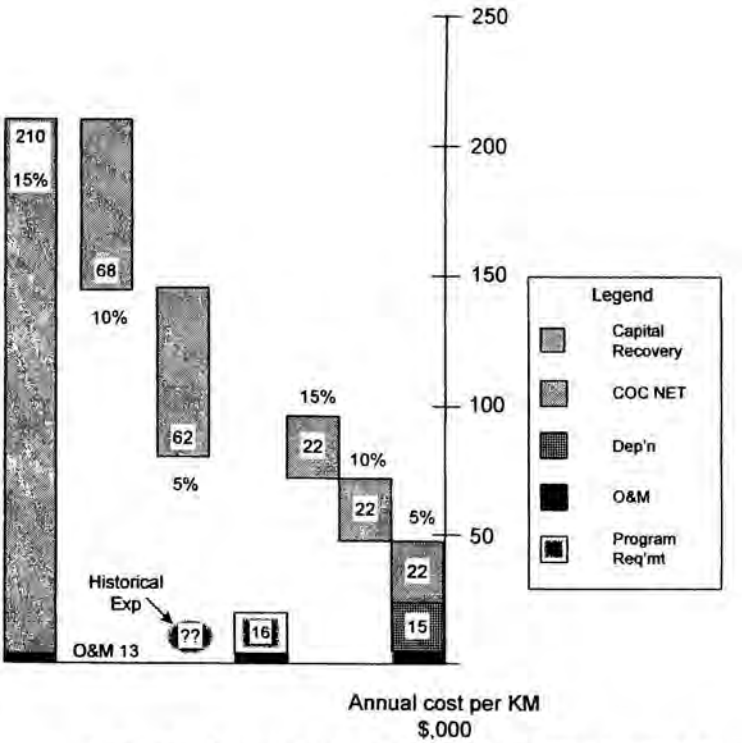
The bar on the left side of the chart illustrates Annual Operations and Maintenance (O&M) plus capital recovery for infrastructure based on full replacement at the cost of new construction, amortized fully over the life cycle using an interest rate of 15%. The next two bars to the right demonstrate the reduction in opportunity cost attributable to lower interest rates.

The bars immediately left of the scale represent a traditional accounting approach. The mathematical model was used to estimate historical gross investment, annual depreciation and current net investment. The leftmost bar reflects the total of annual: O&M, depreciation and cost of capital on net investment in $2001. The key assumptions in deriving these numbers are:

- new construction replacement cost was used as a basis;
- replacement programs were distributed uniformly over the full life cycle, adjusted using the CPI to a current value in

each year, and summed to provide an estimate for historical gross investment;

**Exhibit 4: 2-Lane Highway**




- accumulated depreciation was calculated using the straight-line method to obtain historical net investment;
- annual depreciation was calculated by applying the annual depreciation rate to the gross investment;

- the cost of capital at 5%, 10%, and 15% was calculated using the net investment.

The gap between the left-hand bars and right-hand bars, results from treating the same input factors in different ways. Capital markets intrinsically adjust for risk associated with this gap by assigning a risk premium to the cost of capital. In this example, even a 15% cost of capital in historical records would fall short of an acceptable threshold if full replacement cost is taken into consideration by the investor. An investor would look for a discount in the total capital cost, or in the effective cost of capital (e.g. reduced exposure to losses) as part of his/her arrangement.

The final element in Exhibit 4 is the annual reinvestment required to maintain the integrity of the Roadway in accordance with its initial design specifications. This is the annualized portion of the program replacement values in Exhibit 3. Since the Roadway Infrastructure Study was published in 1987, there has been a steady stream of warnings that the annual expenditures in Canada's Highway and Road System fall short of needs, and that the maintenance backlog is building. This issue was raised again in the final report of the Canada Transportation Act Review Panel in 2001.

It would be difficult to tabulate the actual expenditures, net of new additions to the highway system. However, considering the typical section of Road, the actual expenditures would be somewhat like that shown in Exhibit 4.

The empty space in the middle section of Exhibit 4 represents the gap that contributes to "Sticker Shock" referred to in Exhibit 2.

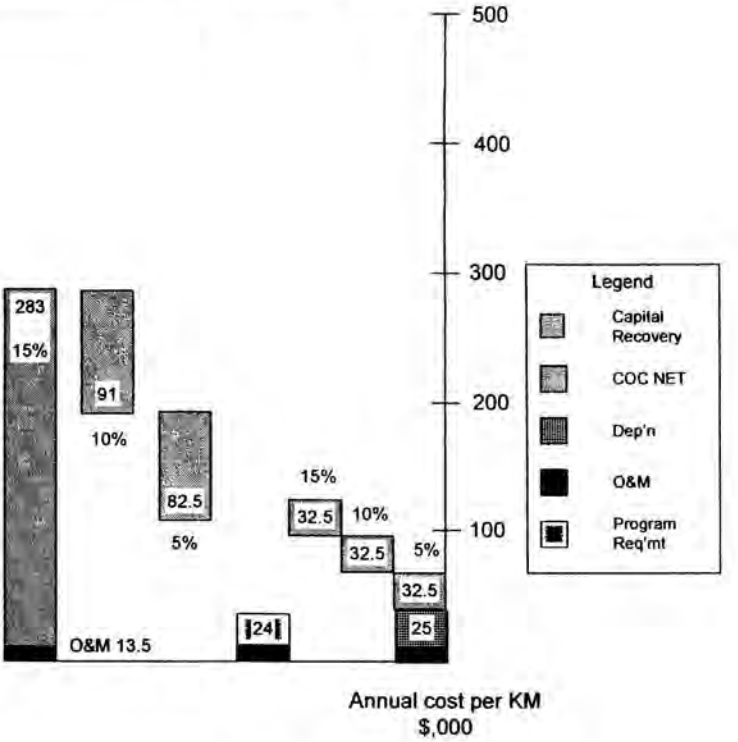
*The Railway Case*

Development of the Railway Case follows the same process as that used for the highway. The relationships in Exhibit 5 carry the same significance as that explained for Exhibit 4.

Capital recovery factors based on full replacement cost are shown on the left hand side; an historical accounting approach is reflected on the right hand side. Annual replacement requirements are shown in

middle. Class 1 railways have sustained these levels of investment on their existing plant. However, there are indications that the Short Line railway industry is struggling with the ongoing requirements for investment infrastructure.

**Exhibit 5: Single-track railway**




Profit margins toward the high-end historical levels shown here would be needed to attract shareholders to reinvest in improvements and renewals. This analysis takes into account the full investment in

infrastructure; as such, it represents income requirements from the aggregate sum of all traffic using the line.

Profit margins below these levels are unsustainable in the long run, and lead to business failure or the need for subsidies. This applies to the use of capital and it is equally evident regardless of the size of the company. In the 1970s the Northeast United States Railroad industry, including large and small railroads, was brought effectively under government control until Conrail emerged eventually.

Private sector evaluation of risk and public sector approach to reward is similar between the highway and the railway cases illustrated here. The main difference is that one mode is predominantly public and the other is predominantly private in Canada's present circumstances. The public sector tends to focus on annual expenditures, because that is the way the system is established.

Annual expenditures on O&M represent only a small portion of the total economic cost. In a commercial situation, opportunity cost is internalized through the capital markets; this is not the case for public infrastructure. Furthermore, for the public sector to increase spending on infrastructure, the funds would have to come from somewhere, meaning program reductions or increased taxes, neither of which is politically appealing.

In the case of railways, the private sector is taking risks and financial rewards. In the case of highways, the private sector has not yet jumped at the opportunity to take risks. One of the reasons for investor reticence is a perception that the reward does not justify the risk.

**Conclusions**

The economic patterns that have become established based on traditional ways of providing transportation infrastructure appear to be unsustainable under public pressure to reduce government spending. At the same time existing facilities need substantial investment.

There are great hopes for Public Private Partnerships (PPP) to help meet these needs, not only in transportation, but in other fields as well, such as health care and education.

Smart choices are needed to integrate policies, investments, operations and uses of transportation. Economic forces need to be brought back in line using full economic accountability (N.B. this is not necessarily "user-pay"). Unless capital is recognized as a cost and accounted for in some explicit way, along with attaching values to environmental priorities, little change in patterns of demand can be expected.

The examples shown here could be extended to include urban roads, marine and aviation infrastructure in Canada, and perhaps refined for the rail and highway examples. Ensuring appropriate stewardship of infrastructure could result in new approaches of sharing risk and reward between private and public sector interests.

Too much energy has been spent arguing over cost allocation studies and assignment of responsibility for wear and tear, environmental and social costs between different users of transportation looking backward at history. It is time to turn to strategic issues: How important is transportation in resource allocation? What should be built (considering all modes and jurisdictions)? By whom? How will it be paid (users, society)?

Europeans appear to have dealt with issues at this level in articulating the Common Transport Policy that moves in the direction of user charges based on marginal social costs. In addressing these issues, it should be understood that transportation infrastructure mainly under government control in all modes of transportation, including rail.

Canada is in the early stages of debating such large issues. One hopes that the sequence of events following release of "Straight Ahead", the Transport Minister's Blueprint, and strategic infrastructure investments indicated by recent federal budgets, will raise the stakes for all stakeholders to work together. Understanding the mutual sharing of risks and rewards will be crucial to success.

# ASSESSING THE IMPACTS OF FREIGHT TRANSPORTATION ON HIGHWAY CAPACITY

Dr. Edward Fekpe, PEng
Transportation Division, Battelle, Columbus, OH 43201
Tel. 614-424-5343. Fax: 614-424-5069
fekpee@battelle.org

Mr. Mohammed Alam, PEng
Transportation Division, Battelle, Columbus, OH 43201

## ABSTRACT

This paper examines the sufficiency of capacity of the highway transportation system in meeting forecast freight demand in the next ten years. Several performance measures are used in assessing highway capacity. The analysis is based on an analytical framework that is implemented within a GIS platform thus allowing visual display of outputs. Time-of-day variations in traffic were considered in the capacity analysis. The analysis identified segments of the highway system that are currently experiencing congestion problems and those that are likely to be congested in the next ten years.

## INTRODUCTION

The critical role of freight mobility in the U.S. economy and its impact on the overall transportation system is recognized. There are growing concerns regarding the capacity of the highway system to support freight transportation demand in the near future. To some extent, management of the network can increase capacity or modify

demand – through tolls, flow restrictions, or coordinated ITS efforts. Local and regional freight movements are and will continue to be dominated by trucks. The issues to consider include, how many trucks, what types of trucks, and what time of day.

This paper examines the effects of freight transportation on capacity deficiency elements for the nation's highway system. The analysis is based on a study that developed a tool for examining the sufficiency of the capacity of the transportation system in meeting forecast trucking demand and identifying corridors with capacity problems.

## METHODOLOGY

Unlike passenger transportation planning, techniques for freight transportation planning, especially at regional levels have not been well developed. To some extent, this can be attributed to the complexity of the freight transportation system particularly in the U.S. in terms of the spatial and temporal diversity of freight generation activities and movement. With specific reference to highway capacity, the existence of multiple time zones is an added dimension to the difficulty in analyzing the capacity effects of the national freight transportation system. The complexity of freight transportation demand modeling is also due to the multi-dimensional nature of freight transportation. It was noted that *(1)* unlike passenger, freight transportation has multiple dimensions (volume, weight, and trips) under the control of a number of decision-makers (dispatchers, drivers, freight forwarders), operation regulations, and restrictions. These dimensions interact in a dynamic way.

The highway freight transportation system capacity analysis was conducted in a Geographic Information Systems (GIS) framework using the TransCAD Transportation Demand Modeling software application *(2)*. The approach comprised three major interdependent

building blocks. The first, establishes the base highway network that was used for the freight transportation system capacity analysis. Several steps were involved including (i) ensuring logical consistency and network connectivity of all links in the entire network, (ii) ensuring connection between the National Highway Planning Network (NHPN) and the Highway Performance Monitoring System (HPMS), (iii) establishing county centroid connection, and (iv) identifying key intermodal connectors with capacity related attributes. The second building block conducts the freight demand analysis. This consists of: (i) development of baseline traffic flow maps based on state Departments of Transportation (DOTs) traffic counts for base year 1998; (ii) conversion of freight flows by tonnage into truck trips for base year and the forecast year; (iii) assignment of truck flow Origin-Destination (O-D) matrices to the highway network for the base year, 1998; and (iv) calibration of assigned flow using the traffic flow count data. The third building block generates capacity related performance measures to determine the capacity deficiencies of the freight transportation highway network based on the freight (truck traffic) flows. Each building block presented a number of challenges. A detailed description of the methodology and challenges encountered are presented elsewhere *(3)*.

The analysis presented in this paper focuses on the National Highway System (NHS) comprising 245,000 miles that represents about 55% of the entire highway system network of the U.S. For the purposes of the capacity analysis, it was assumed that (i) passenger and freight truck traffic volumes increase at different growth rates; (ii) no highway capacity improvements are made between the base year and the forecast year; and (iii) no truck-rail freight diversion occurs.

Traffic assignment models are used to estimate the flow of traffic on a network to establish the traffic flow patterns and analyze congestion points. Freight flow assignment was carried out using TransCAD's

Multimode Vehicle Assignment (MVA) procedure *(2)*. Two assignment scenarios were used:

1. *Capacity Constrained* where assignment is constrained by the highway network's current capacity. The Stochastic User Equilibrium (SUE) traffic assignment procedure in TransCAD was used for this scenario.

2. *Capacity Unconstrained* where freight traffic is assigned to the transportation network with no capacity constraints. The All-or-Nothing (AON) procedure was used for this scenario.

Outputs from the assignment were subjected to a post-processor to estimate the highway capacity measures. Performance is measured in terms of link volume-capacity (v/c) ratios, link delay, truck and total traffic volumes, and vehicle-miles of travel (VMT). This analysis attempts to address the following questions as they relate to freight transportation and highway capacity.

- What is the nature of highway capacity of the NHS and its progression in the next 10 years? Where are the major capacity deficiency points located in the highway network?
- What are the impacts of truck traffic on highway capacity and how does highway congestion affect trucks?
- What are the effects of time of day on truck traffic and highway congestion?
- What are the possible freight transportation policy implications of the findings?

The impact on highway capacity is expressed as the number of miles of highway that fall into one of the three v/c ratio categories:

- Below capacity – v/c less than 0.8
- Approaching capacity – v/c ratio 0.8 to 1.0
- Exceeding capacity – v/c ratio greater than 1.0.

The impact of truck volumes is also expressed in terms of the number of miles of highway carrying different truck traffic volumes by highway functional class. Three categories were used:

- Light Truck Traffic – less than 5,000 Average Annual Daily Truck Traffic (AADTT)
- Moderate Truck Traffic – 5,000 to 10,000 AADTT
- Heavy Truck Traffic – greater than 10,000 AADTT.

## CAPACITY OF THE HIGHWAY SYSTEM

The highway capacity analysis results are summarized in Table 1. Table 1 shows the highway miles in the three categories of capacity as defined by the v/c ratios. Highway miles in each v/c category are also expressed as percentages of the total highway miles. Figure 1 shows the percentage of the total miles exceeding capacity (v/c > 1) by functional class.

The percentage of the total NHS miles that exceeded capacity in 1998 was 3.6%. This value increased to 9.6% in 2010. The percentage NHS miles approaching capacity also increased correspondingly from 4% in 1998 to 7.5% in 2010. The interstate highway system represents 28% of the NHS. The length of rural interstate highway exceeding capacity in 1998 is 460 miles. This value represents only 1.5% of the rural interstate highway systems. By 2010, about 2,621 miles of rural interstate highway will exceed capacity (i.e., 8%). The length of urban interstate highway exceeding capacity in 1998 is 2,641 miles. This value represents about 20% of the urban interstate highways. By 2010, about 5,753 miles or 43% will exceed capacity.

As would be expected, the urban interstate highway system is more congested than the rural interstate system. The percent of urban

interstate mileage exceeding capacity in 1998 is about 5 times that of the rural interstate system. It is also noted that while in 2010 the percent of rural interstate mileage that will exceed capacity will be about 5 times the value in 1998, the corresponding value for urban interstate highway system is only about 2 times. This suggests that rural interstate highway system would experience or is experiencing a higher rate of capacity reduction than the urban interstate system.

**Table 1. Summary Statistics of Capacity**

| Functional Highway Class | | Capacity range | Highway Miles | |
|---|---|---|---|---|
| | | | 1998 | 2010 |
| NHS, Interstate | Rural | < 0.8 | 8,189 | 5,172 |
| | | 0.9 – 1.0 | 2,471 | 2,376 |
| | | > 1.0 | 2,641 | 5,753 |
| | Urban | < 0.8 | 29,760 | 25,412 |
| | | 0.9 – 1.0 | 1,414 | 3,601 |
| | | > 1.0 | 460 | 2,621 |
| NHS, non-Interstate | Rural | < 0.8 | 2,400 | 20,017 |
| | | 0.9 – 1.0 | 1,848 | 3,299 |
| | | > 1.0 | 2,017 | 4,549 |
| | Urban | < 0.8 | 84,020 | 80,602 |
| | | 0.9 – 1.0 | 844 | 2,664 |
| | | > 1.0 | 598 | 2,197 |
| All NHS | | < 0.8 | 145,959 | 131,204 |
| | | 0.8 – 1.0 | 6,577 | 11,940 |
| | | > 1.0 | 5,717 | 15,120 |
| Percent of Total NHS | | < 0.8 | 92.2% | 82.9% |
| | | 0.9 – 1.0 | 4.2% | 7.5% |
| | | > 1.0 | 3.6% | 9.6% |

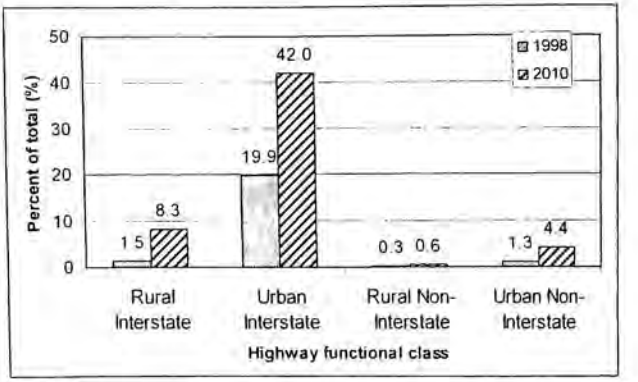



**Figure 1. Percentage of NHS Highway Miles Exceeding Capacity**

It is noted that in 1998, the percent of the NHS that is operating under capacity is more than 90% for both rural and urban highways. These values indicate that highway capacity is not a major concern. However, the few sections that exceed capacity may be critical links in the highway system and may be highly congested.

## TRUCK TRAFFIC AND HIGHWAY CAPACITY

One of the key questions addressed in this paper is the impact of freight truck traffic on highway capacity. In order to address this question, two sets of capacity analyses were performed: (i) without truck traffic (i.e., 'No Trucks') and (ii) with all traffic. The results are summarized in Table 2. The table shows the number and percent of miles of highway in the three v/c ratio categories. It is noted that, having truck traffic on the highways increases the percentage of highway miles that exceed capacity. For example, in 1998 the

percentage of NHS miles exceeding capacity almost doubled (i.e., 1.9% to 3.6%) when trucks are included in the capacity analysis. A similar change is observed in 2010 (4.9% to 9.6%). Obviously, trucks do have significant impacts on highway capacity.

**Table 2. Effect of Truck Traffic on Highway Capacity**

| V/C Ratio | 1998 NHS Mileage (%) | | 2010 NHS Mileage (%) | |
|---|---|---|---|---|
| | No Trucks | All Traffic | No Trucks | All Traffic |
| v/c < 0.8 | 151,457 (95.7%) | 145,969 (92.2%) | 144,792 (91.5%) | 131,203 (82.9%) |
| 0.8 < v/c <1.0 | 3,731 (2.4%) | 6,577 (4.2%) | 5,707 (3.6%) | 11,940 (7.5%) |
| v/c > 1.0 | 3,076 (1.9%) | 5,716 (3.6%) | 7,764 (4.9%) | 15,120 (9.6%) |

The increases in percentage of NHS miles exceeding capacity are accompanied by corresponding decreases in the percentage below capacity and approaching capacity. For example, in 1998 the percentage of NHS miles below capacity decreases from 96% to 92% when trucks are considered in the capacity analysis.

To further explore the effects of truck traffic on highway capacity and the impacts of congestion on truck traffic, a matrix was developed that maps the percentage of highway miles in the three v/c ratio categories on the three levels of truck traffic volume (Table 3).

It is interesting to note that highway links carrying high truck traffic volumes, i.e., greater than 1,000 trucks per day, are not necessarily the ones exceeding capacity. In fact, less than 1.5% of the NHS

network carrying more than 1,000 trucks per day have v/c ratio > 1.0 in 1998. In 2010, this percent increases to about 5%.

**Table 3. Effect of Truck Traffic on Highway Capacity**

| Year | Volume-capacity Ratio | Total Highway Miles | Percent of Highway Miles by Truck Volume | | |
|---|---|---|---|---|---|
| | | | < 500 | 500 – 1,000 | >1,000 |
| 1998 | < 0.8 | 145,970 | 78.8% | 11.1% | 2.4% |
| | 0.8 – 1.0 | 6,577 | 1.6% | 1.5% | 1.1% |
| | > 1.0 | 5,716 | 1.2% | 1.2% | 1.2% |
| 2010 | < 0.8 | 131,203 | 67.1% | 11.1% | 4.7% |
| | 0.8 – 1.0 | 11,940 | 3.0% | 2.0% | 2.6% |
| | > 1.0 | 15,119 | 2.6% | 2.3% | 4.6% |

It is noted that in 1998, only 5% of the NHS carrying truck traffic in excess of 500 vpd exceeded or approached capacity in 1998. This value increases to 11.5% in 2010. This indicates that the contribution of trucks to congestion increases significantly from 1998 to 2010. Of the highway miles carrying less than 500 trucks per day in 1998, 1.2% exceeded capacity and 1.6% approached capacity. In 2010, 2.6% will exceed capacity and 3% will approach capacity. Also, in 1998, more than 79% of the highway network carries 500 trucks per day and was operating below capacity. This percentage reduces to 67% in 2010. These results indicate that truck volume does impact highway capacity. However, the relationship between truck volume and highway capacity reduction is not linear.

### Spatial Distribution of Capacity and Truck Volumes

The GIS framework provides the visual representation of the capacity deficiencies identified in the previous sections. Maps showing the

spatial distributions of highway links by capacity category and distributions of the truck traffic volume over the NHS network were generated. These maps show the locations with capacity problems as well as those carrying heavy truck traffic. Due to page limitations, these maps are not included in this paper. These graphical displays facilitate identification of congestion points within the highway network and allow analysts as well as policy makers to focus on those areas for more detailed review and analysis.

## TIME OF DAY ANALYSIS

Given that truck travel patterns are different from commuter travel patterns, it is important to determine the effects of truck traffic on capacity requirements for truck peak hour flows. A time of day (TOD) analysis was used to estimate of the effects of traffic flow on highway capacity during the peak and off-peak periods. The peak-hour traffic flows are used to assess the highway capacity deficiencies under conditions of maximum traffic flow.

A post processor was developed and used for the TOD analysis. The analysis involves decomposing the 24-hour traffic flows resulting from the assignment process into hourly flows. This transformation was based on information on the percentage flows that occur in each hour of the day. Look-up tables were developed from the Vehicle Travel Information System (VTRIS) database, maintained by FHWA's Office of Highway Policy Information. The look-up tables provide information on the percentage of traffic that takes place in each hour of the day (or selected group of hours), i.e.,. Measures of capacity, such as v/c ratios, were then calculated based on the results of the decomposition.

Since the hourly traffic distributions vary by the day of the week, three groups were identified – Monday and Friday (MF), Tuesday, Wednesday, and Thursday (TWT), and Saturday and Sunday (SS).

### Time of Day Variations of v/c Ratios

The average v/c ratios were plotted for all hours of the day for each functional class. The TOD graphs for rural and urban interstates are shown in Figures 2 and 3. The v/c ratios used in the TOD analysis represent the average for each entire functional highway class. Thus, even though some sections of a given highway functional class may be above or approaching capacity, the average v/c ratio for the entire class could be less than 0.8. The TOD analysis can be performed on a link by link or a corridor-by-corridor basis also.

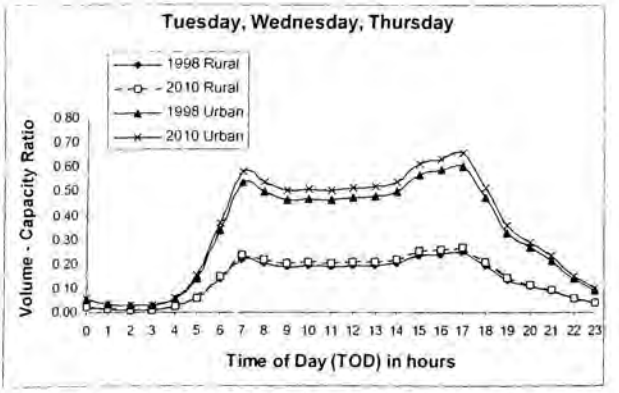



**Figure 2. TOD Variation of v/c for Interstates**

Urban functional classes show two distinct peaks (AM and PM), of which the traffic volume during the evening peak is greater than the

morning peak in almost all of the groupings and functional classes. Rural interstates show less pronounced and more spread out morning and evening peaks. As expected, urban interstates experience the highest v/c ratios. Typically the urban interstate peak average ratios are about two times those of the rural interstates (Figure 2).

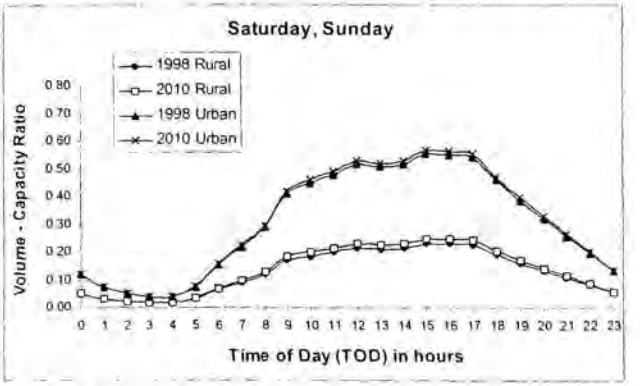



**Figure 3. TOD Variation of v/c for Interstates**

As noted in Figure 3, Saturday and Sunday TOD distributions are distinctly different from the other week groupings. There is no clearly defined morning or evening peak. Traffic flow gradually builds to a single peak occurring over an extended period between 9 AM and 5 PM.

Since the plots are based on average v/c ratios for each functional class, the difference between 1998 and 2010 does not stand out. However, the TOD distributions of 2010 always have a higher v/c ratio than the base year (1998), regardless of the functional class. This is because of higher forecast traffic volumes in 2010. The variations

of the hourly percentage of truck traffic by time of day were plotted for the major highway functional classes and are illustrated in Figures 4 and 5. These graphs indicate the temporal variation of truck traffic. It was noted that, irrespective of the highway functional class or day of the week, the highest truck percent typically occurs between midnight and 5:00 AM. During this period, passenger car volume is at its lowest. Truck traffic percent remains fairly stable between 6:00 AM and 11:00 PM for all days of the week. Rural interstates experience the highest percent of truck traffic on all days of the week and at all times on any given day.

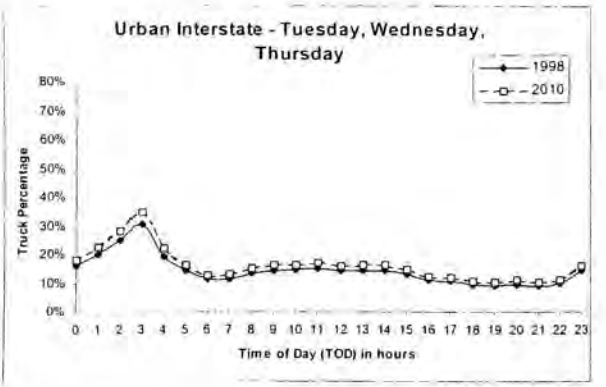



**Figure 4. TOD Variation of Truck Percent on Urban Interstate**

It is noted in Figures 4 and 5 that truck percent on urban highways on Tuesday, Wednesday, and Thursday is lower than for rural interstates. However, the average v/c ratios for urban interstates are generally higher than those of rural interstates, as noted in Figure 2. These

results imply that the passenger traffic does have significant effects on capacity in urban areas.

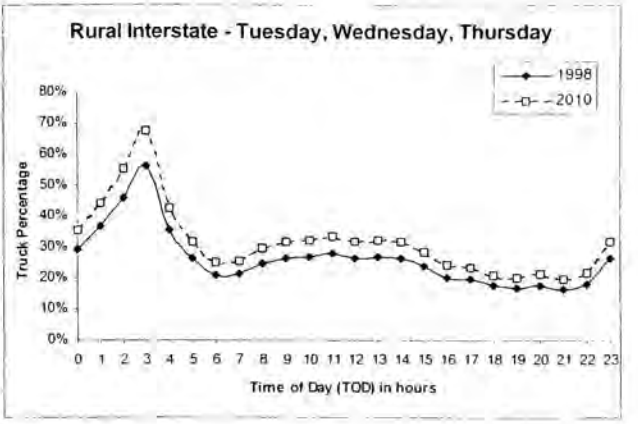



**Figure 5. TOD Variation of Truck Percent on Rural Interstate**

## POTENTIAL FREIGHT POLICY IMPLICATIONS

Freight transportation policy issues include those directed at facilitating the movement of goods and services with limited impacts on safety and the environment. Understanding the nature and extent of the highway capacity problem allows analysts to identify, generate, and evaluate potential alternative solutions. For example, the use of exclusive trucks lanes to alleviate congestion in locations of very high traffic volume and truck percent could be explored. Similarly, the use of tolls and ITS technologies in isolation and/or in conjunction with traffic management measures could be explored. Knowledge of the

extent of freight mobility impacts on highway capacity is critical to decision makers in trying to address the global issue of the highway congestion. It also allows equitable apportionment and allocation of highway costs to various classes of road users.

## CONCLUSIONS

The results clearly show that freight trucks impact highway capacity. However there is no direct relationship between truck volume and highway capacity reduction. The extent of the impacts of freight trucks on highway capacity is dependent on the functional class and time of day. The methodology used allows identification of locations in the highway network that are currently experiencing or will experience capacity problems in the near future. The tool can also be used to evaluate the potential capacity impacts of different truck traffic movement and restriction scenarios on the highway network. The consideration of time of day in the capacity analysis is important in defining and evaluating potential solutions to the highway capacity problem.

## REFERENCES

1. Holguin-Veras, J. and E. Thorson. Trip Length Distributions in Commodity-Based and Trip-Based Freight Demand Modeling. In *Transportation Research Record 1707*, TRB, National Research Council, Washington, D.C. 2000, pp. 37-48.

2. Caliper Corporation. *Travel Demand Modeling with TransCAD: Transportation GIS Software*. Newton, MA. 2001.

3. Fekpe, E.K. and Alam, M. Methodology for Analyzing National Highway Capacity for Freight Transportation. *Presented at the 81st Annual Meeting of the Transportation Research Board*, TRB, Washington, D.C., 2002, Paper # 01-2596.

# Evaluating Short and Long-Term Forecasts for Canadian Air Passenger Data using Time Series Models*

Emir Emiray†
Transport Canada

Gabriel Rodríguez‡
University of Ottawa

This version: February 28 2003

(Submitted for publication in the proceedings of 2003 CTRF Annual Conference, May 11-14, Ottawa, Ontaio, Canada)

**Abstract**

This paper uses six time series models to forecast seasonally unadjusted monthly data of Canadian enplaned/deplaned air passengers, for the domestic, transborder and international sectors. We find that forecasting performance of the models varies widely across series and forecast horizons. Our forecasting results are compared with forecasts published by Transport Canada's Aviation Forecasting Division.

**Keywords:** Forecasts, Seasonal Unit Roots, ARIMA Models, Periodic Autoregressive Models, Structural Time Series Model.

**JEL:** C2, C5.

*Emir Emiray would like to thank the Air Forecasting team at Transport Canada, specifically Robert Duclos, chief - Aviation forecasts, for his encouragement and support throughout the project.

†Author of Correspondence. Economist of Transport Canada; Telephone: (613)-991-2279; Fax: (613)-957-3280; E-mail: emiraye@tc.gc.ca.

‡Professor of the Department of Economics, University of Ottawa, P. O. Box 450, Station A, Ottawa, Ontario, Canada, K1N-6N5; Telephone: (613) 562 5800 (1750); Fax: (613)-562-5999; E-mail: gabriclr@uottawa.ca

# 1 Introduction

Until the 1980's, studies of aviation economics were largely descriptive rather than analytical. Most publications on air transport, highly institutional and rather restrictive, were concerned with the study of monopoly, regulation, and with infrastructure issues such as airport construction and financing. The first and perhaps most known analytical application was Box and Jenkins (1970) study of "airline passenger model" which applied time series analysis to model and forecast passenger numbers in the United States. In the last two decades, analytical applications to both American and Canadian air industry increased, yet they all focused on panel data, and estimation of price elasticities. Today, the long span of Canadian air data, and improved modelling methods of seasonal macro-economic time series, provide us with opportunities to model and test the forecasting performance of these time series methods. To the knowledge of the authors there are no applications of time series models to the Canadian airline passenger data.

In this paper we use six time series models for seasonality of the Canadian airline passenger data series and later examine the out-of-sample forecasting performance of each of these models. The outline of the paper is as follows. Section 2 reviews the models for seasonality. The specification procedure used in the empirical application is outlined for each model and results are presented in the appendix. Section 3 discusses the monthly Canadian enplaned/deplaned passenger data and forecast comparisons and results. Section 4 concludes with some remarks.

# 2 Models of Seasonality

In this section, the time series models of seasonality are reviewed. All models described below are applied to monthly Canadian enplaned/deplaned E/D passenger (pax) data. The first five models assume that each series have a unit root at zero frequency and, hence, the series are detrended by first differencing. For the last model (Filtered ARMA), we actually determine whether the series have seasonal unit roots, therefore the assumption of unit roots is tested. In all models, we work with the natural logarithm of the data. Models are presumably listed in order of their simplicity.

## 2.1 A linear Model with stable deterministic seasonality

The first model of seasonality assumes that the seasonal pattern in the time series $y_t$ is constant over time and can be adequately captured by monthly dummy variables. Dummy variables are defined by $D_{t,s} = 1$ if $s = t$ and 0 otherwise. This model, which is labelled as $AR$, is specified as follows

$$\phi(L)\Delta_1 y_t = \delta_1 D_{t-1} + \delta_2 D_{t-2} + ...\delta_{12} D_{t-12} + \epsilon_t, \tag{1}$$

where $\phi(L)$ is a polynomial of order $p$ in the lag order $L$ with all roots outside of the unit circle, $\Delta_1$ is the differencing operator defined as $\Delta_k = y_t - y_{t-k}$ for all integers $k \neq 0$, and where $\epsilon_t \sim i.i.d.\ \ N(0, \sigma^2)$.

Before estimating (1) is necessary to choose the lag order such that the residuals are approximately white noise. The order of the AR model can be selected by conventional methods, such as the Akaike Information Criterion (AIC) defined as $AIC = T \ln \widehat{\sigma}^2 + 2k$; or the Schwarz Information Criterion (BIC) specified as $BIC = T \ln \widehat{\sigma}^2 + k \ln T$, where $\widehat{\sigma}^2 = \sum_{t=1}^{T} \widehat{\epsilon}_t^2$ with $\widehat{\epsilon}_t$ the residuals from the estimated $AR(p)$ model, and $k = p + 1$ the number of parameters in the model. The value $p \in \{0, 1, ..., p\}$ that minimizes the AIC or BIC is selected as the appropriate lag order, subject to passing a Lagrange Multiplier (LM) test for the first-to-seventh order residual autocorrelation at the 5% significance level. In our application we set $p_{max} = 14$. Due to limitations in space, we do not present model estimation results. These are available upon request from the corresponding author. Table 1 in the appendix presents the $AR(p)$ model specification results found for the four series under study.

## 2.2 A linear model with seasonal unit roots (SUR)

We label this model SUR. This model reads as follows:

$$\phi(L)\Delta_{12} y_t = \mu + \epsilon_t, \tag{2}$$

where $\phi(L)$ and $\epsilon_t$ are as defined before. Equation (2) differs from equation (1) by relaxing the assumption that seasonal patterns are constant over time. Many time series, can be characterized by seasonal patters which evolve over time, while each season sharing a common drift $\mu$. In our domestic series for example this would translate into domestic traffic in season $i = 1, 2, ...12$ depending on the sum of $\epsilon_{t-i}$, $\epsilon_{t-12-i}$ plus an annual linear trend with slope $\mu$.

As in model (1), the only practical decision to be made concerns selecting the autoregressive order $p$. Again, we proceed as before setting $p_{max} = 8$. The results from the application of the specification tests are presented in Table 2.

## 2.3 A SARIMA model

The Seasonal Autoregressive moving average model ($SARIMA$) is nothing but the combination of $AR(p)$ and $SUR$ above with the special case that the only relevant moving average term is the first year error terms. The model relies on moving average model with double differencing. This model that we label $SARIMA$ reads as follows:

$$\phi(L)\Delta_1\Delta_{12} y_t = \mu + (1 - \theta_1 L)(1 - \theta_{12} L^{12})\epsilon_t \tag{3}$$

where it is assumed that $|\theta_1| < 1$, $|\theta_{12}| < 1$. This is the well known "airline model" of Box and Jenkins (1970), where $\phi(L) = 1$ and $\mu = 0$. Basic ARMA(p,q) model would have AR coefficients instead of the lagged dependent variable, i.e.

$\phi(L)(y_t - \mu) = \theta_1(L)\epsilon_t$ (3'). Here we leave $\phi(L)$ and $\mu$ unrestricted. Specification results for the SARIMA model are presented in Table 3.

## 2.4 A periodic autoregressive model

All the models above have had some type of restriction on either the constant, the $AR$ or the $MA$ terms. However, the so-called periodic autoregressive ($PAR$) model allows all the parameters to vary with the season. One may want to consider periodic $ARMA$ models but this is very rarely done in practice. Due to their flexibility the $PAR$ models have been used widely in the literature, but it was first introduced by Osborn (1988) and Osborn and Smith (1989), where the latter study focussed on out-of-sample forecasting of quarterly UK consumption series. See also Franses (1996).

The model for an univariate time series $y_t$ is specified as follows:

$$y_t = \mu_s + \tau_s T_t + \phi_{1,1} y_{t-1} + ... + \phi_{1,12} y_{t-p} + \epsilon_t, \tag{4}$$

where the disturbance $\epsilon_t$ is assumed to be standard white noise process with constant variance $\sigma^2$. One can observe that the number of parameters can be very large for a relatively small $p$ value (the lag value).

One can proceed estimation of PAR by simple OLS[1]. Practical outline of model choosing process for the PAR model is described in Franses (1996). Specification results for the PAR model are presented in Table 4 in the appendix.

## 2.5 A Structural Time Series Model

Harvey et al (1993) argues that it is possible to model a time series with a trend, seasonal, cycle, and irregular component. The model may be written as:

$$y_t = \mu_t + \gamma_t + \psi_t + v_t + \epsilon_t, \tag{5}$$

where $\epsilon_t \sim NID(0, \sigma_\epsilon^2)$, $\mu_t$ is the trend, $\gamma_t$ is the seasonal, $\psi_t$ is the cycle, $v_t$ is the first-order autoregressive and $\epsilon_t$ is the irregular component. It is more clear if we describe this model through an example from our series by decomposing its components into graphs. In Figure 1 below, the graph (A) shows the domestic E/D traffic in Canada between January 1984 and September 2002. Both the trend and seasonal components can be clearly observed. In graph (B) we observe the same series, after the seasonal component has been removed. Graph (C) shows domestic E/D after both the seasonal and trend has been removed. In the same figure, we further decompose the seasonally adjusted domestic E/D without the trend (call it $X$). One can fit a simple random walk plus noise model to $X$, and observe the characteristics of the residuals from this equation. These residuals are plotted in graph (D) and graph (E). What we have here is the disturbance term shown in two separate graphs each calculated with the "disturbance smoother" after Koopman (1993). We can utilize these graphs

[1] Under normality of the error process $\epsilon_t$ and with fixed starting values, the maximum likelihood (ML) estimators of the variables are equal to the OLS results.

in diagnostic checking for detecting and distinguishing between outliers and structural changes. For example, we can observe outliers in 1987:11 and 1988:1-2 in graph (D) (irregular residuals), and a clear dip in 1991 in graph (E) (level residuals). That means, in our modelling exercise we should select 1987:11 and 1988:1-2 as outliers while 1991 should be selected as a structural shift.

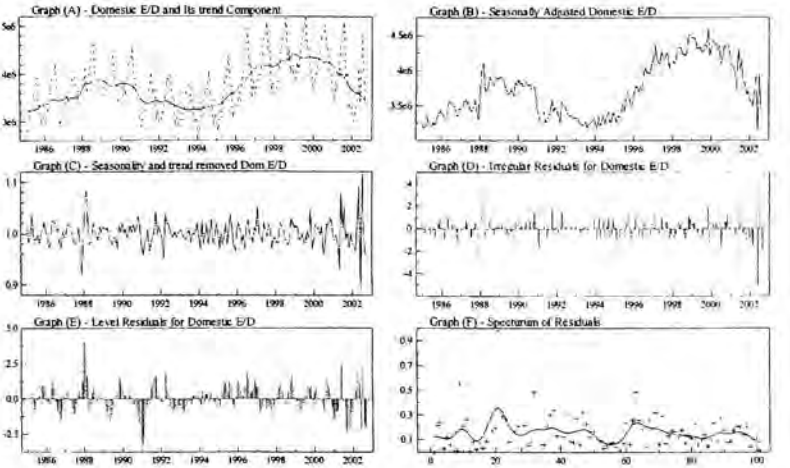



Figure 1. Graphing the "Harvey's" Methodology on Domestic E/D

By now we have covered the trend, seasonal and irregular components. The last two component suggested by Harvey's structural time series analysis is its cyclical component and the autoregressive term $v_t$. The treatment of the autoregressive term is as usual, we focus on the treatment of the cyclical component. Going back again to the domestic E/D, we can investigate the cyclical component by plotting the spectrum of the residuals studied in graphs (C to E). In graph (F), the period is given by the scaled frequency, on the horizontal axis. There appears to be a cycle with a period of around 40 months, or 3 years and four months. This is precisely the cyclical component. See Koopman et al. (1995) for further details. Specification results for model (6) are presented in Table 5 in the appendix.

## 2.6 Testing for seasonal unit roots

All the models above assumed different specification regarding the stationarity of $y_t$. For example, model (1) assumed that $y_t$ has a non-seasonal unit root and consequently a first-differences filter is used as the dependent variable. In model (2) the use of the seasonal filter (twelve differences) assumes that there are twelve unit roots in $y_t$. Finally, model (3), which is a combination of (1) and (2) assumed the existence of thirteen unit roots in $y_t$. As Franses (1996, 1999) argues, there are many cases where seasonal and/or first-differences filters are not relevant. Following this advise, we test for the presence of seasonal unit

roots in $y_t$ using the approach proposed by Hylleberg et al. (1990). Under the null hypothesis, $y_t$ has twelve unit roots given the fact that the filter $(1-L^{12})$ contains twelve unit roots which are $1, -1, \pm i, -0.5(1 \pm \sqrt{3}i)$, $0.5(1 \pm \sqrt{3}i)$, $-0.5(\sqrt{3} \pm i)$, $0.5(\sqrt{3} \pm i)$, where the first root corresponds to the non-seasonal frequency (or frequency zero) and the other corresponds to different seasonal frequencies. Given that, the method for testing for seasonal unit roots consists of estimating (by OLS) the following regression

$$\begin{aligned} \phi(L)y_{8t} &= \mu_t + \pi_1 y_{1t-1} + \pi_2 y_{2t-2} + \pi_3 y_{3t-1} + \pi_4 y_{3t-2} \\ &\quad + \pi_5 y_{4t-1} + \pi_6 y_{4t-2} + \pi_7 y_{5t-1} + \pi_8 y_{5t-2} \\ &\quad + \pi_9 y_{6t-1} + \pi_{10} y_{6t-2} + \pi_{11} y_{7t-1} + \pi_{12} y_{7t-2} + \epsilon_t \end{aligned} \tag{6}$$

where $y_{1t} = (1+L)(1+L^2)(1+L^4+L^8)y_t$, $y_{2t} = -(1-L)(1-L^2)(1+L^4+L^8)y_t$, $y_{3t} = -(1-L^2)(1+L^4+L^8)y_t$, $y_{4t} = -(1-L^4)(1-\sqrt{3}L+L^2)(1+L^2+L^4)y_t$, $y_{5t} = -(1-L^4)(1+\sqrt{3}L+L^2)(1+L^2+L^4)y_t$, $y_{6t} = -(1-L^4)(1-L^2+L^4)(1-L+L^2)y_t$, $y_{7t} = -(1-L^4)(1-L^2+L^4)(1+L+L^2)y_t$, and $y_{8t} = (1-L^{12})y_t$. The critical values for the $t_{\widehat{\pi_1}}$, $t_{\widehat{\pi_2}}$, $F_{\widehat{\pi_3},\widehat{\pi_4}}$, $F_{\widehat{\pi_5},\widehat{\pi_6}}$, $F_{\widehat{\pi_7},\widehat{\pi_8}}$, $F_{\widehat{\pi_9},\widehat{\pi_{10}}}$, and $F_{\widehat{\pi_{11}},\widehat{\pi_{12}}}$ have been tabulated by Hylleberg et al. (1990).

Equation (6) was estimated for the four time series using a maximum lag of 36 to obtain non-autocorrelated residuals. For the series of domestic air passengers we found unit roots at the 2/12 and 10/12 frequencies. For the series of transborder we cannot reject the presence of unit roots at the frequencies 1/12 and 11/12. The series on international passengers presents evidence for unit roots at the frequencies 2/12, 10/12, 1/12 and 11/12. Finally, the series of total passengers presents unit roots at the frequencies 2/12 and 10/12. Given these results we apply the corresponding filters to each time series to deal with a new dependent variable. Specification tests for estimating an $ARMA(p,q)$ model using these "filtered" series is given in Table 6.

# 3 Aviation Forecasting and Data

To the knowledge of the authors there are no time series analysis of Canadian passenger E/D data. All of the studies on Canadian air transportation utilize city pair panel data, where the focus lies on determining the elasticities of the air travel determinants[2]. Passenger forecasts are subsequently calculated by using these elasticities on forecasted explanatory variables. In these studies, the price of air travel is the most important determinant of air travel demand, see Gillen et al (2002) for literature review on air travel demand elasticities. There are various advantages of forecasting pax numbers using panel data. First, price elasticities can only be determined using panel data analysis. Policy makers use price elasticities to determine governmental policies such as air travel taxation, while airlines use them for marketing purposes (air travel pricing, etc.). A

[2]Most common used determinants of air travel are price of air travel, GDP of origion and destination, air and/or car time of travel between the two cities, city-pair dummies, available flight frequency, PDI etc.

second advantage of panel studies is that pooling of information for all city pairs allows researchers to use fixed effects to capture city specific information and to calculate more meaningful elasticities[3]. Nevertheless, due to the lack of availability of quality data on determinants of air travel, panel data studies of air travel may have major measurement errors[4]. Furthermore, forecasts from panel data studies are calculated using forecasted values of independent variables such as future price of air travel, PDI etc., which by themselves introduce further uncertainty.

Time series forecasts of passenger numbers could eliminate these biases by exploring the past behavior of the data and assuming that same behaviour persists in the future. This is most useful when researchers are interested in accurate forecasts rather then specific elasticities of air demand determinants. For example, precise forecasts are needed in planning of airport terminals, airport runways, forecasts of government revenues from air travel taxes, and forecasts of aviation emissions on climate and atmospheric ozone[5]. Obviously, in planning and financing of airport infrastructure it is desirable that one has forecasts of passenger numbers for each airport which are disaggregated by the passenger destination and type[6]. However, one can always distribute the total numbers between airports after the total forecasts are calculated[7]. The distribution would be even more precise if one disaggregates total number of passengers into domestic, transborder and international passenger numbers, as the sector passenger share of each airport in Canada has been fairly constant over the years (see appendix, Table 7).

In this paper we consider the aggregate passenger demand at all Canadian airports for each of the three sectors. The disaggregation also makes sense since it is expected that pax demand for each sector evolves differently over time[8]. The disaggregated passenger numbers are calculated as:

$$Aggregate\ pax = \sum_{a=1}^{A}\sum_{t=1}^{T}\sum_{o=1}^{O} pax_{a,t,o}$$

where $A$ denotes the number of airports, $T$ accounts for the types of passengers, and $O$ are the origins of passengers. Forecasts of total passenger numbers in Canada are produced by several institutions. Transport Canada's air forecasting department (TC) publishes yearly passenger forecasts for each of the Canadian

[3]Price elasticities tend to differ between city-pairs depending on population, GDP, level of competition etc.

[4]For example price of air travel is not widely available, as airlines keep thier pricing information secure.

[5]While emissions from aviation depends on the number of passengers, it also depends on the type of aircrafts being used and their efficiency in fuel use.

[6]Types of air travelers include: business, economy, discount. Furter disagregation of type of air travel could include family related travel, tourism, education related travel etc.

[7]Indeed, airport based forecasts are of limited use, since as Nigel (2002) points out "existing route traffic will be heavily influenced by the current pattern of service and is of limited use when forecasting many years into the future."

[8]For example while the domestic market in the 1990's had entered a state of maturation, demand for international sector had high growth rates.

city-pairs by origin and destination. These numbers are further disaggregated by type of passenger for a horizon of fifteen years. TC also includes different 'scenarios' to accommodate uncertainty in these forecasts. The last column in Table 10 (see appendix) gives the 2002 TC forecasts for different sectors aggregated for all airports, which are used by the TC and the aviation industry for planning. We will use them as a reference to compare with our forecasts.

## 3.1 Canadian Passenger Data

In this section, we describe the data sets used in this paper. The series we consider represent the seasonally unadjusted enplaned/deplaned air passengers in Canada for the domestic, transborder, and international sectors, at the monthly frequency covering the period between January 1984 and September 2002 (225 observations). The series are constructed by adding enplaned and deplaned passenger numbers, which are obtained from Statistics Canada and Transport Canada archives (see appendix for the definitions).

All of the four series, which are shown in level in the first set of graphs in Figure 2 below, contain three common dominant features: distinct seasonal pattern, strong growth during the eighties and a sharp drop after September 2001. In fact, all the series show pronounced seasonal pattern, as air travel is typically high during the summer time (May-August) and below average during the fall and winter. We observe that the series have several dominant outliers. For example in the domestic sector, 1990.12, 1999.5 and 2001.9 are obviously the striking outlier. When we model our series we assume that such behaviour are not a part of the data generating process and they won't repeat in the future. Therefore, we remove them by replacing the value of an outlying observation at time $t^*$ by the average of the values at $t^* - 12$ and $t^* + 12$[9]. The list of outliers is provided in Table 8 in the appendix.

Looking at the third set of graphs below, which corresponds to the seasonally differenced log-transformed series, one observes that air passenger data presents cyclical asymmetries, which are characterized by steep decreases during recessions, followed by slow(er) increases during expansions. This behaviour is due the fact that air travel demand is composed of business and leisure travel, where both are directly related to GDP and employment rates[10]. It is not surprising that in good times business travel is higher as there is more economic activity. Similarly, in good times, leisure travel is higher as leisure travel is usually treated as a luxury good (Brons et al, 2002).

[9] Here we follow Franses et al (2000) in the methodology of choosing and removing the outliers.

[10] Macroeconomic variables such as GDP are most common determinants used to expalin air travel demand in the literature.

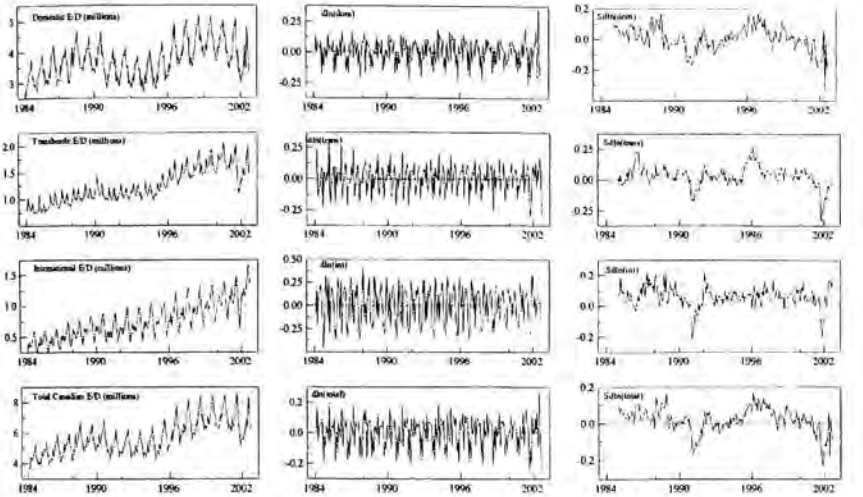


Figure 2. Canadian Sector Specific Data Series: Level (in millions)

## 3.2 Evaluating Forecasts

In general, the fact that a model 'best' fits the data does not necessarily mean that the 'best' model also renders better out-of-sample forecasts. Basically, the theory of economic forecasting lies on two assumptions. First, the model is a good representation of the economy, and secondly the structure of the economy will remain relatively unchanged. Nevertheless, because of the things that we don't know will happen in the future, the forecasts are largely unpredictable. These unknown events can be divided into two groups: the ones whose associated probabilities we understand and incorporate in the measures of forecast uncertainty, and the ones whose probability of happening can not be predicted.. Therefore, given the model that best fits the data, the only judgements that should improve forecasts are those based on advance warnings of events to come (such as notice of future tax changes etc.). Hendry and Clements (1998) further discuss the areas of our understanding in forecasting improvement. Having said this, below we set a forecast evaluating criteria that we use in selecting our final time series model.

For simplicity we assume $m$ 1-step ahead forecasts $y_{t+j|t=j-1}$, $j = 1, ..., m$, where $m$ is the horizon and the corresponding realizations $y_{t+1}, ..., y_{T+m}$ are available. The criteria discussed below can be also applied to multiple-step ahead forecasts as well. One traditional forecast evaluation criteria are the mean squared prediction error ($MSPE$) defined by $MSPE = \frac{1}{m}\sum_{j=1}^{m}\left(y_{T+j|T+j-1} - y_{T+j}\right)^2$. Therefore, models with smaller $MSPE$ have a better forecast performance.

### 3.3 Forecast comparisons

The final 2 years of data (Sept 2000 until Oct 2002), are used to evaluate the forecast performance of the estimated models. For each point in this forecast period, we compute 1, 4, 8 and 12-steps ahead forecasts of the four data series using the seven time series models outlined above.

Using the fact that $E[\epsilon_{t-1} \mid \Omega_t] = 0$, the optimal 1-step ahead forecast of $y_{t+1}$ is obtained as $\widehat{y}_{t+1|t} = E[y_{t+1} \mid \Omega_t] = F(y_{t-1}; \theta, \phi)$. When the forecast horizon is larger than 1 period, for example, for the optimal 2-step ahead forecast it follows that: $\widehat{y}_{t+2} = \widehat{\phi}_1 \widehat{y}_{t+1} + \widehat{\phi}_2 y_t$ (assuming, for example, an $AR(2)$ process). The calculation is similar for $h$-step ahead forecasts. Table 9 (see appendix) contains the ratios of each model's MSPE to that of the unweighted average, where ranks are presented in brackets. We observe that, the model's forecasting success differs depending on the data series forecasted and the forecasting horizon. Accordingly, for each of the series we choose the model that in average performs the "best". These are: for the domestic sector model (4), for the transborder sector model (3), for the international sector model (1), and for the total E/D passengers we simply add all three series..

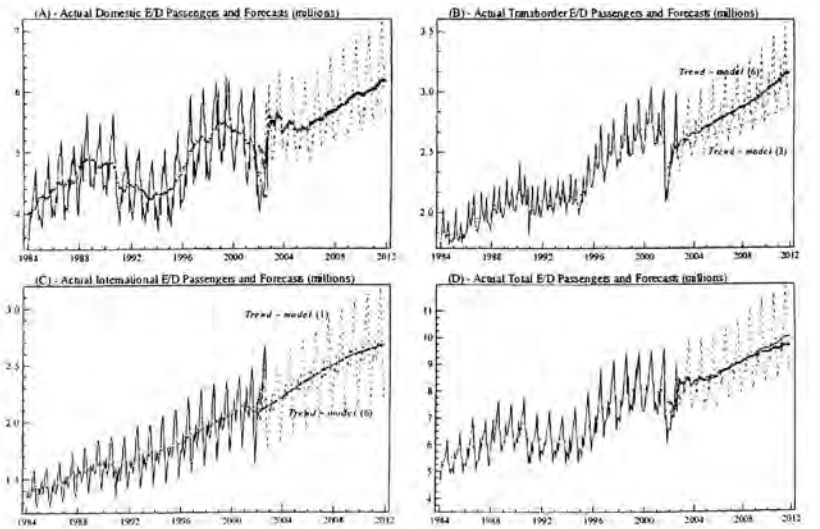



Figure 3. Actual and Forecast of Canadian E/D Air Passenger Data

Figure 3 above, shows each of the time series and their forecasts from Oct 2002 to Dec 2011. We choose to include Harvey's structural time series method (model (6)) in forecasting of each of the data series along with the other "best" model. Except for the transborder sector, naked eye observation of the graphs suggest that Harvey's structural model predicts a trend in growth similar to the "best" model. For the total E/D series we include Total 1, where Total 1 =

$Sum(Dom + Trans + Int)$ obtained by Harvey's structural model (model (6)) and Total 2, where Total 2 = $Sum(Dom + Trans + Int)$ obtained by each of the "best" models Table 10 (see appendix) summarizes the results presented in Figure 3.

# 4 Concluding Remarks

In this paper we used six time series models to forecast seasonally unadjusted Canadian E/D air passenger data. Forecast performance differs depending on the forecast horizon and the series estimated. We find that our forecasts are very similar to Transport Canada's forecasts for the total E/D series. However, for the domestic sector there is a slight difference in our forecasts, due to the actual passenger numbers for 2001 and 2002 being lower than the estimated values utilized by TC.

# References

[1] Box, G. E. P. and G. M. Jenkins, (1970), *Time Series Analysis: Forecasting and Control*, Holden-Day, San Francisco.

[2] Brons, M., E. Pels, P. Nijkamp, P. Rietveld (2002), "Price Elasticities of Demand for Passenger Air Travel: A Meta-analysis," *Journal of Air Transport Management*, **8**, 165-175.

[3] Franses, P. H. (1996), *Periodicity and Stochastic Trends in Economic Time Series*, Oxford University Press.

[4] Franses, P. H. (1999), *Time Series Models for Business and Economic Forecasting*, Cambridge University Press.

[5] Franses, H. P. and R. Paap (1999), "Forecasting with Periodic Autoregressive Time Series Models," *Econometric Institute Report* **9927/A** Erasmus University Rotterdam.

[6] Franses, H. P. and Dick, V. D. (2001), "The Forecasting Performance of Various Models for Seasonality and Nonlinearity for Quarterly Industrial Production," *Econometric Institute Report* **EI 2001-14**, Erasmus University Rotterdam.

[7] Gillen, W. D, W. G. Morrison, and Stewart C. (2002), "Air Travel Demand Elasticities: Concepts, Issues, and Measurement," *Interim Draft Final Report for Finance Canada*, 2002

[8] Grubb, H. and A. Mason (2001), "Long Lead-Time Forecasting of UK air Passengers by Holt-Winters method with Damped Trend," *International Journal of Forecasting* **17**, 71-82.

[9] Harvey, A. C. and N. Shephard (1993), "Structural Time Series Models," in Maddala, G. S., C. R., Rao and H. D.Vinod (eds), *Handbook of Statistics, Volume* **11**, Amsterdam: Elshevier Science Publishers B. V.

[10] Hendry, D.F, and M. P. Clements (2001), "Economic Forecasting: Some Lessons from Resent Research," *European Central Bank Working Paper Series* No. **82.**

[11] Hylleberg, S., R. F. Engle, C. W. J. Granger, and B. S. Yoo (1990), "Seasonal Integration and Cointegration," *Journal of Econometrics* **44**, 215-238.

[12] Koopman, S. J. (1993), "Disturbance Smoother for State Space Models," *Biometrica*, **80**, 117-126.

[13] Koopman, S. J., A. C. Harvey, J. A. Doornik, and N. Shephard (1995), *STAMP, Time Series Analyzer, Modeller and Predictor.* Timberlake Consultatnts LTD.

[14] Nigel, D. P. S. (2002), "Long-term Route Traffic Forecasts and Flight Schedule Pattern for a Medium-sized European Airport," *Journal of Air Transport Management* **8**, 313-324.

[15] Osborn, D. R. (1988), "Seasonality and Habit Persistence in a Life Cycle Model of Consumption," *Joural of Applied Econometrics* **3**, 255-266.

[16] Osborn, D. R., and J. P. Smith (1989), "The Performance of Periodic Autoregressive Models in Forecasting Seasonal U.K. Consumption," *Journal of Business and Economic Statistics* **7**, 117-127.

[17] Stock, H. J., Watson, W. M. (1998), "A Comparison of Linear and Nonlinear Univariate Models for Forecasting Macroeconomic Time Series," *NBER Working Paper* No. **6607.**

Table 1. Specification Tests for Model (1)

| Series | $p$ | $AIC$ | $LM(7)$ | $ARCH(7)$ | $Normality$ | $Skewness$ | $EK$ |
|---|---|---|---|---|---|---|---|
| Domestic | 14 | -3.88 | 0.76 | 0.03 | 0.009 | 0.52 | 1.05 |
| Transborder | 14 | -3.88 | 0.99 | 0.84 | 0.25 | -0.04 | 0.45 |
| International | 14 | -3.41 | 0.82 | 0.01 | 0.007 | -0.46 | 1.15 |

Note: $LM(7)$ is the $\chi^2$test for no residual autocorrelation up to and including lag 7, $ARCH(7)$ is the F-test of no ARCH effects up to order 7, Normality is the $\chi^2$test for normality of residuals, and EK is excess kurtosis. Except skewness and excess kurtosis, numbers are the p-values. Estimation sample is 1985.10-2000.09.

Table 2. Specification Tests for Model (2)

| Series | $p$ | $AIC$ | $LM(5)$ | $ARCH(7)$ | $Normality$ | $Skewness$ | $EK$ |
|---|---|---|---|---|---|---|---|
| Domestic | 4 | -3.62 | 0.84 | 0.53 | 0.69 | 0.12 | 0.09 |
| Transborder | 2 | -3.64 | 0.6 | 0.94 | 0.70 | 0.01 | 0.1 |
| International | 7 | -3.23 | 0.16 | 0.53 | 0.01 | 0.52 | 0.74 |

See note below Table 1. The maximum order is set to $p_{max} = 8$.

Table 3. Specification Tests for Model (3)

| Series | $p$ | $AIC$ | $P(36)$ | $ARCH(7)$ | $Normality$ | $Skewness$ | $EK$ |
|---|---|---|---|---|---|---|---|
| Domestic | 4 | -3.70 | 0.27 | 0.012 | 0.09 | 0.22 | 0.64 |
| Transborder | 4 | -3.70 | 0.76 | 0.1 | 0.05 | -0.14 | 0.79 |
| International | 8 | -3.15 | 0.69 | 0.063 | 0.03 | -0.33 | 0.90 |

See note below Table 1. The maximum order is set to $p_{max} = 8$, $P(36)$ is the Pormanteau test goodness-of-fit test in stationary ARMA models(equivalent of LM)

Table 4. Specification Tests for Model (4)

| Series | $p$ | $AIC$ | $LM(7)$ | $ARCH(7)$ | $Normality$ | $Skewness$ | $EK$ |
|---|---|---|---|---|---|---|---|
| Domestic | 6 | -4.26 | 0.72 | 0.81 | -0.32 | -0.2 | -0.32 |
| Transborder | 6 | -4.28 | 0.17 | 0.95 | 0.08 | -0.14 | 0.67 |
| International | 6 | -3.69 | 0.72 | 0.4 | 0.20 | -0.3 | 0.31 |

See note below Table 1. The maximum order is set to $p_{max} = 6$.

451

Table 5. Specification Tests for Model (5)

| Series | $Q-stat$ | $AIC$ | $Normality$ | $Skewness$ | $EK$ |
|---|---|---|---|---|---|
| Domestic | 0.18 | -6.5 | 0.01 | 0.19 | 0.96 |
| Transborder | 0.17 | -6.5 | 0.3 | 1.81 | 0.26 |
| International | 0.26 | -6.1 | 0.09 | 0.23 | 0.6 |

See note below Table 1. The Q-stat is te Box-Ljung statistics for residual serial autocorrelation based on the first 9 resid autocorrelation; number are the $p-$ values

Table 6. Specification Tests for Model (3') using Filtered series

| Series | $AR$ | $MA$ | $AIC$ | $P(36)$ | $ARCH(12)$ | $Normality$ | $Skewness$ | $EK$ |
|---|---|---|---|---|---|---|---|---|
| Domestic | 10 | 13 | -4.25 | 0.06 | 0.0008 | 0.02 | 0.4 | 0.93 |
| Transborder | 4 | 11 | -3.8 | 0.18 | 0.87 | 0.19 | 0.1 | 0.5 |
| International | 4 | 8 | -3.26 | 0.36 | 0.07 | 0.00 | -0.4 | 2.25 |

Table 7. Canadian Air Passenger Market Distribution

| | | 1997 | 1999 | 2001 |
|---|---|---|---|---|
| Domestic Market | % Passengers Captured by: | | | |
| | | % | % | % |
| | Ontario | 40 | 43 | 46 |
| | British Columbia | 17 | 15 | 14 |
| | Quebec | 12 | 14 | 14 |
| | Alberta | 15 | 12 | 10 |
| | Others | 17 | 16 | 15 |
| Transborder Sector | % Passengers Captured by: | | | |
| | Ontario | 49 | 51 | 50 |
| | British Columbia | 17 | 15 | 15 |
| | Quebec | 16 | 17 | 19 |
| | Alberta | 11 | 10 | 11 |
| | Others | 7 | 6 | 6 |
| International Sector | % Passengers Captured by: | | | |
| | Ontario | 44 | 45 | 47 |
| | British Columbia | 22 | 21 | 20 |
| | Quebec | 18 | 19 | 20 |
| | Alberta | 9 | 9 | 8 |
| | Others | 7 | 6 | 6 |

Note: Data is based on Billing and Setllement Plan (BSP). BSP is collected by IATA. It captures all the airline tickets sold by Canadian travel agents

**Definition 1** *Definition of Observations:*

Enplaned: passengers which embark and take off from an airport in Canada.

Deplaned:Passengers which land and disembark at an airport in Canada.

Domestic: Traffic between an airport in Canada and an airport in Canada

Transborder: Traffic between an airport in the United States (including Alaska and Hawaii and Puerto Rico) and an airport in Canada

Other International: Traffic between an airport in a foreign country (exluding the United States) and an airport in Canada

Data (1984-1988): Location: Catalogue 51-005 "Table 7 - Total All Airports: International and Domestic Detail for Scheduled Services" + (1984-1985) Charter data from Confidential Airport data base (Transport Canada)

Data (1988-2001) Location: — Catalogue 51-5005 (Statement 2) "Table 2.2 Enplaned and Deplaned Passengers for Major Scheduled Services, by Sector" +

— Catalogue 51-5005 (Statement 4) "Table 3.2 Enplaned and Deplaned Passengers for Regional and Local Scheduled Services, by Sector" +

— Catalogue 51-5005 (Statement 6) "Table 4.2 Enplaned and Deplaned Passengers for Major Charter Services, by Sector"

Data (2001-2002) Location: data are from top 25 airport (93% of all traffic) -confidential-

Table 8. Outlying observations

| Series | Date Observations |
|---|---|
| Domestic | 1988.1, 1990.12, 1998.10, 1999.5 and 6, 2001.5 and 9, 2002, 5 and 7 |
| Transborder | 1985.3, 1988.2, 1990.11-12, 2001.9 |
| International | 1985.3, 1990.11-12, 1999.12 |

Table 9. Out-of-sample Forecasting Performance per Quarter and their (Ranks)

| Series | *Horizon* | *AR* | *SUR* | *SARIMA* | *PAR* | *FilteredARMA* |
|---|---|---|---|---|---|---|
| Domestic | 1 | 1.06 (4) | 1.06 (5) | 0.89 (1) | 1.02 (3) | 0.97 (2) |
| | 4 | 1.00 (3) | 0.95 (2) | 1.11 (4) | 0.94 (1) | - |
| | 8 | 0.99 (2) | 0.99 (3) | 1.11 (4) | 0.92 (1) | - |
| | 12 | 0.98 (2) | 1.08 (4) | 1.05 (3) | 0.89 (1) | - |
| Transborder | 1 | 0.95 (3) | 1.02 (4) | 0.89 (1) | 1.23 (5) | 0.90 (2) |
| | 4 | 0.76 (2) | 1.46 (4) | 0.76 (1) | 1.02 (3) | - |
| | 8 | 0.72 (2) | 1.63 (4) | 0.70 (1) | 0.95 (3) | - |
| | 12 | 0.72 (2) | 1.68 (4) | 0.67 (1) | 0.92 (3) | - |
| International | 1 | 0.83 (1) | 0.95 (2) | 1.14 (5) | 1.03 (3) | 1.05 (4) |
| | 4 | 0.63 (1) | 1.13 (3) | 1.23 (4) | 1.00 (2) | - |
| | 8 | 0.43 (1) | 0.78 (3) | 2.12 (4) | 0.66 (2) | - |
| | 12 | 0.34 (1) | 0.59 (3) | 2.55 (4) | 0.52 (2) | - |

The table contains ratios of the different models to the MAPE of an unweighted average forecast at horizon $h = 1$ in individual quarters, with ranks of the models in brackets.

Table 10. Forecasting Results

| Series | *Horizon* | *Structural* | *PAR* | *T.Canada** |
|---|---|---|---|---|
| | 2001 | 50,112 | 50,112 | 51,843 |
| | 2002 | 47,865 | 46,764 | 49,872 |
| | 2003 | 50,535 | 50,434 | 51,469 |
| Domestic | 2004 | 52,166 | 52,194 | 53,836 |
| | 2005 | 52,674 | 53,603 | 55,558 |
| | 2006 | 54,254 | 55,211 | 57,226 |
| | 2011 | 61,853 | 60,889 | 63,697 |
| | *Horizon* | *Structural* | *SARIMA* | *T.Canada* |
| | 2001 | 18,536 | 18,536 | 19,371 |
| | 2002 | 17,848 | 17,862 | 17,957 |
| | 2003 | 19,323 | 18,787 | 18,711 |
| Transborder | 2004 | 20,006 | 19,186 | 19,890 |
| | 2005 | 20,714 | 19,595 | 20,944 |
| | 2006 | 21,447 | 20,011 | 21,992 |
| | 2011 | 25,520 | 22,232 | 26,488 |
| | *Horizon* | *Structural* | *AR* | *T.Canada* |
| | 2001 | 13,185 | 13,185 | 13,043 |
| | 2002 | 13,927 | 13,927 | 12,365 |
| | 2003 | 14,943 | 14,971 | 12,884 |
| International | 2004 | 15,885 | 15,884 | 13,683 |
| | 2005 | 16,727 | 16,567 | 14,409 |
| | 2006 | 17,513 | 17,297 | 15,115 |
| | 2011 | 20,277 | 20,027 | 18,966 |
| | *Horizon* | *Total 1* | *Total 2* | *T.Canada* |
| | 2001 | 81,833 | 81,833 | 84,257 |
| | 2002 | 79,640 | 78,553 | 80,195 |
| | 2003 | 85,743 | 84,192 | 83,064 |
| Total | 2004 | 88,057 | 87,264 | 87,409 |
| | 2005 | 90,115 | 89,765 | 90,912 |
| | 2006 | 93,214 | 92,519 | 94,332 |
| | 2011 | 107,650 | 103,148 | 108,780 |

*source: Transport Canada, see http://www.tc.gc.ca/POL/EN/airforecasting/summary2002final.htm

# The Impact of Travel Time and Cost Changes on the Demand for Short Haul Air Service: The Edmonton – Calgary Market

Philip Davies, Geoffrey Horner, Transport Canada

## Introduction

The imposition of the air security charge, which was required to recover the costs of enhanced security at Canadian airports, and increased security vigilance have heightened interest regarding the influence of cost increases and travel delays on the demand for passenger service on short haul routes. This paper will assess the impact of changes to passenger costs and travel time in the Edmonton-Calgary market.

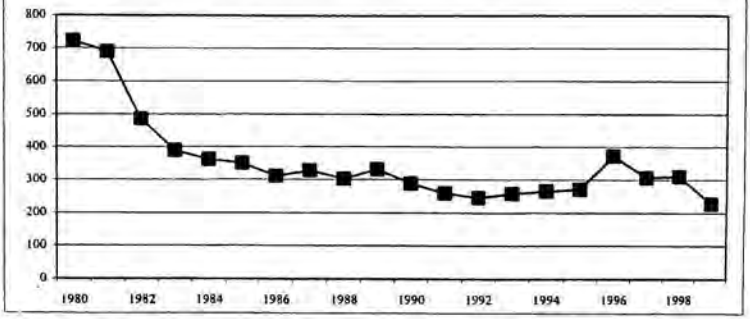
The road distance between these cities is only 300 km. The majority of traffic travels by private automobile. The Edmonton – Calgary city-pair market is ideal for this analysis, because the controversy surrounding the role of the downtown Edmonton Municipal Airport and the eventual decision to consolidate passenger service at the Edmonton International Airport in 1996 resulted in substantial changes in costs and travel time for passengers.

## Background

In 1980, the Edmonton – Calgary city pair was the second busiest origin-destination air corridor in Canada. Driven by a super heated economy, some 723,000 origin/destination (OD) passengers flew between Calgary and Edmonton. Graph 1 illustrates the OD passenger flows[1].

[1] Source: Statistics Canada Catalogue no. 51-204, various issues.

Graph 1: Edmonton-Calgary Origin-Destination Passengers 1980-1999 (000)




Boarding Pacific Western Airlines' "Air Bus" was given no more thought than a city transit ride in the minds of many Albertans. With no reservation system and a cash fare collected in the aisle in the early years, the route operated very much like a high speed 40 minute transit bus ride. This notion was supported by very low fares. In 1980, PWA offered a $36 one-way fare from the downtown Edmonton Municipal Airport (YXD) to Calgary International. Wardair offered an even better deal with a $20 regular fare and a $28 First Class fare, departing from the Edmonton International Airport (YEG), which is located approximately 20 km south of Edmonton. This mindset found its way into Transport Canada planning, design and construction. During the construction of the Calgary air terminal building in the late 1970's, the North Wing (or PWA Wing) was to have the "drive to gate" feature in which a very narrow configuration from the airside to groundside was contemplated to allow a short dash from your vehicle to the aircraft gate. The first set of highjackings prompted the introduction of security screening, thus effectively eliminating the "drive to gate" concept.

The Edmonton to Calgary route was PWA's "bread and butter" with initial service exclusively on this city-pair. The drive time from downtown Edmonton to YXD was no more than 10 minutes with a 20-minute transit to downtown at the Calgary end. While the Calgary transit time was fairly static even with the opening of the new air

terminal building in 1977, the drive time to Edmonton International was 35 minutes, which has now increased to 45 minutes with the expansion of the city southward.

The recession of 1982 drove PWA fares up 50 percent and Wardair fares from $20 to $42. Recessionary pressures and the rising cost of airfare coupled with modal competition had started to erode the market in 1983 and operational requirements were impinging on customer convenience.

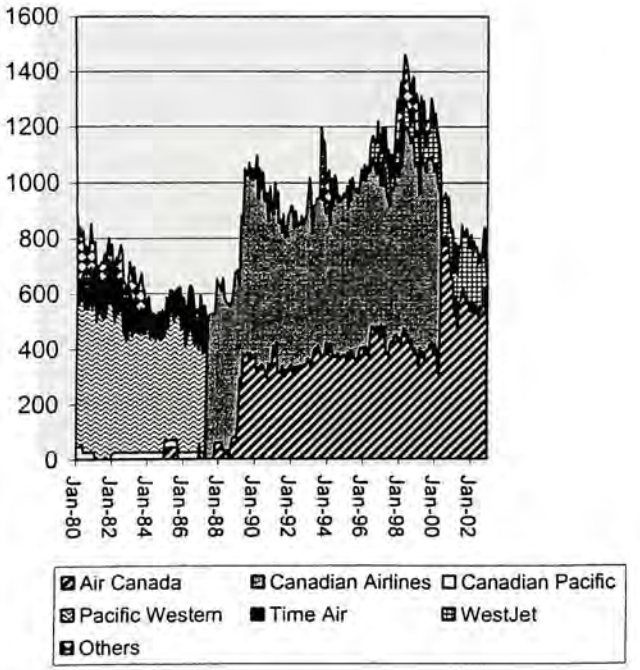
The City of Edmonton, which owned YXD, imposed a rule limiting YXD flights to intra-Alberta routes. PWA was forced to operate a split system between YXD and YEG. Further, noise abatement procedures at YXD were vigorously enforced with a zero tolerance on all aircraft operations from 2400 to 0700. A short runway also limited operations, with full configuration B-737-200 aircraft constrained to the YXD – YYC route by a reduced fuel load. The same issues of limited runway length and fuel load were instrumental in the failure of Air Canada's attempt to compete from YXD using DC-9 equipment in the mid 1980's. This attempt was unsuccessful in part due to the fact that the short runway length limited the aircraft to a 60 percent load factor.

Up to 1987, PWA served as a feeder to Air Canada's traffic at YYC. The merger of PWA and Canadian Pacific to form Canadian Airlines International Limited brought an end to this alliance. Over the next two years, Canadian Airlines had no direct competition on this route. In 1989 Air Canada's regional partner Air BC entered the market using BAE 146 jet aircraft.

**Air Carrier Services**

The number of flights departing weekly from Edmonton (both YXD and YEG) is shown in Graph 2. The period from January 1980 to December 2002 is characterized by three discreet phases. In the first phase from 1980 to 1987, which ends with the PWA/Canadian Pacific merger and deregulation, the level of weekly departing flights fell

**Graph 2: Departing Flights Edmonton - Calgary 1980 - 2002**

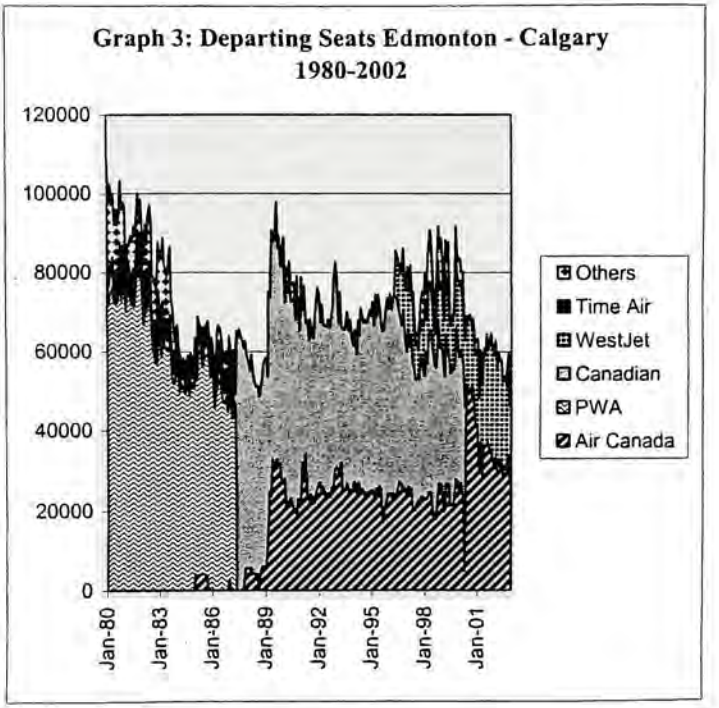


steadily from over 800 to under 600. Over the next period, traffic increased as Air Canada and Canadian Airlines hotly contested the city-pair, driving the number of flights to over 1,400 departures by the summer of 1998. In 1996, YXD was closed to air carrier operations (with the exception of very small aircraft) and operations were consolidated at YEG. Since that time, departures have dropped off and average below the 800 mark. This places air departures at approximately the same level as was recorded in the regulated environment of 1980.

**Departing Seats**

PWA essentially controlled the Edmonton – Calgary air market from YXD until its take-over of Canadian in 1987. Its corporate successor, Canadian Airlines offered more than 60 percent of total seats despite attempts by Air Canada to penetrate the market. A high degree of customer loyalty remained with Canadian, which Air Canada could not break despite some very aggressive fare incentives and the relocation to YEG in May 1996.

Air Canada did not attain market domination with the takeover of Canadian due to the emergence of WestJet. This may have kept the fares in check, despite WestJet having a very small share of the seats. The launch of WestJet was successful by virtue of the transfer of western customer loyalty previously held by PWA/Canadian. Historical levels of capacity by carrier are depicted in Graph 3.

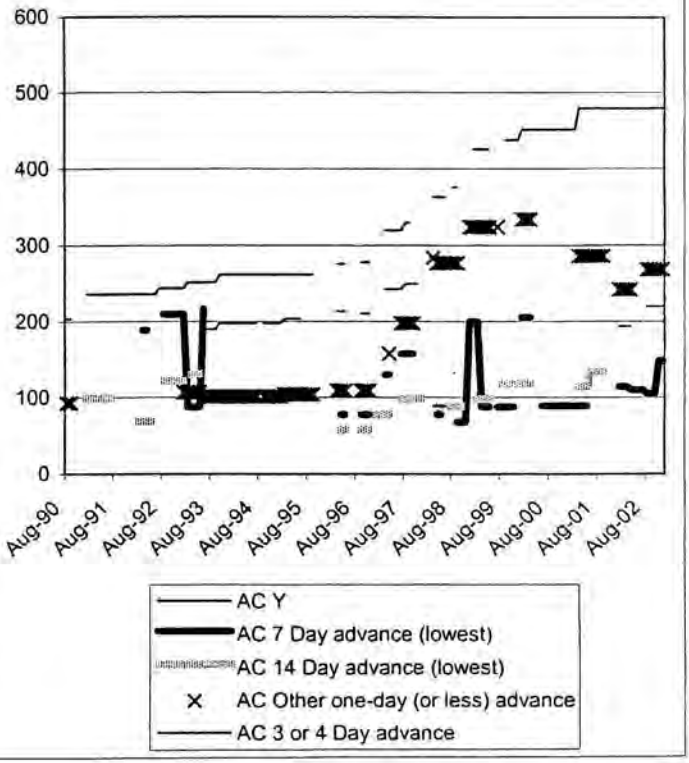



**The Costs of Air Travel**

Fare information was extracted from published fares provided by Airline Tariff Publishing Company. For the period prior to 1990, only two observations per year were used. From 1990 through 2002, monthly data was used. The fares analyzed in this paper were selected to represent fares available to all passengers (i.e. excluding "status" fares such as seniors and youth discounts, rates for accompanied children, etc.), sorted by advance purchase criteria. Discount rates typically also carry minimum stay requirements (usually a Saturday stay). Even for this subset of available fares, the structure can be quite complex. The graph below depicts a selection of Air Canada

fares on the Edmonton- Calgary route from 1990 through 2002: ("YEA" is used in the fare publications as the designator for Edmonton fares.)

**Graph 4: Air Canada Return Fares YYC-YEA 1990-2002**



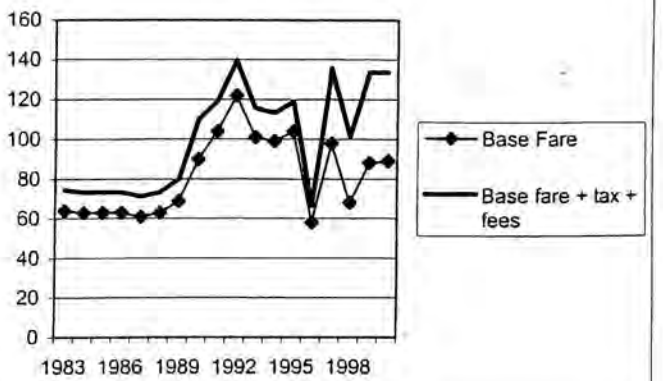

The fare structure for other carriers is as complex. For the purposes of econometric estimation a series was constructed, primarily from 7

day advance fares (or 1 day advance fares where they were lower) which were available for an extended period in each year.
To arrive at the full costs of the flight, additional fees and taxes were added. These include:

- The federal Air Ticket Tax of 10% + $4 (to a maximum of $50) until 1990, and then 7% (to a maximum of $ 40) from 1991 until its removal in 1998.
- The federal Goods and Services Tax (GST) of 7% of the total (including other fees and taxes) from its imposition in 1990.
- The Edmonton Airport Improvement Fee of $10 from 1997.
- The Calgary Airport Improvement Fee of $12 from 1997.
- The NAV CANADA surcharge of $15 imposed by the airlines starting in 1999.

The impact of these charges on air travel costs is shown below:

**Graph 5: Discount Fare Calgary - Edmonton**
**Current $ 1983 - 2002**




The relocation of air carrier flight operations from the Edmonton Municipal to the Edmonton International airport had the effect of increasing the cost and travel time from the airport to downtown Edmonton. The impact on Edmonton-based travelers was a subject of

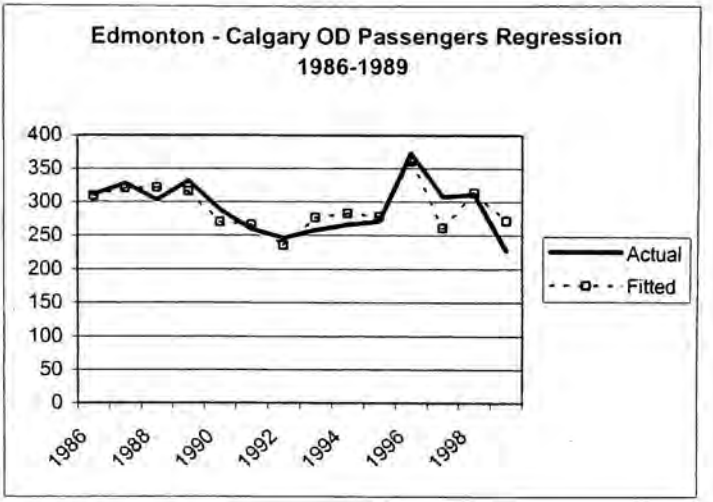
controversy for years prior to the decision to close YXD to air carrier traffic. However, it is logical to assume that it was a major inconvenience for travelers originating in Calgary who would face the additional costs of the longer taxi ride (around $40 as opposed to the $12 - $15 ride downtown from YXD) or increased wait and travel times if they use the airport bus service.[2] Though the impact is difficult to quantify, it seems that a dummy variable valued at 0 prior to the move and 1 thereafter (i.e. from 1997 on) in the regression should carry a negative coefficient if the impact was significantly large.

In addition to the travel cost and YXD dummy variables, a number of other variables were tried in the equation. These included Edmonton and Calgary population, personal disposable income, and gasoline prices (as a proxy for the costs of the alternative mode). All financial variables were deflated using the Consumer Price Index. Of all these variables, only the cost of air travel generated a significant t-statistic. The regression results were:

OD Passengers = 460.8 – 1.612 (Cost of Air Travel)
t stats (14.1) (-5.3)
Adjusted R squared = .67

This results in an estimated arc elasticity of -.58.

[2] I am indebted to Kells Boland of Prolog Planning in Calgary for pointing this out to me.




Interestingly enough, the regressions did not show a statistically significant effect from the relocation of Edmonton air carrier operations to YEG.

An attempt was made to determine if changes in OD passenger levels were reflected in changes in car passenger traffic. Average annual daily traffic (AADT) on a rural stretch of Highway 2 was used as a proxy for passenger traffic. The volume of vehicle traffic on the highway – AADT of 44,460 (equivalent to an annual total of 16.2 million) – suggests that the impact of any reduction in air travel would be so small as to be invisible in the highway statistics.

**Conclusions**

This analysis has shown a strong relationship between OD passenger levels on the Edmonton - Calgary route and total travel costs. Though clearly incomplete as an econometric analysis of the market, this provides a useful starting point for gaining a clearer understanding of market dynamics.

The lack of a clear reference fare level is an impediment to accurately measuring the price elasticity of demand. The fares selected were the lowest generally available published fares – but only the airlines know what percentage of seats were actually sold at these price levels. However, with the exception of the Y fares, it appears that most of the discount fare levels tend to move in concert, so the regression may reflect the sensitivity (though not of course the exact elasticity) of travelers in other fare categories.

This analysis has pointed out the startling increase in non-fare costs on this route since 1997. For the Edmonton-Calgary route, this included Airport Improvement Fees totaling $22 on a round trip, and the NAV CANADA surcharge of $15 per round trip ticket which the airlines imposed when the Air Ticket Tax was removed. Since 2001, additional charges have been imposed – airline insurance surcharges, airline fuel surcharges, the Air Travel Security Charge and an increase in the Edmonton Airport Improvement Fee from $10 to $15 in July 2002.

If the analysis in this paper is correct, we should expect a continuing decline in the Edmonton – Calgary OD market since 1999.

# Airline Strategies Under Deregulation: Fares and Schedules in Three Low Density Routes In Alberta

Philip Davies, Geoffrey Horner, Transport Canada

## Introduction

This paper examines air policy changes and the competitive effects on scheduled air services at three city-pairs: Edmonton-Grande Prairie, Edmonton-Fort McMurray and Edmonton-Peace River, over the period 1983 through 2002. This period encompassed the deregulation of domestic air services and the complete restructuring of the Canadian airline industry.

## History

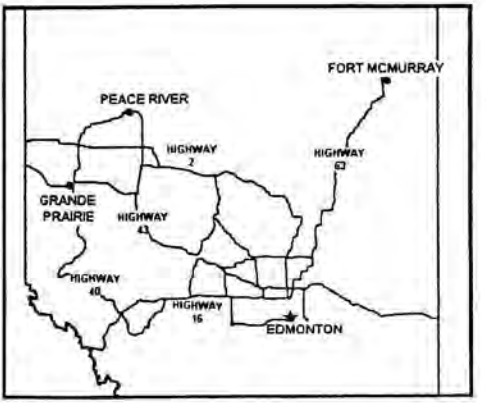
The legislative history includes the National Transportation Act 1967 which granted wide ranging powers to regulate commercial aviation to the Canadian Transport Commission, including the power to issue licences and impose conditions on successful applicants. Market entry and exit was regulated under criteria of public convenience and necessity, and conditions were often imposed to limit competition. Airlines' roles were strictly defined, with transcontinental scheduled services reserved for Air Canada and CP Air. Within Alberta, Pacific Western Airlines was the dominant regional carrier and Time Air, based in Lethbridge, provided local services.

A substantive policy change was announced in May 1984 with the release of the New Canadian Air Policy, which called for gradual deregulation of the industry. Major elements included gradual easing of pricing restrictions, the removal of licence conditions restricting equipment and flight frequency, and increased competition among national, regional and local carriers. Domestic scheduled air service

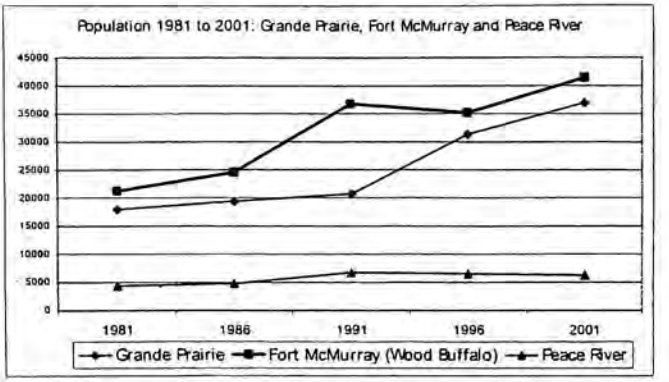
was effectively deregulated with passage of the National Transportation Act 1987. Restrictions on market entry and exit, fares, and equipment were essentially eliminated. This policy was continued with passage of the Canada Transportation Act 1996.

Operationally, the air carriers had anticipated legislative deregulation and the restructuring of the Canadian domestic airline industry began in the fall of 1983. In October 1983, Pacific Western Airlines purchased 40% of Time Air. About the same time, the Alberta government privatised Pacific Western Airlines. On November 28, 1986 Air Canada purchased 100% of Air BC. On December 2, 1986 PWA purchased CP Air. On April 26, 1987, PWA and CP Air operations were integrated under the name Canadian Airlines International. Also in 1988, the Federal Government sold off 45% of its stake in Air Canada. The remaining shares were sold in 1989.

**Community Profiles**




The three centres included in this analysis are located in the northern portion of Alberta. Grande Prairie is located approximately 460 km by road northwest of Edmonton and Peace River is approximately 437 km. Both communities' economies are based on agriculture, forestry and oil and gas. Fort McMurray is approximately 440 km northeast of Edmonton. Its economy is based almost entirely on oilsands extraction.




Grande Prairie and Fort McMurray have had rapid population growth over the last decade. The population of Peace River actually declined over the last ten years.

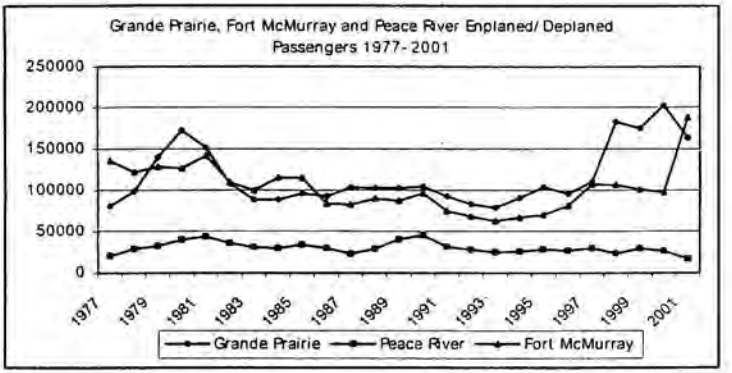
**Data Sources and Limitations**

The data used in this analysis includes airline fares and schedules from 1984 to the end of 2002. Only flights between the local hub of Edmonton (both the Edmonton Municipal and Edmonton International Airports) and the subject sites were analyzed. Airline fares were obtained from Airline Tariff Publishing Company of Washington, DC. Fare data for some periods prior to 1991 is limited to two sample observations per year for cost and availability reasons. The fares were selected to represent fares available to all passengers (i.e.. excluding "status" fares such as seniors and youth discounts, rates for accompanied children, etc.), sorted by advance purchase criteria. Discount rates typically also carry minimum stay requirements (usually a Saturday stay). No published fare data is available for Time Air flights prior to their absorption into Canadian Airlines International.

Airline schedule data was generated from airline schedules published in the Official Airline Guide.

**Air Service History**

Over most of the period, passenger traffic at these communities was stagnant or declining. Passenger demand at all of these sites peaked during the 1980-1981 period when the Alberta economy was experiencing rapid growth due to high oil prices. Traffic at Grande Prairie only surpassed its 1980 peak of 172,000 passengers in 1998, and traffic fell as low as 79,000 passengers in 1993. Fort McMurray

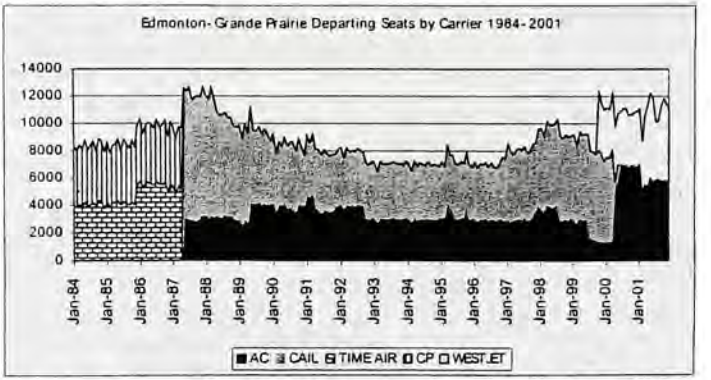



peaked at around 142,000 passengers in 1981, fell as low as 63,000 passengers in 1993 and with WestJet's entrance into the market has rocketed to just under 200,000 passengers. Peace River traffic peaked at 44,000 passengers in 1981 but stagnated at around 30,000 passengers per year since with the exception of a rally around 1990, which coincided with Air Canada's short-lived entry into the market.

**Grande Prairie**

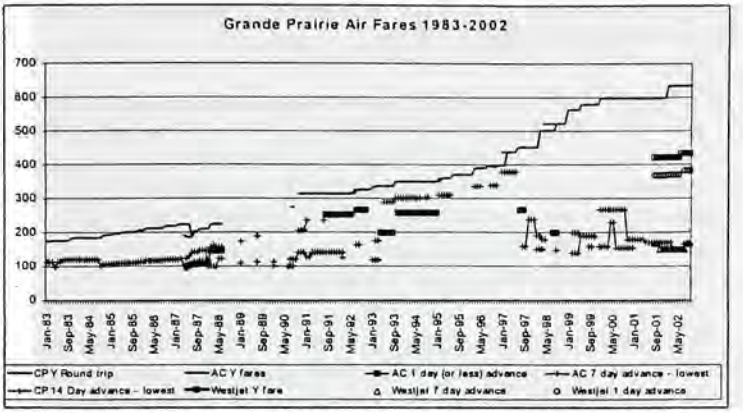
Two competing carriers served Grande Prairie prior to deregulation. In 1985, CP Air provided two flights per day from the Edmonton International Airport using Boeing 737 aircraft. Time Air provided

three flights per day using Convair or DASH 7 aircraft. CP's Edmonton – Grande Prairie route extended westward to Fort St. John, which served as a mini-hub for northern operations and connections to Vancouver. The Edmonton – Grande Prairie section was the first route contested by Air BC on behalf of Air Canada in Alberta; Air BC service started in April 1987. The evolution of capacity on this route is illustrated below:




Capacity increased sharply with the entry of Air BC in April 1987, and remained fairly high in the initial period of intense competition until around mid 1992. From 1992, capacity was stable until around the beginning of 1997, when Canadian Airlines increased their capacity sharply. Capacity reached a level almost as high as the previous peak with the entry of WestJet in October 1999.

Portrayal of airline fares is difficult due to the variety of conditions attached to their use, and inconsistencies in these conditions over




time. The graph illustrates the standard economy "Y" fares (which rarely differed between Air Canada and Canadian Airlines) and some representative discount fares.

Within the limitations of the available graphics capabilities, it is still possible to discern major features of the fare structures over time:

- The economy Y fares (narrow solid line) increased 264% (current dollars);
- The availability of low discount fares (14 day advance – dotted line; 7 day advance – triangles) is evident in the initial period of competition, limited from 1992 to 1997, and again pronounced up to the time of the merger of Air Canada and Canadian Airlines;
- Lower 1 day advance fares (dark solid line) have been available in periods of more intense competition;
- The lowest fare prior to deregulation (CP April 1983) was $97. Adjusted for inflation, this is about 7% higher than WestJet's WestJet's (July 2002) fare of $150.
- The level of discount fares was higher from mid 1992 to mid 1997.

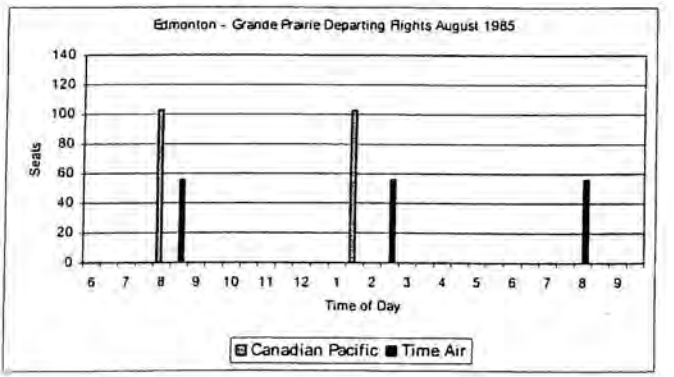
WestJet entered the market with a Y fare (shown as squares on the graph) at a level of around two thirds of the prevailing Y fare, and offered substantial fare discounts.

WestJet's fare structure differs from the traditional fare structure, which typically incorporated advance purchase requirements of 7 or 14 (and sometimes 21) days, though in periods of strong competition low 1-day advance fares have been offered. WestJet offers one-way fares with advance purchase periods of 1, 3, 5 and 7 days. The success of WestJet in becoming the market leader is reflected in Air Canada's adoption of a similar fare structure.

The evolution of airline schedules is shown in the 1985 service and at the end of the study period in 2001. Each graph represents the daily departure times of flights leaving Edmonton; the height of the bar represents aircraft seating capacity.

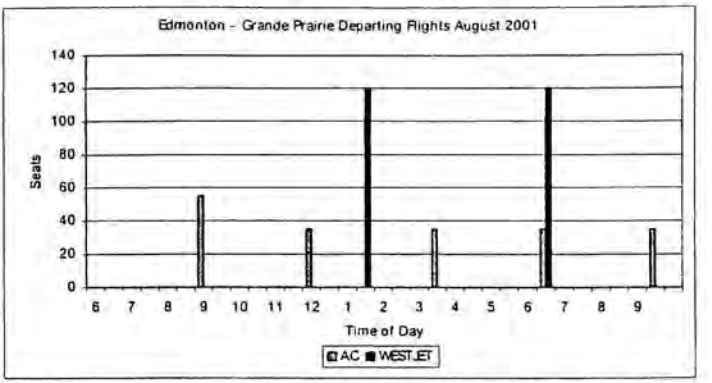
In 1985 CP Air scheduled two Boeing 737 flights and Time Air scheduled three flights using Convair or Dash 7 aircraft.

By 1992, the number of flights had increased from 5 to 10 per day, with both Canadian Airlines and Air Canada scheduling Dash 8 aircraft, supplemented with 19 seat Jetstream J31 aircraft by Air Canada.



By 1995, Canadian had increased to 5 flights per day, and Air Canada had withdrawn its J-31 aircraft in favour of Dash 8 service

Finally, by 2001, with the entrance of WestJet, the schedule closely



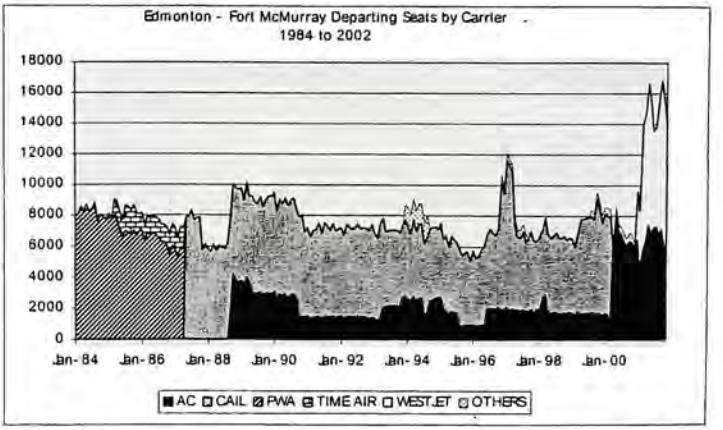

resembles the pre-deregulation schedule, with 2 B737 flights by WestJet and 5 Dash 8 flights by Air Canada.

**Fort McMurray**

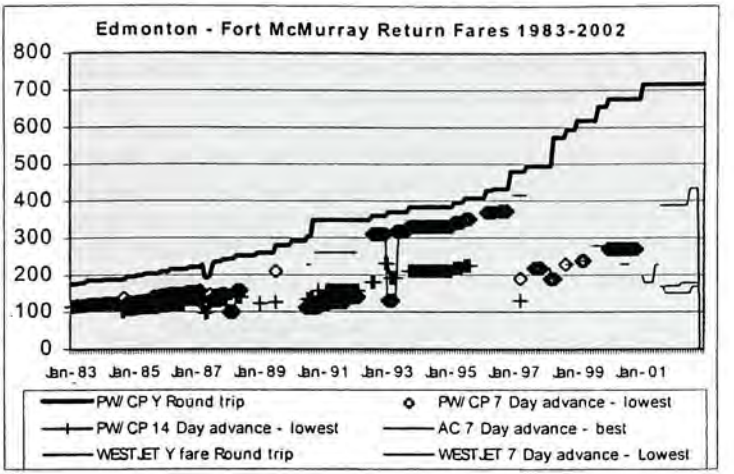
Fort McMurray did not have competitive air service prior to deregulation. During the peak demand period in the early 1980's, Pacific Western Airlines provided 3 flights per day using B737 aircraft. Following their investment in Time Air, they transferred one flight per day to the smaller carrier. Air BC entered this market in mid-1988. Canadian Airlines (PWA's successor) retained the largest capacity share on this route until their absorption by Air Canada in 1999.

Capacity shows a similar pattern on the entry of Air BC as was seen in the Grande Prairie market, with capacity increasing sharply on entry and then leveling out before spiking again in 1997. The entry of WestJet in January 2000 boosted capacity to a new peak. There were two attempts by local carriers to contest this market in competition with Air Canada and Canadian Airlines, both attempting to exploit a

market niche by providing service in small aircraft from the Edmonton Municipal Airport. The first was a scheduled service by North American Airlines using Fairchild Metro Merlin aircraft, which lasted from December 1993 to August 1994. The second was scheduled service provided by Contact Air using Beechcraft aircraft. Neither service was sustainable.

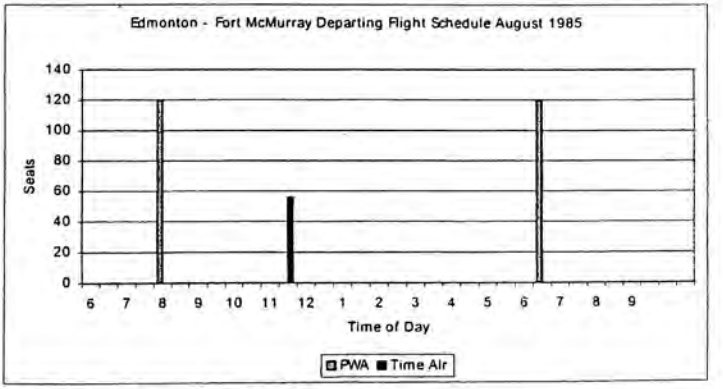



The fare history on the Fort McMurray route also resembles that of the Grande Prairie route, with significant discounts available on Air BC's initial entrance, more limited availability of low fares in the mid 1990's and renewed availability of low fares starting in 1997. The entry of WestJet in January 2001 pushed fares lower.




The 1985 flight schedule and the August 2001 represent the beginning and end of the cycle. Prior to deregulation, Fort McMurray was served by three flights per day.

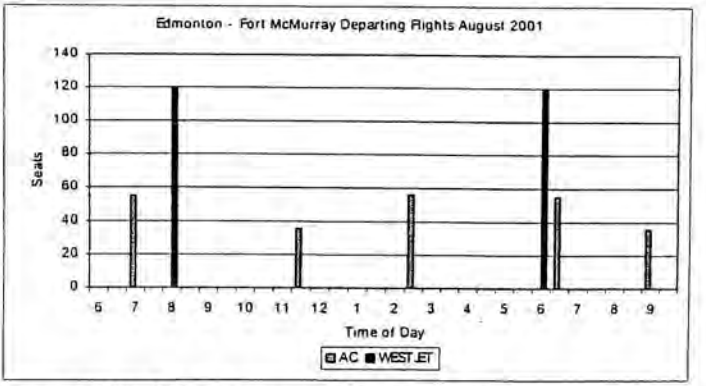
In the initial period of competition brought Air Canada operating as Air BC into the mix with three J-31 and one Bae-146 competing




against PWA's two B-737.

During the lull in competition in the mid 1990's, frequency dropped to four flights per day and B737 service was withdrawn in favour of Fokker F-28 or Dash 8 equipment.

By August 2000, following the rationalization of Air Canada and Canadian Airlines services, daily frequency by Air Canada increased to five flights per day, supplemented by two flights per day operated by Contact Air using Beech aircraft. As previously noted, the Contact Air service was subsequently withdrawn. With the entry of WestJet in




January 2001, flight frequency and capacity reached a competitive peak. The schedule most closely resembles that seen during the initial entry of Air Canada into this market, with WestJet in the role previously played by Canadian Airlines. However, unlike the 2001 Grande Prairie schedule, which approximated the pre-deregulation schedule, Fort McMurray has a higher competitive level of service as illustrated in the August 2001 schedule.

**Peace River**

Prior to deregulation, Time Air served Peace River with three flights per day using Convair aircraft. Air Canada entered the market in May 1989 using J-31 aircraft. Air Canada abandoned this market in May 1991 returning in January 2000 after the merger with Canadian.

Capacity was stable in this market through the turmoil of the 1990's. Air Canada substantially reduced both flights and seats in 2001.

Comparison of Y and discount fares between Grande Prairie and Peace River indicates the impact of the lack of competition on the availability of discount fares. Prior to 1985, both the Y fares and discount fares (14 day advance purchase) were similar in the two markets. The fare history for Peace River is missing for the 1985 to 1987 period due to the lack of published fares for Time Air. Grande Prairie discount fares fell below Peace River fares with the onset of competition in April 1987. While Air Canada contested the Peace River market, discount fare levels and availability were similar between the two markets. With the withdrawal of Air Canada, discount fares for Peace River were similar in level to those for Grande Prairie but availability was much less – primarily limited to seasonal discounts.

Peace River has seen a decline in both frequency and capacity following deregulation. In 1985, Time Air provided three flights per day using Convair or Dash 7 equipment. With the entry of Air Canada in 1989, there were two flights per day by Canadian Airlines and an additional three flights per day by Air Canada using J-31 aircraft. Following the 1991 withdrawal of Air Canada's services, CP provided three flights per day with Dash 8 aircraft. Following the merger, Air Canada has cut back service to two Beechcraft aircraft daily.

## Conclusions

This paper has examined the evolution of air services between Edmonton and the communities of Grande Prairie, Fort McMurray, and Peace River. Grande Prairie and Fort McMurray exhibited similar patterns following deregulation, with a period of intense competition following Air Canada's entry, characterized by larger capacity and low discount fares; a lull in competition from 1992 to 1997, with capacity stabilizing and limited availability of deep discount fares; and renewed competition from 1997 to the end of 1999 when Air Canada took over Canadian Airlines. Competition has been maintained by the entry of WestJet, which has emerged as a market leader.

The Peace River market, much smaller than the other two, did not experience the same trends. Air Canada contested this market only briefly between 1989 and 1991, and following their withdrawal, capacity was stable and the availability of discount fares was limited. Following the merger of Air Canada and Canadian Airlines, capacity has been reduced by around 70%.

The disparity in air service between these three sites raises some interesting questions regarding the effects of unregulated competition in smaller markets. It would be interesting to expand this analysis to other regions to see if the routes examined in this paper are representative and if this analysis could be extended to draw general conclusions regarding the impact of deregulation on various classes of markets.

# The Prediction of Shipping Accidents In Inland Waterways Using Formal Concept Analysis

Ray R. Hashemi[1]
Louis A. LeBlanc[2]
Tetsuya Kobayashi[3]

## 1.0 Introduction

Past research (Le Blanc and Rucks, 1995; Le Blanc and Rucks, 1996) has employed statistical procedures such as cluster and discriminant techniques for policy analysis of the effectiveness of vessel traffic services. Also, Le Blanc et al. (2001) and Hashemi et al. (1995) reported the application of artificial intelligence models to marine safety. The research reported herein represents an

1 Department of Computer Science, Armstrong Atlantic State University, Savannah, GA 31419.

2 Campbell School of Business, Berry College, Mount Berry, GA 30149.

3 Department of Computer Science, University of Arkansas at Little Rock, Little Rock, AR 72204.

application of Formal Concept Analysis (FCA) to the prediction of marine accidents.

A number of objects (or events) may be grouped and labeled to signify a fact. The label for the group represents the fact that the group stands for. The group of objects along with their label is referred to as a "concept". For example, a set of vessel accidents that are labeled as "winter" makes a concept. The meaning of the label in this case may represent the season that the marine accidents took place. Several concepts may create a super-concept and a give concept may serve as a sub-concept of a super-concept.

A data set that represents marine accidents includes a set of attributes for each accident. These attributes are categorical attributes, for example "low river stage" or "medium river stage" or "high river stage", "day time accident" or "night time accident", "medium traffic level" or "high traffic level". To create all the concepts and sub-concepts, as well as super-concept relationships for the given data set, the Formal Concept Analysis (FCA) approach introduced by Wille (1982) is employed. The details of this methodology along with some of its applications may be found in Snelting (1996), Godin et al. (1994, 1998), Cole and Eklund (1996) Mineau and Godin (1995) and Priss (1999).

This methodology generates all the possible concepts for a given data set and establishes the relationships among the concepts. These relationships will determine the role

of each concept as a super-concept and/or a sub-concept in multiple levels. The results are displayed in the form of a lattice.

This research effort applies FCA to a data set that consists of a number of vessel accidents on the lower Mississippi River for the purpose of predicting the vassal accidents. Three types of accidents may occur: "Collision", "Ramming", and "Grounding". A collision is defined as the contact between two vessels that are both underway without regard to monetary damage to the respective vessels or personal injury. A ramming refers to a type of accidents in which one vessel . . . (Loui, please provide a definition) . . . A grounding is defined as . . . (Loui, please provide a definition) . . .

We provide a background about FCA shortly. The methodology used in this research is presented in section 3. Results are discussed in section 4, and Conclusion and Future Research are covered in section 5.

## 2.0 Background

A formal context K is a triplet (O, R, A) in which O is a set of objects, A is a set of attributes, and R is a relation between O and A (i.e. $R \subseteq O \times A$). A formal concept in K is A pair (E, F) such that $E \subseteq O$, $F \subseteq A$, $E' = F$, and $F' = E$, where the operators E' and F' are defined as follows: $E' = \{a \in A \mid oRa \text{ for all } o \in E\}$ and $F' = \{o \in O \mid oRa \text{ for all } a \in F\}$. The first operator, E', delivers the set of attributes common to the objects in E. The second

operator, F', delivers the set of objects common to the attributes in F. A context has several formal concepts.

If all the concepts of the context K are ordered, then the result is a *concept lattice* in which each concept, $C_i = (E_i, F_i)$, is shown by a node (an oval shape) that is annotated with the sets $E_i$ and $F_i$.
To explain it further, let us present an example. A data set with attributes S, T, U and D is given, Table 1.a. The first three attributes are the conditions (i.e., independent variables) and the last attribute is a decision attribute (i.e., the dependent variable.) The possible values for S, T, U, and D are {e, f}, {g, h}, {p, q, w}, and {d1, d2, d3}, respectively. The context for the data set of Table 1.a is shown in Table 1.b. The decision attribute does not participate in the creation of context for the data set. The concept lattice for the context of Table 1.b is illustrated in Figure 1.

## 3.0 Methodology

Let Y be a given data set in which each object is made of k +1 attributes ($a_1, a_2, \ldots, a_k$ ) and a decision. Let L also be the concept lattice for Y. Furthermore, let $C_i = (E_i, F_i)$, be a node of lattice L that has m objects $E_i = \{r_1, r_2, \ldots, r_m\}$ and n attributes $F_i = \{a_i, a_j, \ldots, a_h\}$ ($|F_i| = n$.) The following algorithm is presented to extract rules from the concepts of the lattice L.

| Record No. | S | T | U | D |
|---|---|---|---|---|
| 1 | e | g | p | d1 |
| 2 | e | g | q | d1 |
| 3 | e | h | q | d1 |
| 4 | e | g | w | d2 |
| 5 | e | h | w | d1 |
| 6 | e | h | p | d1 |
| 7 | f | h | w | d3 |
| 8 | f | g | w | d3 |

(a)

| Record No. | e | f | g | h | p | q | w |
|---|---|---|---|---|---|---|---|
| 1 | x | | x | | x | | |
| 2 | x | | x | | | x | |
| 3 | x | | | x | | x | |
| 4 | x | | x | | | | x |
| 5 | x | | | x | | | x |
| 6 | x | | | x | x | | |
| 7 | | x | | x | | | x |
| 8 | | x | x | | | | x |

(b)

Table 1: The data set and its context: (a) The data set and (b) the context of the data set.

**Algorithm Extraction**

Given: A concept lattice L which is made of z concepts.

Objective: Extracting rules from the concepts in L.

Step 1. Repeat steps 2 through 3 for every concept, $C_i = (E_i, F_i)$ in L.

Step 2. Group the m objects in $E_i$ based on their decision values $(g_1, \ldots, g_p)$

Step 3. If p = 1 //all the objects in $E_i$ have the same decision (e.g., d1)

Then assign the "certainty factor" equal to 1 to the decision.

Else use the Bay's theorem to determine a dominant decision among the objects in $E_i$. The "certainty factor" of the dominant

decision is equal to the conditional probability of the dominant decision.

Step 4. Eliminate those concepts from L for which the certainty factor of the dominant decision $\leq 0.5$.

Step 5. Invoke hierarchical rules.

Step 7. End.

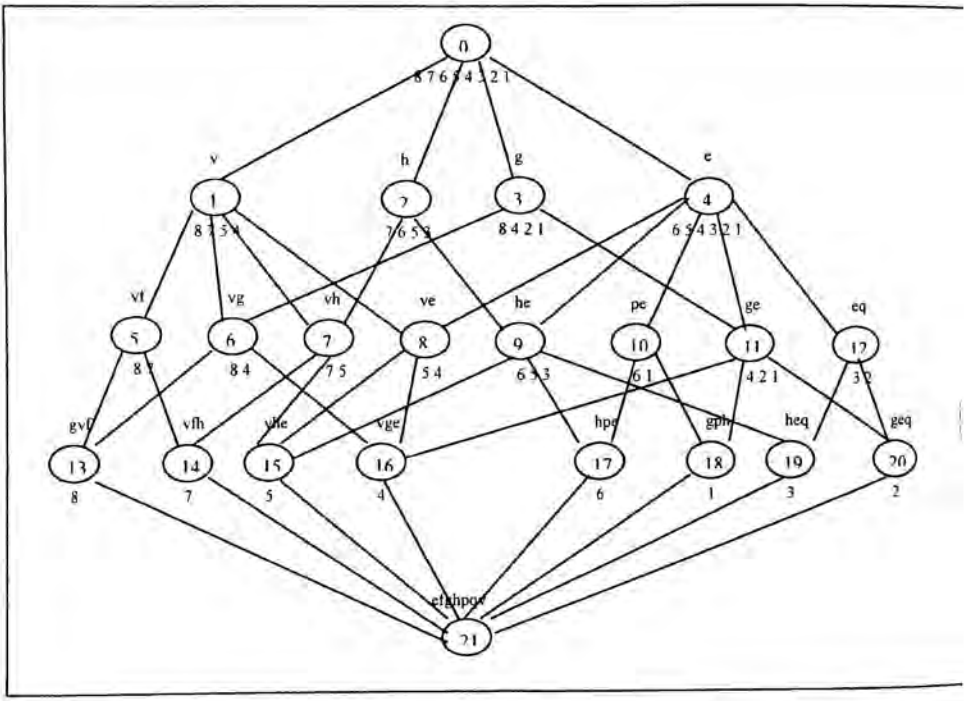



Figure 1: The concept lattice for the context in Table 1.b.

The results of completion of steps 1-4 for all the concepts (nodes) of the lattice of Figure 1 are shown in Table 2. The Algorithm Extraction does not process the node 0 and 21 because the former one has a number of records with no common attributes and the later one is empty.

| Concept No. | Attributes of the Concept ($F_{concept}$) | Records of the Concept ($E_{concept}$) | Dominant decision and Certainty factor |
|---|---|---|---|
| 2 | h | 3-5-6-7 | d1 (0.75) |
| 4 | e | 1-2-3-4-5-6 | d1 (0.83) |
| 5 | vf | 7-8 | d3 (1) |
| 9 | he | 3-5-6 | d1 (1) |
| 10 | pe | 1-6 | d1 (1) |
| 11 | ge | 1-2-4 | d1 (0.67) |
| 12 | eq | 2-3 | d1 (1) |
| 13 | gvf | 8 | d3 (1) |
| 14 | vfh | 7 | d3 (1) |
| 15 | vhe | 5 | d1 (1) |
| 16 | gve | 4 | d2 (1) |
| 17 | hpe | 6 | d1 (1) |
| 18 | gpe | 1 | d1 (1) |
| 19 | heq | 3 | d1 (1) |
| 20 | geq | 2 | d1 (1) |

Table 2. The results of applying steps 1-4 to all the concepts in Figure 1.

**Algorthm Hierarchical-Rules**

Given: A table of concepts, $\tau$, for which the dominant decisions of each concept is greater than 0.5 (e.g., Table 2.)

Objective: Generation of Hierarchical rules.

Step 1. Repeat step 2 for all the concepts in $\tau$.
Step 2. If the dominant decision is the same for all the occurrences of the $F_{concept_i}$ through out Table $\tau$, then mark those concepts that have $F_{concept_i}$ in their set of attributes.
Step 3. Remove all the marked concepts from T.
Step 4. Group the remaining concepts of Table T based on their certainty factors.
Step 5. Sort the groups in ascending order of their certainty factors.
Step 6. Generate rules for each group.
    a) If i > j, then rules belong to group i has a higher precedence over the rules in the group j.
    b) If a rule in a group with higher precedence has the same dominant decision as a rule in lower precedence and the antecedents of the rule in the group with the higher precedence is a subset of antecedents in the rule with lower precedence, then remove the rule with the lower precedence.
Step 7. End.

The results of applying algorithm Hierarchical-Rules are illustrated in Tables 3.a and 3.b. To apply the Hierarchical-rules and predict the decision for a test set the following algorithm is used.

| Group No. | Concept No. | ($F_{concept}$) | ($E_{concept}$) | Dominant decision & Certainty factor |
|---|---|---|---|---|
| 1 | 5 | vf | 7-8 | d3 (1) |
| 1 | 9 | he | 3-5-6 | d1 (1) |
| 1 | 10 | pe | 1-6 | d1 (1) |
| 1 | 12 | eq | 2-3 | d1 (1) |
| 1 | 16 | gve | 4 | d2 (1) |
| 2 | 4 | e | 1-2-3-4-5-6 | d1 (0.83) |
| 3 | 2 | h | 3-5-6-7 | d1 (0.75) |
| 4 | 11 | ge | 1-2-4 | d1 (0.67) |

(a)

**Group 1 (highest precedence)**

If U = v & S = f then D = d3 (1)
If T = h & S = e then D = d1 (1)
If U = p & S = e then D = d1 (1)
If S= e & U = q then D = d1 (1)
If T = g & S = e & U = v then D = d2 (1)

**Group 2**

If S = e then D = d1 (0.83)

**Group 3**

If T = h then D = d1 (0.75)

**Group 4** is empty

(This group has only one rule and that rule is removed based on step 5.b of the algorithm.)

(b)

Table 3. The hierarchical rules generated by the Hierarchical-Rules Algorithm: (a) grouping of the concepts and (b) set of Hierarchical rules.

**Algorithm Test**

Given: A set of hierarchical-rules and a test set.

Objective: Prediction of the decisions for each record in the test set.

Step 1. Use the rules of highest precedence to predict the decisions.

Step 2. If there are records that cannot be predicted, then use the group of rules with the next highest precedence to predict only those records.

Step 3. Repeat step 2 until either all the records in the test set are predicted, or the groups of the rules are exhausted.

Step 4. End.

## 4.0 Results

We first explain the setting for data collection and then our findings are presented.

The New Orleans Vessel Traffic Service (NOLA-VTS) monitors vessel traffic on the lower Mississippi River from Baton Rouge south to the Gulf of Mexico beyond New Orleans - a distance of about 250 miles. As a voluntary vessel movement reporting system, NOLA-VTS provides ocean-going ships, large barge tows, and other river traffic with pertinent information to aid in making decisions as to the proper navigation strategy for the lower Mississippi River. The output device is similar to an air traffic control display but with computer-simulated movement rather than real-time radar.

Movement reports are made when a vessel enters the system, crosses a sector boundary, or passes any one of several checkpoints; if necessary, the tracking is updated. A series of VHF-FM transceiver stations are positioned along the lower Mississippi River, and microwave relays beam transmissions to and from the VTC via antennas. Coast Guard personnel at the VTC provide vessel navigators with the information relevant to developing situations and the proximity of other vessels. In addition, the NOLA-VTS audits vessel accidents and records them on a daily log.

We have a data set made of 199 records of accidents. The make up of the data set is as follow: 46 rerecords have the accident type of "Collision", 83 records have the accident type of "Ramming", and 70 records have the accident type of "Grounding". For each type of accident, 17% of its records (8 from "collision", 14 from "Ramming" and 11 from Grounding"; the total of 33 records) are randomly chosen as a test set. To create a training set from the remaining of 199 records, we pick the equal number of records for each category of accidents such that the number of records in the training set is the maximum possible. The result is a training set composed of 114 records (38 records for each category of accidents.) We have repeated this process four times and created 4 pairs of training and test sets.

The FCA methodology uses a pair of training and test set to generate rules from the training set and test the rules against the test set. The results are illustrated in Table 4.

To show the validity of approach and provide a basis for comparison, we have repeated the prediction process for the same four pairs of training and test sets using the Discriminant analysis and the Rough Stes methodology (Hashemi et. al. (1997), Hashemi et. al. (2002), and Pawlak (1984).) The results for these two new prediction methodologies are also shown in table 4.

| | | METHODOLOGY | | |
|---|---|---|---|---|
| | | FCA | DA | RS |
| Test sets | # of Records | % of correct classifications | % of correct classifications | % of correct classifications |
| Test set 1 | 33 | 26/33 = 78.8 | 24/33 = 70.6 | 13/33 = 38.2 |
| Test set 2 | 33 | 25/33 = 70.6 | 21/33 = 63.6 | 9/33 = 27.3 |
| Test set 3 | 33 | 24/33 = 73.5 | 23/33 = 69.7 | 9/33 = 27.3 |
| Test set 4 | 33 | 21/33 = 63.6 | 20/33 = 60.6 | 12/33 = 36.4 |
| Average | 33 | 71.8% | 66.1% | 32.3% |

Table 4: The prediction results using FCA (Formal concept analysis), DA (Discreminant Analysis), and RS (Rough Sets) for four randomly chosen test sets (none of the records in a test set is participating in its corresponding training set.)

## 5.0 Conclusions and Future Research

The results in Table 4 reveals that the FCA is a viable approach for prediction of vassal accidents in inland waterways. The validity of approach stems from the fact that more than one pair of training and test sets are used. The comparison of the FCA performance in reference to

Discriminant Analysis and the Rough Sets approach adds to the credibility of FCA.

As future research we are in the process of applying FCA against a larger data set and for a different type of data. The case input is the use of FCA for predicting the inflation in the united states based on data collected from 1950.

## 6.0 References

Cole, R. J. and P. W. Eklund, "The Application of Formal Concept Analysis to Text Retrieval in the Medical Domain," *Proceedings of the 5th International Conference on Conceptual Structures*, 1996.

Godin, R., G. Mineau, R. Missaoui, M. St-Germain, and N. Faraj, "Applying Concept Formation Methods to Software Reuse," *International Journal of Software and Engineering,* Volume 5, Number 1, 1994, pp. 119-142.

Godin, R., H. Mili, G. Mineau, R. Missaoui, M. Arfi, and T-T Chau, "Design of Class Hierarchies Based on Concept (Galois) Lattices," *Theory and Practice of Object Systems,* Volume 4, Number 2, 1998, pp. 117-134.

Hashemi, R. R., L. A. Le Blanc, C. T. Rucks, and A. Shearry, "A Neural Network for Transportation Safety Modeling," *Expert Systems With Applications*, Volume 9, Number 3, 1995, pp. 247-256.

Hashemi R. R., Pearce B., Arani R., Hinson W., and Paule M. "A Fusion of Rough Sets, Modified Rough Sets, and Genetic Algorithms for Hybrid Diagnostic Systems", *Rough Sets and Data Mining: Analysis of Imprecise Data*, Kluwer Academic Publishers, pp 149-176, 1997.

Hashemi R. R., F. Choobineh, W. Slikker, and M. Paule, "A Rough-Fuzzy Classifier for Database Mining", *The International Journal of Smart Engineering System Design*, No. 4, pp.107-114, 2002,

Le Blanc, L. A. and C. T. Rucks, "A Cluster Analysis of Vessel Accidents," *The Logistics and Transportation Review*, Volume 31, Number 1, March 1995, pp. 47-62.

Le Blanc, L. A. and C. T. Rucks, "A Multiple Discriminant Analysis of Vessel Accidents," *Accident Analysis & Prevention*, Volume 28, Number 4, 1996, pp. 501-510.

Le Blanc, L. A., R. R. Hashemi, and C. T. Rucks, "Pattern Development for Vessel Accidents: A Comparison of Statistical and Neural Computing Techniques," *Expert Systems with Applications*, Volume 20, Number 2, March 2001, pp. 163-171.

Mineau, G. and R. Godin, "Automatic Structuring of Knowledge Bases by Conceptual Clustering," *IEEE Transactions on Knowledge and Data Engineering*, Volume 7, Number 5, 1995, pp. 824-829.

Pawlak Z. "Rough Classification", *Intl. J. of Man-Machine Studies*, 20, pp. 469-483, 1984.

Priss, U., "Efficient Implementation of Semantic Relations in Lexical Databases," *Computational Intelligence*, Volume 15, 1999, pp. 79-87.

Snelting, G., "Reengineering of Configurations Based on Mathematical Concept Analysis," *ACM Transactions on Software Engineering and Methodology, Volume* 5, Number 2, 1996, pp. 146-189.

Wille, R., "Restructuring Lattice Theory: An Approach based on Hierarchies of Concepts," *Ordered Sets*, Ivan Rivali Editor, Reidel Dordecht-Boston Publisher, 1982, pp. 445-470.

ISSN #1183-2770

Printing Services • 966-6639
University of Saskatchewan • CUPE 1975